Request for Information (RFI)

Analysis of Cancer Risks in Populations near Nuclear Facilities: Phase 2 Pilot

October 7, 2014

To: Interested Responders

Re: Request for Information (RFI)

The National Academy of Sciences (NAS) is requesting information regarding provision of research support and the associated costs for executing a feasibility pilot study on cancer risks near seven nuclear facilities in the United States in support of the NAS Committee on Analysis of Cancer Risks in Populations near Nuclear Facility: Phase 2 Pilot Execution (the “Committee”). The pilot study is designed to help confirm whether a nationwide study of cancer risks near nuclear facilities is feasible. The pilot study is expected to take about two and a half years to complete.

NAS invites all interested individuals to submit written responses to this Request for Information (RFI). This document and its attachments provide background information and list the services (tasks) desired by NAS.

This RFI is being issued strictly for the purpose of soliciting input from responders, understanding their research capabilities, and estimating the costs for carrying out the tasks desired by NAS. This RFI shall not be construed as a commitment or promise by NAS to acquire the services, support, or solutions offered by responders. **No contract is guaranteed as a result of any response to this RFI.** NAS will not compensate responders for the information requested by this RFI, nor is NAS liable for any costs incurred by responders. Information submitted in response to this RFI may be used by NAS to prepare a request for proposal (RFP)¹. Responders to this RFI are instructed not to include any proprietary or non-public information in their responses.

The award of a contract for the Pilot Study is subject to receipt of funding from the sponsor, the U.S. Nuclear Regulatory Commission. Upon receipt of funding, NAS intends to contract with appropriate individuals and/or organizations to carry out the pilot study. NAS anticipates that completion of the pilot study will take about two and a half years. If deemed feasible and upon receipt of further funding, a nationwide study would be initiated.

¹ See Attachment A to this RFI for the RFP draft.
RFI responses must be received prior to 5 PM (ET), November 24, 2014, at the following e-mail address: crs@nas.edu.

We appreciate your response to this request.

Sincerely,

Kevin Hale
Director, Purchasing & Corporate Insurance
1. STUDY BACKGROUND

1.1. STUDY REQUEST

In 2010, the National Academy of Sciences (NAS) was asked by the U.S. Nuclear Regulatory Commission (U.S. NRC) to examine cancer risks in populations near the nuclear facilities it regulates (power plants and other nuclear facilities). These facilities presently include 100 operating nuclear reactors at 62 sites in 31 states and 13 fuel-cycle facilities in operation in 10 states. The U.S. NRC has requested this study because it needs current information for communicating with the public about cancer risks near the nuclear facilities that it regulates.

The U.S. NRC is using the results from a 1990 National Cancer Institute study\(^2\) as its main information resource to discuss cancer risks around nuclear facilities. That study found overall that there is no increased risk in cancer mortality near the nuclear facilities. However, the National Cancer Institute study is over 20 years old. Since it was conducted, the list of nuclear facilities in the United States has changed and so have the characteristics of the populations that live near the facilities. In addition, the 1990 National Cancer Institute study had several methodological limitations that could potentially be addressed in a new study. In particular, it utilized county-level information on cancer death (mortality), making it difficult to identify local effects around nuclear facilities. Focusing on cancer mortality is also not the best indicator of risk because advances in cancer treatments have lowered mortality rates for many types of cancer. Studies of incident cancer are needed and are feasible through population-based cancer registries. Also, the National Cancer Institute study did not include an estimation of the radiation doses received by the studied populations.

1.2. STUDY PHASING

NAS is carrying out the analysis of cancer risks near nuclear facilities in two phases:

- The goal of Phase 1 was to recommend scientific approaches for examining cancer risks in populations near nuclear facilities. Phase 1 was completed in May 2012; its report, referred to as the "Phase 1 report," can be downloaded here: http://www.nap.edu/catalog.php?record_id=13388.
- Phase 2 will implement the Phase 1 report recommendations (discussed in Attachment B to this RFI). These recommendations are primarily related to assessing the feasibility of a nationwide study of cancer risks in populations near nuclear facilities by performing a pilot study that involves seven nuclear facilities.

The pilot study will have two steps: pilot planning and pilot execution. A nationwide study could be carried out if the Committee concludes that it is feasible at the end of the pilot execution step.

NAS is currently planning for the pilot study and anticipates the completion of this step in December 2014. **Subsequent execution of the pilot study is subject to receipt of funding from the U.S. NRC.** Subject to receipt of funding, NAS will contract with appropriate individuals and/or organizations to carry out the pilot study. NAS anticipates that completion of the pilot study will take about two and a half years. If deemed feasible and upon receipt of further funding, a nationwide study would be initiated.

### 1.3. THE PILOT STUDY

Conducting a pilot study of cancer risks in populations near nuclear facilities was a recommendation of the Phase 1 report\(^3\) (see Attachment B to this RFI, Section B.2, for a summary of the Phase 1 report recommendations). Based on the Phase 1 report, seven nuclear facilities were selected for the pilot: Dresden Nuclear Power Station, Morris, Illinois; Millstone Power Station, Waterford, Connecticut; Oyster Creek Nuclear Generating Station, Forked River, New Jersey; Haddam Neck, Haddam Neck, Connecticut; Big Rock Point Nuclear Power Plant, Charlevoix, Michigan; San Onofre Nuclear Generating Station, San Clemente, California; and Nuclear Fuel Services, Erwin, Tennessee.

The study designs to be examined in the pilot for their feasibility in assessing cancer risks in populations near nuclear facilities are as follows (see Attachment B to this RFI, Section B.1, for more details):

- **An ecologic study** that would describe both cancer incidence and mortality in populations living in census tracts within 50 kilometers (~30 miles) of the nuclear facilities.\(^4\) This study would examine all relatively common cancer types at all ages across the operational histories of the facilities to the extent allowed by available data. Dose to the populations residing within a census tract will be assigned based on estimated exposure levels at the centroid of the census tract.

- **A linkage-based case-control study** (hereafter referred to as the case-control study) that would assess whether children younger than 15 years of age whose mother lived close to the nuclear facilities at the time of their birth are at higher risk of developing cancer compared to those whose mother lived farther away but within 50 kilometers (~30 miles) of the nuclear facilities. This study would attempt to provide a more focused assessment of the association of pediatric cancers in relation to early life exposure to radiation during the more recent operating periods of nuclear facilities. Dose to the individuals will be assigned based on the address where the mother lived at the time of delivery of the child, as reported in that child’s birth certificate.

The Committee will oversee the pilot. For more information on NAS study process please visit this link: [http://www.nationalacademies.org/studyprocess/](http://www.nationalacademies.org/studyprocess/).

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\(^3\) [http://www.nap.edu/catalog.php?record_id=13388](http://www.nap.edu/catalog.php?record_id=13388)

\(^4\) This distance represents a range of potential radiation exposures to persons near these facilities.
1.3.1. Pilot Planning

During the pilot planning NAS staff, in consultation with its pilot planning advisory committee (see Attachment C to this RFI for committee membership) focused on related tasks for the three main activities described below: epidemiology, dosimetry, and public engagement.

Epidemiology

1. Investigate data availability from pilot state cancer registries and vital statistics offices and state requirements for data sharing and transfer of health information.

Dosimetry

2. Initiate radioactive effluent release and meteorological data collection in preparation for computer modeling of estimated doses to the people who live near the pilot nuclear facilities.

Public Engagement

3. Identify key stakeholders and processes for communicating with them.

Progress with regard to activities 1-3 related to epidemiology, dosimetry, and public engagement is presented in Attachment D to this RFI. (Responders to this RFI are encouraged to review Attachment D.)

1.3.2. Pilot Execution

Upon completion of the pilot planning step in December 2014 and contingent upon receipt of funding from the U.S. NRC, NAS will execute the pilot study and issue the RFP. The current draft of the RFP is set out in Attachment A to this RFI. NAS intends to contract with appropriate individuals and/or organizations who will provide research support for the execution of the feasibility pilot study. For the role of NAS, the NAS Committee, and the contractors in carrying out the pilot, see RFI, Section 2.2.

At the conclusion of the pilot execution phase, NAS will prepare a report with findings regarding the scientific feasibility of carrying out an assessment of cancer risks at additional U.S. NRC-licensed facilities. The report will also include, if feasible, an analysis of cancer risks in the populations near the seven pilot facilities.
2. OVERVIEW OF THE RFI

The purpose of this RFI is to understand responders’ capabilities to support this research, and to obtain their estimates of the costs for carrying out the tasks listed in the statement of work of the draft RFP (Attachment A to this RFI) related to the execution of a feasibility pilot study of cancer risks near seven nuclear facilities. For simplicity, these tasks are described separately as epidemiology (Attachment A, Section A.1) and dosimetry (Attachment A, Section A.2). Responders are requested to indicate an interest in performing either the epidemiology or the dosimetry tasks or both. There are additional activities that will be conducted during the pilot study that relate to public engagement. Those will be handled by NAS and its advisory committee. However, contractors are expected to cooperate and facilitate these outreach and communication activities.

Contractors may subcontract for services with other parties to obtain needed expertise and capabilities. However, all subcontracts are subject to approval by NAS. Contractors are responsible for payments to its subcontractors and for subcontractor-related coordination and communication.

