UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
Philadelphia Electric Company	)	Docket Nos. 50-352 50-353
(Limerick Generating Station, Units 1 and 2)	)	

TESTIMONY OF V.S. BOYER, M.I. GOLDMAN, G.D. KAISER, E.R. SCHMIDT AND R. WALLER RELATING TO THE CITY OF PHILADELPHIA CONTENTIONS CITY-18 AND CITY-19

City Contentions 18 and 19, as admitted by the Atomic Safety and Licensing Board, read as follows

> CITY- 18 - The State Plan is inadequate in the area of emergency planning because in the plan there is no adequate implementable plan for providing an alternate source of water for the City of Philadelphia which is appropriate to the locale of Philadelphia and which gives consideration to the PAG guidelines, namely, substitution of other drinking water sources, importation of water, rationing, substitution of other beverages and designation of critical users. "Implementable plan" includes consideration of ability to implement in which is included resources available.

> CITY-19 - The State Plan is inadequate in the area of emergency planning because in the plan there is no adequate implementable plan or implementable alternatives and methods for decontamination of the City's water supply and water supply system. "Implementable plan" includes consideration of ability to implement in which is included resources available.

INTRODUCTION

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1. This testimony discusses the reasons why no detailed planning for providing alternative sources of water or methods of decontamination is necessary, even in the unlikely event that the City of Philadelphia's water supplies might be affected as a result of an accidental release of radioactive material from the Limerick Generating Station (LGS). This testimony shows that effective countermeasures can be taken at the time using resources which would be readily available and procedures which are routine and within the capabilities of the Philadelphia Water Department and Federal, State and local organizations that would be involved in providing protective actions.

DESCRIPTION OF THE PHILADELPHIA WATER SUPPLY SYSTEM

V.S. Boyer
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2. The City of Philadelphia obtains raw water for its water system from both the Delaware and Schuylkill Rivers. About 215 MGD are withdrawn from the Delaware River and treated at the Samuel S. Baxter Plant (Ref. 1, Appl. Exh. 166, p. 3). This facility is designed to treat an average flow of 282 MGD with a peak rate of 423 MGD (Ref. 1, Appl. Exh. 166, p. 7). Water is taken from the eastern side of the Schuylkill

River and treated at the Queen Lane Plant. This plant normally processes about 100 MGD (Ref. 1, Appl. Exh. 166, p. 3). It is designed for an average flow of 120 MGD and could treat at a peak rate of 150 MGD (Ref. 1, Appl. Exh. 166, p. 7). The Belmont Plant typically treats about 65 MGD of water removed from the western side of the Schuylkill River (Ibid., p. 3). The Belmont Plant is designed for an average of 78 MGD and can handle a peak rate of 108 MGD (Ref. 1, Appl. Exh. 166, p. 7).

V.S. Boyer
E.R. Schmidt
R. Waller

3. At the Baxter plant, water from the Delaware River enters the presedimentation basin through tide gates. Low lift pumps convey the water to rapid mixing basins where chemicals are added. After flocculation, the partially treated water flows by gravity to sedimentation basins where settleable solids are removed. The effluent from the basins flows through rapid sand filters and then to covered filtered water basins. Chlorine, ammonia, ferric chloride and lime are added to the water during treatment. The plant also has facilities to feed activated carbon as well as other chemicals. The capacity of the presedimentation basin ranges from about 90 to 180 MG (Ref. 1, Appl. Exh. 166, p. 7), depending upon the amount of sediment collected in the bottom since the last dredging. The water can be taken directly from the river and pumped

to the rapid mixing basins, thus bypassing the presedimentation basin. The covered filtered water basins can hold about 193 MG (Ibid., p. 7) of treated water. From these basins, water is pumped to the distribution system. Normally, the Baxter Plant serves those customers generally east of Broad Street. However, it is possible for treated water from Baxter to serve all the City except the Belmont and possibly the Roxborough High Service Districts (Ref. 2, Appl. Exh. 169).

V.S. Boyer
E.R. Schmidt
R. Waller

4. Raw water for the Queen Lane Plant is pumped from the Schuylkill River to a presedimentation basin with a nominal capacity of 177 MG (Ref. 1, Appl. Exh. 166, p. 7). Normally, about three quarters of this capacity is usable. The presedimentation basin can be bypassed, but the size of the existing bypass pipeline will limit the amount of water that can be pumped. The Queen Lane Plant has the same treatment sequence as the Baxter Plant. Chlorine, lime, ferric chloride, and ammonia are added during treatment. Provisions are available to feed other chemicals, such as activated carbon. After treatment, the finished water flows to covered filtered water basins with a total capacity of 90 MG (Ref. 1, Appl. Exh. 166, p. 7). Treated water is then supplied to various pressure districts and to the East Park Reservoir. A

portion of the East Park Reservoir is being covered and is expected to be back in service before the end of 1984. The covered portion of the East Park Reservoir will then have a usable capacity of approximately 320 MG (Ref. 2A).

V.S. Boyer
E.R. Schmidt
R. Waller

5. Raw water for the Belmont Plant is pumped from the Schuylkill River to two presedimentation basins with a nominal capacity of 72 MG (Ref. 1, Appl. Exh. 166, p. 7). The exact capacity depends upon the amount of sediment in the basins. These basins can be bypassed, if necessary. The treatment sequence is the same as in the Baxter Plant. Normally, chlorine, lime, alum, and ammonia are added during treatment. Provisions are also available to feed other chemicals, such as activated carbon. Treated water flows to the clear well and then to either the filtered water basins or to the Belmont High Service Pumping Station. About 12 MGD are pumped to the Belmont High Service District (Ref. 2, Appl. Exh. 169). The remainder of the district served by the Belmont plant is fed by gravity from the filtered water basins.

