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UC-707

Milk Cow Feed Intake and Milk Production and Distribution Estimates for Phase I

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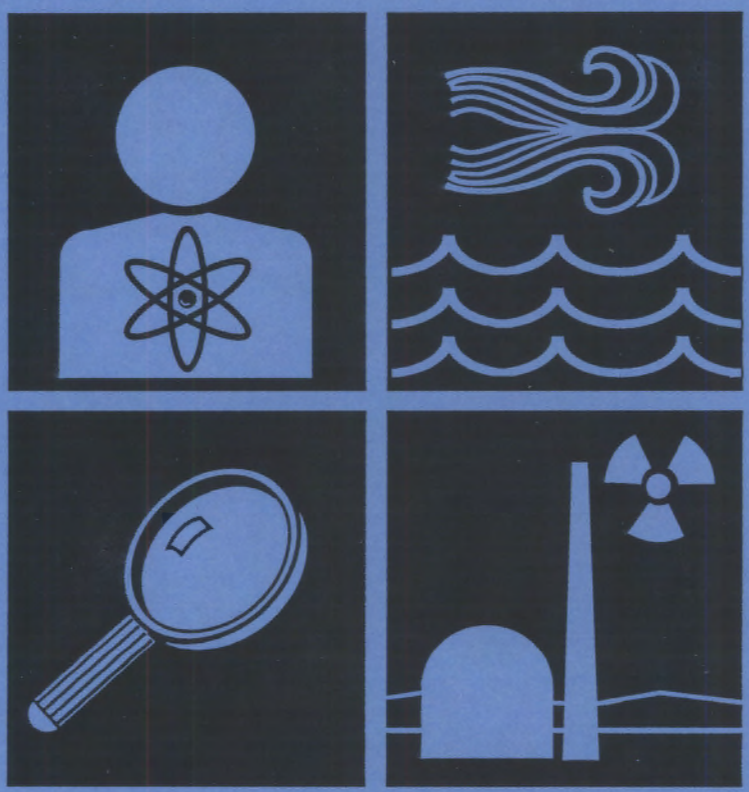
April 1992



Prepared for the Technical Steering Panel

Battelle

PNL-7227 HEDR

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MILK COW FEED INTAKE AND MILK PRODUCTION AND DISTRIBUTION ESTIMATES FOR PHASE I

Hanford Environmental Dose
Reconstruction Project

D. M. Beck
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April 1992

Prepared for the
Technical Steering Panel

Pacific Northwest Laboratory
Richland, Washington 99352

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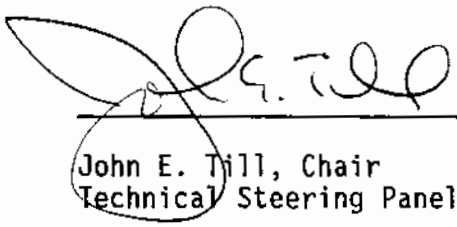
This document has been reviewed and approved by the Technical Steering Panel.



3-29-92

John E. Till, Chair
Technical Steering Panel

Date

PREFACE

This report summarizes the milk production and distribution estimates of Phase I of the Hanford Environmental Dose Reconstruction (HEDR) Project. These estimates were used to develop preliminary dose estimates.

PROJECT OBJECTIVES

Phase I of the HEDR Project had several objectives. Foremost among these was to determine whether sufficient information exists or could be reconstructed from incomplete records to enable a dose reconstruction study to proceed. A second objective was to design conceptual and computational models specifically to deal with uncertainties in the dozens of variables needed to estimate doses to offsite populations. The final objectives were to determine whether the data and models were sufficient to enable credible doses to be estimated and to compare HEDR doses with previously published dose estimates. In summary, Phase I was a pilot or demonstration phase. The Phase I preliminary dose estimates, which were calculated to demonstrate the feasibility of reconstructing doses, will definitely change as input and model structures are refined in later phases.

It is also important to note that the objectives of the HEDR Project do not include estimating risk or extrapolating to health effects that might have resulted from radiation exposures. A related epidemiological study, the Hanford Thyroid Disease Study, is being conducted for the Centers of Disease Control (CDC) by the Fred Hutchinson Cancer Research Center. This study will seek to determine whether there is increased thyroid disease from exposures to iodine-131 releases during the early years of Hanford Site operation.

OBJECTIVES OF THIS REPORT

This report was prepared to describe the results of searching for, evaluating, processing, and/or reconstructing the data needed for the feasibility study (Phase I). The report is intended as a demonstration of feasibility and not as a definitive, technical treatise on Hanford data; computer models; or regional demographic, agricultural, or lifestyle patterns.

Only enough information to demonstrate feasibility was developed, analyzed, and documented in this report.

SUBSEQUENT-YEAR OBJECTIVES

In the remainder of the project, scientists will identify and minimize errors and shortcomings of Phase I work, including the work reported herein. Scientists will evaluate and enhance the Phase I data and apply improved computer models; evaluate uncertainties in data and models; establish geographic areas, radionuclides, and pathways of interest; support the Hanford Thyroid Disease Study; and carry out activities that will result in better dose estimates for specified populations and for individuals.

The term "Phase I" is used in this report to refer to the first of four phases originally planned for the project. Phase I ended in July 1990. In February 1991, the TSP decided to shift the project planning approach away from phases--which were centered around completion of major portions of technical activities--to individual fiscal years, which span October of one year through September of the next. Therefore, activities that were previously planned for one of the three remaining phases are now designated to occur in one or more of the next several fiscal years.

FUTURE DOCUMENTATION

Much of the HEDR documentation is yet to be produced. The scope, level of detail, level of peer review, and mode of publication for each document will be defined during task planning. It is expected that documents will fall into one of four categories:

- *summary documents intended primarily for the non-technical lay reader*
- *summary documents intended primarily for the general technical reader*
- *detailed topical documents intended primarily for the technical peer reviewer (e.g., refereed technical journals)*
- *letter reports to transfer information among HEDR tasks or related projects or to provide information to the TSP or its subcommittees.*

The intention is to provide information for readers with all levels of interest.

PROJECT DIRECTION, QUALITY ASSURANCE, AND COMMENT INCORPORATION

The HEDR Project is directed by an independent Technical Steering Panel (TSP) of scientists and representatives of the states of Oregon and Washington, of regional Native American Tribes, and of the public. The TSP's charter is to direct, review, evaluate, and approve all HEDR Project work. The work described here was conducted by Battelle staff at the Pacific Northwest Laboratory. The U.S. Department of Energy funded Phase I of the project, but provided no technical direction, oversight, or review. Beginning in mid-1992, Battelle will continue dose reconstruction activities under contract to the Centers for Disease Control, which will fund HEDR and TSP work. The TSP will continue to provide technical direction for the project.

The work described in this report was conducted in accordance with the requirements of ANSI/ASME NQA-1 1986 Edition, Quality Assurance Program Requirements for Nuclear Facilities, as interpreted by the PNL Quality Assurance (QA) program.

Appendix E is a record of TSP comments and Battelle's responses to those comments; the TSP has reviewed and approved Battelle's responses. The comment numbers appear in this document in the left margin next to the paragraphs in whicn the corresponding comments are addressed. Any text that has been changed is shown in italics. In addition to changes to address TSP comments, some text has been changed for correction of errors and for further clarification.

SUMMARY

The Hanford Environmental Dose Reconstruction (HEDR) Project was established to estimate radiation doses that people could have received from nuclear operations at the Hanford Site since 1944. Radioactive iodine was one of the most important contributors to radiation doses from Hanford operations during the years 1944-1947, the HEDR Phase I study period. Consumption of milk from cows that ate vegetation contaminated by this iodine is likely the dominant pathway of human exposure *for individuals who drank milk.* In Phase I, initial information was collected on what the milk cows in the ten-county study area ate and how the milk they produced was distributed during the 1944-1947 period.

Records and reports are available from the U.S. Bureau of Census, the Dairy Herd Improvement Association, the Washington State Dairy Products Commission, and other governmental and dairy industry organizations. They provide some information on the amount of milk produced and sold in each county, the locations of individual dairies and distributors, and dairy industry practices from 1944 to 1947. Additional information was obtained through discussions with dairymen, farmers, ranchers, and agricultural extension agents. These *key contacts* knew specific milk producers, processors, and distributors and were familiar with dairy practices in specific geographical areas.

Published information on milk production indicates that more than enough milk was produced in the study area to supply demand. Some counties didn't produced enough milk for their own needs; others, because they had more irrigated land, produced more milk than they consumed. Yakima County, for instance, produced nearly 50% of the milk in the entire study area.

Four representative "feeding regimes" were used to describe the feed intake of milk cows in each census subdivision in the ten-county study area. Each feeding regime consisted of a different combination and portion of basic feed components (grain, alfalfa hay, grass hay, pasture, and silage). Using the available information, experts estimated the percentage of milk produced under each feeding regime for each census subdivision. Seasonal and

year-to-year variations in feed intake were also considered by estimating average pasture start and finish days and hay cutting dates for each census subdivision.

Information provided by informants associated with individual processor/distributors was used to estimate where milk processed by the various plants originated. Expert opinion was utilized to estimate 1) the percentage of milk processed by each milk plant that came from each census subdivision and 2) what percentage of milk consumed in each subdivision came from each commercial distributer or from cows kept in a family's backyard.

The results of this preliminary study indicate that the irrigated areas were the major sources of milk in the study area. Fresh forage in these irrigated areas was an important feed component of dairy cows in these irrigated areas during the spring, summer, and fall months. If pasture lands in an irrigated area were contaminated by radioactive iodine during those months, the milk produced there may have been an important source of radioiodine exposure for the human population that consumed it.

Other preliminary conclusions on milk production and distribution include the following:

- Backyard cows supplied between 40% and 90% of the milk consumed by rural families, while the vast majority of urban residents received milk from commercial sources.
- 100% of the commercial milk consumed by Richland residents came from the Carnation Plant in Sunnyside.
- Franklin County produced very little Grade A milk. That which was *bottled and* sold was processed at the Twin City Creamery in Kennewick *or two small processing plants in Connell.*
- All of the milk consumed in the Walla Walla area was produced locally.
- Overall, the study area was self-sufficient in milk production; no large amounts of milk were shipped into or out of the study area.

ACKNOWLEDGMENTS

Several agricultural experts served as valuable resources in the development of various estimates presented in this report. These major contributors include Dr. Gerald Ward of Colorado State University and Grady Williams, Bob Duncan, and Eddie Thomason of Washington State University.

We would also like to express our appreciation to the numerous milk producers who provided input to this report.

CONTENTS

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INTRODUCTION

This report provides initial information on milk production and distribution in the Hanford Environmental Dose Reconstruction (HEDR) Project Phase I study area. The Phase I study area consists of eight counties in central Washington and two counties in northern Oregon (see Figure 1). The primary objective of the HEDR Project is to develop estimates of the radiation doses populations could have received from Hanford operations. The objective of Phase I of the project *was to determine the feasibility of reconstructing data, models, and development of preliminary dose estimates* received by people living in the ten counties surrounding Hanford from 1944 to 1947.

One of the most important contributors to radiation doses from Hanford during the period of interest for Phase I (1944-1947) was radioactive iodine. Consumption of milk from cows that ate vegetation contaminated with iodine is likely the dominant pathway of human exposure *(Napier 1991)*. To estimate the doses people could have received from this pathway, it is necessary to estimate the amount of milk that the people living in the Phase I area consumed, the source of the milk, and the type of feed that the milk cows ate. This task is challenging because the dairy industry has undergone radical changes since the end of World War II, and records that document the impact of these changes on the study area are scarce.

47 The objective of the milk model subtask is to identify the sources of milk supplied to residents of each community in the study area as well as the sources of feeds that were fed to the milk cows. In this report, we focus on Grade A cow's milk (fresh milk used for human consumption). Other commercially produced milk products (e.g., canned milk, cheese, and butter) contributed less to the radiation dose to humans than did fresh milk because of a longer lag time and lower consumption levels. The half life of radioactive iodine is eight days. Products other than fresh milk were seldom consumed within days of production.[a]

(a) Interviews with milk processing plant operators suggest that commercially produced ice cream was often stored for weeks before it was consumed.