This RFI provides background information and describes the services (listed as tasks set out in the draft RFP shown as Attachment A to this RFI) required in order to carry out the epidemiology and dosimetry activities.

2.1. RFI RESPONSE FORMAT

Responders are requested to provide a letter of interest (limit of five pages in Word or PDF) with regard to providing support for the epidemiology or dosimetry tasks, or both. The page limitation does not apply to additional information such as curriculum vitae of key investigators involved in the response to the RFI and a listing of relevant publications, both of which could be included in the response as attachments.

The responders’ letter of interest should include the following:

- Statement of capabilities and relevant experience of the individuals and their organization that will be undertaking the tasks.
- Available facilities and resources relevant to the tasks set out in the draft RFP shown as Attachment A to this RFI. (Note that the draft RFP is subject to revision following the pilot planning step.)
- Timeline based on a target date of completion of all tasks within 2.5 years from award.
- Description of how the work will be organized, staffed, and managed.
- Itemized cost estimate (or cost range) per task set out in the draft RFP to be completed over the estimated 2.5-year period. The cost breakdown should include the type of labor, number of hours, fringe benefits, overhead, other direct costs, and general and administrative costs including subcontracts.

For purposes of estimating costs, responders shall assume four trips annually for contractor staff to one of the NAS facilities located in Washington, DC, Irvine, CA, and Woods Hole, MA, during the contract period (i.e., 10 trips total).
Responders are not expected to provide scientific input to the tasks described in Attachment A to this RFI. If responders wish to submit scientific input that may be helpful to NAS in further developing the current RFP draft they can do so in an attachment to the letter of interest for the RFI.

Responders to both the epidemiology and dosimetry tasks are requested to submit two separate letter responses using the format indicated above so that their evaluation can be performed independently.

2.2. PILOT STUDY-TEAM ORGANIZATION

NAS will direct the pilot study and will be serving as the project manager and study coordinator. As such, NAS will be the principal decision maker in substantive procedural and technical issues.

NAS, the Committee, and the contractors who will provide research support for the execution of the pilot feasibility study will meet regularly (~four times annually) and have regular conference calls (~monthly) so that NAS can review progress and provide advice and direction.

The contractors who undertake the epidemiology and dosimetry tasks (if different) are expected to communicate and interact on a regular basis with each other. NAS can facilitate these interactions.
ATTACHMENT A
DRAFT REQUEST FOR PROPOSAL

A.1. DRAFT STATEMENT OF WORK FOR EPIDEMIOLOGY CONTRACTOR

The purpose of this work is to obtain information on cancer incidence and mortality from cancer registries and vital statistics offices of the states that are part of the pilot study and to link birth and cancer registration information in order to conduct the recommended ecologic and case-control studies.

A.1.1 Tasks to Be Performed by the Epidemiology Contractor

The tasks to be performed by the epidemiology contractor are the following:

TASK 1: Develop an administrative and coordination structure with the dosimetry contractor and NAS.

Successful conduct of the pilot study will require a well-documented administrative and coordination structure among the contractors that undertake the epidemiology and dosimetry tasks and NAS which will provide the study oversight. The epidemiology and dosimetry contractors, in collaboration with NAS, will need to describe such a structure in sufficient detail at the beginning of the study and adjust as needed as the pilot study is carried out.

TASK 2: Develop research protocols for carrying out the recommended studies.

In consultation with NAS and its advisory committee, the epidemiology contractor will develop research protocols for conducting the ecologic and case-control studies. These protocols will describe in sufficient detail the following information:

1. The populations to be examined in the ecologic and case-control studies

In order to assess the feasibility of the ecologic study of cancer incidence and mortality at the census tract level, the contractor will retrieve information on cancer cases and deaths that occurred within 50 kilometers from the pilot facilities. While requesting the information from the cancer registries and vital statistics offices, the contractor will need to define the geographic boundaries of the information requested. For example, depending on what variables the cancer registries and vital statistics offices of the states hold, the request might be by listing the census tract codes included in the 50-kilometer radius from a nuclear facility, by county names, or by defining a circular geographic area within specific coordinates. For the ecologic study the data (cancer incidence and mortality) from each state will eventually need to be described by census tract, and only those data included in the 50-kilometer radius around the nuclear facility will be included in the study.

Preliminary investigation of available information in the cancer registries and vital statistics offices that hold the cancer incidence and mortality information indicated that although cancer registries typically geocode their data at least for the more recent years, vital statistics offices
typically do not. In addition, states may have used different geocoding methodologies to geocode their data, leading to different levels of accuracy of geocoding across locations.

Therefore, it may be required that the contractor either works with the state, conducts on their own, or subcontracts with an independent GIS company to geocode the addresses located within 50 kilometers from the pilot nuclear facilities using common criteria across states and administrative databases. Particular attention needs to be paid in dealing with instances where the address is incomplete or described as a P.O. Box or rural route number. The contractor, in consultation with the NAS committee and staff, will make uniform decisions across states as to how to deal with this issue. Independent of the approach selected, the contractor shall have sufficient knowledge of GIS to compile and analyze relevant data.

Similar issues with defining the cases and controls for the case-control study exist.

2. The range of years for which data are available and can be used for the ecologic and case-control studies

The ecologic study will examine risks as far back in the operational histories of the nuclear facilities as allowed by available data. The first year of inclusion of data for each state will be the year that address, or census tract, or coordinates are available for all (or almost all) cancer cases or deaths described in the state’s electronic database. Based on a preliminary request for information, it is understood that this year varies among cancer registries and the variation will be greater for the vital statistics offices (see discussion in Attachment D to this RFI, Section D.1.1). The criteria for selection of the first year of inclusion of data from each state will need to be logically defined and clearly described by the contractor in consultation with NAS and its advisory committee.

The case-control study will involve years that cancer incidence data can be cross-linked to birthplace information to identify eligible cases.

3. Method for selecting cases and controls for the case-control study

Selection of cases and controls was described in the Phase 1 report and is as follows: Children diagnosed with cancer at age 0-14 years will be identified from the cancer registries of states that have or have had a nuclear facility or are adjacent to such a facility. Children with cancer identified in the registry are linked to birth records within the respective state(s). Those born within the area of interest (e.g., 50 kilometers from a nuclear facility) are eligible cases. One or more controls will be randomly selected from birth records restricted to those born within the 50-kilometer zone from the facilities, with matching to cases on year of birth at minimum and gender if possible. Children diagnosed with cancers but who were born outside the study area (50 kilometers from the nuclear facility) could be excluded from the control group.

More selective targeting schemes could be considered, such as requiring the cases selected for study to be residents of a 50-kilometer proximity zone at the time of diagnosis. However, as the design does not rely on follow-up of the controls to establish if they also remained at the 50-kilometer zone from birth to the time that the cases were diagnosed, the potential for selection bias increases and false relationships between case status and distance could appear if the probability of moving versus staying within the same region is inhomogeneous with respect to distance from nearest nuclear facility.
4. Sources of information on the populations under study

Sources of information on the populations under study should be used to characterize the populations within the 50-kilometer radius of the nuclear facilities to the extent possible in terms of their demographic characteristics, socioeconomic characteristics, and lifestyle factors.

For the ecologic study a source of such information is the U.S. census data at the census tract level.

For the case-control study certain relevant characteristics of the parents and child are available in birth records and, depending on the year and state, would include mother's address; parental age, race/ethnicity, and educational level; and date of birth, gender, birth weight, and order of birth of the index child. Additional information on the birth certificate such as substance abuse by the mother (including smoking and alcohol) does exist in certain instances but will have varying reliability and completeness depending on the state.

5. Sources of information to characterize the areas under study

For both the ecologic and case-control studies the areas within which the populations under study reside are to be characterized to the extent possible, for example, in terms of land use, water supply, and other factors that could affect exposure to radiation released from the nuclear facilities. For the ecologic study this information will be available from the U.S. census. For the case-control study the same sources of information as with the ecologic study will be used as it is not possible to acquire individual-level data without conducting interviews with the subjects and/or their parents. Such interviews are not planned.

6. Sources of information for other releases located in the study area

The contractor will identify the nuclear facilities not regulated by the U.S. NRC\(^5\) that are in the area of study (within 50 kilometers from the pilot nuclear facilities) and to the extent possible using publicly available data estimate the releases from these facilities for the study period.

In addition to releases from non-U.S. NRC regulated nuclear facilities, an inventory of releases from other facilities will be taken in the areas around the nuclear facilities under study. This inventory might be obtained from the U.S. Environmental Protection Agency's (EPA's) Toxic Release Inventory (TRI) and Superfund databases. The online TRI databases contain names of facilities required to report under section 313 of the Emergency Planning and Community Right-to-Know Act and include information about location, reporting year, chemicals released, and estimated pounds per year released into various environmental media, such as air and water bodies.

Information about other sources of environmental releases and types of chemicals involved will provide a more comprehensive assessment of potential environmental exposures in the vicinity of nuclear power plants. This information will also help rule out other sources of potential carcinogens in the areas under study.

