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HEDR Modeling Approach

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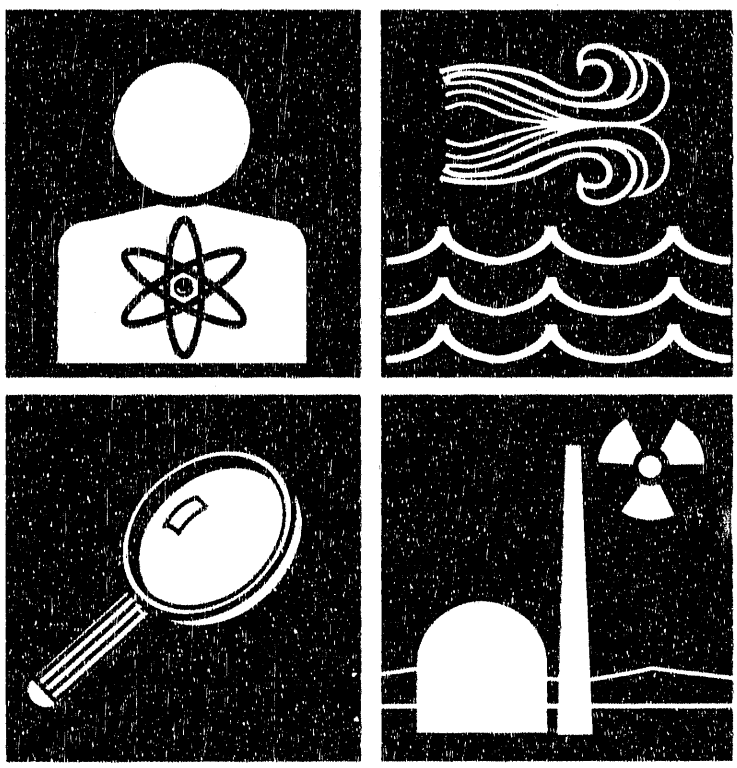
July 1992



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and the Centers for Disease Control
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HEDR MODELING APPROACH

Hanford Environmental Dose
Reconstruction Project

D. B. Shipler
B. A. Napier

July 1992

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the Technical Steering Panel
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July 15, 1992

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Dear Mr. Donnelly and Dr. Till:

HEDR MODELING APPROACH

Attached is a conceptual discussion of the approaches the HEDR Project is planning to use in calculating individual doses throughout the entire period of Hanford Site operations. Each of the major environmental transport pathways is considered - atmosphere, surface water, and groundwater. For each of the transport pathways, a different sequence of modeling techniques is projected, depending on the level of sophistication deemed appropriate. This discussion is an elaboration on the assumptions initially presented in the HEDR Project Summary Schedule and refined in the FY 1992 and FY 1993 task plans.

We presented the concepts in this working paper at the Quality Assurance and Technical Integration Subcommittee meeting in Pasco on April 23, 1992, and discussed it in the full public meeting on April 24, 1992. The report contains a number of refinements and subtle variations from the TSP-approved task plans. We anticipate a thorough discussion with the TSP and CDC.

Very truly yours,

M.D. Freshley for DBS

Dillard B. Shipler, Manager
Hanford Environmental
Dose Reconstruction Project

DBS:smf

enclosure

cc: RH Gray
MS Power
LE Sewell

SUMMARY

This report details the conceptual approaches to be used in calculating radiation doses to individuals throughout the various periods of operations at the Hanford Site. The report considers the major environmental transport pathways--atmospheric, surface water, and ground water--and projects an appropriate modeling technique for each. The modeling sequence chosen for each pathway depends on the available data on doses, the degree of confidence justified by such existing data, and the level of sophistication deemed appropriate for the particular pathway and time period being considered.

Scientifically defensible dose reconstruction requires varying levels of effort and detail, depending on the types of activities engaged in by the subjects, the time periods during which such activities took place, and the adequacy of the recorded data. Thus, the staff of the Hanford Environmental Dose Reconstruction (HEDR) Project, under the policies set by the Technical Steering Panel (TSP), strive to adapt their focus according to the pertinent facts and circumstances, both historical and technical.

It has, therefore, been a general operational assumption of the HEDR Project that more detailed reconstruction, and consequently more effort, should be expended on the earlier, rather than the later, periods of Hanford Site operations. For example, for the mid-1940s the modeling sequence requires a very fine temporal resolution--because the largest releases of radionuclides to the air occurred during that period. This approach, then, also justifies progressively less detailed modeling efforts for the middle and later periods of Site operations--for reasons such as the existence of contemporaneous dose estimates in the middle period (1950 - 1972), the increasing reliability of dose estimates during the later period (1973 - 1991), and the shutdown of the original eight reactors and their reprocessing plants in 1972.

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APPENDIX - HEDR PROJECT SUMMARY SCHEDULE AND ASSUMPTIONS A.1

1.0 INTRODUCTION

The purpose of this letter report is to formalize the conceptual approach being considered for the calculation of radiation doses to individuals throughout the period of Hanford Site operations. Each of the major environmental transport pathways--atmospheric, surface water, and ground water--is considered. For each of the transport pathways, a different sequence of modeling techniques is projected, depending on the available data, confidence in existing doses, and level of sophistication deemed appropriate. This discussion is an elaboration on the assumptions initially presented in the Hanford Environmental Dose Reconstruction (HEDR) Project Summary Schedule, April 1991; the Technical Steering Panel (TSP) work plan, September 1991; and the refinements in the Fiscal Year (FY) 1992 and FY 1993 task plans.

The general magnitude of the radionuclide releases over time decreased radically from the mid-1940s to the present. In addition, the availability of reliable monitoring data and technically defensible dosimetric projections increased from the mid-1940s to the present. Therefore, it has been a general operational assumption of the HEDR Project that more detailed reconstruction, and consequently more effort, should be expended on the earlier times than on the later periods. This general assumption has been apparent in the Project Summary Schedule assumptions and in the TSP-approved task plans. For reference, the assumptions from the Project Summary Schedule are included here as an appendix. A brief summary of the nature of these assumptions is provided in Table 1 for the atmospheric pathways and in Table 2 for the surface-water pathways. (Because of the frequent references throughout this document to the relevant tables, they are grouped together immediately before the appendix.) Each of the items indicated by letter in Tables 1 and 2 is described in the following paragraphs.