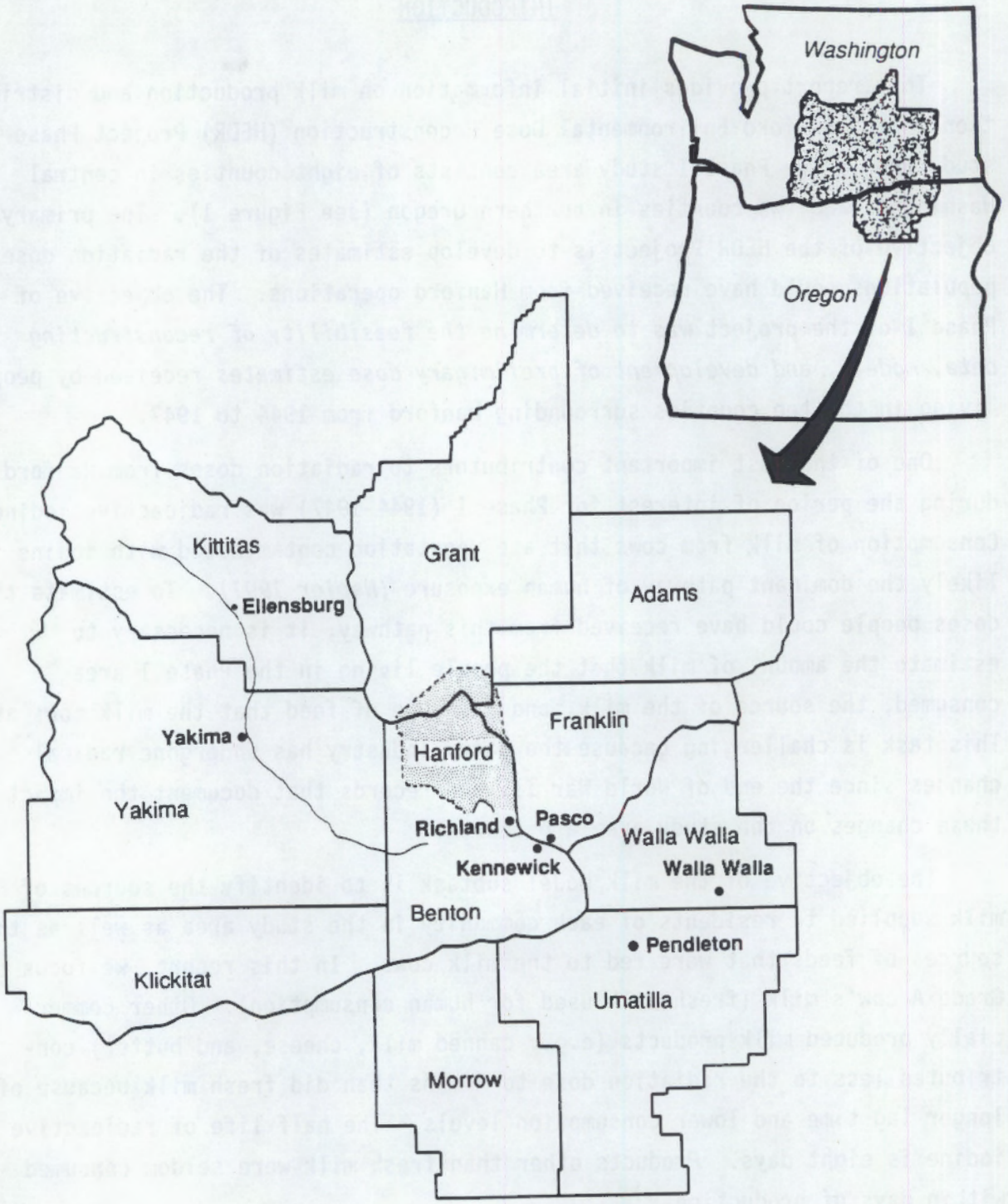

FIGURE 1. Hanford Environmental Dose Reconstruction Study Area for Phase I Research

To achieve the objective of the milk model subtask for Phase I, it was necessary to reconstruct, to the extent possible, specific information on the following:

- types, quantities, and sources of feeds fed to dairy cows in the study area
- location, relative size, and distribution routes of all the fresh milk processors/distributors in the study area
- location of all fresh milk producers in the study area and where they distributed the milk they produced.

To provide finer resolution, estimates are reported by county census divisions (CCDs) (see Figure 2). The census bureau developed CCD boundaries based on population density and regional economic organization. The HEDR CCD boundaries are identical to those developed by the U.S. Census Bureau *(U.S. Bureau of the Census 1971)* with the following three exceptions: 1) Each CCD was renamed with the first two letters of the respective county name in front of the division number (e.g., BE1 is located in Benton County). 2) The Pasco North CCD was divided into two sections (FR4 and FR5) to provide greater detail to an area that may have received relatively high levels of radioactive deposits due to its proximity to Hanford. 3) Several of the very small CCDs in Yakima County were aggregated into larger divisions. This was done to limit the number of CCDs in this county to a manageable number and keep it in rough equivalence to the number of CCDs in the other counties. Metropolitan aggregation was based on city boundaries (e.g., all of the Yakima City CCDs were aggregated into one CCD for the city of Yakima). Rural aggregation decisions were based on topography and location of dairy farms. For example, many dairies were clustered around the town of Sunnyside. All of the CCDs that encompassed these dairies were aggregated into one HEDR CCD (YA9).

Phase I information will be used in the sensitivity analysis to be conducted in *FY 1992 and 1993*. The sensitivity analysis will help to identify which of the milk model parameters most directly affect the potential doses that people could have received from drinking milk.

The first section of this report contains a detailed discussion of the milk pathway and the information required to delineate it. The second

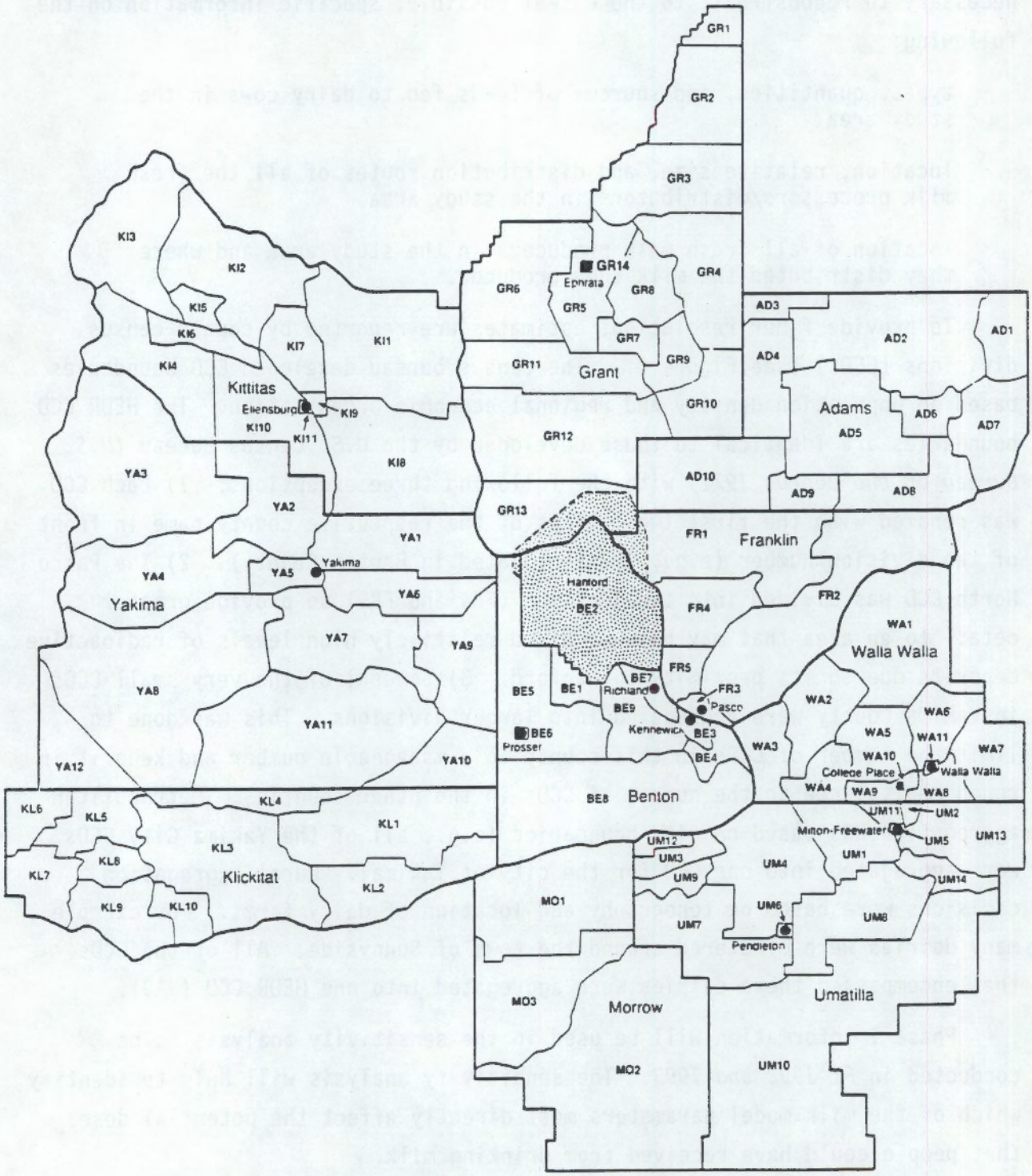

FIGURE 2. Hanford Environmental Dose Reconstruction County Census Divisions

section describes the information sources reviewed to prepare this report. The third section describes how the initial estimates were made for the production and distribution portion of the milk pathway. The fourth section describes the methodology used to estimate the dairy cow feed intake portion of the pathway and the initial estimates. The final section suggests possible follow on work that could be undertaken to refine the estimates. Appendices contain tables on commercial dairy sources, estimates of milk distribution, and feed intake assigned values.

The work described in this report was conducted in accordance with the requirements of ANSI/ASME NQA-1 1986 Edition, Quality Assurance Program Requirements for Nuclear Facilities, as interpreted by PNL's Quality Assurance (QA) program.

All staff performing work described here are adequately trained and qualified. All procedures used to support this report were appropriately written and controlled in accordance with PNL QA program requirements. Records that support the data in this report were created and stored in accordance with applicable HEDR record control requirements.

3 Results were reviewed by a QA representative to ensure that the results are traceable back to the raw data and that the work was performed in accordance with applicable QA requirements. *As part of the QA review, 317 different data points were randomly chosen from the report to verify traceability back to the raw data. Five minor errors were noted and corrected.* The staff member entering the data into data bases ensured correct entry by comparing raw data with the hard copy of the data listing and indicated acceptance by signing and dating the hard copy. Calculations used to produce the reported results were checked as a primary verification of accuracy and correctness. The checking was performed by qualified staff members who did not perform the calculations.

Drafts of this document underwent internal independent technical review. Review comments were satisfactorily resolved with no controversial resolutions to the comments.

4 Finally, the estimates reported in this document were prepared to meet the demands of Phase I research only. The purpose of Phase I *was* to produce reasonable "first cut" numbers to ensure that the HEDR computer model *was* viable and to run a sensitivity analysis. Should the sensitivity analysis suggest that greater resolution is needed for the parameters discussed in this report, additional research will be required. Several suggestions for additional research are discussed in the final section.

THE MILK PATHWAY

In this section, a more detailed discussion of the milk pathway in the HEDR study area is presented.

MILK PRODUCTION, PROCESSING, AND DISTRIBUTION

Once dairy cows convert the feeds they receive into fresh liquid milk, the milk enters into the production, processing, and distribution system (see Figure 3). To estimate where milk consumed by residents in the study area originated, the milk processing and distribution system for the study area needs to be reconstructed. Few written records on the subject exist. To complicate matters, milk production and distribution evolved dramatically in the study area between 1944 and 1947. World War II brought about rapid in-migration to the study area. The most dramatic in-migration occurred in Benton County where more than 34,000 construction workers moved into the Hanford area in 1944. As a result, the demand for fresh milk increased dramatically. To meet the new demand, dairy farmers were encouraged to switch from producing the lower grades of milk they were used to producing (used to manufacture cheese, dried milk, etc.) to producing Grade A liquid milk for human consumption. *(Based on interview with William Snell, 2/15/90.)* The economies of scale associated with these changes favored larger milk

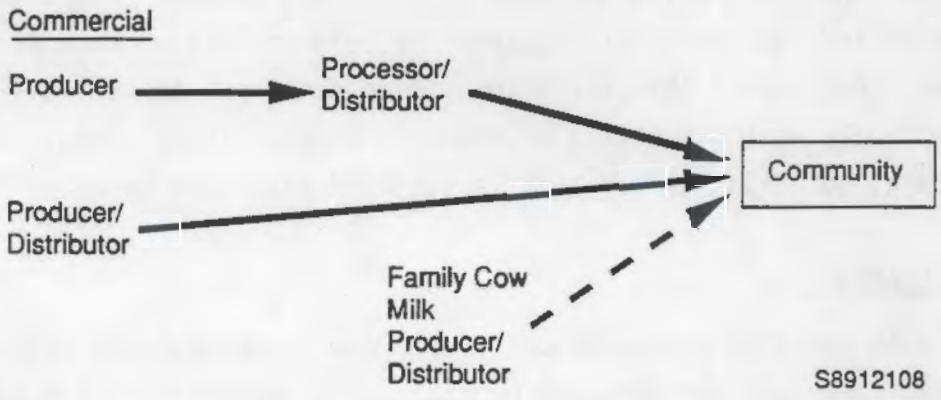

FIGURE 3. Systems for Milk Production, Processing, and Distribution

producers. As a result, many small milk producers went out of business while the farms capable of making the transition grew larger.

The rapid restructuring of the dairy industry during the HEDR study period makes the task of accurately describing the distribution system at a particular point in time extremely challenging. The structural dynamics encouraged the development of several milk production, processing, and distribution pathways. Figure 3 illustrates the possible pathways milk could have taken from the various types of producers to a particular community.

Three commercial production systems are depicted in the diagram: producer, producer/distributor, and processor/distributor. Producers are those farmers who produced milk and then shipped their product to a processor/distributor who processed the milk and distributed it to different communities. Producer/distributors produced milk but also processed and distributed it.

In addition to the three types of commercial producers, there were family cow producers/distributors. These producers were either non-dairy farmers or rural non-farm families that may have raised one or two cows. These small producers usually produced only enough milk for personal consumption; any excess they produced was sold or bartered to their immediate neighbors.

48 Each distribution pathway has a unique delay time. For instance, in the case of the family cow, the time lag between milking and consuming could have been less than one hour, while the time lag for milk shipped from a producer to a processor and then to a retail store for sale could have been *as long as* several days. Because of this variation, it is necessary to estimate for each community not only what percentage of the milk supply flowed through each distribution path, but also the lag times associated with each pathway.

DAIRY COW INTAKES

Cow's milk contains radionuclides if the cow has eaten feed originating in areas that have been contaminated by radioactive material. This radioactive material may be deposited from the air or, in the case of irrigated agriculture, from irrigation water.

An important part of this task is to delineate the feed source areas for specific farms and/or milk sheds within the study area (see Figure 4). These food sources serve as the link between milk production and radionuclide contamination. Four general geographic areas are delineated: on-farm, local, non-local, and imported. The reference point of these areas is a specific dairy farm. On-farm, for example, refers to the land upon which the reference dairy farm is located. Local pertains to all CCDs within the same county as the reference farm. Non-local refers to land outside the county in which the dairy is located but still within the study area. Imported refers to land located outside the study area.