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\(^5\) For example, these might be Department of Energy-regulated nuclear facilities.
7. Statistical plan

The contractor will devise a plan of statistical analysis for the ecologic and case-control studies. The plan will include, among others, methods for the following:

- Matching or adjustment for individual variables (i.e., birth year and gender) in the case-control study analysis;
- Adjusting or controlling for census data or other sources of information pertaining to characteristics (including temporal changes in these characteristics) of birthplace or place of residence at time of diagnosis or death in the case-control and ecologic analyses;
- Incorporation of the (dosiometry contractor-generated) dose variable into the analyses (e.g., as a continuous variable or categorized into dose groups), and decisions of whether and how to treat dose as an aggregated and/or time-dependent variable in either the ecologic or case-control analyses;
- Justification of whether any dose surrogates, such as distance from nearest plant, are to be considered in addition to the contractor-generated dose variable;
- Correction for over-dispersed counted data in dose-response analysis for the ecologic study; and
- Dealing with multiple comparisons/multiple testing issues, including how or if sitespecific results and preliminary combined results from the feasibility pilot study are to be released and/or included in a nationwide study report, if such a study is conducted.

**TASK 3:** Obtain Institutional Review Board and other approvals to carry out the studies.

The contractor will be responsible for complying with all applicable Department of Health and Human Services (DHHS) policies and regulations on the protection of human subjects in research (45 CFR Part 46, as amended). Contractor shall be responsible for ensuring initial and continuing review by Contractor’s Institutional Review Board (IRB), which shall have an approved Federal Wide Assurance on file with DHHS, and shall conduct the research in accordance with an IRB-approved protocol. Contractor shall be further responsible for maintaining the confidentiality of personally identifiable research data in conformance with the approved research protocols and informed consent procedures. The Contractor shall cooperate with NAS in submitting the research protocol for review by the NAS Committee to Review Studies on Human Subjects (NAS IRB) and shall comply with any requirements or conditions imposed on the research by the NAS IRB. Contractor agrees to notify NAS of any known non-compliance with the approved research protocol or applicable laws as specified herein.

Preliminary request for information from the states indicated that state IRB approvals would take about 3-4 months upon submission of a research protocol. Additional approvals are required from some states.

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6 See Appendix J of the Phase 1 report.
TASK 4: Obtain cancer incidence and mortality data to conduct the ecologic study.

As discussed under Task 2, cancer incidence and mortality data held by the state cancer registries and vital statistics offices could be released to the contractor (depending on availability of information collected by the state) as individual records of people diagnosed with cancer within the counties or census tracts within a 50-kilometer radius of the nuclear facilities. Eventually, the data will need to be aggregated by census tract.

The geocoded data on where populations reside will be transferred to the contractor tasked with performing the dosimetry tasks (see Section A.2 of this Attachment) and be used as geographic point estimates of all dose assessments. The dosimetry contractor needs this information to conduct its work. Therefore, there is urgency for the epidemiology contractor to put a system in place as soon as possible to geocode the data and transfer the information to the dosimetry contractor.

TASK 5: Obtain other data.

To conduct both the ecologic and case-control studies, additional information is needed to characterize the populations under study and the areas where these populations reside. For a discussion see points 4-6 under Task 2 of this section.

TASK 6: Link birth registration and cancer incidence data to identify appropriate cases and controls for the case-control study.

To conduct the case-control study, cancer registration and birth records need to be linked within each of the pilot states. The linkages could be extended as far back as registries with good quality data exist and birth years of cases and controls would co-extend with good practices of registry operation. The contractor will work with individual states to identify the appropriate protocol to perform these linkages. The ultimate goal is to achieve a common documented protocol across all pilot states when performing the linkages.

For some information regarding linkages see Attachment D to this RFI, Section D.1.3.

TASK 7: Develop and manage the databases.

The contractor will develop and manage databases (single or multiple, as appropriate) for merging data submitted by the pilot cancer registries and vital statistics offices. There is no intention (currently) that these databases will be shared or transmitted to NAS. As the contractor will be the only party having access to the data, backups of all data files should be made as appropriate to ensure recovery of all data in the event of hardware or software failure or another event that might compromise data.

In addition, the contactor will need to maintain sufficient internal documentation for all systems and computer programs to allow easy and prompt changes and resolution of any problems identified. At any point NAS may request the programs used to compile the databases and create user-defined data variables.
TASK 8: Develop data quality management plan.

The contractor will consult with NAS and its advisory committee regarding data quality issues and will suggest management plans.

TASK 9: Characterize data availability and completeness from different states.

The contractor will assess the availability and completeness of the data released from the states. To the extent feasible, the contractor will assess differences in data quality among the pilot states. The contractor will also provide feedback on results to NAS and opinions as to how interstate differences in data quality and linkage capabilities might be expected to influence reliability and interpretation of findings in the respective states and in the overall pilot study.

TASK 10: Incorporate radiation doses to the populations or individuals included in the study.

NAS will contract with an individual or organization to perform dose calculations (the dosimetry contractor) that will be incorporated in the analysis of cancer risks near nuclear facilities. These dose calculations will be based on the geocoded data on where populations or individuals reside. When the dosimetry contractor completes the dose calculations for the ecologic and case-control studies, they will transfer the dose information back to the epidemiology contractor to incorporate in their database.

TASK 11: Perform statistical analysis.

Any data collected during the pilot study may have limited use for estimation of risks per site or for the seven sites combined. However, as discussed under Task 2, the contractor is expected to provide statistical expertise in selecting appropriate statistical analytic methods for specific analyses and be able to demonstrate their feasibility with the pilot data.

TASK 12: Report on all tasks.

The contractor will participate in regular (~monthly) conference calls with NAS staff and its advisory committee and quarterly face-to-face meetings for the duration of the study (estimated to be 2.5 years) to provide updates on work progress and to discuss potential issues. The contractor will maintain ongoing records of project activities and goals, methods, and procedures (including those that were attempted but did not work) and will submit monthly progress reports on key milestones, e.g., data retrieval. The contractor will also submit quarterly reports to NAS that will be posted on the study website. These reports will contain information such as:

- A detailed list of activities performed or initiated during the quarter, and
- The amount of funding expended for activities during the quarter.

TASK 13: Develop a technical report.

At the end of the pilot study, the contractor will prepare a technical report that describes in sufficient and appropriate detail all tasks performed during the pilot and research results in language suitable for an educated lay audience. The contractor will meet with the NAS committee and staff after delivery of the report to transfer knowledge and ensure total comprehension of products.
A.1.2. Tasks to Be Performed by NAS

NAS will facilitate the epidemiology contractor's work by doing the following:

- Introduce the contractor to its points of contact at the cancer registries and vital statistics offices;
- Transfer to the contractor knowledge related to availability and release criteria of the cancer registry and vital statistics office data;
- Assist with writing the study protocols to be submitted to the states for release of the health and other information; and
- Cover the costs related to data processing and release from the state cancer registries and vital statistics offices.

A.2. DRAFT STATEMENT OF WORK FOR DOSIMETRY CONTRACTOR

The purpose of this work is to provide annual doses resulting from nuclear facility operations to specified organs. For the ecologic study doses will be calculated for a representative individual located at the centroid of each of the study census tracts for each year of facility operation. For the case-control study doses will be calculated for individuals residing at specific locations for specified years. Some dosimetric considerations related to estimating doses for the ecologic and case-control studies are presented in Table A.1 of this attachment. In general, dosimetry for the case-control study is expected to be more rigorous compared to that for the ecologic study in the ways described in Table A.1.

A.2.1. Tasks to Be Performed by the Dosimetry Contractor

The tasks to be performed by the dosimetry contractor are the following:

TASK 1: Develop an administrative and coordination structure between dosimetry contractor and NAS.

Successful conduct of the pilot study will require having a well-documented administrative and coordination structure among the contractors that undertake the epidemiology and dosimetry tasks and NAS who will provide the overall oversight of the study. The epidemiology and dosimetry contractors, in collaboration with NAS, will need to describe such structure in sufficient detail at the beginning of the study and adjust as needed as the pilot study is carried out.

TASK 2: Develop research protocols for calculating the annual organ absorbed doses for the participants in the recommended studies.

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7 These dosimetric considerations may change based on further exploration of data availability or other factors.
In consultation with NAS and its advisory committee, the contractor will develop research protocols for calculating the annual organ absorbed doses for the recommended studies. These protocols will describe in sufficient detail the following information:

1. The years for which the doses will be calculated for each of the pilot nuclear facilities,
2. The organs and tissues that will be selected to reflect the cancer endpoints,
3. The ages/age groups of the individuals/populations for whom the doses are to be calculated, and
4. The input data that will be used to model the atmospheric and aquatic dispersion of the activities released.

**TASK 3:** Develop data quality management plan.

The contractor will consult with NAS regarding the data quality issues and will suggest management plans.

**TASK 4:** Create electronic database of airborne and waterborne effluent release data from the pilot facilities into a form that is usable for dose estimation.

NAS staff has started collection of effluent release reports for the nuclear facilities (six nuclear power plants and one fuel-cycle facility) that are part of the pilot and two additional facilities in Illinois (Braidwood and La Salle) that are in proximity to the pilot facility (Dresden) and therefore might result in additional exposure to the populations being studied. (See Attachment D to this RFI, Section D.2, for progress with retrieving the effluent release reports.) These reports will be used to extract source term information to be used for dose estimations. Decisions on what information from the reports is relevant to the conduct of the pilot study will be made by the contractor in consultation with NAS and its advisory committee.