The largest releases of radionuclides to the air occurred in the mid-1940s. In order to properly account for the transport and deposition of these radioactive materials, and to properly propagate the uncertainties in the release and meteorological conditions, a very fine temporal resolution is required (Table 1). The staff working on the Source Term Task (03) and the Atmospheric Transport Subtask (04A) are developing information for the early

time period on an hourly basis (Item A, Table 1). It is unreasonable to require individuals to recreate their life histories on an hourly basis; it is also unnecessary because the individual daily variations are averaged over the entire exposure period. Therefore, the dose calculations performed by staff of Task 07 for this period are based essentially on seasonal variations, but use the Task 03 and Task 04 input concentrations and depositions on a daily basis for computational accuracy and, again, to properly propagate the uncertainties throughout the calculation (Item A, Table 1).

During the middle years of Hanford operations, 1950 - 1972, the releases to the air were much lower than during the early period; they were also relatively continuous. Because of the destruction of basic data, the difficulties in obtaining complete records from multiple operating contractors, and because contemporaneous dose estimates are, in fact, available, the HEDR Project plans to use monthly values for the source term; this will result in less need for extremely detailed information from the transport and dose portions of the models (Item B, Table 1). The shut-down of the original eight reactors and their reprocessing plants in 1972 caused a concomitant large reduction in releases and (potentially) in doses. This fact coupled with the availablity of reliable dose estimates for the last period (1973-1991) justifies increasing the temporal resolution from monthly to annually for this period (Item C, Table 1).

In order to make the best use of the early source term and transport temporal resolution, a fine grid of receptor locations was established. Beyond the Hanford Site boundaries (off-site), a 6-mile by 6-mile (10-km by 10-km) grid is being used (Item D, Table 1). Within the Site boundaries (on-site), a series of radial grids is proposed, centered on each release point. This finer on-site grid will allow calculation of doses to individuals exposed to more than one source of release (Item F, Table 1). For the period of intermediate releases, these same scales will be used (Items E and G, Table 1). In the period after 1972, use of such a fine grid is probably excessive, so a much more general approach will be taken (Item H, Table 1).

A major consideration in estimating doses is the source and amount of food eaten by people. To best use the information developed by the source term and transport activities, a resolution approaching the 6-mile by 6-mile

transport grid would be ideal. In general practice, a high level of resolution in agricultural production can be achieved on a county or sub-county level. A high resolution is being developed for the counties closest to Hanford for the early period (Item I, Table 1). A decision as to the level of detail for the period 1950-1972 has not yet been made, but the operating assumption at this time is that, like the source term, a more general (county-level or regional) production and distribution system should be adequate (Item J, Table 1). For the later period, when even doses to the most exposed group should be relatively small, initial calculations will be made assuming local production of all foods (Item K, Table 1). This will be a bounding approximation that will be reviewed at the time calculations begin.

The magnitudes of doses resulting from transport of radioactive materials in the Columbia River do not follow the same temporal pattern as those from the air, and in general the peak doses via this pathway are expected to be lower than the peak doses from the air pathway. Because releases to the river are not transported as quickly through the environment as those to the air, a weekly time resolution is anticipated for most of the operating period of the reactors (Item L, Table 2). Following reactor shut-down, an annual scale is proposed (Item M, Table 2).

Although a final decision on the level of effort for Columbia River modeling has not been made, planning is proceeding on the assumption that doses will be calculated for individuals at only selected locations (no more than a dozen or two) along the river's length, and perhaps into the coastal areas (Item N, Table 2). Doses to people in intermediate locations would be bounded by those on either side. Following reactor shut-down, the highest doses are likely to be those of residents closest to the Site. These are bounded in the Site annual reports for residents of the Tri-Cities of Richland, Kennewick, and Pasco (Item O, Table 2).

The modeling techniques anticipated for use for each of the pathway/time combinations are presented in Table 3. The approaches presented in this table constitute the "tools" that will be used for estimating individual doses. Each of the "tools" is further described in the sections below.

2.0 MAJOR OFFSITE AIR PATHWAYS

The pathways of exposure considered in this category are those of inhalation, air submersion, and ingestion of milk, meat, eggs, poultry, leafy vegetables, other vegetables, fruits, and grains, as currently included in the HEDR codes DESCARTES and CIDER. Target populations are all those living within the study area during this period. Additional pathways may be added as the result of additional research, sensitivity analysis, testing, or TSP direction. Paragraph numbers refer to the numbers in Table 3.

2.1 SOURCE TERM ESTIMATION, 1944-1949

Detailed hourly release estimates will be prepared with the Source Term Release model (STRM) by staff of Task 03. The derivation of these estimates will be based on the operating histories of individual reactors and on records of individual batches processed through the separations plants. This is required so that the uncertainty of the amount released and the time it is released can be coupled with the uncertainty of the atmospheric dispersion model. (The original work plans envisioned this process for the time period 1944-1952, so that the bulk of the releases of I-131 would be accounted for, including the period in mid-1951 during which the iodine-collection systems failed and a secondary peak of releases of I-131 occurred. However, the HEDR Project has evidence that the necessary daily records no longer exist to allow detailed daily reconstruction for the period beginning in 1950 through about 1953. The option of estimating the operating history of the reactors and separations plants during this period was investigated; however, meteorological data are also lacking for the Hanford Meteorological Station [HMS] during this time, adding an additional complicating factor. See Section 2.3 below.)

2.2 SOURCE TERM ESTIMATION, 1950-1972

Staff of Task 03 will provide cumulative monthly release estimates for this time period. These estimates will be based on available Hanford-originated monthly reports. Regular operation of the separations plants ceased initially in 1972. The Source Term Task staff will prepare additional information on the period 1973-1992, but that will be primarily for

completeness and the public record; it will not be formally used in the dose calculations. (See Section 2.7 below.)