V.S. Boyer
E.R. Schmidt
R. Waller

6. The Philadelphia water system includes about 323 MG of covered filtered water storage at the three treatment plants. With the newly covered section of the East Park Reservoir (320 MG) and numerous smaller covered basins and standpipes located in the distribution system (121 MG), the City water system has a total of approximately 764 MG of filtered water under cover. Generally, this provides more than two days of supply at the current average demand rates, assuming no decrease due to conservation measures or restrictions in the rate of usage.

SUMMARY OF PREVIOUS TESTIMONY AND BOARD FINDINGS

G.D. Kaiser
E.R. Schmidt

7. The risks to the people of Philadelphia arising from the consumption of drinking water that was assumed to be contaminated after a severe (but highly improbable) accident at the Limerick Generating Station, have been considered in previous hearings before this Atomic Safety and Licensing Board (Tr. 11, 996--12,282) and in a Second Partial Initial Decision, LBP-84-31 dated August 29, 1984 (pp. 241-263, "Second PID"). Some of the material in these references is pertinent to the present testimony and is summarized here for convenience.

G.D. Kaiser
E.R. Schmidt

8. In its previous written testimony (Ref. 3) and in oral testimony, the Applicant, Philadelphia Electric Company (PECo), demonstrated that the public risks arising from the consumption of drinking water that might be contaminated as a result of accidents at the Limerick Generating Station (LGS) are very small. The public risk was calculated as follows. First, a model was constructed, based on the computer code CRAC2, to calculate the total quantity of each radionuclide that could be deposited within the Schuylkill and/or Delaware watersheds following an airborne release of radioactive materials from LGS. Both wet and dry deposition mechanisms were considered. This calculation was repeated for each of the fission product source terms that are tabulated in the Limerick Generating Station Severe Accident Risk Assessment (SARA), Table 12-7* and for a range of combinations of weather conditions, wind speeds and wind directions. Thus, the full spectrum of possible contamination of the watersheds was considered. Together with each calculated result, an associated frequency was also calculated which was obtained by multiplying the point estimate frequency of occurrence of the source term from

*Accident sequences more probable than those in SARA have such small release fractions (at most, a fraction of a Curie of iodine and no predicted release of strontium and cesium, see Tables 7.1-7 through 7.1-19 of the ER-OL) that they would not lead to the contamination of drinking water supplies above Protective Action Guides.

SARA Table 12-8 by the probability of occurrence of the weather condition, wind speed and wind direction. Thus, an intermediate result of the calculation was a probabilistic distribution of the quantity of each radionuclide deposited in the Schuylkill and Delaware watersheds.

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9. Of the 54 radionuclides that are considered in the analysis, three were selected as important for the drinking water pathway; strontium, cesium and iodine. Strontium and cesium, by virtue of their long radiological half lives, and recognized radiotoxicity, dominate the long term contamination of ingestion pathways (Ref. 4, Appl. Exh. 154; Ref. 5, Appl. Exh. 155; see Second PID, p. 247). In the short term, however, isotopes of iodine such as ^{131}I, by virtue of the relatively large quantities that may be released in the event of an accident (see SARA Table 12-7) and their high radiotoxicity, must also be considered (see Second PID, p. 248). However, the half life of ^{131}I, which is the longest lived of the isotopes of iodine that were considered significant is only eight days so that, after a short period, it will no longer be a problem because it will have been eliminated by the process of radioactive decay.

D. Kaiser

R. Schmidt

10. Once the total amount of each radionuclide that has been deposited within each watershed has been calculated, the subsequent temporal variation of each radionuclide in the City of Philadelphia's drinking water supply (Ref. 3, paragraphs 7 through 14; paragraph 18; Transcript 12,048-12,051) can be calculated. For strontium and cesium, data representative of northeastern river valley sites were processed to give predicted concentrations of strontium and cesium in tap water derived from the Schuylkill or Delaware rivers (see Second PID p. 246), given the results of calculations of the amount of each radionuclide deposited on the watersheds. The data show that about two percent of the deposited strontium is washed into the rivers within the first month. Subsequently, an average of one to two percent of the remaining strontium finds it way into the rivers each year. The cesium behavior is similar to that of the strontium except that the rates for cesium are about one tenth of those of strontium. Thus, for both of these nuclides, there is an initial pulse of concentration in the river, followed by a long term, steady rate of elution. For iodine, there can be no corresponding long term contamination of the rivers because of its relatively short half life. In the short term, it is possible that about five percent of the iodine initially

deposited on the watersheds will make its way into the rivers over a short period of time (Tr 12,049; Ref. 6, Appl. Exh. ; Ref. 7, Appl. Exh.).

G.D. Kaiser
E.R. Schmidt

11. The Applicant's previous testimony also considered the direct deposition of the plume onto raw or finished water basins in the City's water supply system. Whenever the radioactive plume was predicted to pass over a reservoir, some radioactive material was predicted to be deposited onto the surface by dry and/or wet deposition.

M.I. Goldman
G.D. Kaiser
E.R. Schmidt

12. The calculations outlined in paragraphs 8 through 11 resulted in time-dependent probabilistic distribution of the concentrations of cesium and strontium in the Schuylkill and Delaware rivers (Ref. 3, Figures 4 and 5) and probabilistic distributions of the instantaneous concentration of these two radionuclides and iodine in the City's uncovered raw and finished water basins (Ref. 3, Figures 6 and 7). For each of the spectrum of calculated levels of contamination in the rivers and reservoirs, the Applicant carried out a calculation of the population dose in which the assumption was made that the inhabitants of the City continued to drink the contaminated water for fifty years with no countermeasures. The City's entire needs were assumed to be supplied from the Delaware