Information in the effluent release reports needs to be extracted into a database for use for dose estimations. As some of the reports are old, the image quality and format likely will not permit the use of optical character recognition software to convert its text into machine-encoded and computer-readable text. Therefore, digitization of the effluent report data will need to be done manually for those reports.

The electronic database may also contain information on batch and episodic releases,\(^8\) such as the date and timestamp. (See Task 7 and Table A.1 for further details.)

**TASK 5:** Assemble information on site-specific topography and land and water use over time.

Atmospheric and aquatic dispersion and therefore doses to the populations within 50 kilometers from a nuclear facility depend on the topography of the area and land-use characteristics. The contractor will develop sufficient site-specific characterization of the 50-kilometer area around the pilot facilities. This will include data on agricultural production of foodstuffs and on water usage for human consumption. Possible sources of information include U.S census data,

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\(^{8}\) *Batch releases* are planned, monitored, noncontinuous effluent releases from the nuclear facilities. Batch release information can be found in the effluent release reports; however, date and timestamp for each batch release is not routinely included. *Episodic releases* include unplanned, unmonitored, and/or abnormal releases from the nuclear facilities that are also noncontinuous. Often, episodic releases are reported in effluent reports but some are not.
environmental monitoring reports, and offsite dose calculation manuals (ODCMs) from the nuclear facilities.\(^9\)

**TASK 6:** Create a database of meteorological and hydrological data for the pilot sites required for calculating dispersion of releases from each facility.

The atmospheric characteristics at a nuclear facility are an important consideration in evaluating the dispersion of radioactive effluents from routine releases. Although nuclear facilities collected meteorological data\(^{10}\) as frequently as every hour, only quarterly or semiannual joint frequency distributions are reported in the effluent release reports and the data are not always readable. Also, the data often are not available over the entire period of interest for this study. Therefore, the contractor will need to explore other sources of information for meteorology data, particularly for investigating significant batch or episodic releases to the atmosphere for the case-control study. One such source is the National Center for Atmospheric Research (NCAR) reanalysis project that has used analysis and forecast systems to perform data assimilation using past data from 1948 to the present and to calculate at a minimum daily averages.

Meteorology information for specific times is particularly important for episodic release events. The dosimetry contractor will work with NAS and its advisory committee to develop a plan for estimating atmospheric dispersion for batch and/or episodic releases that exceed a threshold value (see Table A.1).

Hydrological data of interest for the calculation of the dilution of the liquid releases such as flow rates for rivers/streams in which liquid effluents are released will also need to be collected when not found in the effluent release reports.

**TASK 7:** Estimate releases for years when data are missing or unreadable.

At the present time\(^{11}\) approximately 57% of the reports from the pilot nuclear facilities have been retrieved and determined to be human-readable (see discussion in Attachment D to this RFI, Section D.2).\(^{12}\) The exact percentage varies from site to site (see Table D.4).\(^{13}\) The contractor will, in consultation with NAS and its advisory committee, develop methods to estimate individual nuclide releases for missing periods and will enter these estimates into the database discussed under Task 4 of this section.

Batch and episodic releases (as shown in Table A.1) for the ecologic study can be averaged over yearly periods. For the case-control study, case-by-case analyses will be needed for all batch and/or episodic releases that exceed a threshold value using appropriate estimates of hourly meteorology. The protocol for these analyses will be developed by the contractor in consultation with NAS and its advisory committee.

---

\(^9\) ODCMs contain some relevant information at least for the close proximity to the facilities, i.e., about 5 kilometers.

\(^{10}\) The meteorological data included in the facility's effluent release reports are wind speed, direction, and stability. They do not include precipitation.

\(^{11}\) October 2, 2014.

\(^{12}\) Retrieval of effluent release reports from the pilot nuclear facilities is in progress. Therefore, the information contained in Attachment D to this RFI, Section D.2, is subject to change.

\(^{13}\) In addition to interpolation, the U.S. NRC's NUREG 2907 series contains yearly summaries of nuclear power facilities' effluent releases; NAS has collected NUREG 2907 summaries from 1980 through 2009.
**TASK 8:** Model the atmospheric and aquatic dispersion of the activities released using standard models.

The contractor will select the computer model(s) that will be used to obtain estimates of atmospheric and aquatic dispersion and also to estimate radiation exposure and age-dependent absorbed doses to individual organs of representative individuals (ecologic study) and to individuals at specific locations (case-control study) resulting from effluent releases.

A number of models exist that could be adapted and used to obtain estimates of atmospheric and aquatic dispersion, radiation exposure, and age-dependent absorbed doses to individual organs of representative individuals (ecologic study) and to individuals at specific locations (case-control study) resulting from effluent releases. In general, off-the-shelf modified Gaussian plume dispersion models such as those recommended by EPA or U.S. NRC\(^{14}\) will be sufficient for use in estimating average annual air concentrations for the ecologic study. However, some nuclear facilities may require more complicated models, particularly for the case-control study where batch or episodic releases may need to be calculated separately (see Table A.1 for suggested threshold values) or those with more complicated geographies. In that case, models such as the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSLIP\(^{15}\) ) model or the Regional Atmospheric Transport Code for Hanford Emission Tracking (RATCHET\(^{16}\) ) model may need to be used for estimating air concentrations at specific nuclear facilities and events.

**TASK 9:** Estimate annual organ doses via external and internal irradiation from all potential exposure pathways for each facility.

For the ecologic study, age-dependent organ doses to representative individuals, assumed to be permanently located at the centroid of each census tract within 50 kilometers of the plant, will be calculated for each year of nuclear facility operation. Annual data will be used to estimate doses to organs, year by year from all pathways. The first year of exposure will be the first year of operation of the nuclear facility. All radiogenic cancers and common cancers will be examined.

The dose assessment for the ecologic study will be conducted using simplified assumptions, such as no migration over the period of facility operation up to diagnosis, no changes with time on water and land uses as well as food consumption and origin, and, if detailed meteorological data are not available for the year under consideration, average seasonal meteorology from previous years. (See Table A.1 for more information.)

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For the case-control study, the age-dependent annual organ doses will be calculated for all cases and controls at specific locations within 50 kilometers from the plant. The earliest year of dose calculation will be 16 years\textsuperscript{17} before the reports of cancer incidence. Quarterly data will be used to estimate doses to organs year by year from all pathways at the address level (address of the mother at the time of delivery as reported in the child’s birth certificate). The first year of exposure will be the year prior to birth of the cases in order to capture in utero exposure. All pediatric cancers will be examined.

Assumptions will have to be made to estimate the annual organ absorbed doses for the case-control study because personal data on residential history and dietary and lifestyle habits will not be available. Doses will be calculated on a quarterly or semiannual basis to take into account the seasonal differences due to the period of time when the vegetation is growing and seasonal variations in average meteorology (wind rose). Particular attention should be paid to the releases of carbon-14, which are believed to account for a substantial fraction of the doses in recent years.\textsuperscript{18} The estimates of quarterly or semiannual doses and batch-release doses for each census tract should be summed up to obtain the annual organ doses of interest for the epidemiologic analysis.

Specific decisions on these simplifications for each facility would be decided by NAS and its advisory committee in consultation with the contractor.

\textbf{TASK 10:} Validate the effluent releases and doses and describe their uncertainties.

The contractor will validate selected effluent data reported by each pilot nuclear facility. Validation of the reported releases (including batch and episodic releases) and dose estimates can include demonstrating that the doses could not have exceeded a specific level, based on the minimum detection limits of the environmental monitoring data reported by independent entities such as the states and other agencies such as EPA. Preliminary research performed by NAS staff showed that such independent monitoring is performed but the years it started varies from state to state (see Attachment D to this RFI, Table D.5).

Regarding uncertainties, for the ecologic study, the contractor will provide a qualitative description of sources of uncertainty in dose estimations arising from the source term, dispersion model, population variability factors, and dose factors.

For the case-control study, the contractor will provide a quantitative description of sources of uncertainty in dose estimations arising from the source term, dispersion model, population and/or individual variability factors, and dose factors and for individual annual dose estimates. (See Table A.1.)

\textbf{TASK 11:} Investigate possible sources on doses from natural background radiation with distance and direction for the pilot sites.

\textsuperscript{17} As noted in Attachment A to this RFI, Section A.1, the case-control study will examine children diagnosed with cancer at age 0-14 years and matched controls. This involves estimating doses for 15 years. Since the case-control study will attempt to answer the question of whether estimated radiation exposure during pregnancy is associated with childhood cancer occurrence (see Attachment B to this RFI, Section B.1), doses will be calculated also for the 9 months (for convenience rounded to 1 year) of pregnancy. Therefore, overall, doses will be calculated for 16 years.

\textsuperscript{18} See Section 2.1.4 of the Phase 1 report.
The contractor will investigate possible sources to estimate variations in the doses from natural background radiation with distance and direction for the pilot sites and variations in mean dose between the pilot nuclear facilities. Potential sources of natural background radiation data include:

- Pre-operation survey data performed for each facility;
- Pre-operation thermoluminescent dosimetry (TLD) monitoring data; and
- Other data on geographical variations in natural background levels around each facility, such as EPA's map of radon zones.\(^{19}\)

If available data allow, the contractor will prepare a natural background dosimetry report for use by the epidemiology contractors in assessing possible confounding.