6 Another important part of this task is to determine the types and quantities of major *feed* crops grown in the study area. Each geographic area can supply a number of different crops, many of which are or could be used for fodder (i.e., food for cattle, horses, or sheep). Each fodder crop, in turn, has its own radionuclide-trapping characteristics. Thus, the amount of a radionuclide traveling down the milk pathway depends on the amount and types of fodder available in the study area.

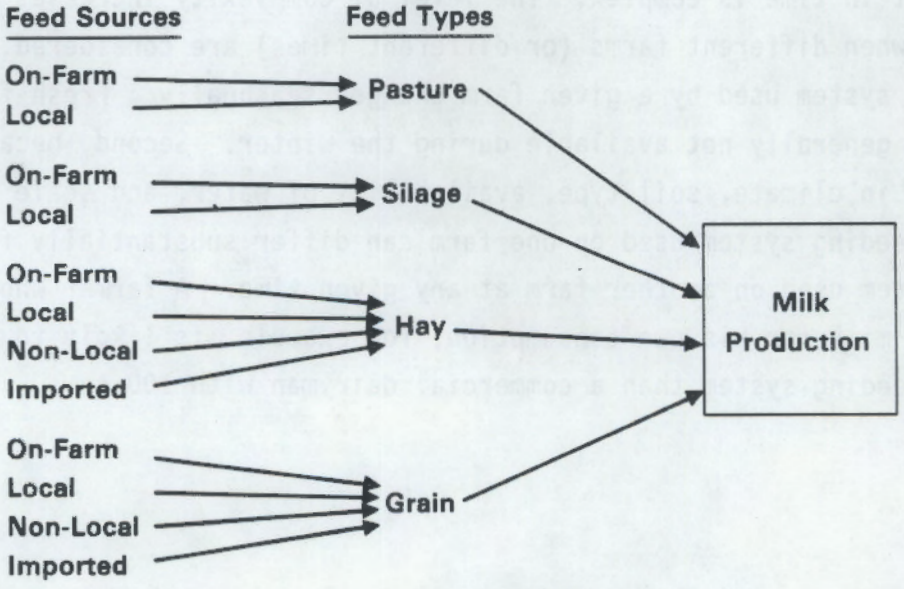

FIGURE 4. Dairy Cow Feed Intake

The crops from a particular location can be converted into various types of feed. The time lag between when fodders are harvested at their source and when they are fed to dairy cattle has a major impact on the quantity of contamination in milk. For iodine-131, the most important pathway to milk is through freshly grazed or chopped forage.

As indicated in Figure 4, farmers have numerous feeding options. They can mix the different feed types in various combinations. The choice is generally based on what feeds are available and the relative costs. Both the availability and the costs of the various feed types change during the course of a year and from one year to the next.

Although the feeding regime has the greatest impact on the amount and kind of feed consumed by a particular cow, the characteristics of the cow also have an effect. The individual characteristics that most affect feed intake include the weight of the cow, the amount of milk produced by the cow, and the fat and protein content of the milk. The characteristics of the cow also help to define an upper bound on feed intake. Even when allowed to consume as much as she wants, the cow can only consume a finite amount of fodder in a day.

Determining dairy cowfeed intake even for a specific dairy farm at a single point in time is complex. The level of complexity increases substantially when different farms (or different times) are considered. First, the feeding system used by a given farm changes seasonally. Fresh forage, for example, is generally not available during the winter. Second, because of differences in climate, soil type, availability of water, and scale of operation, the feeding system used on one farm can differ substantially from the feeding system used on another farm at any given time. A farmer who produces only enough milk for his own consumption, for example, is likely to use a much different feeding system than a commercial dairyman with 100 cows.

DATA SOURCES REVIEWED

82,83, *INTRODUCTION*
84,85,
86 *U.S. Census of Agriculture Data*

Though the Census of Agriculture data are the richest source of published data, there are many inconsistences in the way data were collected and reported. For example, for the years ending in 5, the census was conducted on January 1, while for the years ending in 0, data were collected on April 1. Furthermore, in 1940 and 1945, milk production figures were recorded for the preceding year, while in 1950, milk production was recorded only for the "day preceding enumeration." According to the Census Bureau, several points should be kept in mind when comparing census data (Bureau of the Census and U.S. Department of Commerce 1942):

1) *It is characteristic for some classes of livestock to change in numbers between years through rather definite cycles, i.e., from a low point to a high point and back again over a period of years. These cycles often follow price relationships. A census taken every five years might fall at different points of the cycle and thus interfere with the determination of long-time trends. Cyclical changes have an effect on the volume of production.*

2) *A variation in the months of enumeration seriously affects the comparability of the statistics for most kinds of livestock, again making it difficult to determine the trend in numbers between census periods...In the period from January 1 to April 1 (or April 15), rapid changes are taking place in numbers of each class of livestock due to decreases from farm slaughter, deaths, and marketing during this three months period and increases due to births and purchases...*

   In theory, a change in the data of the enumeration should have little effect on the volume of production reported for the previous calendar year. However, experience indicates that, when accurate records of production are not kept, daily production of milk and of eggs at the time of the enumeration does affect the total volume reported for a year. This means that a census of milk and egg production taken near the peak of production in April, for the previous year, would tend to give somewhat higher figures than a census taken in January which is near the low point.

Given the uncertainty associated with the collection of census information, it is not surprising that several farmers familiar with the dairy industry for the study area raised serious concerns when confronted with census milk production information. Two farmers and Dr. Gerald Ward (based on interviews with William Snell, 2/15/90 and Darl Henckel, 2/15/90) concluded that the census numbers were far too high, based on their first-hand knowledge of the dairy industry. Despite these caveats, the data clearly indicate trends in county milk production and give a general idea of the relative magnitude of dairy production in each of the counties. For these reasons, the census numbers are summarized in Table 1 and discussed below.

Uses of Milk in the HEDR Study Area

The dairy industry in the mid to late 1940s was very different than the dairy industry today. Farms were smaller and more diversified. While most farms had cows, most farmers only produced enough milk for home consumption. Large-scale refrigeration was not available, so milk had to be consumed quickly or turned into products that had longer shelf lives than liquid milk or cream (e.g., cheese and butter). The milk that was sold to plants was collected in 10-gal canisters and picked up daily in flatbed trucks usually owned and operated by the processing plant. Because refrigeration wasn't available, farmers would place the milk cans in irrigation ditches or other cool places until it was picked up.

Milk used on the farm was churned into butter, consumed as fluid milk or cream, or fed to calves or other animals. Farmers would often choose to separate the milk they produced, selling the cream to milk plants while using the skim milk for animal feed. These "on farm" uses of milk help to explain the large differences between the amount of "milk produced" in a county and the amount of "whole milk" sold in the county. For instance, according to the Census of Agriculture (U.S. Bureau of the Census 1945), Franklin County produced 276,266 gal of milk in 1945, but only 71,101 gal were sold as whole milk. This means that 74% of the milk was either used "on farm" or sold as farm-separated cream, cheese, or butter.

Furthermore, most of the "whole milk" that was sold was never consumed as liquid milk, but used by the milk plant for the manufacture of butter, cheese,

TABLE 1. Dairy Statistics for the Phase I Study Area

		1940[a]	% of 10-Co. Area	1945[b]	% of 10-Co. Area	1950[c,d]	% of 10-Co. Area
BENTON COUNTY	Pop:	12053	5.2	30325	11.2	51370	14.6
Gallons of milk produced		3082142	8.2	2548840	7.5	2771445	7.8
Farms reporting whole milk sold		77	5.5	307	10.8	274	10.9
Gallons of whole milk sold		271356	3.4	1345510	7.7	1064198	6.2
FRANKLIN COUNTY	Pop:	6300	2.7	9800	3.6	13560	3.8
Gallons of milk produced		403600	1.1	276266	0.8	371205	1.0
Farms reporting whole milk sold		18	1.3	41	1.4	24	1.0
Gallons of whole milk sold		90870	1.1	71101	0.4	72865	0.4
GRANT COUNTY	Pop:	14670	6.4	12000	4.4	24350	6.9
Gallons of milk produced		1018888	2.7	658365	1.9	613200	1.7
Farms reporting whole milk sold		43	3.1	28	1.0	35	1.4
Gallons of whole milk sold		128618	1.6	127499	0.7	140950	0.8
YAKIMA COUNTY	Pop:	99000	42.9	112100	41.3	135700	38.5
Gallons of milk produced		15307803	40.5	13977829	41.3	16092850	45.0
Farms reporting whole milk sold		713	51.3	1653	58.1	1372	54.8
Gallons of whole milk sold		4109066	52.0	9262812	53.1	9002883	52.2
WALLA WALLA COUNTY	Pop:	30550	13.2	35500	13.1	40140	11.4
Gallons of milk produced		3033388	8.0	2878858	8.5	3212000	9.0
Farms reporting whole milk sold		108	7.8	123	4.3	109	4.4
Gallons of whole milk sold		885765	11.2	1298904	7.4	1360033	7.9
ADAMS COUNTY	Pop:	6200	2.7	6400	2.4	6600	1.9
Gallons of milk produced		855374	2.3	774024	2.3	508445	1.4
Farms reporting whole milk sold		16	1.2	12	0.4	9	0.4
Gallons of whole milk sold		70575	0.9	66001	0.4	26764	0.2
KITTITAS COUNTY	Pop:	20200	8.8	20300	7.5	22200	6.3
Gallons of milk produced		5852453	15.5	5571944	16.5	4820555	13.5
Farms reporting whole milk sold		170	12.2	400	14.1	420	16.8
Gallons of whole milk sold		991585	12.5	2904700	16.6	3095623	18.0

TABLE 1. (contd)

		1940[a]	% of 10-Co. Area	1945[b]	% of 10-Co. Area	1950[c,d]	% of 10-Co. Area
KLICKITAT COUNTY	Pop:	11400	4.9	11200	4.1	12050	3.4
Gallons of milk produced		2152947	5.7	2159783	6.4	1979760	5.5
Farms reporting whole milk sold		94	6.8	131	4.6	117	4.7
Gallons of whole milk sold		640181	8.1	1143382	6.6	893333	5.2
MORROW COUNTY	Pop:	4340	1.9	4000	1.5	4780	1.4
Gallons of milk produced		1205209	3.2	850739	2.5	996815	2.8
Farms reporting whole milk sold		28	2.0	10	0.4	23	0.9
Gallons of whole milk sold		62463	0.8	69657	0.4	133266	0.8
UMATILLA COUNTY	Pop:	26030	11.3	29700	10.9	41700	11.8
Gallons of milk produced		4839385	12.8	4138746	12.2	4365400	12.2
Farms reporting whole milk sold		123	8.8	138	4.9	120	4.8
Gallons of whole milk sold		655567	8.3	1157338	6.6	1447368	8.4

(a) *U.S. Bureau of Census. 1941. U.S. Census of Agriculture: 1940. Volume 1. U.S. Government Printing Office, Washington, D.C.*

(b) *U.S. Bureau of Census. 1946. U.S. Census of Agriculture: 1945. Volume 1. Statistics for Counties. Part 32. U.S. Government Printing Office, Washington, D.C.*

(c) *U.S. Bureau of Census. 1952. U.S. Census of Agriculture: 1950. Volume I. Counties and State Economic Areas. Part 32. Washington and Oregon. U.S. Government Printing Office, Washington, D.C.*

(d) The 1950 Census of Agriculture did not report a yearly figure for gallons of milk produced. Instead they reported number of gallons produced the day before enumeration. This number was multiplied by 365 days to get a yearly figure.

evapcrated and canned milk, dry milk, or frozen dairy products. The main point here is that the majority of milk produced was either consumed on the farm or used for manufactured dairy products. Though no county-level percentages are available, national data are reported in Table 2 (Beal and Bakken 1956). In 1945, only 44% of the milk produced in the U.S. was consumed as fluid milk. According to the 1956 publication "Fluid Milk Marketing" (Beal and Bakken 1956, p. 42-43),

> *"During the 20 year period from 1926 to 1945, there was never a year when the amount of milk used in manufactured dairy products did not exceed one-half of the total quantity produced in the United States. In 1926, almost 54.5 billion pounds were used for manufacturing purposes, including farm butter production. The quantity of milk diverted for manufacturing during these two decades was below 54 billion pounds only once, and attained a high point of almost 68 billion pounds in 1942. However in terms of percentages, a significant downward trend developed after the United States became an active participant in World War II. In 1941, almost 59 per cent of all milk produced on farms was used in manufactured dairy products, and although the total quantity was greater in 1942, the percentage was lower and continued to decline steadily to 49.5 per cent in 1946. Manufacturing increased proportionately as fluid milk and cream consumption declined after 1946; thus utilization, including farm churned butter, remained above 50 per cent of all milk produced on farms until 1951. The record low of 48.2 per cent came in 1952, but the unprecedented increase of 6 billion pounds in milk production for 1953 and 1954 boosted plant utilization to over 50 per cent."*

Based on the low percentage of milk produced in the HEDR study area that was 'sold," the percentage of milk produced in the study area that was consumed as fresh milk was probably low.

Locating data sources useful for reconstructing the milk production and distribution system for the study area since 1944 has been challenging. However, with the help of Washington State University research and extension personnel, researchers working on similar reconstruction projects, and key contacts in the dairy industry, the following data sources have been identified and reviewed.