River, with the exception of the Belmont High Service District and Roxborough High Service District, which represent about 21 mgd out of the City's total needs of about 330 MGD or about 7 percent (Ref. 2, Appl, Exh. 169, Ref. 8, Appl Exh. 170; see Second PID, p. 254). Therefore, it was assumed that 93 percent of the City's needs would be supplied by the Delaware and 7 percent by the Schuylkill. The prediction of the whole body population doses received as a result of ingesting the various radionuclides was calculated by standard methods as described in paragraphs 16 of Ref. 3. The calculations were repeated for each of the possible levels of contamination of the rivers and reservoirs to generate a Complementary Cumulative Distribution Function of population dose, Figure 1. This curve gives the predicted probability per reactor year (frequency) with which the corresponding levels of population dose would be exceeded. The curve itself is an indication of the risk to the population of Philadelphia associated with the waterborne pathways. A more convenient measure is the area under the CCDF, which is 0.24 man-rem per reactor year and is made up of 0.02 man-rem per reactor year (8 percent) from the consumption of water contaminated by direct deposition into the system, 0.16 man-rem per reactor year (67 percent) from strontium and cesium deposited on the watershed and 0.06 man-rem per reactor year (25 percent) from the iodine deposited on the watershed. This 0.24 man-rem per year to the population of Philadelphia from drinking water is very small, as evidenced by the fact that the 1.7 million inhabitants of Philadelphia each receive approximately 0.1 rem per year from background radiation, of which about 25 percent arises from naturally occurring radionuclides in the body, leading to a continually incurred population dose of 170,000 man-rem per year, including 43,000 man-rem per year from internally deposited radionuclides.

V.S. Boyer
M.I. Goldman
G.D. Kaiser
E.R. Schmidt

13. The population dose can be converted into an equivalent prediction of the number of latent cancer fatalities arising in the City of Philadelphia. This was also done by the Applicant and it was shown that the public risk of latent cancer fatalities would be one ten millionth of the existing annual incidence of cancers in the City of Philadelphia arising from all other causes (Tr. 12,015). Predictions of very small risks are relevant to the City's present contentions because the thoroughness and detail needed for an emergency plan should take account of the magnitude of the predicted risks. If these risks are very small, as in the present case, substantial efforts to develop detailed emergency plans are not justified.

M.I. Goldman
G.D. Kaiser
E.R. Schmidt

14. In its Second PID the Board concluded that, for circumstances in which the water supply is influenced by contaminated run-off and fall-out the probability that the Commonwealth of Pennsylvania Emergency Management Agency's (PEMA) Protective Action Guide (PAG)* will be exceeded in the Schuylkill river is one in 300,000 per reactor year (see second PID at F-135; Ref. 3, p. 17). The corresponding probability for the Delaware is one in 7,000,000 per reactor year. These probabilities are derived on the assumption that no countermeasures are taken.

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E.R. Schmidt

15. While these probabilities are already very small, the Applicant believes that they contain conservatisms which further reduce them if calculated realistically. One important conservatism is the estimated quantity of ^{90} Sr released to the atmosphere. The largest releases of ^{90} Sr considered in the Applicant's testimony, which were derived from the Applicant's Severe Accident Risk Assessment (SARA, Table 12-7) are 0.35 of the total core inventory (for the release

*The PEMA PAGs are summarized in the Second PID in paragraphs F-133 and F-134 and Table 1. The PAG referred to above is for concentrations of radionuclides averaged over one year. The radionuclide ^{90}Sr is considered to be the principal contributor to long term contamination of drinking water and its PAG is 96 pCi/l averaged over 12 months. The Applicant's calculations show that the probability of exceeding the PAGs for radiocesium (the other radionuclide that is considered to be important for long term contamination of the drinking water supplies) is less than one chance in a billion per reactor year (Ref. 3, p. 18; see Second PID, p. 257-258).

category labelled VRH20) and 0.15 of the total core inventory (for the release category labelled VR). These release fractions are conservative because, in the SARA analysis, it was assumed that the core melt temperature was 2800C. Recent experimental results from the Power Burst Facility in Idaho Falls indicate that the effective core melt temperature will be about 2300C, due to the formation of liquid eutectics from the reaction of liquified cladding with solid uranium dioxide (Ref. 9, Appl. Exh.). In these circumstances, the amount of ^{90} Sr released from the fuel is expected to be smaller than predicted in the SARA analysis. Furthermore, the SARA analysis did not take into account the retention of radionuclides on surfaces in the reactor coolant system or the reactor building. Overall, an application of the currently evolving understanding of source terms would be expected to show that the largest strontium release fractions in the previous testimony (Ref. 3) are too high by a factor of 5-10 or more. Modifying Figures 4(a) and 5(a) of Ref. 3 to reflect this would show that the probability that the PEMA one-year PAG will be exceeded in the Schuylkill after one month is less than one chance in 1 million per reactor year (factor of 5 lower), while the corresponding probability for the Delaware ranges from one chance in

100 million per reactor year (factor of 5), ... than one chance in a billion per reactor year (factor of more than 10).

Kaiser
Schmidt

16. In summary, the Applicant's prior testimony already shows that the probability that either the Delaware or the Schuylkill will be contaminated above PEMA's one year PAG is very small. Additional conservatisms discussed above lead to further reduced probabilities. First, the probability that there would be a requirement for long term (in excess of a month) clean up measures in the Schuylkill is very small indeed, less than one chance in a million per reactor year. Second, the probability that the Delaware would be contaminated above PEMA PAGs for long periods is vanishingly small (less than one chance in a hundred million per reactor year). The City can, therefore, rely on the availability of the Delaware as a source of potable water and any emergency plans need not anticipate the unrealistic possibility that both rivers might be contaminated above PEMA's PAGs for a long time.