**Task 12:** Transfer the estimated doses and other relevant information to the epidemiology contractor.

Organ doses estimates will be transferred to the contractor charged with performing the epidemiology tasks (see Section A.1 of this attachment) as soon as they are completed. Information will be transferred in a format that is compatible with the database generated and maintained by the epidemiology contractor.

**Task 13:** Report on all tasks.

The contractor will participate in regular (~monthly) conference calls with NAS staff and its advisory committee and quarterly face-to-face meetings for the duration of the study (estimated to be 2.5 years) to provide updates on work progress and to discuss potential issues. The contractor will maintain an ongoing record of project activities and goals, methods, and procedures (including those that were attempted but did not work) and will submit monthly progress reports on key milestones. The contractor will also submit quarterly reports to NAS that will be posted on the study website. These reports will contain information such as:

- A detailed list of activities performed or initiated during the quarter, and
- The amount of funding received and expended to activities during the quarter.

**Task 14:** Develop a technical report.

At the end of the pilot study, the contractor will prepare a technical report that describes in sufficient and appropriate detail all tasks performed during the pilot and research results in language suitable for an educated lay audience. The contractor will meet with the NAS committee and staff after delivery of the report to transfer knowledge and ensure total comprehension of products.

**A.2.2. Tasks to Be Performed by NAS**

NAS will facilitate the dosimetry contractor's work by doing the following:

• Forward to the contractor effluent release reports and other relevant reports that contain information needed for dosimetry estimation obtained during the pilot planning (see Attachment D to this RFI, Section D.2).
• Continue to work on retrieving missing reports and data.
Table A.1: Dosimetric Considerations for the Ecologic and Case-Control Studies

<table>
<thead>
<tr>
<th>TASK</th>
<th>PARAMETERS</th>
<th>ECOLOGIC STUDY</th>
<th>CASE-CONTROL STUDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine gaseous releases</td>
<td>Time period of interest</td>
<td>Operational history</td>
<td>Beginning 16 years before report of cancer incidence from pertinent registry&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>Annual</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>Batch releases</td>
<td>Include in the annual total</td>
<td>Estimate amounts and times of release separately if exceeding a threshold (for example &gt;5% of the quarterly total activity released)</td>
</tr>
<tr>
<td></td>
<td>Episodic releases</td>
<td>Estimate amounts and times of release separately if exceeding a threshold (for example &gt;5% of the total annual activity released)</td>
<td>Estimate amounts and times of release separately if exceeding a threshold (for example &gt;5% of the quarterly total activity released)</td>
</tr>
<tr>
<td></td>
<td>Release points</td>
<td>Elevated only (stack)</td>
<td>All release points</td>
</tr>
<tr>
<td></td>
<td>&lt; Lower limit of detection (LLD)</td>
<td>Half the LLD</td>
<td>Half the LLD</td>
</tr>
<tr>
<td></td>
<td>Required radionuclides</td>
<td>All contributing to reported total Ci released</td>
<td>All contributing to reported total Ci released</td>
</tr>
<tr>
<td></td>
<td>Missing radionuclides (RN)</td>
<td>Interpolate or estimate if exceeding a threshold (for example &gt;1% of annual release)</td>
<td>Interpolate or estimate if exceeding a threshold (for example &gt;1% of annual release)</td>
</tr>
<tr>
<td></td>
<td>Missing years</td>
<td>Interpolate</td>
<td>Interpolate</td>
</tr>
<tr>
<td></td>
<td>C-14</td>
<td>Calculate from thermal power unless measured</td>
<td>Calculate from thermal power unless measured</td>
</tr>
<tr>
<td>Obtain meteorological data</td>
<td>Time period of interest</td>
<td>Operational history</td>
<td>Beginning 16 years before report of cancer incidence from pertinent registry&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>Annual</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>Missing years</td>
<td>5-year annual average joint frequency distribution (JFD)</td>
<td>5-year average JFD for quarter (seasonal)</td>
</tr>
<tr>
<td>Event Type</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Episodic releases</td>
<td>Use annual average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous releases</td>
<td>Gaussian using annual Pasquill categories from JFD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch releases</td>
<td>Average annual at centroid census tract (CTT) for each nuclide from releases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous releases</td>
<td>If gaseous release determined separately, estimate deposition velocity, release times</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch/episodic</td>
<td>If gaseous release determined separately, calculate and record separately</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous releases</td>
<td>Calculate RN from dispersion model and estimated deposition velocity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch releases</td>
<td>Ignore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous releases</td>
<td>Calculate RN from dispersion model and estimated deposition velocity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch releases</td>
<td>Include precipitation (washout/rainout)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous releases</td>
<td>Calculate separately, if exceeding a threshold (for example &gt;5% of the total annual activity released)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Atmospheric dispersion model</th>
<th>Calculate all RN air concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate RN deposition densities</td>
<td>Determine liquid releases</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time period (years)</th>
<th>Frequency</th>
<th>Batch releases</th>
<th>Include in the annual release</th>
<th>Calculate separately, if exceeding a threshold (for example &gt;5% of the total annual activity released)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational history</td>
<td>Annual</td>
<td>Batch releases</td>
<td>Include in the annual release</td>
<td>Calculate separately, if exceeding a threshold (for example &gt;5% of the total annual activity released)</td>
</tr>
</tbody>
</table>

RFI: Analysis of Cancer Risks in Populations near Nuclear Facilities Pilot Study
### RFI: Analysis of Cancer Risks in Populations near Nuclear Facilities Pilot Study

<table>
<thead>
<tr>
<th>Release points</th>
<th>Release point location</th>
<th>Release point location</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;LLD</td>
<td>Half the LLD</td>
<td>Half the LLD</td>
</tr>
<tr>
<td>Required radionuclides</td>
<td>All contributing to reported total Ci released</td>
<td>All contributing to reported total Ci released</td>
</tr>
<tr>
<td>Missing RN</td>
<td>Interpolate if likely significant (for example &gt;1% fraction of annual total)</td>
<td>Interpolate if likely significant (for example &gt;1% fraction of annual total)</td>
</tr>
<tr>
<td>Missing years</td>
<td>Interpolate</td>
<td>Interpolate</td>
</tr>
</tbody>
</table>

### Obtain hydrological data<sup>a</sup>

<table>
<thead>
<tr>
<th></th>
<th>Long-term annual average flow rate</th>
<th>Annual average flow rate, river width and depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>River</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lakes</td>
<td>Average dilution factors at sites of water intake and of harvesting of fish and invertebrates</td>
<td>Specific (by year) data for calculation of RN concentrations in water and sediments at sites of interest</td>
</tr>
<tr>
<td>Bays</td>
<td>Average dilution factors at sites of harvesting of fish and invertebrates</td>
<td>Specific (by year) data for calculation of RN concentrations in water and sediments at sites of interest</td>
</tr>
<tr>
<td>Ocean</td>
<td>Average dilution factors at sites of fishing</td>
<td>Average dilution factors at sites of fishing</td>
</tr>
</tbody>
</table>

### Develop/select liquid dispersion models

<table>
<thead>
<tr>
<th></th>
<th>See discussion in Task 8</th>
<th>See discussion in Task 8</th>
</tr>
</thead>
</table>

### Calculate RN concentration in environmental media per unit of activity released

<table>
<thead>
<tr>
<th></th>
<th>Annual average RN concentrations at each location of drinking water intakes, fisheries (if applicable to site)</th>
<th>Quarterly average RN concentrations at each location of drinking water intakes, fisheries (if applicable to site)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water bodies</td>
<td>Average annual total RN plus contribution from previous years deposition if within 50 km of site</td>
<td>Average annual total RN plus contribution from previous years deposition if within 50 km of site</td>
</tr>
<tr>
<td>Sediments</td>
<td>Average annual total RN plus contribution from previous years deposition at CCT</td>
<td>Cumulative RN from quarterly deposition plus from previous years at address</td>
</tr>
<tr>
<td>Soil</td>
<td>Average annual total RN plus contribution from previous years deposition at CCT</td>
<td>Cumulative RN from quarterly deposition plus from previous years at address</td>
</tr>
</tbody>
</table>