TABLE 2. Production and Utilization of Milk, United States, 1944-1954 (adapted from Beal and Bakken 1956)

Item	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954[i]
	Mil. lb.	Mil lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.
Milk Production											
On farms	117,023	119,828	117,697	116,814	112,671	116,103	116,602	114,841	115,197	121,149	123,502
Total [a]	118,123	120,628	118,697	118,114	113,671	117,003	117,302	115,341	115,597	121,449	123,702
Utilization (milk equivalent)											
Manufactured in plants											
Creamery Butter, Total	30,620	28,065	24,145	27,430	24,980	29,149	28,641	24,906	24,378	28,871	29,640
From Whey Cream	713	780	772	830	771	842	838	817	815	932	940
Net	29,907	27,285	23,373	26,600	24,209	28,307	27,803	24,089	23,563	27,939	28,700
Cheese											
American	8,090	8,777	8,058	9,394	8,597	9,384	8,972	8,791	8,551	10,243	10,270
Other	2,045	2,346	2,894	2,381	2,332	2,569	2,883	2,778	3,089	3,104	3,180
Canned Milk											
Evaporated	7,384	8,147	6,567	6,899	7,271	5,898	6,177	6,221	6,086	5,449	5,500
Sweetened Condensed	330	339	269	389	295	234	143	135	125	96	60
Bulk Condensed Milk											
Unsweetened	289	310	237	423	483	492	537	558	533	556	560
Sweetened	138	167	151	179	98	102	85	92	105	112	110
Dry Whole Milk	1,355	1,650	1,421	1,250	1,293	956	952	999	774	794	700
Frozen Dairy Products											
Ice Cream, Total	5,354	5,788	9,558	8,698	8,027	7,835	7,808	8,017	8,363	8,520	8,370
Other [b], Total	230	306	143	152	194	292	387	472	561	665	710
Fat from Other Products [c]	860	925	1,501	1,341	1,501	1,306	1,301	1,488	1,399	1,421	1,400
Net from Milk and Cream	4,724	5,169	8,200	7,509	6,720	6,821	6,894	7,001	7,525	7,764	7,680
Other Factory Products [d]	678	949	552	514	561	561	724	939	930	960	990
Total Factory Products [e]	54,940	55,139	51,722	55,538	51,859	55,324	55,170	51,603	51,281	57,017	57,750

TABLE 2. Contd

Item	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954[i]
Farm Butter	6,621	6,714	6,557	6,154	5,808	5,440	5,160	4,910	4,514	4,321	4,202
Fluid Consumption, Farm[f]	12,900	12,800	13,100	12,600	12,100	11,800	11,500	11,500	11,400	10,800	10,500
Nonfarm	38,400	40,700	42,200	41,100	40,600	41,200	42,200	43,300	44,200	45,300	46,700
Fed to Calves	3,258	3,290	3,228	3,194	3,064	3,163	3,286	3,450	3,349	3,334	3,335
Exports and Storage[g]	-148	-39	487	-342	148	-242	-56	116	79	-148	-45
Other[h]	2,152	2,024	1,403	-130	92	318	42	462	774	825	1,240

(a) Includes an allowance for milk produced by cows not on farms.
(b) Milk sherbet, ice milk, and miscellaneous minor frozen products.
(c) Milk equivalent of butter and condensed milk used in ice cream.
(d) Includes dry cream, malted milk, dry part skim milk, dry ice cream mix, and cottage cheese.
(e) Includes net milk equivalents of butter and frozen dairy products to avoid double counting of milk from which fat was reused in making a second dairy product.
(f) Includes an allowance for fluid consumption on farms not producing milk in addition to the consumption on farms where milk is produced.
(g) Net movement of whole milk or cream into export or storage channels. A negative figure represents net imports or net out-of-storage movement during the year.
(h) Residual, including miscellaneous minor uses and any inaccuracies of independently determined production and use items.
(i) Preliminary at the time this book was published in 1956.

U.S. CENSUS OF AGRICULTURE PRODUCTION RECORDS

The U.S. Census Bureau conducted nationwide censuses of U.S. farms in 1940, 1945, and 1950 (U.S. Bureau of the Census 1941; 1946; 1952).[a] These censuses provide production and acreage data for various fodder crops, as well as estimates of the number of farms, the number of dairy cows, and the amount of milk produced and sold in each county for the various census years. These data are reported for states and counties but not for sub-county areas. Since the U.S. Census of Agriculture contains data on the total amount of milk produced and the number of milk cows on reporting farms by county, average milk production per cow can be calculated for some years.

Although the Census of Agriculture data constitute the richest source of published data, it has several drawbacks. Based on interviews with several farmers, respondents tended to guess about the amount of milk they produced, sold, etc. They did this because, while the data were collected at only one point in time, the farmers were forced to estimate yearly values. Several of the individuals interviewed, as well as Dr. Gerald Ward (based on interviews with William Snell, 2/15/90 and Darl Henckel, 2/15/90), expressed grave concerns about the accuracy of the data. Despite these caveats, the data clearly indicate trends in county milk production and give a general idea of the relative magnitude of a dairy production in each of the counties.

DAIRY HERD IMPROVEMENT ASSOCIATION RECORDS

The Dairy Herd Improvement Association (DHIA), which dates back to the 1930s, is a national educational, support, and *production testing* organization for dairy producers. Annual DHIA narrative reports have been located for Yakima, Benton, Franklin, and Kittitas Counties. These documents provide the only written records of where individual dairy producers were located.

The DHIA's reports for Yakima County contain anecdotal information about fodders used on specific farms from 1949 to 1969. Also, the 1951 Yakima

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(a) Although censuses were conducted in 1940, 1945, and 1950 the data reported are for 1939, 1944, and 1949, the year preceding the census year.

County DHIA (1952) report contains fairly detailed dairy management data at the farm level. A preliminary analysis of these data indicates that farms in the county used a wide variety of dairy management systems. This implies that, given a uniform level of environmental contamination, the amount of radionuclides transmitted through the study area's milk supply may have varied greatly from one farm to the next.

The main drawback of DHIA information is that most of the dairy producers in the study area did not participate in DHIA programs. As a result, particularly in the early study years, DHIA records reflect only a small percentage of the dairy farms in the study area. Since participation in farm programs has been shown to be strongly correlated with the size of farms (Rogers 1983), the DHIA data probably are not representative of the smaller dairy farms that characterized the dairy industry in the early years of the period of interest.

WASHINGTON STATE DAIRY PRODUCTS COMMISSION

In 1939 dairy producers in Washington lobbied successfully to pass a state law levying a tax on each hundred pounds of butterfat sold by producers in the state. The revenue from this tax was used for marketing campaigns for dairy products. The Washington State Dairy Products Commission (WSDPC) has provided us with a list of the producers who contributed to this fund from 1944 to 1955. This listing is the most comprehensive database of dairy processors we have been able to locate to date.

USDA ECONOMIC RESEARCH SERVICE REPORTS

The USOA Economic Research Service published a report (USDA 1965) that provides national per capita milk consumption estimates for the years 1944-1947. These estimates, when compared with the per capita production information from the Census of Agriculture information, produce a rough indicator of whether counties in the study area were net surplus or net deficit producers of milk. The indicator is rough because it assumes each county represents a perfectly self-contained milk market. Information from other sources shows that this assumption is clearly unrealistic. For this reason,

this indicator is only used to classify counties for discussion purposes into three broad categories: 1) milk surplus counties; 2) milk deficit counties; and 3) counties in relative balance. Other sources provide additional resolution regarding the milk production and distribution pathways.

FEDERAL MILK MARKET ORDER INFORMATION

The Federal Milk Market Administration maintains statistics on the source of all milk that enters a particular geographic area, commonly called a milk market order. Point of origin statistics are reported by county. The oldest milk market order in the Northwest (established in 1951) is the Puget Sound Milk Order, which consists of several counties in western Washington. The next milk order developed in Washington was the Inland Empire Milk Order established in 1956. The Inland Empire Milk Order comprised a few counties immediately surrounding the city of Spokane. The records kept by these entities document how much milk was shipped into each area as well as the county of origin for the milk. Unfortunately, no information is available for the time period currently under consideration (1944-1947).

LAND USE MAPS

7 Several types of land use maps have been identified as potential sources of information. For example, a USDA land use map *(USDA 1950)* of the entire United States based on the 1945 Census of Agriculture has been located. This map indicates the location of irrigated farm land; this is useful information because *the majority of all commercial dairies were likely located* on irrigated land to ensure enough pasture to support the herds.[a] Thus, in the absence of more detailed data, this map will help us locate areas of significant milk production for the years of interest.

A number of land use maps have been located for later decades in the HEDR Project. For instance, the Soil Conservation Service produced county-level land use maps for most counties during the 1970s and 1980s. These maps

(a) This statement is based on interviews with state dairy officials and several dairy producers. There is no evidence that dry lot dairying was practiced in the study area during the early years of interest.

clearly delineate irrigated land and areas used for agricultural production. In addition, several land use maps have been found in a variety of state and national atlases. Most of these maps were constructed using USDA or Census of Agriculture information.

United States Geological Survey maps of the area immediately surrounding the Hanford Site have been located. Some of these maps date back to 1948. These maps identify buildings and ranches and, therefore, may be useful in a later phase should we need to identify the exact locations of farms near the Hanford Site.

DAIRY HERD LOCATION MAPS

In special reports, the Census Bureau has periodically included maps showing the geographical distribution of milk cows. Unfortunately, these maps are not detailed. However, like the land use maps, they do provide a general idea as to where dairy farms were located on a sub-county level. The Washington State Department of Agriculture published milk cow distribution maps *(WSDA 1967)* for the entire state based on 1959 and 1964 Census of Agriculture information. Despite several talks with federal, state, and local sources, we still have not been able to clarify how the herds were distributed within the county boundaries.

Three additional maps locating dairy farms for several of the counties in the state of Washington have been located. One, from the 1954 Atlas of the Pacific Northwest *(Oregon State University 1954)*, locates heavy concentrations of dairy cows based on the 1950 U.S. Census of Agriculture. Another map, provided by a county extension agent, locates all of the dairy farms in Yakima and Benton Counties for the approximate time span 1970-1975. A third map, provided by a retired creamery operator in Ellensburg, locates all of the farms that provided milk to that particular processor for the year 1963.

MISCELLANEOUS INFORMATION SOURCES

Other sources have been located that provide general information on dairy industry practices during the period addressed by the HEDR study. Included in this category are extension bulletins, congressional reports, state Department

of Agriculture publications, reports generated by other dose reconstruction efforts, and general histories of American agriculture. Other sources of information that are available (but not yet located) include growth studies for particular crops and detailed weather data.

INDIVIDUAL EXPERTS

Mr. Grady Williams, a dairy scientist affiliated with Washington State University, has provided us with annual data on dairy industry characteristics for Washington for 1944-1987. The data were developed from DHIA records and federal statistical data. The data included estimates of the average weight of dairy cows, the average quantity of milk produced per cow, the number of cows per herd, the average quantity of concentrate consumed per cow, the average quantity of forage consumed per cow, and the average number of days on pasture per cow. "Forage," as defined by Mr. Williams, consists of hay, silage, and green chop. Mr. Williams also provided annual estimates of the net energy that lactating dairy cows in the state received from three major feed sources: concentrate, forage, and pasture.

Dr. Gerald Ward is a professor in the Animal Science Department at Colorado State University and has extensive experience in researching the link between milk production and radionuclide contamination. He is the lead author of Milk Production and Distribution (Ward and Whicker 1987) and has served as a consultant on numerous national and international dose reconstruction efforts. In addition to his academic experience, Dr. Ward served as a dairy extension agent in the study area during the early 1950s. Dr. Ward participated in the HEDR milk market workshop and two sessions of working meetings.

Mr. Bob Duncan is an Extension Agent at the Washington State University Irrigated Agriculture Research and Extension Center, Prosser, Washington. Mr. Roy Darwin and Dr. Ward interviewed Mr. Duncan on June 27, 1989. Mr. Duncan provided us with information on haying practices in the region.

Mr. Eddie Thomason worked on a dairy farm in the 1940s and has served as a dairy extension agent for Dairy Extension Agent Washington State University

since 1964. His current position is Area Dairy Extension Agent for Yakima, Benton, Kittitas, Grant, and Adams Counties. Mr. Thomason provided information on milk cow feeding regimes and general dairy practices.

MILK PRODUCTION AND DISTRIBUTION ESTIMATES

Estimates of where milk was produced, processed, and ultimately distributed were developed in three stages: 1) All relevant information from published sources was summarized. 2) Information from key contacts was then used to create as detailed of a picture as possible of where milk supplying each of the major processor/distributors originated. 3) Based on information collected in steps one and two, an expert judge was asked to estimate what percentage of the milk consumed in each CCD came from the various commercial and backyard producers, and what percentage of the milk produced by commercial sources originated in each CCD. A detailed description of the information generated by each step is provided below.

SUMMARY OF INFORMATION DERIVED FROM PUBLISHED SOURCES

Published information on milk production in the study area consists of USDA land use maps, U.S. Census of Agriculture reports, USDA Agricultural Statistics reports, and Washington State Dairy Board records. As mentioned earlier, by combining county milk consumption estimates with the amount of whole milk sold, it is possible to get a crude estimate of whether a specific county produced a milk surplus or a milk deficit in a particular census year. Per capita whole milk consumption estimates were taken from the USDA Statistical Bulletin, U.S. Food Consumption: Sources of Data and Trends 1909-1963 (USDA 1965).

8 The U.S. consumption estimate is *typically* reported in pounds *(hundred weight)*. Gallons per capita sold was calculated by dividing gallons of milk sold (provided in the U.S. Census of Agriculture) by the county population estimate. The difference between the per capita consumption and production estimates was used to classify each county as a milk surplus, deficit, or a county "relatively in balance." This is just a crude indicator of a county's milk situation, since it assumes closed economies and that "milk sold" was used for human consumption. It is also important to point out that most milk recorded as "milk sold" was not Grade A milk (milk deemed suitable for human fresh liquid consumption). Most of the milk sold between 1944 and 1947 was

49 classified as "manufacturing milk" and was used to produce processed milk products such as cheese, *butter*, powdered milk, and canned milk.