G. D. Kaiser
E.R. Schmidt

17. PEMA has defined a PAG for acute crisis conditions where no other water supply is available, and the exposure time does not exceed 30 days. For ^{90}Sr alone, the probability of exceeding this limit

(8,000 PCi/l) is about one chance in 3 million per reactor year for the Schuylkill and less than one chance in a billion per year for the Delaware (Ref. 3, p. 19; see Second PID p. 258). If the source term revisions discussed in paragraph 15 are considered, the probability that the ^{90}Sr thirty day PAG would be exceeded in the Schuylkill could be as low as one chance in a hundred million per year (factor of 5) or less than one chance in a billion per year (factor of 10 or more). It is estimated that the isotopes of iodine might be significant contributors to the dose (330 mrem in one month) which constitutes PEMA's PAG. The calculation of the rate at which iodine, deposited on a watershed, leaches into the river is discussed in paragraph 10. Using the model described there, there would be a chance of about one chance in 100,000 per reactor year that the PEMA short-term PAGs for ^{131}I (3000 pCi/l) might be exceeded in the Scnuylkill River, and about one chance in 600,000 per reactor year that they might be exceeded in the Delaware River. These probabilities are smaller than upper bound probabilities given in the previous written testimony (Ref. 3, p. 19) and on page 258 of the Second PID because the calculation given there assumed that the fraction of the deposited iodine that would enter the drinking water source in the short term would be 50 times that of the strontium (i.e., close to 100 percent of the deposited iodine), rather than the more realistic 5 percent in paragraph 10. In conclusion, the probability of contamination of either or both rivers above PAG levels in the first thirty days is small.

EMERGENCY PLANNING

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G.D. Kaiser
E.R. Schmidt

18. The Environmental Protection Agency (EPA) has issued guidance on emergency planning regarding protection against the ingestion of radionuclides (Ref. 10, Appl. Exh.) which clearly does not envisage detailed plans for every conceivable emergency action. This document states at p. 1.2:

> "During planning, it is possible to assess value judgments and determine which steps in response are not required, which steps can be answered on the basis of prior judgements, and which remain to be decided in an actual emergency," "The efforts of planning activities can usually be based on the need for immediate response."

In considering the function to be served by emergency planning activities to deal with the consequences of severe accidents at the Limerick Generating Station, it is therefore important to distinguish between events requiring immediate action and those for which long-range responses are appropriate. Emergency planning, which considers all actions necessary to protect the public in the event of a disaster, is focused on immediate actions, *i.e.*, those actions which cannot be implemented at the time of an emergency unless planned in advance.

V.S. Boyer
M.I. Goldman
G.D. Kaiser
E.R. Schmidt

19. The Ingestion Exposure Pathway Emergency Planning Zone (EPZ) is not usually accorded as high a priority in emergency planning activities because more time is available to evaluate field data and arrive at decisions as to longer term protective actions appropriate under the given circumstances. This longer time scale is recognized in NRC and FEMA's guidance on emergency response plans.

> "Local government plans and response mechanisms are particularly important for the 10 mile EPZ. This is because relatively shorter times may be available to implement immediate protective measures associated with the plume exposure pathway (sheltering, thyroid blocking, evacuation), as opposed to the generally longer times available for implementing protective measures for the ingestion exposure pathway." (Ref. 11, Appl. Exh. , pp. 20, 21)

The NRC-EPA task force that originally advised a radius of 50 miles likewise did not envisage excessively thorough and detailed emergency plans. It stated: "The Task Force does not recommend that massive emergency preparedness programs be established around all nuclear power stations." (NUREG-0396, p.14; Ref. 12, Appl. Exh. ; emphasis in original). Rather, NRC guidance is that, because "the time available to implement protective measures associated with the ingestion exposure pathway is generally greater than the time available to implement protective measures associated with the plume exposure pathway--the State, with support from the Federal Government, should be able to respond quickly enough to implement any desirable protective measures for the ingestion exposure pathway." (NUREG-0654 p.22, Ref. 10 Appl. Exh.).

V.S. Boyer
M.I. Goldman
G.D. Kaiser
E.R. Schmidt

20. As discussed above, emergency planning must assure the availability of procedures, material and personnel required for prompt actions appropriate to immediate needs. There is a very wide range of accident scenarios which, with widely varying likelihoods (the greatest of which is still very low), may affect in some measure the City of Philadelphia's ability to supply normal quantities of drinking water. The consequences of radioactive releases from such accidents can be both immediate, such as deposition directly into open system reservoirs and basins, and long-range, such as deposition and wash-off of long-lived contaminants on portions of the watershed feeding the system. For all but the most immediate impacts, adequate time is available to determine

the extent and nature of the contamination and the best means to mitigate the consequences. The immediate impacts, on the other hand, require actions that would normally be taken by a prudent supplier of water to protect consumers when the source of supply is temporarily threatened by an upstream or in-plant discharge or spill of noxious materials. In the remainder of this testimony, several scenarios are considered which might lead to contamination of the City's water supplies with radionuclides. These scenarios are representative of the full range of potential impacts on the City's water supplies following an accidental release of radioactive material from LGS. The extent of any planning required for each is discussed.

MONIT RING

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E.R. Schmidt

21. In the event of an accidental release of radioactive material from LGS, the choice and implementation of protective actions in the ingestion pathway would be guided by the results of monitoring. In particular, if contamination of drinking water is a concern, the Commonwealth of Pennsylvania's Department of Environmental Resources, Bureau of Radiation Protection ("BRP") would be responsible for obtaining ". . .water