### Calculate RN concentrations in food, water

<table>
<thead>
<tr>
<th></th>
<th>Annual average RN concentrations in food consumed in each CCT</th>
<th>Quarterly average RN concentrations in food consumed at each subject address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce, meat, other&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Annual average RN concentrations in food consumed in each CCT</td>
<td>Quarterly average RN concentrations in food consumed at each subject address</td>
</tr>
<tr>
<td>Milk, milk products</td>
<td>Annual average RN concentrations in milk and milk products consumed in each CCT</td>
<td>Quarterly average RN concentrations in milk and milk products consumed at each subject address</td>
</tr>
<tr>
<td>Determine production sources</td>
<td>Fish</td>
<td>Annual average concentrations at each location of fish harvesting within 50 km from site</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Origin⁴</td>
<td>Site dependent; within 50-km zone only</td>
<td>Site dependent; within 50-km zone only</td>
</tr>
<tr>
<td>Production Source History</td>
<td>Assume no changes during operational history</td>
<td>Consider annual changes (if applicable)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculate age-dependent external radiation doses to each specified organ</th>
<th>Fish</th>
<th>Annual sum from all RN at each CCT</th>
<th>Quarterly sum from all RN at each address</th>
</tr>
</thead>
<tbody>
<tr>
<td>From cloud: continuous releases</td>
<td>Annual sum from all RN at each CCT</td>
<td>Quarterly sum all RN at each address</td>
<td></td>
</tr>
<tr>
<td>From cloud: batch/episodic releases</td>
<td>Annual sum from all RN at each CCT</td>
<td>Quarterly sum all RN at each address</td>
<td></td>
</tr>
<tr>
<td>From RN cumulative activity in soil</td>
<td>Annual sum from all RN at each CCT</td>
<td>Quarterly sum all RN at each address</td>
<td></td>
</tr>
<tr>
<td>From contaminated sediments</td>
<td>Ignore</td>
<td>Site dependent: annual</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculate age-dependent inhalation doses to each specified organ</th>
<th>Fish</th>
<th>Annual from calculated RN air concentrations at CCT</th>
<th>Quarterly from calculated RN air concentrations at address</th>
</tr>
</thead>
<tbody>
<tr>
<td>From cloud: continuous releases</td>
<td>Annual from calculated RN air concentrations at CCT</td>
<td>Quarterly from calculated RN air concentrations at address</td>
<td></td>
</tr>
<tr>
<td>From cloud: batch/episodic releases</td>
<td>If RN activity calculated separately</td>
<td>If RN activity calculated separately</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculate age-dependent ingestion doses to each specified organ</th>
<th>Fish</th>
<th>Annual sum from all relevant RN for each specified organ, truncated annually</th>
<th>Annual sum from all RN except H-3, C-14, truncated annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>From food, water</td>
<td>Annual sum from all relevant RN for each specified organ, truncated annually</td>
<td>Annual sum from all RN except H-3, C-14, truncated annually</td>
<td></td>
</tr>
<tr>
<td>H-3 and C-14 calculated separately</td>
<td>H-3, C-14 included in RN total</td>
<td>Tabulated separately</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculate doses from minor pathways to each specified organ</th>
<th>Fish</th>
<th>Ignore</th>
<th>Site dependent: annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation, bathing, direct radiation from site</td>
<td>Ignore</td>
<td>Site dependent: annual</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VALIDATION</th>
<th>Fish</th>
<th>Calculation of upper bounds for major contributors to dose; compare with TLD data</th>
<th>Calculation of upper bounds for major contributors to dose-compare with TLD data</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>Calculation of upper bounds for major contributors to dose; compare with TLD data</td>
<td>Calculation of upper bounds for major contributors to dose-compare with TLD data</td>
<td></td>
</tr>
<tr>
<td>Internal</td>
<td>Calculation of upper bounds; examples for higher dose years</td>
<td>Calculation of upper bounds; major contributors to dose, annual</td>
<td></td>
</tr>
<tr>
<td>UNCERTAINTIES</td>
<td>See Task 10 for details</td>
<td>See Task 10 for details</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------</td>
<td>-------------------------</td>
<td></td>
</tr>
<tr>
<td>External</td>
<td>Discussion of assumptions and limitations</td>
<td>Quantitative, largely subjective, evaluation</td>
<td></td>
</tr>
<tr>
<td>Internal</td>
<td>Discussion of assumptions and limitations</td>
<td>Quantitative, largely subjective, evaluation</td>
<td></td>
</tr>
</tbody>
</table>

*a* Assuming adequate percentage of reporting of incident cases is available.

*b* If applicable for the site

*c* Includes fruit, vegetables, invertebrates, other.

*d* Where produced.
ATTACHMENT B
PHASE 1 NAS REPORT RECOMMENDATIONS

The goal of Phase 1 was to recommend scientific approaches for examining cancer risks in populations near nuclear facilities. Three recommendations emerged from the Phase 1 NAS scoping study which serve as the basis of the subsequent study phases. These recommendations are described in the following sections.

**B.1. RECOMMENDATION 1 ON STUDY DESIGNS**

"Should the U.S. Nuclear Regulatory Commission decide to proceed with an epidemiologic study of cancer risks in populations near nuclear facilities, the committee recommends that this investigation be carried out by conducting the following two studies, subject to the feasibility assessment described in Recommendation 2: (1) an ecologic study of multiple cancer types of populations living near nuclear facilities and (2) a record-linkage-based case-control study of cancers in children born near nuclear facilities."

The Phase 1 report considered a number of study designs that could be used to assess cancer risks in populations near nuclear facilities. Of the several study designs considered, two were judged to be suitable: an ecologic study of multiple cancer types in populations near nuclear facilities and a record-linkage-based case-control study of cancers in children born near nuclear facilities.

*Ecologic Study*

The ecologic study would describe both cancer incidence and mortality in populations living in census tracts within 50 kilometers (~30 miles) of the nuclear facilities. This study would examine all relatively common cancer types at all ages for the operational histories of the facilities to the extent allowed by available data.

The ecologic study is intended to answer the following two questions:

1. Do cancer incidence and mortality vary by proximity to nuclear facilities?
2. Does cancer incidence or mortality reflect patterns of radiation exposure associated with the nuclear facility?

A year-by-year average exposure will be assigned to populations residing in census tracts within 50 kilometers of the nuclear facilities being examined. Dosimetry information will take into account the magnitude and temporal variations of radioactive effluent releases from the facilities and the factors that provide directionality and distance variations in materials transport from those facilities. Organ doses to representative individuals at the geographic centroid points of the census tracts will be estimated for all cancers examined. These estimated values will be used in dose-response analyses of cancer incidence and mortality for all radiogenic and all common cancers.
Case-Control Study

The case-control study would assess whether children younger than 15 years of age born near nuclear facilities are at higher risk of developing cancer compared to those that were born farther away. This study would attempt to provide a more focused assessment of the association of pediatric cancers in relation to early life exposure to radiation during the more recent operating periods of nuclear facilities.

The case-control study is intended to answer the following two questions:

1. Is a mother’s residential proximity to a nuclear facility at time of delivery associated with cancer in her children?
2. Is estimated radiation exposure during pregnancy, early infancy, or childhood associated with childhood cancer occurrence?

Organ doses to children will be assigned based on the mother’s address at time of birth. In utero exposure to the mother will also be estimated. Estimated values will be used in dose-response analysis of cancer incidence for all pediatric cancers.

B.2. RECOMMENDATION 2 ON CONDUCTING A PILOT STUDY

"A pilot study should be carried out to assess the feasibility of the committee-recommended dose assessment and epidemiologic studies and to estimate the required time and resources."

The Phase 1 report recognized that there are several challenges associated with carrying out epidemiologic studies of cancer risks in populations near U.S. NRC-licensed nuclear facilities, including the following:

- Uneven availability and completeness of data on cancer mortality and incidence at geographic levels smaller than a county;
- Uneven availability and quality of data on nuclear facility effluent releases; and
- Inability to reliably capture information on population mobility, risk factors, and potential confounding factors.

Because of these limitations, one of the main recommendations of the Phase 1 report was that a pilot study involving seven nuclear facilities be conducted to determine whether the recommended epidemiologic studies can be carried out with available data. In other words, the purpose of the pilot study is to evaluate the feasibility of the recommended epidemiology studies and to develop the necessary specific operational procedures and data collection methods.

Seven facilities are included in the pilot study: Dresden Nuclear Power Station, Morris, Illinois; Millstone Power Station, Waterford, Connecticut; Oyster Creek Nuclear Generating Station, Forked River, New Jersey; Haddam Neck, Haddam Neck, Connecticut; Big Rock Point Nuclear Power Plant, Charlevoix, Michigan; San Onofre Nuclear Generating Station, San Clemente, California; and Nuclear Fuel Services, Erwin, Tennessee. (See Figure B.1 for the relative locations of the pilot nuclear facilities.)
These facilities were selected because they started operation at different times and represent both currently operating and decommissioned nuclear facilities. Moreover, these facilities have some variation in surrounding population sizes, the quality and maturation of the state's cancer registration, and the level of complexity for registry's research approval processes and research support.

Figure B.1: Geographic distribution of the seven pilot nuclear facilities

B.3. RECOMMENDATION 3 ON STAKEHOLDER INVOLVEMENT

"The epidemiologic studies should include processes for involving and communicating with stakeholders. A plan for stakeholder engagement should be developed prior to the initiation of data gathering and analysis for these studies."

Stakeholder engagement is an essential element of the study on analysis of cancer risks near nuclear facilities. Several approaches were used in this Phase 1 study to engage with stakeholders and subsequent phases will build on those efforts. These include the following:

1. A dedicated project website supplementing the NAS website to provide additional information of interest to the public about the study and to further enable interested parties to submit information for the committee's consideration.
2. A listserv to notify interested parties about project milestones such as appointment of the study committee, and meeting dates, locations, and agendas.
3. Public comment sessions scheduled at the end of the committee's information gathering meetings.
ATTACHMENT C
PILOT PLANNING ADVISORY COMMITTEE MEMBERSHIP

Jonathan M. Samet (IOM), Chair, University of Southern California
Harold L. Beck, Independent Consultant
Steven M. Becker, Old Dominion University
Jean D. Breder, Texas A&M Health Science Center
Andre Bouville, National Cancer Institute (retired)
Christie R. Eheman, Centers for Disease Control and Prevention
R. William Field, University of Iowa
Daniel O. Stram, University of Southern California
Margot Tirmarche, Nuclear Safety Authority of France
Jonathan C. Wakefield, University of Washington
ATTACHMENT D
PROGRESS WITH PLANNING FOR THE PILOT STUDY

NAS is currently planning for the pilot study and anticipates the completion of this step in December 2014. During the pilot planning, NAS staff in consultation with the pilot planning advisory committee made progress with collecting information relevant to carrying out the pilot. This information is summarized in the following sections: epidemiology, dosimetry, and public engagement.