Despite the crudeness of the indicator, it is useful for heuristic purposes. The results of the above calculations are illustrated in Figure 5. The study area as a whole had a positive balance of 18.5 gallons per person per year in 1945, suggesting that there was more than enough milk produced in the study area to satisfy demand. This conclusion is consistent with information gathered at the milk market workshop (Beck, Darwin, and Eckert 1989), where a consensus was reached that the vast majority of the milk consumed in the study area was produced in the study area. However, workshop participants did conclude that small amounts of milk were likely shipped into Adams County from the Spokane milk pool. With the possible exception of small amounts of milk produced in Kittitas County, none of the milk produced in the study area was shipped outside of the area as Grade A milk during the years 1944-1947.

51 The rough estimate of milk surplus/deficit was used to group the ten counties into three general categories: 1) milk surplus counties (Yakima, Kittitas, and Klickitat); 2) milk deficit counties (Franklin, Grant, Adams, and Morrow); and 3) counties that recorded a milk deficit or surplus of 10 gallons or less per person, which were classified as counties in "relative balance" *(Walla Walla, Benton, and Umatilla)*.

The variability in milk production between the counties can be explained in large part by the amount of irrigated pasture land available for raising dairy herds. Figure 6 illustrates the distribution of irrigated pasture land for the study area reproduced from a 1945 USDA land use map. All of the surplus counties have significant areas of irrigated land; the deficit counties have very little or none at all.

Table 1 lists all of the relevant Census of Agriculture statistics for the study area for the census years 1940, 1945, and 1950. Figures 7, 8, 9, and 10 illustrate the relative number of farms reporting whole milk sold, number of cows milked, gallons of milk produced, and the number of gallons of whole milk sold for each of the ten counties. A more detailed description of county milk production in the study area is presented below.

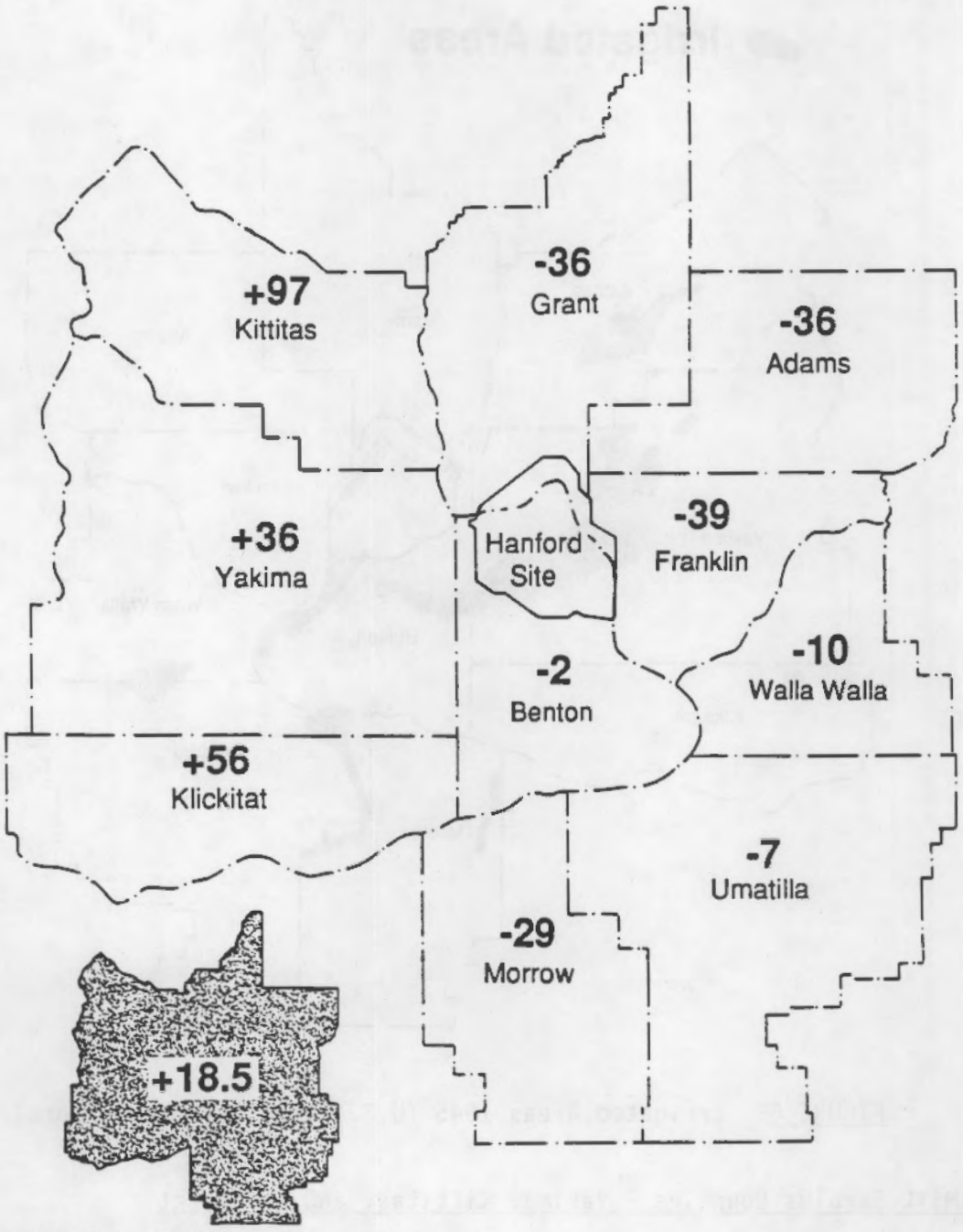

FIGURE 5. 1945 Per Capita Milk Surplus/Deficit
(Numbers indicate gallons per person.)

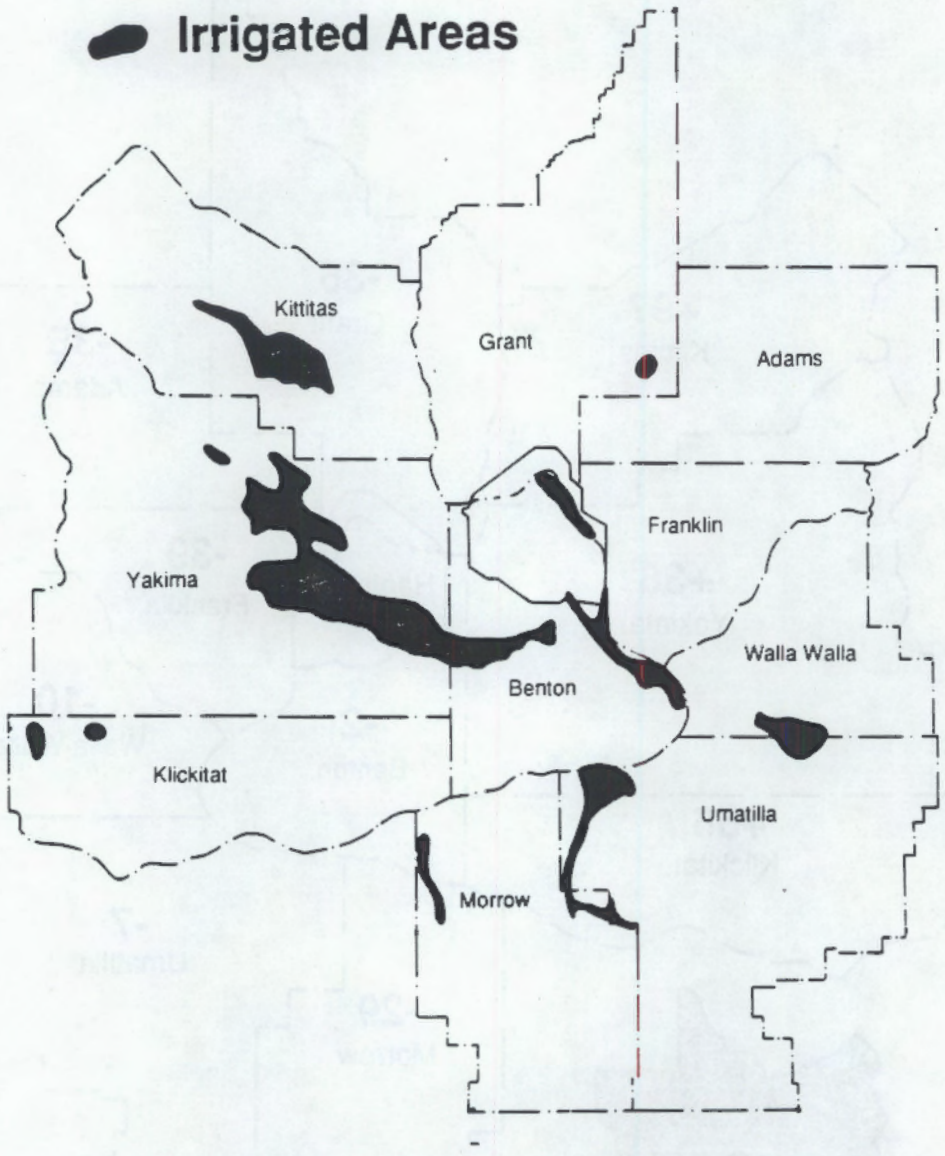

FIGURE 6. Irrigated Areas 1945 (U.S. Census of Agriculture)

The Milk Surplus Counties - Yakima, Kittitas, and Klickitat

Of the three counties in this category, Yakima stands out as a giant in terms of milk production. Yakima reported 4,109,066 gallons of whole milk sold in 1940, 9,262,812 gallons in 1945, and 9,002,883 gallons in 1950, accounting for just over half of all the milk produced in the entire study area in each of the three census years (see Figure 10). In 1945 Yakima sold three times the amount of whole milk as Kittitas County, the next largest

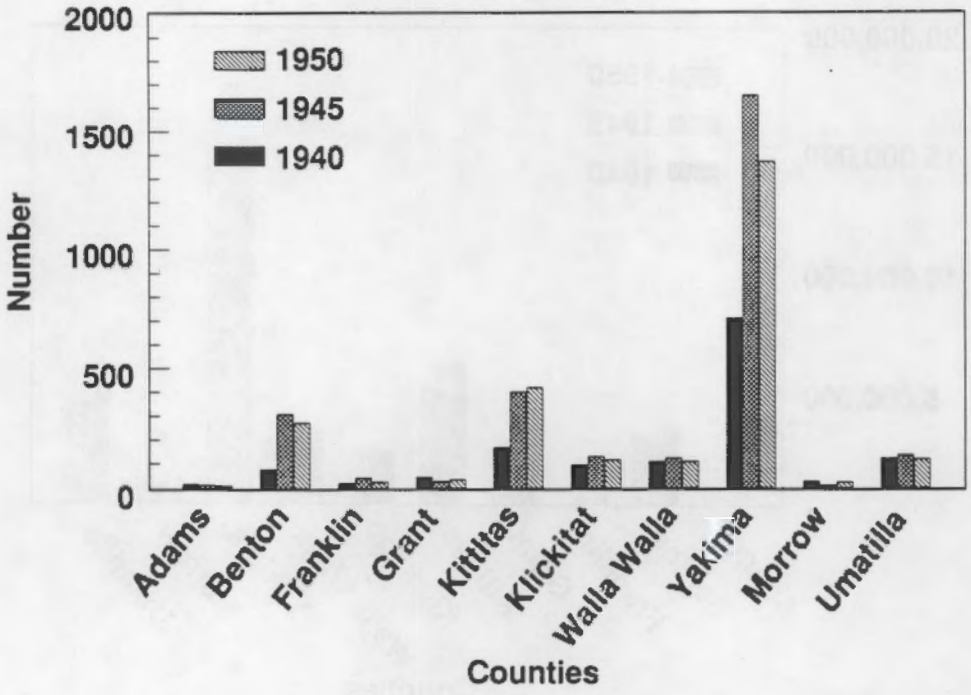

FIGURE 7. Farms Reporting Whole Milk Sold (U.S. Census of Agriculture)

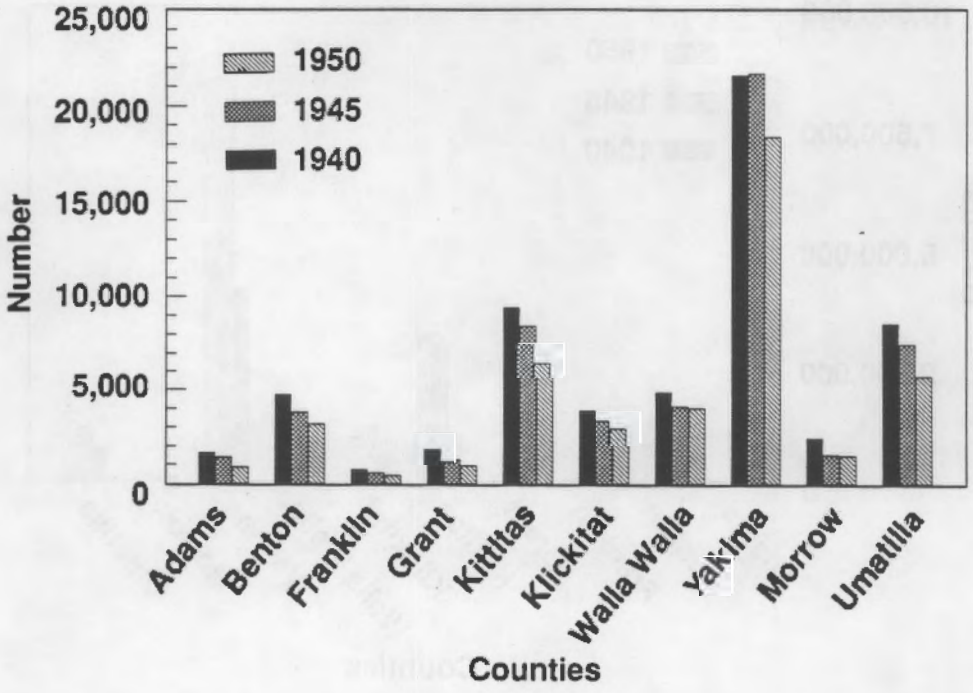

FIGURE 8. Number of Cows Milked (U.S. Census of Agriculture)