samples from appropriate public reservoirs, water intake points, and water supply systems," (Ref. 14, Appl. Exh. , p. E-17-3, II.A.2--b(1)). In addition, the Bureau of Community Environmental Control within the Department of Environmental Resources maintains plans for "---timely notification of downstream water companies regarding contamination of water resources," (Ref. 14, Appl. Exh. , p. E-17-3, III.A.2--b(2)). The BRP will call upon monitoring support from Federal agencies under the Interagency Radiological Assistance Plan (IRAP), which is initiated through the U.S. Department of Energy at the Brookhaven National Laboratory. (Ref. 14, Appl. Exh. , p. E-12-9, 1.5.C and D). The Federal agencies responsible for responding to a nuclear incident under IRAP are the U.S. Department of Energy; the U.S. Environmental Protection Agency; the U.S. Department of Health and Human Services, Food and Drug Administration, Bureau of Radiological Health; and the Nuclear Regulatory Commission (Ref. 14, Appl. Exh. , p. E-12-8, 1.2). The capabilities of each of these organizations are described in Ref. 14 (Appl. Exh. , page E-12-10). For example, the U.S. Department of Energy can provide a specially equipped aircraft capable of carrying out aerial surveillance for deposited radioactivity, the Aerial Measuring System. The U.S. Department of Energy could send monitoring teams to LGS in about 6 hours by helicopter and 9 hours by truck with laboratory equipment (Ref. 14, Appl. Exh. , p. E-12-16). The U.S. Environmental Protection Agency could send a Health Physics team in about 6 hours, with a mobile lab arriving from Alabama in 20-24 hours. Staff from Las Vegas could arrive in 8 to 24 hours (Ref. 14, Appl. Exh. , p. E-12-16). The Bureau of Radiological Health, DHHS/FDA, has staff trained in radiological protection who are based in Rockville, Maryland and in the regional offices in Philadelphia. There is a district office in Harrisburg. Therefore, FDA can respond within 2 hours to an accident at LGS (Ref. 14, Appl. Exh. , p. E-12-17). Overall, there would be considerable monitoring capability available within a few hours.

THE RANGE OF EVENTS FOR WHICH PROTECTIVE ACTIONS MAY BE NEEDED

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22. One event for which the City may need to protect its water supplies is an accidental spillage of radionuclides directly into the Schuylkill river at LGS. The river takes about a day to flow from LGS to Philadelphia, giving ample warning time for the implementation of protective measures, such as those already available for spills of toxic chemicals. For example, the plant intakes could be closed until the slug of contaminated water has passed by.

G.D. Kaiser
E.R. Schmidt

23. The remainder of the events considered below arise from the deposition of radioactive material onto the watershed or reservoirs after an accidental airborne release of radionuclides from LGS. The most immediate threat to the water supplies would arise if the radioactive plume were to be blown towards the City. Within a few hours, the plume could pass over some or all of the City's water treatment plants and could deposit radionuclides onto uncovered raw and finished water basins. A similar impact could also occur if the plume passed just upstream of the intakes, and radionuclides were deposited directly into the river and onto nearby areas of the watershed. Thereafter, radionuclides would quickly arrive at the intakes and prompt protective actions would be necessary.

G.D. Kaiser
E.R. Schmidt

24. In general, a scenario involving an accidental airborne release of radionuclides from LGS would develop as follows. The plume would first begin to travel over the Schuylkill watershed and material would be deposited by dry deposition. If the plume were to encounter rain, a substantial portion of it could be deposited in a small area of the watershed, leading to localized "hot spots" of ground contamination. Some of the plume would be deposited directly into the river, but this would be only a small

fraction of the total amount deposited because the area of all of the open water surfaces in the Schuylkill basin is only about one percent of the total area of the watershed (Ref. 3, Appl. Exh., Table 2). The plume would then pass out of the Schuylkill watershed. There is about a 40 percent chance that all or part of it would pass over the Delaware watershed, based on wind direction probabilities.

M.I. Goldman
G.D. Kaiser
E.R. Schmidt

25. Accordingly, the first impact on the City's water sources would occur when the radionuclides deposited directly on the river arrive at the intakes. This could happen almost immediately after deposition if the initial deposition were to occur near to the City, or it could take several days if the deposition were to occur far upstream. This initial slug would be followed in the short term (days to weeks) by that fraction of the radionuclides initially deposited on the watershed that is quickly leached into the rivers - e.g., 2 percent for strontium (see paragraph 10). The rate at which the radionuclides enter into the river during this phase will depend on the nature of the vegetation and soil at the point of deposition and on the weather conditions. Heavy rain could cause a relatively large amount to enter the river in a short time, while prolonged dry weather would result in a

lower rate. During the first few days after the accident, iodine would be the nuclide most likely to exceed PEMA's thirty-day PAG, if it is exceeded at all, as discussed in paragraph 16. After the first month or two, the iodines would no longer be a problem because of their relatively short half lives. Strontium and cesium would continue to enter the river over many years at a rate equal to about one to two percent per year of the quantity remaining (see paragraph 10). To provide perspective, there is a small probability, less than one chance in a million per reactor year, that the concentrations of ^{90}Sr in the Schuylkill would exceed the PEMA long-term PAG of 96 pCi/l after one month, and a vanishingly small probability that such levels of concentration would exist in the Delaware (see paragraph 15).

DESCRIPTION OF ACTIONS

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26. Thus, there is a wide range of possible consequences ranging from immediate through the short term of a few days to weeks and on to the long-term of several years. Different protective actions are appropriate for each of these cases. The following paragraphs contain discussion of several of these actions. These discussions are not intended to provide every single detail of every possible protective

action. Instead, they should be taken as an effort to conceptualize a range of possible actions that would be feasible when an actual emergency occurs, at which time actions suiting the particular circumstances can be taken. First, as to immediate threats from a radioactive plume from LGS travelling towards the city, and leading to the possibility of direct deposition onto the open raw water basins, the City would be warned of such a possibility by the LGS emergency team's Health Physics and Chemistry Coordinator. Provision has been made to accommodate a representative of the City at the Emergency Operations Facility. In the event of an actual emergency, of this type, prudence would dictate that the Philadelphia Water Department should isolate the raw water basins which are open, and continue to serve its customers from the covered finished water basins, while ordering that all non-essential uses of water should be discontinued. The City has authority to restrict the use of water under its Drought Water Emergency Plan, (see also Second PID at p. 260). The bulk of the City has sufficient finished, covered water supplies for two days at normal demand, and for much longer if strong conservation measures are implemented (see paragraph 6). Within a few hours, monitoring equipment would be available which would determine whether contamination of the open basins had in fact occurred (see paragraph 23). If contamination to levels of concern had indeed occurred, the City could flush the basin and refill with uncontaminated water from the river when available, following normal procedures.