D.1. EPIDEMIOLOGY

Health information needed to conduct the recommended ecologic and case-control studies is collected and maintained by the state cancer registries and vital statistics offices. These two entities are typically found in the state’s department of public health and despite the regular key relations they are separate in terms of administrative processes, statutes, and regulations. Cancer registries collect information related to incident cancer cases. Vital statistics offices collect information related to deaths (including cancer deaths) and births.

The seven pilot sites are located in six states as shown on Table D.1. Therefore, these six states need to approve release of the health information that they collect and that is relevant to the study. Additional states whose populations reside within 50 kilometers (~30 miles) of the nuclear facilities will also be part of the pilot and they would need to approve release of information on their portion of the population that lives near a nuclear facility.

<table>
<thead>
<tr>
<th>Main States</th>
<th>Additional States</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>San Onofre</td>
</tr>
<tr>
<td>Connecticut</td>
<td>Millstone, Haddam Neck</td>
</tr>
<tr>
<td>Illinois</td>
<td>Dresden</td>
</tr>
<tr>
<td>Michigan</td>
<td>Big Rock Point</td>
</tr>
<tr>
<td>New Jersey</td>
<td>Oyster Creek</td>
</tr>
<tr>
<td>Tennessee</td>
<td>Nuclear Fuel Services</td>
</tr>
</tbody>
</table>

Table D.1: Pilot States

An example of exposed populations from a nuclear facility crossing state boundaries is illustrated in Figure D.2 with Millstone. Although the Millstone power plant is located in Connecticut, part of the population living within a 50-kilometer zone from the plant lives in Rhode Island and part in New York. Therefore, to study cancer risks near the Millstone nuclear power plant information from all three states is needed.

NAS staff visited the pilot states and engaged in discussions with the cancer registries’ and vital statistics offices’ staff to better understand

[20] Information related to North Carolina was collected by a phone interview. At the time of this writing (September 2014), NAS staff have not collected the relevant information from Rhode Island or New York.
availability of data and release criteria of these data. These discussions started with an introduction to the study's scope and a description of what information is anticipated to be requested from the states. NAS staff also requested information on data completeness, privacy issues related to the release of the data, linkage possibilities between administrative databases (birth records and cancer registration), policies and mechanisms, and costs and timeframes for release of the data.

D.1.1. Data Completeness

Address at Time of Diagnosis

Availability of address at diagnosis is essential for the conduct of both the ecologic study of cancer incidence and the case-control study. Table D.2 summarizes the information on the first year that address exists in almost all records of the cancer registries. It should be noted that the states were not asked to run data queries in their databases to provide precise answers; instead they were asked to provide rough estimates. In addition, the percentages given by the states on completeness of data (noted as records missing address (%) in Table D.2) may not represent completeness of data at the areas of interest (i.e., 50 kilometers around the pilot nuclear facilities). In fact, a number of states commented that in rural areas such as those near nuclear facilities completeness of information may be lesser than the state average.

Table D.2: Availability of Cancer Incidence Data from Pilot States

<table>
<thead>
<tr>
<th>State</th>
<th>Year of operation</th>
<th>First year that address exists in almost all records</th>
<th>Records missing address (%)</th>
<th>Geocoded?</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>1988&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1988</td>
<td>6</td>
<td>yes</td>
</tr>
<tr>
<td>CT</td>
<td>1935&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1992</td>
<td>~0.3</td>
<td>yes</td>
</tr>
<tr>
<td>IL</td>
<td>1986&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1986</td>
<td>~10</td>
<td>yes</td>
</tr>
<tr>
<td>MI</td>
<td>1981&lt;sup&gt;g&lt;/sup&gt;</td>
<td>late 1990s</td>
<td>10</td>
<td>yes</td>
</tr>
<tr>
<td>NC</td>
<td>1980&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1995</td>
<td>15</td>
<td>yes</td>
</tr>
<tr>
<td>NJ</td>
<td>1979&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1995</td>
<td>~5</td>
<td>yes, mostly</td>
</tr>
<tr>
<td>TN</td>
<td>1986&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2004</td>
<td>~5</td>
<td>yes</td>
</tr>
</tbody>
</table>

<sup>a</sup>Part of the state or a selected population within the state is part of the Surveillance, Epidemiology, and End Results (SEER) program.

<sup>b</sup>Entire state is part of the SEER program.

<sup>c</sup>Entire state is part of the National Program of Cancer Registries.

As shown in Table D.2, the time periods for which information such as address at time of cancer diagnosis is available is electronically extend from 1988 to 2004. However, addresses are missing or are incomplete for some records (i.e., described as P.O. Box or rural route number). All states geocode address information to census tract at least for the more recent years.

Veterans Affairs Cases

The U.S. Department of Veterans Affairs (VA) changed its policy regarding the sharing of VA cancer data in 2007. This policy change results in incomplete reporting of VA hospital patients to some state cancer registries and inability of the states to share data with third parties such as investigators requesting cancer incidence data from the state registries.
NAS staff enquired for information on the proportion of VA hospital cancer cases within the pilot states to roughly estimate the impact of the missing VA hospital patients in the pilot study. The annual percentage of estimated VA hospital cases ranged between 0.5% and 2% of the total number of cases reported annually within the state.

Address at Time of Death

The time periods for which information on address at time of death is available electronically extends from 1949 to 2008. The address at time of death is reported in the death certificates. However, transfer of the information from the death certificate to an electronic database is estimated to cost about $1.00 per death certificate.\(^{21}\) Given that there are about 15,000 to 55,000 cancer deaths annually in the pilot states, transfer of the information is an expensive and time-consuming exercise.

Address at Time of Birth

Address at time of birth is needed for the conduct of the case-control study and selection of appropriate cases and controls. (This address is actually the address of residence of the mother at the time of delivery and for the purposes of the study is also assumed to be the mother’s residence during pregnancy and until the child is 15 years of age.) Typically, the address is available electronically from 1995 onward with some exceptions. For example, in Illinois the information exists electronically since 2010.

Other Data

NAS staff enquired for availability of additional information that is relevant to the study. A sample of the variables of interest is listed in Table D.3. States reported that they collect this information.

\(^{21}\) Communication with state of Michigan cancer registry and vital statistics office director.
Table D.3: Sample Variables of Interest Collected from the States

<table>
<thead>
<tr>
<th></th>
<th>Ecologic study</th>
<th>Case-control study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer Registries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of diagnosis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Age at diagnosis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gender</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cancer site and histology</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Vital Statistics Offices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Death Records</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of death</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Age at death</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cancer site</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Birth Records</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother’s age</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Mother’s race/ethnicity</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Child’s birth weight</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

An additional issue related to the mortality data that affects the ecologic study of cancer mortality is the variability within states of the quality of missing or incorrect information of the death certificates. Examples include lack of information on cancer site or, if a cancer metastasizes, listing of the underlying cause of death as the metastatic site instead of the primary cancer site.

D.1.2. Policies and Mechanisms

The health information required for the pilot study is generally not publicly releasable due to privacy and patient protection considerations. Registries will need to review the research proposal and protocol before approving a study and releasing the information. Some states have multiple levels of protocol approvals; in general it would take 3-4 months for a protocol to be approved by the state IRB.

The pilot states interviewed agreed that it is reasonable for the two study designs (ecologic study of cancer incidence and mortality and case-control study) to be under the same IRB approval since they are part of the same scientific protocol. This integrated approach would minimize the administrative burden related to IRB approval including initial submission and renewal.

All variables discussed (address at time of diagnosis or death, address at time of birth, and those listed in Table D.3) could be released to the investigators upon approval of a detailed research protocol by the state’s IRB. States reported that there were no different restrictions for release of the information for children and adults. An exception was health information and other
identifiable information related to the mother found in the birth certificates in Illinois.\textsuperscript{22} NAS staff did not discuss with the Illinois vital statistics office staff whether this barrier could be overcome.

D.1.3. Data Linkages

To conduct the case-control study, birth records would need to be linked with cancer registration records in order to identify suitable cases and controls. None of the pilot states reported to \textit{routinely} perform the type of linkages required for this study. However, all states had some experience with linkages. Since no unique identifier such as the child’s or the mother’s social security number is typically present in both administrative databases, the linkage would be (at least partially) probabilistic using variables such as name, date of birth, gender, race of the child, and possibly address at time of birth.

In general the pilot states would want to do the linkages “in house.” However, some indicated that they could release the data to the investigators so that they perform the linkages in their facilities, and others were open to the idea of the investigators performing the linkages in the state’s facility. Although the specifics were not discussed, cost and timeframe for release of the linked information would vary based on the approach.

D.1.4. Costs and Timeframes

States were unable to provide a precise cost estimate for the data and services to be requested to conduct the pilot study. A reliable cost estimate can only be provided when a formal request for data and services is done upon submission of the research protocol. However, states were able to provide some indication on the level of funds that would be required. Because of the uncertainty of the cost estimates they are not further discussed here.