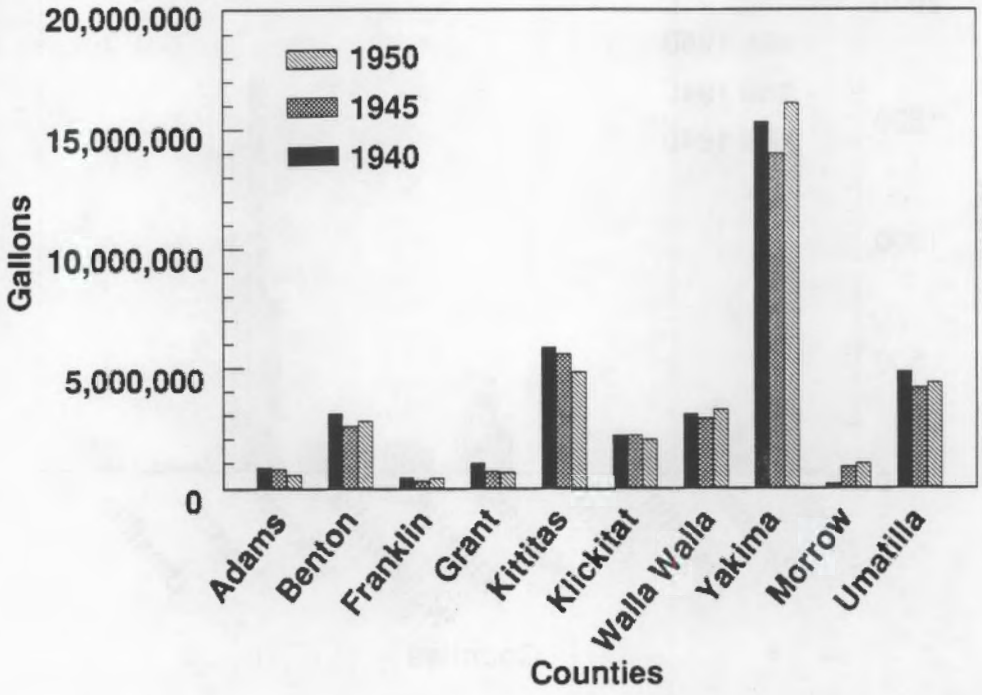

FIGURE 9. Gallons of Milk Produced (U.S. Census of Agriculture)

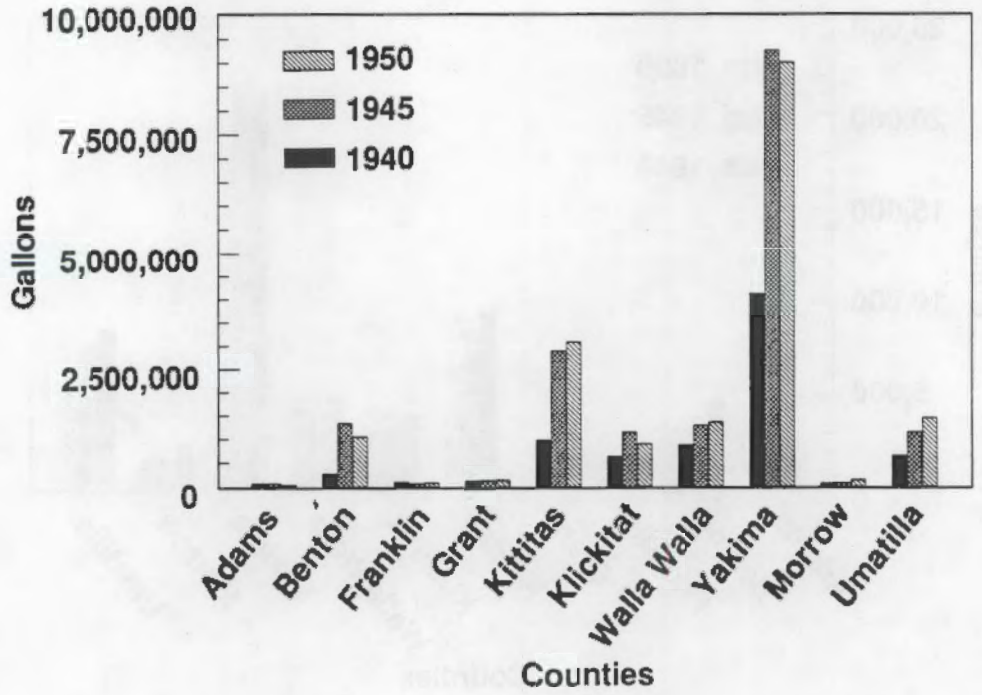

FIGURE 10. Gallons of Milk Sold (U.S. Census of Agriculture)

milk producer in the study area (see Figure 11). Yakima's productivity is due to the existence of the large irrigated Yakima Valley extending from north central Yakima County southeast into Benton County. Based on the tax records published by the Washington State Dairy Product Commission (WSDPC), there were four very large milk processors in Yakima County, two in Sunnyside (Carnation and the Milk Products Company) and two in the city of Yakima itself (Yakima City Creamery and the Yakima Dairymans' Association, known as Dairygold). A listing of all commercial milk producers gleaned from the WSDPC records is reproduced in Appendix Table A.1.

11,52 From 1940 to 1945, the amount of *whole* milk sold in Yakima County *increased from 4,109,066 gal to 9,262,812 gal*. This was *largely* due to the influx of more than 34,000 Hanford employees in 1944. Monthly reports produced by Hanford administration offices clearly document that all milk products prior to 1947 for the Hanford Site were purchased from the Carnation

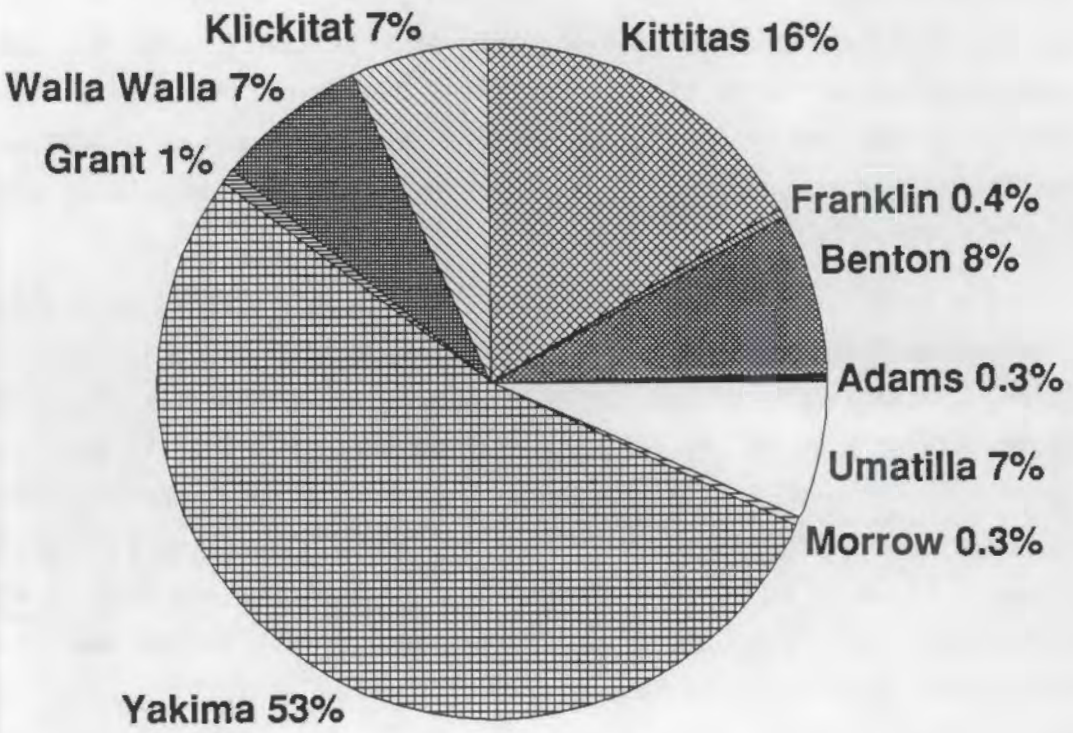

FIGURE 11. Percentage of Milk Sold (U.S. Census of Agriculture 1945)

plant (previously called the Morning Milk Company) located in Sunnyside, a small town in Yakima County. A summary of the information contained in the contractor reports is reproduced in Appendix Table A.2.

Kittitas County sold 2,904,700 gallons of milk in 1945, 16.6% of the milk sold in the study area. The Kittitas Valley, which surrounds the town of Ellensburg and extends northwest to the town of Cle Elum, was home to the vast majority of the county's dairy farms. As in Yakima, milk production increased greatly in Kittitas during the war years. Two military bases were constructed in the two neighboring Grant County towns of Ephrata and Moses Lake. Because of the lack of irrigated farm land in Grant County, the processor/distributor that supplied the bases (Morning Sun Company) was forced to buy its milk from Kittitas County producers. As a result of the booming demand, the amount of milk sold from 1940 to 1945 in Kittitas tripled from 991,585 to 2,904,700 gallons. By 1945 Kittitas County produced 16.6% of all the milk sold in the ten county study area. The largest processing plant in Kittitas was the Kittitas County Dairyman's Association; however, its main product was cheese. The major suppliers of fresh milk for Kittitas County residents were Enfield Dairy and other smaller producer/distributors; much of fresh milk produced in Kittitas County was shipped to the Morning Sun Company in Moses Lake, and to the Carnation plant located in Sunnyside.

The milk producing regions of Klickitat County are located in small pockets of irrigated land on the western side of the county. Relative to its population, Klickitat County farmers sold a large amount of milk (1,143,382 gallons in 1945 or 6.6% of all the milk sold in the study area). Despite the relatively large amount of milk produced in the county there were no large scale Grade A processing plants in Klickitat County. Since the milk producing region was so close to the Oregon border, the surplus milk was most likely shipped to Hood River, The Dalles, or to Portland for processing and ultimate distribution for manufacturing purposes.

<u>The Milk Deficit Counties - Franklin, Grant, Adams, and Morrow</u>

59,61 *According to the owner of Twin City Creamery, Twin City picked up and processed all available milk in and around the cities of Kennewick and Pasco (based on interview with Darl Henckel, 2/15/90). Twin City picked up milk*

from six farms in Franklin county. All these dairy farms were restricted to the small patches of irrigated land surrounding the city of Pasco and a band along the east bank of the Columbia River stretching from Pasco to the Ringold area. All the milk picked up by Twin City was processed in Twin City's Kennewick plant located across the river from Pasco in the city of Kennewick. Though Twin City picked up all the available milk in the Pasco area, it shared the Pasco retail market with Carnation and Darigold. Thus, the three largest, and probably the only, commercial sources of milk for Pasco during the mid- to late-1940s included Twin City Creamery based in Kennewick, Carnation based in Sunnyside, and Darigold based in Yakima.

There were two small dairies producing and marketing milk in North Franklin County in the town of Connell: the Connell Dairy and the Conrad-Nelson Dairy. These two dairies produced just enough milk to meet the commercial needs of Connell, Kahloutus, Washtucna, and Othello. To date, we have not located any other commercial sources of milk in Franklin County for the time period of 1945-1950. (Based on interviews with George R. Thompson 4/2/90, Darl Henckel 2/15/90, and William Snell 2/15/90, Arthur Pursor 4/21/88, and Wallace Harris 4/8/88.)

12 Similarly, Grant and Adams Counties produced very little milk. In 1945, Grant County farmers sold 127,499 gallons and Adams County reported only 66,001 gallons. Together these two counties produced only 1% of the milk sold in the study area. Both of these counties were heavily dependent on milk shipped from the Kittitas Valley. As mentioned before, the demand from the growth of the two military bases in Grant County was met by the shipment of milk from the Kittitas Valley. Unlike the other counties, much of Adams County milk supply may have come from outside the study area. Due to its close proximity to Spokane, fresh milk from the Spokane milk shed was probably marketed in Adams County *(Beck et al. 1989)*.

Morrow County also sold very little milk, recording just 69,657 gallons or 0.4% of the milk sold in the study area. It is likely that milk from adjacent Umatilla County was brought in to fill demand.

Counties in Balance - Walla Walla, Benton, and Umatilla

56,13 *Benton County produced only about 8% of the total milk in the study area in 1945. However, the amount of milk sold in Benton County increased by 400% from 271,356 to 1,345,510 gallons between 1940 and 1945. Much of this growth in sales was likely the result of the rapid in-flux of the Hanford work force. Twin City Creamery was the only large processing plant in Benton County. Milk that wasn't processed by Twin City Creamery could have been processed in a small processing plant in Benton County (Fairview Guernsey Dairy) or shipped to milk plants in Yakima County. Commercial sources of milk for Benton county residents included Darigold, Carnation, Twin City Creamery, and the Fairview Guernsey Dairy (based on interviews with Darl Henckel 2/15/90 and William Snell 2/15/90). According to plant records, 100% of the milk supplied to the town of Richland and the Hanford Site for the time period 1942-1950 was provided by Carnation and Darigold plants.*

Walla Walla County, home to four processor/distributors and at least eight producer/distributors, recorded milk sales of 1,298,904 gallons for the year 1945, 7.4% of the milk sold in the study area. The majority of dairy farms were located in the immediate vicinity of the town of Walla Walla, the major population center. No information has been found to suggest that significant amounts of milk were shipped into or out of the Walla Walla Valley, although according to one farmer some milk was marketed across the Oregon border into Umatilla County.