V.S. Boyer
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R. Waller

27. While the City as a whole has about two days worth of treated water in covered storage, there is one area that could require special attention. As stated in paragraph 5, the Belmont High Service District is fed at an average rate of 11-12 MGD by the Belmont Treatment Plant. Water is sent to the High Service pumps immediately after filtration. There is no intermediate storage. Therefore, if the Belmont Treatment Plant is shutdown, water is not supplied to the High Service pumps. There is no auxiliary storage in the Belmont High Service District. Consequently, if the Belmont Plant is shut down, pressure would begin to drop in the High Service District. One short term emergency measure would be to use fire truck pumpers to lift water from the Monument Road reservoir or filtered water basins and transfer the water to the High Service Pump Suction. Fire trucks could be obtained within a very short time and could be used until other provisions were made available.

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E.R. Schmidt
R. Waller

28. Direct deposition onto the watershed and river close to the intakes would also require a prompt response. By virtue of notification by the Limerick Health Physics and Chemistry Coordinator and, thereafter, its presence at the EOF, the City would know if the plume were traveling in such a direction as to make it likely that contaminated water would soon arrive at the intakes. The prudent response would be to shut the intakes until monitoring establishes the level of contamination, if any, in the rivers, and to continue to serve the city at a reduced rate from supplies within the plants until the contamination had passed by the intakes. In both of these prompt-response scenarios, only a working familiarity with the supply system's valves and connecting lines, which the City already possesses, is needed. No sophisticated capabilities are required.

V.S. Boyer
M.I. Goldman
G.D. Kaiser
E.R. Schmidt
R. Waller

29. The remaining actions discussed below would not be required immediately. Sufficient time would be available to monitor and assess the nature and magnitude of the potential contamination prior to taking any action. The amount and behavior of radionuclides deposited on watershed areas will vary with the nature of the accident, the meteorological conditions prevailing at the time, the time of year and the characteristics of the watershed. As discussed in

paragraph 21, monitoring of the plume track and deposition will be accomplished by aerial and ground measurements performed by Federal and State agency personnel, and others. Such monitoring would indicate the extent and concentration of radionuclides deposited on ground surfaces. Appropriate response actions can best be undertaken on the basis of such in situ measurements recognizing that watershed deposition will persist for periods longer than the direct deposition, but will also take longer to reach the water intakes.

V.S. Boyer
M.I. Goldman
G.D. Kaiser
E. R. Schmidt
R. Waller

30. During the first few days to weeks, approximately 2 percent of the deposited radiostrontium is expected to pass directly into the river (Ref. 3, Appl. Exh. , p. 13) and perhaps 5 percent of the radioiodine in a form that could eventually enter the drinking water (Tr. 12,049). If drinking water containing these radionuclides is consumed, iodine is expected to be the dominant contributor to the population dose accumulated over this initial period. The concentration of the radioiodine in the drinking water is expected to fluctuate considerably as weather conditions vary, but the bulk of the iodine is expected to pass by within a few days. As a protective action, water intakes would be shut while water contaminated above PAG levels passes by. Using monitoring, the intakes could be

opened when concentrations were lower. Another option is the use of activated carbon to reduce the concentrations of iodine in the drinking water supply. The addition of activated carbon with the other chemicals prior to flocculation gives a decontamination factor ("DF") for iodine of from 4 to 5 (Ref. 13 Appl. Exh. 172, Table 8.3). Little planning is needed for the implementation of this measure. Activated carbon is already used by the Philadelphia Water Department for taste and odor control. Previous studies have shown that, in order to achieve such decontamination factors, 5 to 15 milligrams of activated carbon per liter would be needed (Ref. 13, Appl. Exh. 172). Each of the City's three plants has a capacity to feed on the order of 25 to 28 milligrams per liter. Adding a layer of activated carbon to the surfaces of the sand filters would provide additional decontamination, perhaps by a factor of 2, for a total DF for radioiodine of from 8 to 10.

V.S. Boyer
E.R. Schmidt
R. Waller

31. In the unlikely event that there is contamination of river water from which the City takes its supplies, the most likely problem facing the City would be contamination of the Schuylkill above PEMA PAGs, but with the Delaware available as a source of clean drinking water. The Baxter Plant can, therefore, be used to serve the roughly 93 percent of the City that can be

fed from the Delaware with the existing water supply system (Ref. 3, p. 12; Ref. 2, Appl. Exh. 169; Ref. 8, Appl. Exh. 170). A feasible plan would be to install supplementary pumps and pipelines to serve those districts which could not be served by existing connections to the Baxter-served majority of the city. For example, the Belmont High Service District might still be supplied water by means of the City's existing covered water reservoirs and the addition of pumps to the system. The covered East Park Reservoir is normally fed with treated Schuylkill River water via the Queen Lane Plant; it can also be fed with Baxter Plant water from the Delaware River. Although not a normal operating mode, it would appear that Delaware water in the East Park Reservoir has the potential for being fed to the fully covered Monument Road Reservoir at the Belmont Plant through the Girard Avenue crossing of the Schuylkill River. While, it may not be possible to do this when there are other, heavy demands on the water supply system, at times of relatively low demand such as at night or during periods of strict conservation this measure appears feasible. The water in Monument Road Reservoir could subsequently be pumped with temporary pumps and piping to the fully covered clear well at Belmont, which is capable of supplying water to the High Service Pumping Station. The clear well is located at an elevation approximately ten feet higher and about 400 to 500 feet away from the Monument Road Reservoir (across Ford Road).