Provided that a research protocol has obtained IRB approval, release of the information to the investigators would typically take a few weeks. However, delays may occur if the cancer registry or relevant office has received requests from other investigators, in which case requests are processed based on the time they are received. Moreover, the timeframe for linkages varies based on the approach used (see discussion in Section D.1.3).

\footnote{http://www.iiga.gov/commission/jcar/admincode/077/077005000000200R.html}
D.2. DOSIMETRY

The data required to conduct dosimetry estimates includes information about each facilities' radiological effluents releases (gaseous and liquid releases, the types and quantities of isotopes, and locations of the release points), meteorology (wind speed, direction, and stability), and ecology (for example, flow rates of rivers in which effluents are released).

D.2.1. Effluent Report Collection

NAS staff considered the following sources for retrieving information on radioactive effluent release reports:

- Facility effluent release reports which are dictated by U.S. NRC licensing requirements,\(^{23}\)
- Facility Environmental Monitoring reports and ODCMs,
- Yearly summaries of effluent releases,
- Historic meteorological data, and
- Independent environmental monitoring and effluent release measurement programs.

Data collection efforts focused on the facilities' effluent release reports because it was expected that they would contain the required data. Required first by the Atomic Energy Commission and later by the U.S. NRC, licensees submit effluent release reports throughout the operational lifetime of the facility and during decommissioning. The U.S. NRC technical specifications (10 CFR 50.36 (a)(2)) define the content of nuclear power facilities' effluent release reports to include the quantity of principle radionuclides released to unrestricted areas in gaseous and liquid form including additional information needed to estimate maximum potential doses to the public (i.e., the locations of the release points, information on batch and/or episodic releases, and meteorological data such as wind speed, direction and stability). The effluent reports routinely list 20 to 35 radionuclides. Carbon-14, a radionuclide of particular interest today, was first required to be reported in effluent release reports in 2010. For licensees of facilities processing special nuclear material, the U.S. NRC technical specifications (10 CFR 70.59) define similar effluent release reporting requirements. Ecology information such as flow rates of rivers in which effluents are released is routinely reported in the facilities' environmental monitoring reports and the ODCMs.

\(^{23}\) In 1972, the Atomic Energy Commission (AEC) drafted effluent release reporting requirements for its licensees (http://pdbdupws.nrc.gov/docs/ML0808/ML080800400.pdf). In 1974, the U.S. NRC was established and the effluent release requirements for all licensees were updated in 10 CFR 50.36a. The latest version may be accessed at http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0036a.html
During the pilot planning, NAS staff initiated collection of effluent release reports from the seven nuclear facilities that are part of the pilot. In the case of the Dresden Nuclear Power Plant, a large portion of the population that lives within 50 kilometers of the plant is also exposed to releases from the two neighboring plants (Braidwood and LaSalle; see Figure D.3). In order to estimate doses to that portion of the population, releases from all three plants need to be considered.

D.2.2. Effluent Release Report Data Completeness

As of today\textsuperscript{24} approximately 57 percent of the reports from the pilot nuclear facilities were retrieved and determined to be human-readable. The reports were collected from the following three sources:

1. The U.S.NRC’s Agencywide Documents Access and Management System (ADAMS)\textsuperscript{25} Public Legacy Library and Public Library (approximately 50 percent of those retrieved)
2. The U.S.NRC’s offsite archival storage facility (approximately 45 percent)
3. The nuclear facilities (approximately 5 percent)

A summary of retrieved reports is presented in segmented timeframes in Table D.4. Briefly, this table shows that the majority of recent reports (1990 and later) have been retrieved. A major gap in effluent release reports’ retrieval effort remains collection of reports prior to 1974.

\textsuperscript{24} That is as of October 2, 2014. Retrieval of effluent release reports from the pilot nuclear facilities is work in progress. Therefore, the information contained in this attachment is subject to change.

\textsuperscript{25} The USNRC’s ADAMS Public Legacy Library was used to identify microfiche numbers associated with copies of effluent reports submitted to the USNRC before approximately 1995. These microfiches are available at the USNRC’s Public Documents Room in Rockville, Maryland, however they are not considered the official effluent release reports. The ADAMS Public Library was used to identify and directly retrieve effluent reports submitted to the USNRC after about 1995. Reports retrieved from ADAMS Public Library are considered official reports.
Table D.4: Summary Description of Effluent Release Reports Retrieved

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Rock</td>
<td>1962-1997</td>
<td>0</td>
<td>70</td>
<td>65</td>
<td>57</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Braidwood</td>
<td>1987-present</td>
<td>N/A</td>
<td>N/A</td>
<td>17</td>
<td>47</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Dresden</td>
<td>1959-present</td>
<td>6</td>
<td>80</td>
<td>85</td>
<td>75</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Haddam Neck</td>
<td>1968-1996</td>
<td>0</td>
<td>80</td>
<td>90</td>
<td>92</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>LaSalle</td>
<td>1982-present</td>
<td>N/A</td>
<td>N/A</td>
<td>94</td>
<td>78</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Millstone</td>
<td>1970-present</td>
<td>0</td>
<td>30</td>
<td>50</td>
<td>71</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Oyster Creek</td>
<td>1969-present</td>
<td>100</td>
<td>60</td>
<td>70</td>
<td>43</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>San Onofre</td>
<td>1967-2012</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>7</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Nuclear Fuel</td>
<td>1957-present</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>90</td>
<td>75</td>
</tr>
<tr>
<td>Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table notes:
1. "Years of operation" accounts for the operation of any unit at a given site (for example, San Onofre includes operational years for Units 1, 2, and 3).
2. For the time period 2010 to 2013, many of the 2013 effluent release reports were not yet released to the ADAMS Public Library at the time of data collection. Percentage of available and readable effluent release reports for that period will increase as these reports become available in the near future.
3. Additional NFS reports prior to 2000 are being reviewed for public release by U.S. NRC staff.

Efforts to collect the remaining reports or identify better quality copies of the reports are ongoing. However, it is possible that some gaps will remain and release data will need to be interpolated or data from yearly summary reports may be used for those missing years.

In 1977, EPA produced a report on yearly summed measurements of effluent releases from nuclear power facilities. The report includes a listing of yearly summed releases of 27 isotopes. This report might be a useful tool for interpolation purposes.

D.2.3. Environmental Monitoring from Other Sources

EPA and individual state environmental protection programs have collected radiological data from the areas near the pilot nuclear facilities. Table D.5 lists the state agencies that have collected and reported radiological measurements in areas near the pilot facilities and provides the estimated start of each state's monitoring program.

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26 Several sources of yearly effluent release summary reports exist, including the U.S. NRC's NUREG 2907 series. This series, which was originally produced by Brookhaven National Laboratory for the U.S. NRC, contains yearly summaries of nuclear power facilities' effluent releases; NAS staff has collected summaries from 1980 through 2009.

27 See EPA-520/3-77-012.
Table D.5: State Environmental Monitoring Programs

<table>
<thead>
<tr>
<th>State Agency</th>
<th>Year monitor program started</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois Emergency Management Agency, Division of Nuclear Safety</td>
<td>~1994</td>
</tr>
<tr>
<td>New Jersey Department of Environmental Protection, Bureau of Environmental Radiation</td>
<td>~1990</td>
</tr>
<tr>
<td>California Department of Public Health, Radiologic Health Branch</td>
<td>2009$^a$</td>
</tr>
<tr>
<td>Michigan Department of Environmental Quality, Radiation Environmental Monitoring Program</td>
<td>1958</td>
</tr>
<tr>
<td>Connecticut Department of Energy and Environmental Protection, Radiation Division</td>
<td>1980</td>
</tr>
<tr>
<td>Tennessee Department of Environment and Conservation, Division of Radiological Health</td>
<td>~1984</td>
</tr>
</tbody>
</table>

SOURCE: Communication with state representatives.
$^a$ Monitoring has been in place since 1962 but data prior to 2009 are not accessible without significant effort.

Additional information on environmental monitoring from other sources can be found in the Phase 1 report.$^{28}$

D.3. PUBLIC ENGAGEMENT

The committee and staff used several processes to communicate with and invite the participation of interested members of the public during the pilot planning. These included:

1. A dedicated project website supplementing the National Academy of Sciences website to provide additional information of interest to the public about the study and further enable interested parties to submit information for the committee’s consideration.
2. A listserv to notify interested parties about project milestones such as appointment of the study committee; meeting dates, locations, and agendas.
3. Web conferencing capabilities for remote participation of interested members of the public unable to be present at the committee’s information gathering sessions.
4. Public comment sessions scheduled at the end of the committee’s information gathering meetings in Washington, DC, and Irvine, California.
5. A public meeting near the Oyster Creek Generating Station located in New Jersey.
6. Creation of a Frequently Asked Questions document$^{29}$ that discusses several issues related to the pilot, the methods and nuclear facilities selected, processes

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$^{28}$ Specifically, see Chapter 2, Section 2.3.6 of the Phase 1 report.
$^{29}$ See: http://nas-sites.org/cancerriskstudy/
of the National Academy of Sciences, and ways for interested members of the public to be kept informed about the study and provide comments.

These efforts are expected to continue and will be expanded in the next phases of the study.