2.3 ATMOSPHERIC DISPERSION, 1944-1949

Daily integrated values of air concentration and areal deposition for each of the grid locations will be prepared by Task 04 staff using the HEDR gaussian-plume/lagrangian-trajectory model RATCHET. The daily values are essentially the sums of the hourly values determined by using the source term model. As with the source term, this is described in the earlier work plans as occurring for the period 1944-1952. However, data from the local meteorological stations (HMS and, sometimes, Pasco) are not available during the 1950-1953 window. The only two options available in this instance are use of "surrogate data" (e.g., the 1983-1987 data set used in the Phase I calculations) or long-term monthly averages. Given the unavailability of the source term data described above in Section 2.1, it is logical to reduce both efforts to the next most defensible level.

2.4 ENVIRONMENTAL ACCUMULATION, 1944-1949

Daily values of concentration of radionuclides in soil, vegetation, and animal products will be prepared for each grid location by staff of Task 07 using the HEDR environmental model DESCARTES. This requires the input of a considerable amount of data, which are being prepared by staff of Task 06, regarding the agricultural production and distribution systems in existence during that time. The reduction in the period from 1944-1952 to 1944-1949 means that proportionally fewer of these demographic data must be collected.

2.5 INDIVIDUAL DOSE CALCULATIONS, 1944-1949

Staff of Task 07 will calculate estimates of individual radiation doses with the HEDR dose code CIDER. Annual doses will be reported (or annualized doses, if the individual only lived in the study area for a portion of a year). These are calculated as a sum of daily exposures from all sources. The person's movements about the study area are accounted for, as well as his or her probable sources of food.

2.6 ATMOSPHERIC TRANSPORT, ENVIRONMENTAL ACCUMULATION, AND INDIVIDUAL DOSE CALCULATIONS, 1950-1972

The shift to a monthly average source term requires that the subsequent calculations also be changed to a monthly basis. Staff of Task 04 work calculate atmospheric transport for the same grid area using representative results of the RATCHET program. It is most likely that this will be done using repetitive applications of long-term meteorology, coupled with "likely-but-unknown" release rates, to give a distribution with a wide but realistic uncertainty for a given month of the year (i.e., arbitrary distributions for the air concentrations will not be assigned). (For selected individual known releases, actual daily dispersion calculations may be done if warranted.) The DESCARTES code will continue to be used to calculate the environmental concentrations in plants and animals, but with less detail. (This can be thought of as a degraded version of DESCARTES or an enhanced version of the Phase I model.) At this time, it is not anticipated that grid-to-grid transport of food products will be simulated because the cost of such an undertaking would not provide commensurate benefits, although a TSP directive to do so could be incorporated with this structure. Doses would thus be calculated with a simplified version of CIDER--one that allows age dependence but uses less detailed monthly inputs, and can operate on data for only a single grid node at a time.

2.7 DOSE ESTIMATES FOR TIMES BEYOND 1972

With the initial shut-down of all the once-through Hanford production reactors and the reprocessing plants in 1972, the major source terms at Hanford ended. Although some spot checks with the system described in Section 2.6 above may be made, most individual doses will be done with reference to the estimates made in the Hanford Site Annual Reports. Doses to any individuals during this time period should be well below the TSP-approved cut-off levels, and may be bounded by the annual report values.

2.8 INDIVIDUAL DOSE CALCULATIONS FOR AREAS BEYOND THOSE COVERED BY THE DISPERSION GRID

For estimating doses for which the extent of the model described in Section 2.6 is insufficient, approximations will be made on the basis of time-of-exposure, nearby grid node monthly values, and dose rates calculated for similar circumstances in adjacent areas. Examples here are areas within Indian reservations that fall outside the edges of the current grid, or locations where there are local anomalies between the calculated and monitored data caused by sub-grid-scale effects.

3.0 MINOR OFFSITE AIR PATHWAYS

The pathways of exposure considered here are all those not included in the main codes described above. If, upon consideration, it is determined that any given pathway has the potential to add more than 5% to the total annual dose for any individual at a time when the dose exceeds the TSP guidelines, it will be upgraded to a major pathway and added to the main models (effectively leaving this category). Being added to the main model does not necessarily imply full implementation in DESCARTES or CIDER--some simple pathways may be dealt with as post-processed additions to individual doses, particularly if the number of people potentially exposed is known to be small.

3.1 SOURCE TERM ESTIMATION, 1944-1949

Detailed hourly release estimates will be prepared with the Source Term Release model (STRM) by staff of Task 03. This uses the identical source term as prepared for the major pathways. As long as the detail is available, it will be used.

3.2 SOURCE TERM ESTIMATION, 1950-1972

Cumulative monthly release estimates will be prepared by staff of Task 03 for this time period. These estimates will use the same source term as the major pathways.

3.3 ATMOSPHERIC DISPERSION, 1944-1949

Staff of Task 04 will prepare daily integrated values of air concentration and daily areal deposition for each of the grid locations by using the HEDR gaussian-plume/lagrangian-trajectory model RATCHET. The logic for dispersion is the same as for the source term.

3.4 ATMOSPHERIC TRANSPORT, ENVIRONMENTAL ACCUMULATION, AND INDIVIDUAL DOSE CALCULATIONS, 1950-1972

The shift to a monthly average source term requires that the subsequent calculations also be changed to a monthly average basis. Atmospheric trans-

port will be calculated for the same grid area using representative results of the RATCHET program as described for the main pathways. A simplified, integral formulation of the DESCARTES code will be used to calculate environmental concentrations in designated media. Doses would thus be calculated with a simplified version of CIDER--one that allows age dependence, but uses less detailed monthly inputs, and can operate on data for only a single grid node at a time.