V.S. Boyer
E.R. Schmidt
R. Waller

32. In order to supply 12 MGD to the Belmont High Service District, the City would need pumps that could provide an average flow of 9,000 gpm. Diesel/gas driven centrifugal construction pumps or portable electric submersible pumps with capacities up to 4,500 gpm are available for rental thru such agencies as Sander Pump Sales, Inc., one of the largest renters of large pumps in the Philadelphia area. Fire Department pumps and hoses could also be used. The discharge pipe or hose would run across Ford Road. The discharge pipes would have a diameter of approximately 8 to 12 inches each, depending on pump size. That one block, which is occupied on both sides by the Water Department, could be closed or ramps could be built over the piping so that cars could use the road. Philadelphia Water Department personnel have stated that there is access to both the Monument Road Reservoir and the clear well via manholes. All of these actions could be implemented within a day.

V.S. Boyer
E.R. Schmidt
R. Waller

33. Alternatively, depending upon the nature and extent of the contamination, another option would be to supply water for drinking and other potable uses by tank

truck to areas without existing connections to Delaware River sources, while maintaining water pressure for fire-fighting and other non-potable uses from the Schuylkill water supplies. These trucks could be parked in strategic locations, easily accessible to residents. Available tanks hold between 6,000 to 7,500 gallons of water. These tankers would only have to supply potable water since the ingestion of contaminated water is the identified concern. In order to provide an estimate for the number of truck loads needed, it was assumed that Belmont High Service District supplies 100,000 people each needing only one gallon for drinking and cooking per day (see Second PID, p. 261). This corresponds to the need for 100,000 gallons of water daily, which could be supplied by approximately 15 truckloads of water. Thus, the number of trucks needed would be small. Both Matlack, Inc. and Chemical Leaman Tank Lines, Inc. are large firms with several terminals in the area that would have suitable available tankers. In fact, a much larger part of the City could be supplied with tank trucks if need be. For example, one million people could be supplied by about 150 truckloads daily.

M.I. Goldman
G.D. Kaiser
E.R. Schmidt
R. Waller

34. Should monitoring data and analyses indicate the potential for even longer-term contamination, several other alternatives could be examined. These include (1) the selective decontamination of watershed areas; (2) diversion and/or treatment of small streams draining those areas; (3) instituting treatment process modifications to reduce the contaminant levels in the finished water below PAGs; or (4) constructing a more permanent interconnection and pumping capability to supply the areas served by the Schuylkill intakes from the Delaware.

M.I. Goldman
G.D. Kaiser

35. The feasibility of the decontamination of contaminated land was discussed in Appendix K to Appendix VI, WASH-1400 (Ref. 15, Appl. Exh.). Decontamination, in the broad sense of the word, is the cleanup and removal of radionuclides. The possible modes of decontamination include the physical removal of the radionuclides, stabilization of the radionuclides in place, and management of the environment. The particular procedure used in a given case would depend on many factors, including (1) the type of surface contaminated, (2) the external environment to which the surface is exposed, (3) the possible hazards to people arising from the decontamination process, (4) the costs, (5) the degree of decontamination that is

required, and (6) the consequences of the decontamination operation.

Typical procedures that can be followed to remove radioactivity are as follows:

1. Hard surfaces (roofs, walls, pavements, etc.)
   a. Replacement of roofing material.
   b. Sandblasting of walls and pavements.
   c. Resurfacing of pavements.
2. Land areas (soil, vegetation, etc.)
   a. Vegetation removal and disposal.
   b. Surface soil removal and burial.
   c. Deep plowing.

A decontamination factor of 20 was considered to be the practical maximum on the basis of the review carried out for the Reactor Safety Study, averaged over large areas. This limitation is based on the practicality of large-scale decontamination operations, the costs, and the consequences of the decontamination operation. Such decontamination measures would not be done solely to protect the City's water supplies, but would be part of an overall effort, coordinated by the Commonwealth, to provide long term protective measures in areas contaminated by deposited radionuclides. They would only be undertaken after the appropriate areas had been determined by careful monitoring and an assessment of the feasibility of decontamination had been made, taking into account local conditions, such as the nature of the topsoil.

M. I. Goldman
E.R. Schmidt
R. Waller

36. Modifications of water treatment plants would be feasible to provide decontamination factors of between 5 and 100 for ^{90}Sr (Ref. 3, pp. 24, 25). Dissolved strontium can be effectively removed by the use of a lime-soda softening process normally employed to remove dissolved calcium and magnesium carbonates from "hard" water, due to the chemical similarity between magnesium, calcium and strontium (all are Group IIA elements). Decontamination factors of from 5 to 10 can be obtained by co-precipitation of strontium with calcium and magnesium carbonate in a conventional softening process with dosages of soda ash (sodium carbonate) in excess of those indicated by stoichiometric requirements alone (see Second PID, p. 261). "Repeated-precipitation," in which a small quantity of calcium is added and removed with soda ash could provide an equal decontamination factor in each step. Thus, a second step in which a DF of between 5 and 10 is obtained, would produce an overall process

DF of between 25 and 100 (Ref. 8, Appl. Exh. 172). This second stage of processing could be implemented without constructing a major plant addition because the affected plant could be operated as two sequential process lines. That is, the treated effluent from one half of the plant would be returned to the rapid mixing stage of the other half to provide the second stage of treatment. This would, of course, also reduce the throughput capacity of the affected plant by half and would probably require additional pumping capacity.