Umatilla County sold 1,157,338 gallons of milk in 1945, accounting for 6.6% of all the milk sold in the study area. Milk production was limited to the Milton-Freewater area, which is located just south of the Walla Walla Valley, and the Hermiston/Umatilla area. The Hermiston Dairy Cooperative managed a processing plant in Hermiston that supplied fresh milk for most of the county and a processing plant in Pendleton. We have found no information on other processing plants in Umatilla County. Due to its location, we assume that surplus milk from Umatilla County was marketed in parts of Morrow County.

LINKING PRODUCERS WITH PROCESSOR/DISTRIBUTORS

14 To estimate where milk processed by the various processor/distributors originated, we relied on key contacts associated with the individual plants *(Beck, Darwin, and Eckert 1989)*. We presented the key contacts with county maps and asked them to identify the specific location of farms that supplied milk to the plant they were familiar with, and if possible, how much milk each farm supplied. The majority of this work was completed at the Milk Market Workshop. This procedure was undertaken only for processor/distributors since we assumed that backyard producers and producer/distributors *obtained* all of their milk from the CCD in which they were located.

We were able to develop detailed producer maps for Twin City Creamery, Carnation, Kittitas County, and Yakima City Creamery. A copy of the computerized versions of these maps are reproduced in Figures 12, 13, 14 and 15. In addition, information on the Yakima Dairyman's Association was collected on a CCD level. Although we have not been able to link specific producers with the processor/distributors in Walla Walla County, one key contact was able to locate most of the producers in the Walla Walla area. Key contacts for other processor/distributors have not been located at the time of this writing. Figure 16 summarizes all of the information collected to date by this process. The data collected by this process supports our assumption that commercial dairy farms were restricted to areas of irrigated pasture land.

DEVELOPING SPECIFIC PRODUCTION AND DISTRIBUTION ESTIMATES BY COUNTY CENSUS DIVISION

As mentioned before, the computer model used for the HEDR Project demands that estimates be developed for each CCD in the study area. In the case of the milk model, this requires estimates of the percentage of milk processed by each milk plant that was produced in each CCD. In addition, for each CCD we must estimate what percentage of the milk consumed came from the various commercial (e.g., Twin City Creamery as opposed to Carnation) as well as family cow producers. Since there are no specific written information sources available to develop these estimates, we relied on expert judgement.

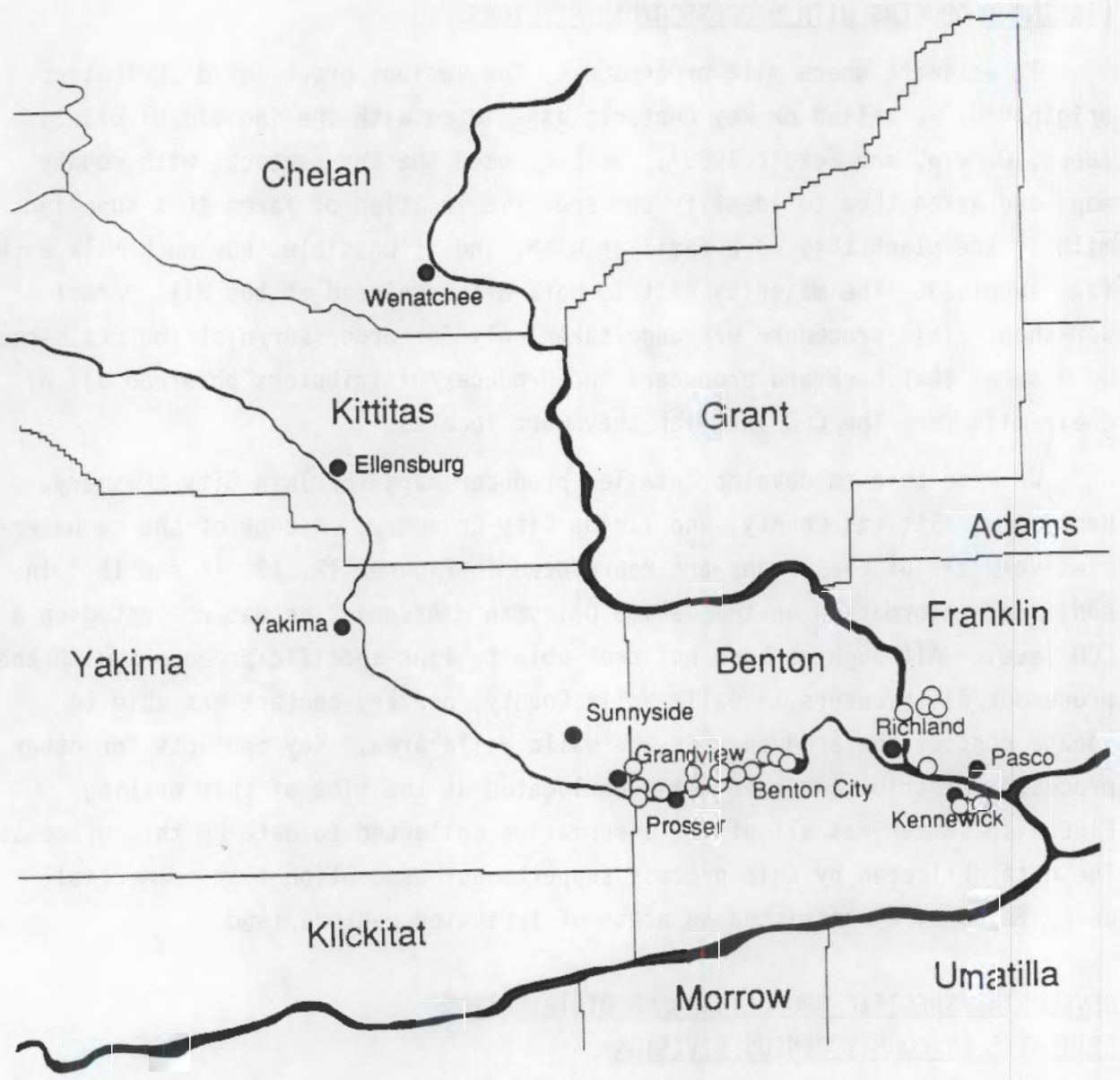

FIGURE 12. Locations of Dairy Producers for the Twin City Creamery (1950) (Artist's rendition of digitized information; because of resolution constraints, not all data points are reproduced.)

FIGURE 13. Locations of Dairy Producers for the Carnation Plant (1944-1949) (Artist's rendition of digitized information; because of resolution constraints, not all data points are reproduced.)

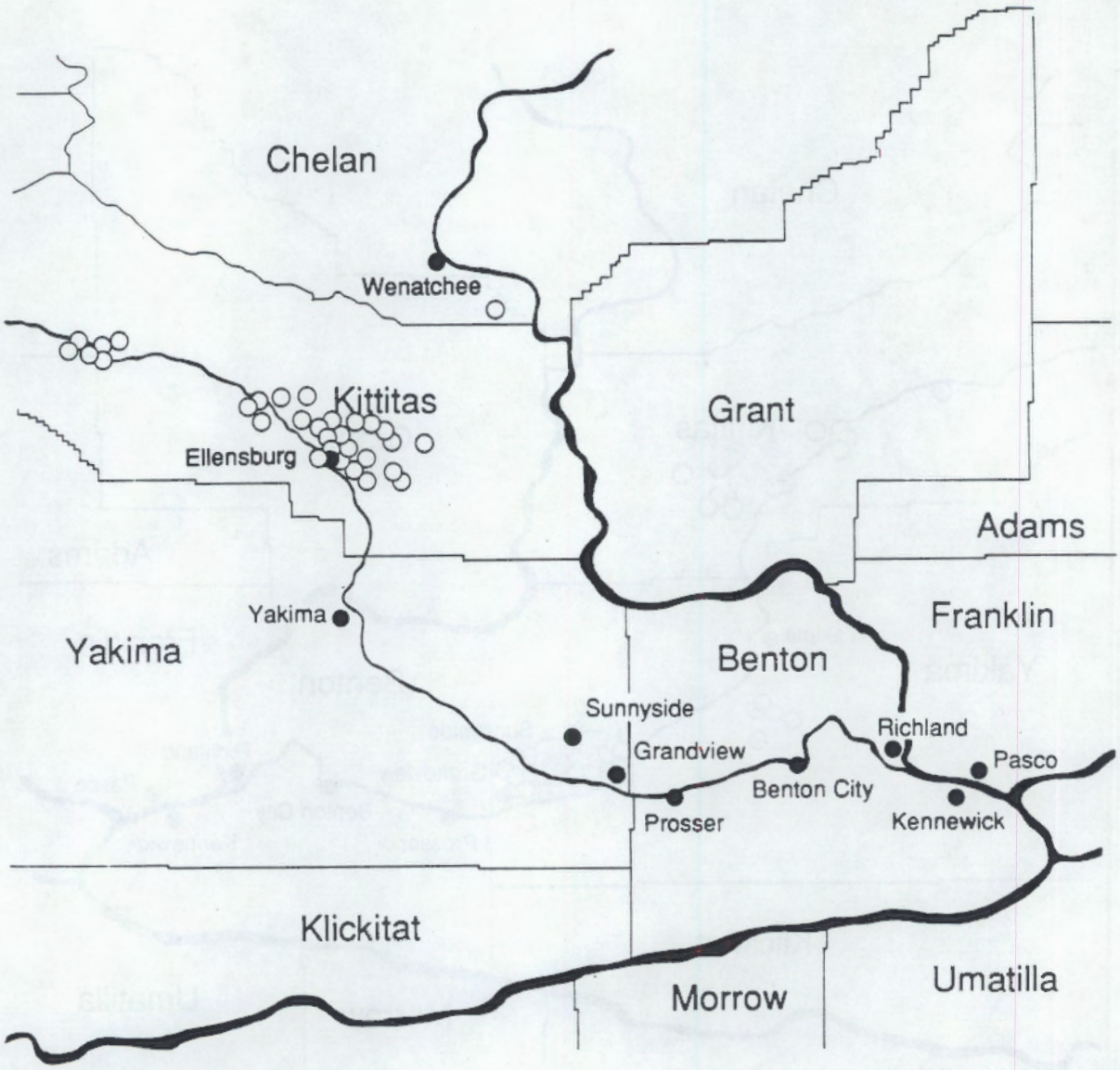

FIGURE 14. Identified Producer Locations in Kittitas County (1944-1949) (Artist's rendition of digitized information; because of resolution constraints, not all data points are reproduced.)

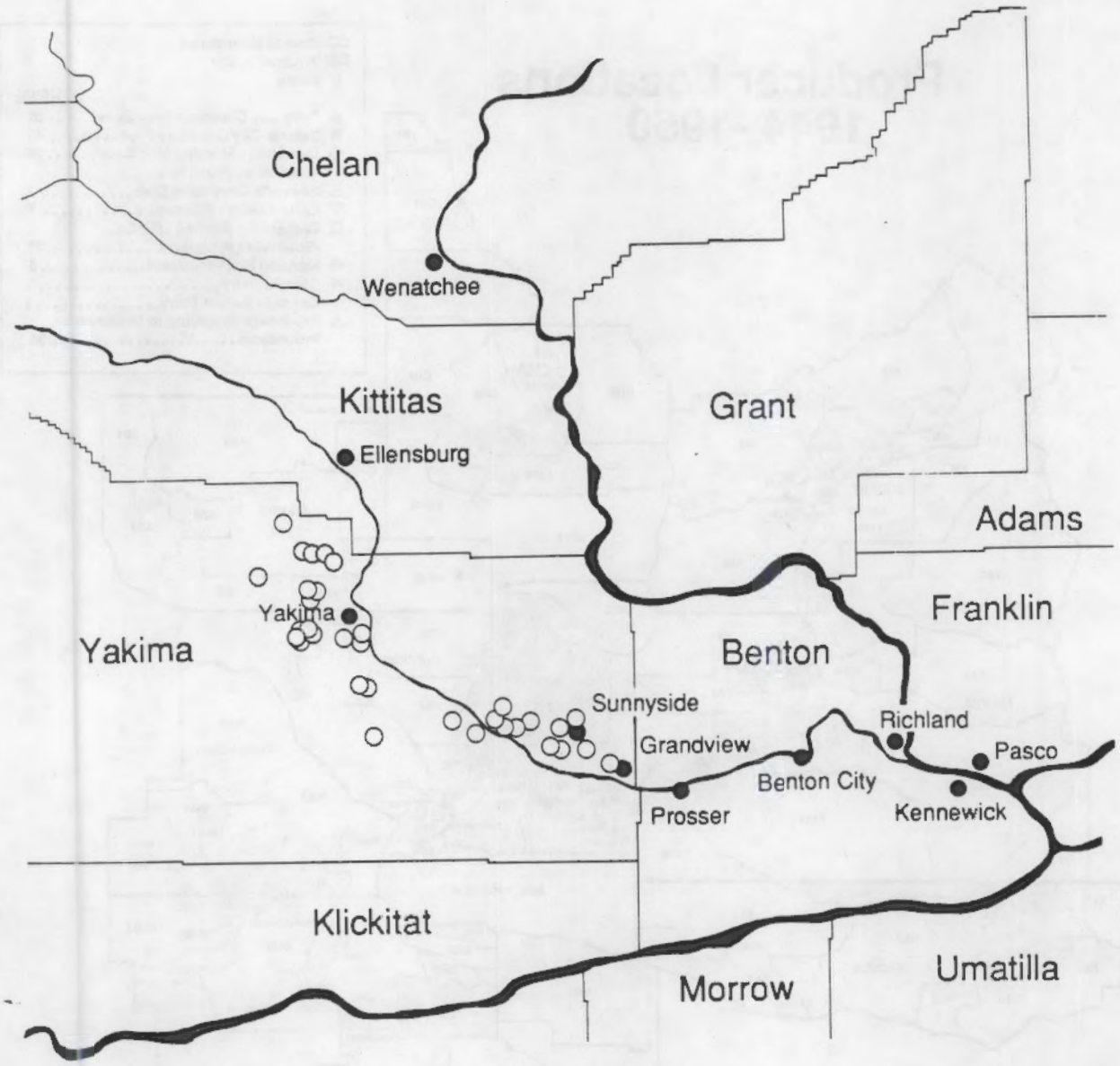

FIGURE 15. Locations of Dairy Producers for the Yakima City Creamery (1944-1945) (Artist's rendition of digitized information; because of resolution constraints, not all data points are reproduced.)