3.5 EVALUATION OF PATHWAY CONTRIBUTION TO DOSE, 1944-1949

Using deposition and air-concentration data available from the complex models used for the major pathways, initial calculations will be performed to determine the relative magnitude of pathways under consideration. Generally, these will be simple hand calculations, or occasionally simple numerical algorithms, that implement the basic requirements for a given pathway on a daily basis. The results will be ranked, and only those pathways that indicate the potential for significant contributions to the total dose (measured by the criteria described above) will be elevated to the status of "major pathways." Those so elevated will fall into the categories defined in Sections 2.4 or 2.5 above. Those found not to contribute significantly will be documented and removed from further consideration.

3.6 EVALUATION OF PATHWAY CONTRIBUTION TO DOSE, 1950-1972

Using deposition and air-concentration data available from the simplified models used for the major pathways for this period, initial calculations will be performed to determine the relative magnitude of pathways under consideration. Generally, these will be simple hand calculations, or occasionally simple numerical algorithms, that implement the basic requirements for a given pathway on a monthly basis. The results will be ranked, and only those pathways that indicate the potential for significant contributions to the total dose (measured by the criteria described above) will be elevated to the status of "major pathways." Those so elevated will fall into the categories defined in Section 2.6 above. Those found not to contribute significantly will be documented and removed from further consideration.

3.7 EVALUATION OF PATHWAY CONTRIBUTION TO DOSE, 1973-1991

Using deposition and air-concentration data available from the annual reports, initial calculations will be performed to determine the relative magnitude of pathways under consideration. Generally, these will be simple hand calculations, or occasionally simple numerical algorithms, that implement the basic requirements for a given pathway on an annual basis. The results will be ranked, and only those pathways that indicate the potential for significant contributions to the total dose (measured by the criteria described above) will be elevated to the status of "major pathways." Those so elevated will be evaluated in a manner similar to that used on the available data in the annual reports, as done in Section 3.8 below. Those found not to contribute significantly will be documented and removed from further consideration.

3.8 EVALUATION OF INDIVIDUAL DOSES, 1973-1991

Annual reports for estimated doses for individuals and populations surrounding Hanford are available for annual increments for this period. These dose estimates are for the current major pathways (Section 2.7, above). It will be verified that exposure pathways currently unexamined in the annual reports would contribute a significant fraction of the dose already reported. The relative contribution of the pathways identified in Sections 3.6 and 3.7, above, will be evaluated, and those for which a potential may exist for the period under consideration will be evaluated and the annual report results modified if necessary.

4.0 ONSITE AIR PATHWAYS

The pathways of exposure considered here are air submersion, inhalation, and ground-shine from deposited radionuclides. Target populations are unbadged, on-site workers, and on-site military personnel.

4.1 SOURCE TERM ESTIMATION, 1944-1949

The same hourly source term from the separations facilities will be used for onsite dose estimation (inhalation, submersion, and ground-shine calculations) as for the major offsite pathways.

4.2 SOURCE TERM ESTIMATION, 1950-1972

Cumulative monthly release estimates will be prepared by staff of Task 03 for this time period. These estimates will be the same as those used in Sections 2.2 and 3.2, above.

4.3 ATMOSPHERIC DISPERSION AND DOSE, 1944-1949

Within about 10 km of the source, a straight-line gaussian plume model is reasonably accurate. Dispersion and the attendant submersion and inhalation doses can be easily calculated with a simple routine adapted from those currently available. Hourly variations can be considered, as well as work shifts.

4.4 ATMOSPHERIC DISPERSION AND DOSE, 1950-1972

Within about 10 km of the source, a straight-line gaussian plume model is reasonably accurate. Dispersion and the attendant submersion and inhalation doses can be easily calculated with a simple routine adapted from those currently available. Monthly exposures can be approximated from the average air concentration and knowledge of the fraction of time spent on site.

4.5 ATMOSPHERIC DISPERSION AND DOSE, 1973-1991

Extensive atmospheric and external dose rate monitoring records exist for this period. Average dose rates can be approximated from these records and the fraction of time workers were on site.

4.6 DOSES FROM MINOR ONSITE PATHWAYS, 1944-1949

It is anticipated that potential pathways of exposure other than direct exposure and inhalation may be investigated (e.g., dermal absorption of iodine from surfaces). Most of these cases will be investigated using hand calculations or simple numerical algorithms. Only in instances where the potential for dose is relatively high would the calculation be formalized in the technique described in Section 4.3. This is analogous to the approach described in Section 3.5.

4.7 DOSES FROM MINOR ONSITE PATHWAYS, 1950-1972

It is anticipated that potential pathways of exposure other than direct exposure and inhalation may be investigated. Most of these cases will be investigated using hand calculations or simple numerical algorithms. Only in instances where the potential for dose is relatively high would the calculation be formalized in the technique described in Section 4.4. This is analogous to the approach described in Section 3.6.

4.8 DOSES FROM MINOR ONSITE PATHWAYS, 1973-1991

It is anticipated that potential pathways of exposure other than direct exposure and inhalation may be investigated. Because the basic approach will be the use of monitoring data and estimates from the Site annual reports, little additional work is anticipated. Any additional calculations would be of a screening nature, performed and documented as single calculations.

4.9 DATA FOR ATMOSPHERIC DISPERSION AND DOSE, 1973-1991

Most data required for the calculations described in Section 4.5 are available in the Site annual reports. Some onsite dose estimates may also be included directly in the reports.

5.0 MAJOR OFFSITE RIVER PATHWAYS

Pathways of exposure to contaminated river water include direct consumption, swimming, boating, shoreline exposures, consumption of resident fish, anadromous fish, and other seafoods, and possibly consumption of irrigated crops. The exposed populations include the general public in communities using river water for domestic purposes, sportsmen and others using the river for recreation, and Native Americans and other groups consuming fish and seafood from the river. The exact level of detail for modeling of the river and its pathways has not been determined.

5.1 SOURCE TERM ESTIMATION, 1944-1972

Staff of Task 03 will prepare detailed weekly release estimates. The derivation of these estimates will be based on individual reactor operating histories, monitoring data on reactor effluents, and (for the period of at least 1944-1957) a relationship between measured gross beta activity and radionuclide spectrum. Summary data are available for either daily or monthly releases; these will be used to benchmark and calibrate the weekly estimates.