V.S. Boyer
E.R. Schmidt
R. Waller

37. The Applicant has considered the water supply systems closest to that of the City and discussed the feasibility of interconnections between the systems. There is no real need to construct interconnections between these systems merely to provide limited supplies in the highly unlikely event of an accident at Limerick Generating Station contaminating the City's water supplies because the Delaware will be available as a source of clean drinking water (see paragraph 16). Any decision to connect these systems to provide a regional transmission network should therefore be based on the likely needs in the event of far more probable emergencies, such as severe drought. If it wishes, the City could easily make arrangements

so that nearby systems could be used to fill tankers in an emergency.

V.S. Boyer
M.I. Goldman
G.D. Kaiser
E.R. Schmidt
R. Waller

38. The alternatives and options regarding long term protective measures, are far-reaching in their implications. Decisions made as part of detailed emergency plans in advance of the situation, at which time precise needs become known, cannot be justified. At the present, sensible planning requires only consideration of possible approaches to resolution of potential requirements in such an event to a degree consistent with its likelihood. It would be reasonable to maintain information as to the availability of large capacity pumps and drivers (i.e,, engines or motors) and piping to permit transferring processed water from one source of supply to the region served by another; the availability of tank trucks in the general area which would be suitable for supplying potable water (including filling points); the size and nature of water treatment chemical inventories maintained by suppliers; and the locations and requirements for interconnections necessary to recycle water for reprocessing in the existing treatment plants. Preparedness at this time, however, need not extend to stockpiling these materials in anticipation of their immediate need in response to an accident, or to drafting detailed plans of action.

CONCLUSION

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39. It is concluded that the probability of a severe accident causing significant contamination of the City of Philadelphia water supplies is very small. The risks to the public, even in the absence of countermeasures, are also very small. These small risks and probabilities do not require or justify detailed emergency planning. Prompt response capabilities required by the City to protect water consumers from the consequences of accidental contamination by radionuclides are those which the City already possesses: a communications system and a detailed knowledge of the design and construction of the water supply system. More complex and extended mitigation measures, if required at all, cannot be anticipated in detailed emergency plans and should and could be developed on an ad hoc basis after measurements and analyses had defined the scope of the problem and the most effective solution in light of available information at the time.

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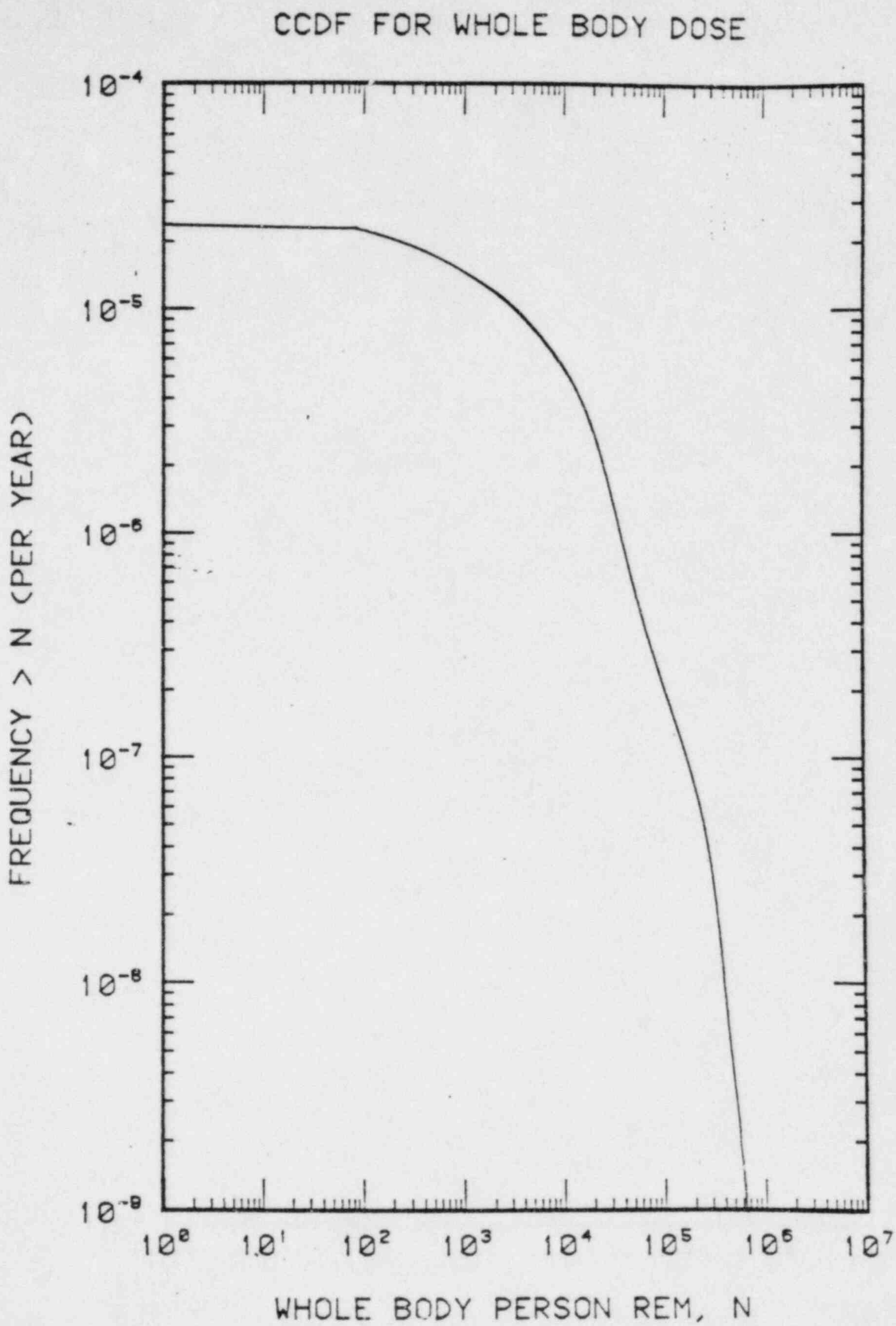

Figure 1. CCDF of population dose to the City of Philadelphia