5.2 SURFACE-WATER TRANSPORT, 1944-1972

River-water concentrations of radionuclides will be prepared by staff of the Surface-Water Transport Subtask (04B) at a selected number of locations on weekly averages. The model employed is thought at this time to be a relatively simple dilution/routing model that will account for the river hydrograph and travel times to the various locations. Because the water concentrations vary relatively more slowly than air concentrations do, the weekly average will be used throughout the period of reactor operations. The peak concentrations are anticipated to occur in the late-1950s to mid-1960s. Calculations will be verified using available monitoring data. (See Section 5.6.)

5.3 ENVIRONMENTAL ACCUMULATION, 1944-1972

Concentrations of radionuclides in treated drinking water, fish, and possibly other media will be calculated by staff of Task 07 for the selected

locations on a weekly basis. For most radionuclides and media, simple bioaccumulation factors will be used. Some radionuclides with more complex behavior may require more detailed simulation models, or the use of monitoring data if available (as for phosphorous-32 and zinc-65 in the Phase I model). The level of detail has not yet been selected.

5.4 INDIVIDUAL DOSE CALCULATIONS, 1944-1972

Staff of Task 07 will calculate estimates of individual radiation doses. Annual doses will be reported (or annualized doses, if the individual only lived in the study area for a portion of a year). These are calculated as a sum of weekly exposures from all sources.

5.5 VERIFICATION OF CONCENTRATION, ACCUMULATION, AND DOSE ESTIMATES, 1944-1972

An extensive database is available of measurements made of various radionuclides at various times and at various locations of various media associated with the river. While insufficient of themselves to allow calculation of doses at all times and places, these data will be useful in verifying the approaches taken in Sectopms 5.2, 5.3, and 5.4.

5.6 RIVER TRANSPORT, ENVIRONMENTAL ACCUMULATION, AND INDIVIDUAL DOSE CALCULATIONS, 1973-1991

For the period following shut-down of the reactors, dose rates from the river pathway should fall well below the TSP-designated levels of interest. This will be verified using the estimates provided in the Hanford Site annual reports.

5.7 DOSE CALCULATIONS FOR AREAS BEYOND THOSE COVERED IN THE SITE ANNUAL REPORTS, 1973-1991

Because the annual reports focus on the Tri-Cities area, dose estimates for people or pathways outside the scope of the annual reports will be done using extrapolation of the annual report results. Simple dilution corrections or consumption adjustments will be used.

6.0 MINOR OFFSITE SURFACE-WATER PATHWAYS

The pathways of exposure considered here are all those not included in the main approaches described above. If, upon consideration, it is determined that any given pathway has the potential to add more than 5% to the total dose for any individual at a time when the dose exceeds the TSP guidelines, it will be upgraded to a major pathway and added to the main models (effectively leaving this category). Being added to the main model does not necessarily imply full implementation in the environmental accumulation and dose models--some simple pathways may be dealt with as post-processed additions to individual doses, particularly if the number of people potentially exposed is known to be small.

6.1 SOURCE TERM ESTIMATION, 1944-1972

Staff of Task 03 will prepare detailed weekly release estimates. These will use the identical source terms as those prepared for the major pathways. As long as the details are available, they will be used.

6.2 ENVIRONMENTAL ACCUMULATION, 1944-1972

An extensive database is available of measurements made of various radionuclides at various times and at various locations of various media associated with the river. While insufficient of themselves to allow calculation of doses at all times and places, these data will be used where possible to estimate concentrations in media associated with minor pathways.

6.3 EVALUATION OF PATHWAY CONTRIBUTION TO DOSE, 1944-1972

Using concentration data available from the models used for the major pathways and the monitoring data mentioned in Section 6.2, initial calculations will be performed to determine the relative magnitude of pathways under consideration. Generally, these will be simple hand calculations, or occasionally simple numerical algorithms, that implement the basic requirements for a given pathway on a weekly basis. The results will be ranked, and only those pathways that indicate the potential for significant contributions to the total dose (measured by the criteria described above) will be elevated

to the status of "major pathways." Those so elevated will fall into the categories defined in Sections 5.3 or 5.4, above. Those determined not to contribute significantly will be documented and dismissed from further calculation.

6.4 MINOR RIVER TRANSPORT, ENVIRONMENTAL ACCUMULATION, AND INDIVIDUAL DOSE CALCULATIONS, 1973-1991

For the period following shut-down of the reactors, dose rates from the river pathway should fall well below the TSP-designated levels of interest. This will be verified using the estimates provided in the Hanford Site annual reports.

6.5 MINOR DOSE CALCULATIONS FOR AREAS BEYOND THOSE COVERED IN THE SITE ANNUAL REPORTS, 1973-1991

Because the annual reports focus on the Tri-Cities area, dose estimates for people or pathways outside the scope of the annual reports will be done using extrapolation of the annual report results. Simple dilution corrections or consumption adjustments will be used.

7.0 OFFSITE GROUND-WATER PATHWAYS

Outside of the Hanford Site boundaries, the pathways of exposure to ground water are essentially those of the surface water, described above. Exposed populations are also the same.

7.1 RIVER TRANSPORT AND ENVIRONMENTAL ACCUMULATION, 1944-1972

An extensive database is available of measurements made of various radionuclides at various times and at various locations of various media associated with the river. This includes measurements of radionuclides associated with ground-water discharge to the river, as well as those contributed directly from the reactors. While insufficient of themselves to allow calculation of doses at all times and places, these data will be used where possible to estimate concentrations in the river resulting from ground-water discharge.

7.2 INDIVIDUAL DOSE CALCULATIONS, 1944-1972

It is anticipated that the contributions to the surface water from ground-water discharge will be proportionally very small. Dose estimates have been made and documented to verify this assumption. No additional effort is anticipated.

7.3 TRANSPORT, ENVIRONMENTAL ACCUMULATION, AND INDIVIDUAL DOSE CALCULATIONS, 1973-1991

For this period, dose rates from the river pathway should fall well below the TSP-designated levels of interest. This has been verified using the estimates provided in the Hanford Site annual reports. No additional effort is anticipated.

7.4 DOSE CALCULATIONS FOR AREAS BEYOND THOSE COVERED IN THE SITE ANNUAL REPORTS, 1973-1991

Because the annual reports focus on the Tri-Cities area, dose estimates for people or pathways outside the scope of the annual reports will be done

using extrapolation of the annual report results. Simple dilution corrections or consumption adjustments will be used.

TABLE 1. Calculational Resolution as a Function of Time for the Atmospheric Pathways

	TIME PERIOD		
	1944-1949	1950-1972	1973-1991
TEMPORAL RESOLUTION			
Hourly/Daily	A		
Monthly		B	
Annual			C
SPATIAL RESOLUTION			
Off-site 6mi x 6mi grid	D	E	
On-site radial grid	F	G	
General Area			H
AGRICULTURAL RESOLUTION			
High (Sub-county)	I		
Medium (County/Regional)		J	
Low (Area Average)			K

TABLE 2. Calculational Resolution as a Function of Time for the Columbia River Pathways

	TIME PERIOD	
	1944-1972	1973-1991
TEMPORAL RESOLUTION		
Weekly	L	
Annually		M
SPATIAL RESOLUTION		
Selected Locations	N	
Tri-Cities		O

TABLE 3. Modeling Techniques Anticipated to be Used

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	HANFORD ENVIRONMENTAL DOSE RECONTRUCTION PROJECT															
2																
3	DOSE ESTIMATING APPROACH															
4																
5			MAJOR			MINOR					MAJOR OFF-		MINOR OFF-		OFF-SITE	
6			OFF-SITE			OFF-SITE			ON-SITE		SITE RIVER		SITE RIVER		GROUND	
7			AIR PATHWAYS			AIR PATHWAYS			AIR PATHWAYS		WATER PATH		WATER PATH		WATER PATH	
8		1944-	1950-	1973-	1944-	1950-	1973-	1944-	1950-	1973-	1944-	1973-	1944-	1973-	1944-	1973-
9	ESTIMATING METHODOLOGY	1949	1972	1991	1949	1972	1991	1949	1972	1991	1972	1991	1972	1991	1972	1991
10																
11	HEDR-AIR SOURCE-hourly	1			9			17								
12	HEDR-AIR SOURCE-monthly		2			10			18							
13	HEDRS-AIR DISPERSE	3			11											
14	HEDR-AIR PATH	4														
15	HEDR-AIR DOSE	5														
16	HEDR-WATER SOURCE										26		33			
17	HEDR-WATER TRANS										27					
18	HEDR-WATER PATH										28					
19	HERD-WATER DOSE										29					
20	MINI-RATCHET		6			12		19	20							
21	MONITORING DATA									21	30		34		38	
22	HAND CALCULATIONS				13	14	15	22	23	24			35		39	
23	HANFORD ANNUAL REPORTS			7			16			25		31		36		40
24	EXTRAPOLATIONS		8									32		37		41
25																
26	30-Apr-92															

APPENDIX

HEDR PROJECT SUMMARY SCHEDULE AND ASSUMPTIONS

APPENDIX

HEDR PROJECT SUMMARY SCHEDULE AND ASSUMPTIONS

1. All meetings of the TSP for planning, budgeting, technical direction, review, and announcements will be performed in public. The public is invited to observe and participate in the activities of the Panel.

2. Use of the puff-trajectory model approach will continue; therefore, the maximum area for computer code dose estimating is generally defined by

   - West - 121.5° W
   - East - 116° W
   - North - 49° N
   - South - 44° N

3. Data necessary to calculate dispersion on this grid will be obtained and input in FY 1992.

4. A milk model will be developed on two levels (outside Phase I area):

   - *Detailed* - (census-tract-level information) Douglas, Lincoln, Spokane, Whitman, Columbia, Garfield, and Asotin Counties in Washington, and Sherman and Gilliam Counties in Oregon. This is known as the 19-county area.

   - *Moderate* - (county-level information) Chelan, Okanogan, Stevens, Ferry, and Pend Oreille Counties in Washington; Kootenai, Benewah, Latah, Nez Perce, Bonner, and Lewis Counties in Idaho; and Wasco, Jefferson, and Wheeler Counties in Oregon.

5. Time periods to be addressed are:

   - *Detailed* - 1944 to 1957 (includes transport modeling, and food production and distribution). The milk model will be derived from primary sources for this time period.

   - *Monitoring data corroboration* - 1957 through 1972 (confirmation of consistencies with HEDR models - extrapolation and summarization of monitoring data). The milk model will be derived from secondary sources for this period.

- *Monitoring data and dose estimate integration* - 1972 through 1990 (integration and summation of annual monitoring data and dose estimates with earlier time period HEDR results). Food distribution models will be developed only in a general sense in this period.

6. Food production/distribution information, other than fresh leafy vegetables, will be deferred to FY 1994. Fresh leafy vegetable information will be developed for the 10-county Phase I area for 1944-1950 only.

7. The maximum number of radionuclides considered in dose-estimating calculations is 12 in the air pathway and 13 in the water pathway:

Air	Water
Dosimetry-related	Dosimetry-related
I-131	P-32
Ru-103	Zn-65
Ru-106	As-76
Co-60	Np-239
Ce-144	Na-24
Te-132	Mn-56
Public concern	Cu-64
Pu-239	Cr-51
I-129	I-131
Sr-90	Te-132
Cs-137	Public concern
Ar-41	Sr-90
Kr-85	H-3
	Cs-137

8. The only health study being supported is the Hanford Thyroid Disease Study.

9. Pathways being considered for FY 1992 and 1993 are only the "major" ones. Model development of "minor" pathways is deferred until 1994. Some letter reports on pathways of interest may be prepared.

10. The project model will address Native American food harvesting, trading, and consumption; and migration information. "Lifestyle" will be used as a definition of specific categories of reference individual, rather than as a type of input information.

11. The project model will not include a military food model and will not address onsite exposures of military personnel prior to additional work in FY 1994.

12. The project model will not address construction workers' onsite exposures prior to additional work in FY 1994.

13. The project model will not address migrant farm workers' food and lifestyle considerations prior to additional work in FY 1994.

14. The project work breakdown structure (as modified at the February planning workshop) represents the full scope of work to be performed during the life of the project.

15. Population dose distributions by area and pathway will not be recalculated for the entire area as they were in Phase I. Instead, a series of representative individual doses for I-131 and for other radionuclides will be prepared and displayed in map/isopleth form.

16. Review of Hanford-originated documents deemed to be useful to the HEDR Project will be effectively complete when HEDR Project is completed.

17. No work on ground water will be performed beyond January 1992.

18. The scope of monitoring data collection will be refocused toward support of surface-water model development. Air, vegetation, and food-product monitoring data will support model-validation activities.

19. Surface-water source terms will be prepared, but may not be used directly unless so ordered by the TSP following a decision.

20. In FY 1992, initial sensitivity/uncertainty evaluations will be made to support a workshop. Following the workshop, additional work will be scoped according to TSP directives.

21. Records management, QA, Information Resources, and TSP Communications Support will continue as level-of-effort tasks.

22. An outside agency, either Indian Health Service or Centers for Disease Control, will take over contract monitoring for Native American contracts. Task 06 will continue to supply about 0.5 FTE in support of the tribes. Additional Native American Working Group support will come from Task 02. The project will continue to calculate doses as required.

23. Work on the Transfer Package, including user interfaces (i.e., making it easy to use), will not occur before FY 1994.

HEDR Project Deliverables (Those that are shaded are before or after the CDC contract period; unshaded ones are within the contract period.)

RFP[a]	PSS[b]	Task Plans[c]	Description	Date
1.	1.	0101C 0101B	Project Management Plan and FY 1992 Task Plans	1/01/92
2.	2.	0101D	FY 1992 Task Plans, Mid-Year Review	6/30/92
3.	3.	0101G	FY 1993 Task Plans	1/01/93
4.	4.	0101E	FY 1993 Task Plans, Mid-Year Review	6/30/93
5.	5.	0101I	Project Final Report	12/31/93
6.	6.	--	Information Resources Plan	1/01/92
7.	7.	1102A	Information Resources Summary Report	1/01/93
8.	8.	1103B	Information Resources Summary Report	9/30/93
--	9.	--	Information Resources Final Report	9/30/95
--	10.	--	Key Nuclides Decision (TSP)[d]	9/30/92
9.	11.	0303C	I-131 Source Term (1944-1991)	12/31/92
10.	12.	0303D	Key Radionuclides Report, Air	6/30/93
--	13.	--	All Key Radionuclides, All Years	6/30/94
--	14.	--	Other Special Interest Nuclides	9/30/94
11.	15.	0304B	Reactor Releases to Surface Water (1944-1991)	6/30/93
12.	17.	0502C	Monitoring Data Report	9/30/93
13.	16.	0404A	Columbia River Pathway Report	2/01/92
--	18.	--	Monitoring Data Report	3/31/95
14.	19.	0402B	Atmospheric Transport/Deposition Model	2/01/92
--	20.	--	Atmospheric Transport, Extended Region Decision (TSP)	3/31/94
--	21.	--	Atmospheric Transport Model, Extended Region (TSP)	12/31/94
--	22.	--	Surface Water Dose Monitoring/Modeling Decision (TSP)	3/31/92
--	23.	--	Surface Water Extended Region Decision	9/30/92
15.	24.	0404C	Surface Water Transport Model	6/30/93
16.	25.	0403A	Groundwater Report	1/01/92
17.	26.	0702A	Individual Dose Model, Major Pathways	2/01/92
18	27.	0702B	Population Dose Model	9/30/92
--	28.	--	Individual Dose Model, Minor Pathways	6/30/94
--	29.	--	Special Group Dose Model	12/31/95
--	30.	--	Verification/Validation Plan Decision (TSP)	9/30/92
19.	31.	0803B	Model Verification/Sensitivity/Uncertainty Report	9/30/93
--	32.	--	Model Verification/Validation Status Report	6/30/95
--	33.	--	Milk Model, Extended Region Decision (TSP)	9/30/92
20.	34.	0603D	Milk Production and Distribution Model (19 counties)	3/31/93
21.	35.	0603E	Milk Production and Distribution Model, Extended Region	9/30/93
22.	36.	0603C	Food Production and Distribution, Green Leafy Vegetables (19 counties)	6/30/92
--	37.	--	Food Production, Extended Region Decision (TSP)	6/30/93

RFP[a]	PSS[b]	Task Plans	Description	Date
--	38.	--	Food Production Report, Extended Region	12/30/94
23.	39.	0602C	Food Consumption Report	3/31/93[e]
--	40.	--	Leafy Vegetables, Extended Region Decision (TSP)	9/30/92--
	41.	--	Demographic Data, Special Groups Decision (TSP)	6/30/93
--	42.	--	Demographic Data, Special Groups	3/31/94
--	43.	--	Demographic Data, Extended Region	9/30/94
24.	44.	--	Native American Phase I Doses (Battelle - dose calculations; TSP - report)	9/30/92[e]
25.	45.	0705A	I-131 Dosimetry Report	6/30/93
26.	46.	0705C	Key Radionuclides Dosimetry Report, Air	9/30/93
--	47.	--	Native American Doses (Battelle - dose calculations; TSP - report)	9/30/94
--	48.	--	All Radionuclides Dosimetry Report, All Regions, All Years	3/31/95
--	49.	--	Native American Continuing Research Plan (TSP)	9/30/92
27.	50.	0705B	Surface Water Dosimetry Report	9/30/93
--	51.	--	Native American Phase I Data Report (TSP)	3/31/92
--	52.	--	Continuing Native American Research Report (TSP)	9/30/93
--	53.	--	Continuing Native American Research Report (TSP)	9/30/95
--	54.	--	Communications Report (TSP)	9/30/93
--	55.	--	Communications Report (TSP)	9/30/95
--	56.	--	Final Dosimetry Report	6/30/95
--	57.	--	Dose Calculation Methodology (hardware and software turnover package)	9/30/95

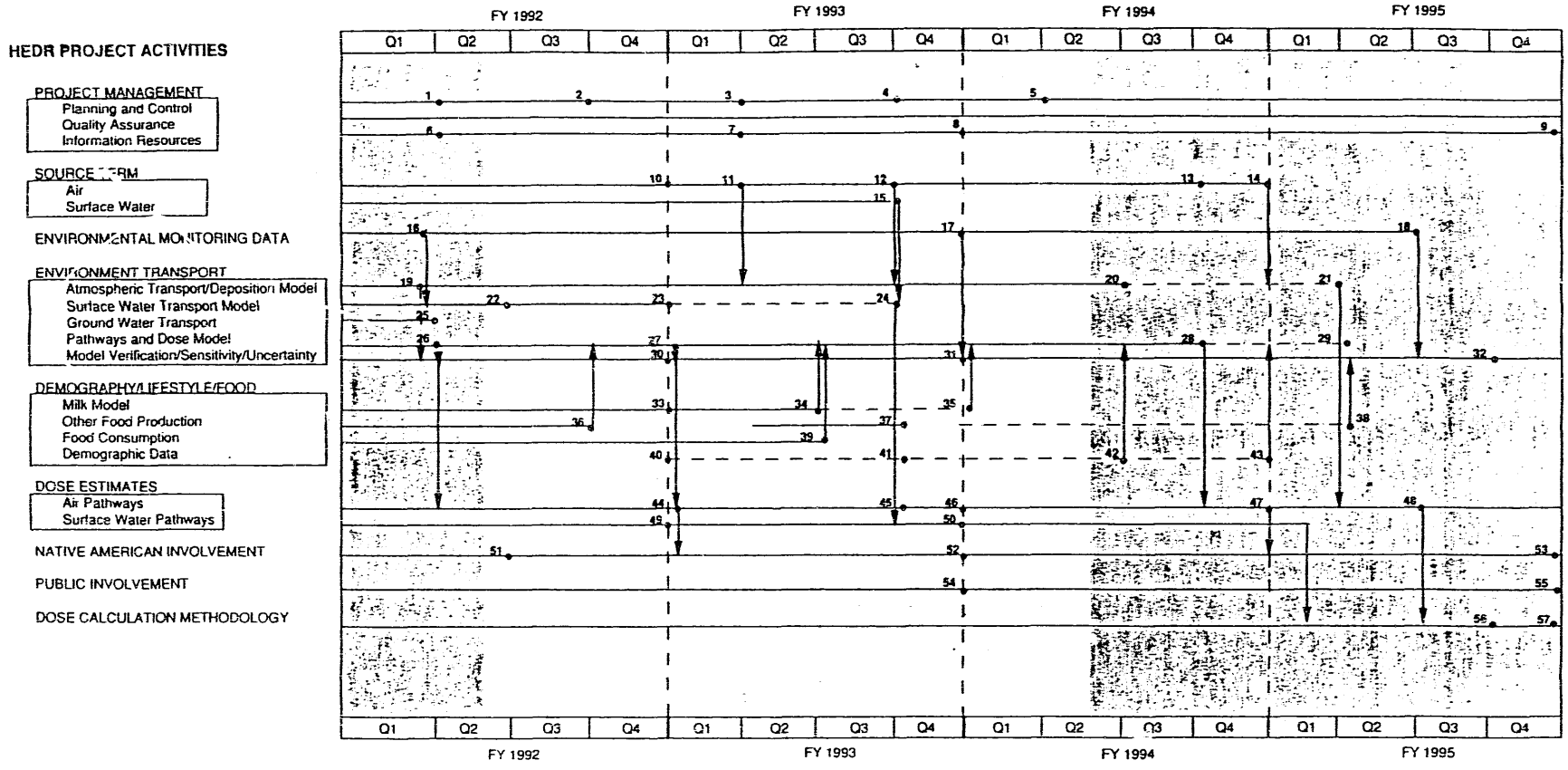
(a) RFP = Deliverable number that appears in Solicitation (Request for Proposal).
(b) PSS = Deliverable number that appears in Project Summary Schedule (Figure 4.1).
(c) Task plans in which these milestones are described are provided as Appendices D, E, and F of this proposal.
(d) TSP = Deliverable or decision of the Technical Steering Panel. The technical scopes and approaches described in this proposal, and the costs in the Business Proposal Volume for work during the contract period, are based on the assumption that all TSP decisions shown in this table result in a "yes," i.e., that the work will be done. For example, Project Summary Schedule deliverable 22--Surface Water Dose Monitoring/Modeling Decision (TSP)--is assumed to result in the TSP directing HEDR staff to create the surface water transport model shown in Project Summary Schedule deliverable 24 (RFP deliverable 15).
(e) The dates for these deliverables differ from those in the Solicitation. The dates here are based on TSP-approved task plans.

NOTES:

Assumptions associated with deliverables are described in the task plans in Appendices D, E, and F to this proposal.

Dates shown are when the draft deliverables are provided to the TSP and CDC for review. Comments by the TSP and CDC on deliverables will be returned to BNW within one month, via the TSP. Battelle-Northwest will provide final reports one month later. Comment delinquency by the TSP and CDC will constitute an excusable delay under the contract, and will result in a day-for-day slippage by BNW in publication of the final report, with associated cost adjustments.

TSP decisions made after the dates shown in Table 4.1 will result in a day-for-day slippage of the schedule of work described in the detailed task plans and in associated milestone (deliverable) dates.



December 19, 1991

Notes

- White area indicates contract period; shaded areas indicate TSP-approved work that contributes to, or was begun in, the contract period.
- Numbers in chart indicate deliverables, which are listed in Table 4.1 and described in more detail in the appended task plans.
- Work elements associated with HEDR activities are shown in Table 4.3.

HEDR Project Summary Schedule

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