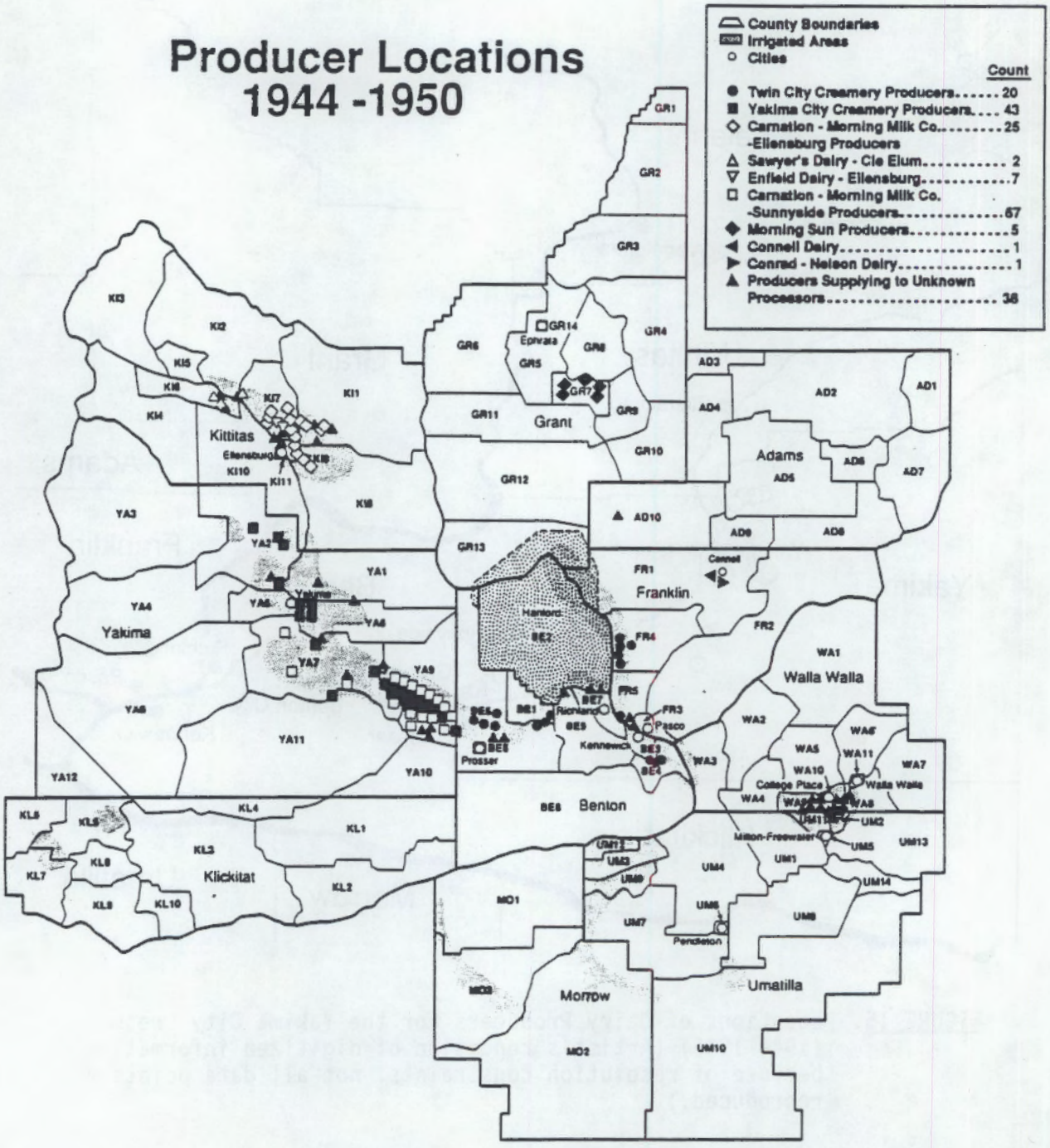

FIGURE 16. Locations of All Known Dairy Producers (as of December 1989) in the Hanford Environmental Dose Reconstruction Phase I Study Area (1944-1950) (Artist's rendition of digitized information; because of resolution constraints, not all data points are reproduced.)

Dr. Gerald Ward produced estimates based on all the available information and on his expertise in the field. Dr. Ward developed his estimates over a period of two days. The morning of the first day was spent reviewing all of the available information on the study area and summarized in this report. The following day and a half was spent recording his judgements for each CCD. Dr. Ward made the following assumptions when preparing his estimates:

- With the exception of few areas in Adams County, the study area was self-sufficient in terms of milk production.
- All commercial dairy farms were located on irrigated pasture land.
- The uncertainty distribution associated with each estimate was assumed to be triangular and symmetric around the mean.
- Unless information was available to the contrary, commercial milk for a particular CCD was assumed to be supplied by the closest processor/ distributor.
- Information provided by key contacts on the location and amount of milk produced on various farms was accurate.
- People living in urban areas within a CCD received all their milk from commercial sources (urban areas were defined as incorporated places).
- The distribution of time lags between production and consumption were the same for all commercial producers.

Once Dr. Ward completed his estimates for each CCD, the numbers were checked to ensure that mean values added to 100%. Dr. Ward's estimates are reproduced in Appendix B.

DELAY TIMES

As mentioned at the beginning of this report, delay times, that is the time lag from milk production to actual consumption, varies depending upon the particular milk pathway. Delay times associated with commercial pathways are longer than the pathway from family cow to human consumption. To provide estimates of the delay times for the various pathways, Dr. Ward was asked to provide mean, minimum, and maximum delay times for family cow, producer/ distributor, and processor/distributor. Table 3 summarizes this information.

TABLE 3. Milk Production to Consumption Delay Times

	Delay Time, h		
	Family Cow	Producer/Distributor	Processor/Distributor
Mean	24	48	48
Maximum	48	72	96
Minimum	1	12	18

Dr. Ward was also asked to develop an uncertainty distribution around the above estimates. This was done through a probability encoding procedure whereby Dr. Ward was asked to estimate what percentage of milk was consumed by X number of hours. For example, Dr. Ward was asked what percentage of the milk produced by family cows was consumed within 40 hours, 30 hours, etc. The results of this procedure are summarized in Table 4 and graphically displayed in Figures 17 through 19.

MILK PRODUCTION AND DISTRIBUTION SUMMARY

Although information on milk production and distribution is incomplete, some preliminary conclusions can be drawn based on available documents and expert judgement of Dr. Ward. The most important findings are summarized below:

- Backyard cows supplied a significant amount of the milk consumed by rural families during 1944-1947 but not by people living in urban areas (within incorporated places). Dr. Ward estimated that backyard cows supplied between 40% and 90% of the milk consumed by rural families while the vast majority of urban residents received milk from commercial sources.

58 - 100% of the commercial milk consumed by Richland residents *from 1942-1947* came from the Carnation Plant in Sunnyside. These results were based on the construction administration records for that time period (see Appendix A) and information gathered at the milk workshop.

TABLE 4. Delay Times and Percent Consumed For Different Milk Pathways (Based on Expert Judgement by Dr. Gerald Ward)

Hours	Amount Consumed, %		
	Family Cow	Producer/Distributor	Processor/Distributor
0	0	0	0
2	2	0	0
6	5	0	0
9	15	0	0
12	30	2	0
18	50	10	15
21	--	--	30
24	95	40	50
30	96	--	60
36	98	55	75
42	99	--	--
48	100	95	85
54		97	--
60		98	90
66		99	--
72		100	97
84			99
96			100

59

- Franklin County produced very little Grade A milk. That which was sold was most likely processed at the Twin City Creamery in Kennewick *and the two small processing plants located in Connell.* Information gathered at the milk market workshop indicates that in 1950 Twin City Creamery picked up all the Grade A milk produced in *the southern part of* Franklin County and distributed most of it in the immediate vicinity of the Tri-Cities.

- All of the milk consumed in the Walla Walla area was produced locally.

- Adams and Grant Counties were heavily dependent upon milk shipped in from Kittitas County, and to a much smaller degree from the Spokane milk pool.

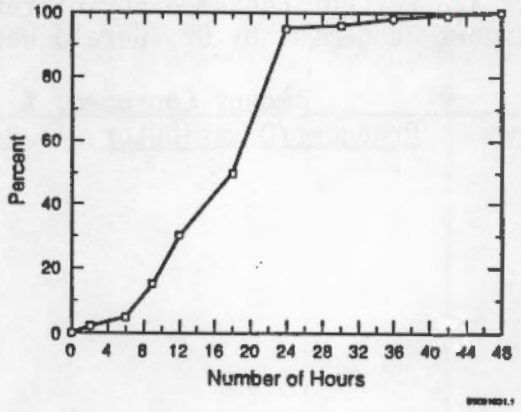

FIGURE 17. Delay Times for Consumption of Milk from Family Cows

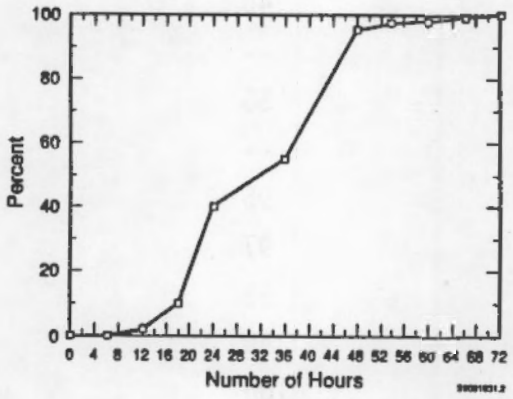

FIGURE 18. Delay Times for Consumption of Milk from Producer/Distributors

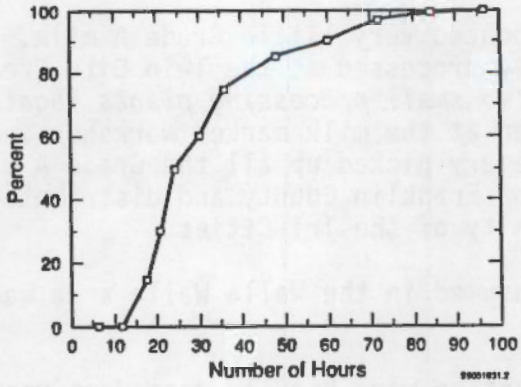

FIGURE 19. Delay Times for Consumption of Milk from Processor/Distributors

- Like the Walla Walla area, CCDs located in Kittitas consumed milk produced in the local area.

- Although Klickitat County recorded relatively large amounts of milk produced, most of the milk was used for manufacturing purposes.

- Umatilla County was largely self-sufficient in milk; however, some was supplied by Walla Walla processors.

- Morrow County filled its milk demand by importing milk from Umatilla County and to some degree from the Portland milk pool.

- Overall, the study area was self-sufficient in milk productions; no large amounts of milk were shipped into or out of the study area.

DAIRY COW FEED INTAKE ESTIMATES

The purpose of this section is to describe the methods used to arrive at the dairy cow feed intake parameters for the sensitivity analysis. The goal of this portion of the study is to track the conversion of local and nonlocal crops into milk that in turn was consumed by humans in the study area. The objectives, therefore, were to 1) determine what feeds were commonly consumed by dairy cows in the study area during the 1944-1947 period, 2) ascertain what factors might underlie differences or cause changes in feed consumption, and 3) use information on the occurrence of the major variability-causing factors to design a regional feed intake model for dairy cows. The basic approach was to generate a set of feeding regimes with which to link dairy fodder crops with milk production in the study area's CCDs.

23 *Ideally, estimates of dairy cow feed intake would be derived from the results of a formal survey on feeding practices within the region. And that was the intent when this research was started. However, as the goals of Phase I were clarified (and as the funding levels were adjusted accordingly), it became clear that a survey would not be possible. The estimates, therefore, are based on information that was immediately available.*

The remainder of this section is divided into three subsections. In the first subsection, the various feeding regimes hypothesized for the region during the 1944-1947 period are described. The major focus is on the types and amounts of feed generally consumed by dairy cows in the HEDR study area. The main sources of variability are the goals, resources, and decisions of individual dairy cow owners. In the second subsection, the geographic distribution of the feeding regimes is presented. The major focus is on the proportions of milk attributed to specific feeding regimes within the CCDs. The main source of variability is the distribution of irrigated farmland over the study area. In the third subsection, the temporal distribution of the feeding regimes's components are outlined. The major focus is on seasonal periods when dairy cows in the study area consumed particular feeds. The main source of variability is local climate and weather conditions.

FEEDING REGIMES

17 The term "feeding regime" refers to the diet that dairy cows are placed on by their owners over the course of a year *(see Whicker and Kirchner 1987)*. Four representative feeding regimes were identified for the HEDR study area during the 1944-1947 period (see Figures 20 through 23). Each feeding regime can be generally defined by its major feed components. The major components of the first feeding regime are grain, alfalfa hay, pasture, and silage (GAPS). The major components of the second feeding regime are grain, alfalfa hay, and pasture (GAP). The major components of the third feeding regime are grain and alfalfa hay (GA). The major components of the fourth feeding regime are grain and grass hay (GG).

The basic feed components of the models were selected on the basis of information in the Yakima County Dairy Herd Improvement Association publications and the expert opinion of dairymen, farmers, ranchers, and agricultural extension agents who are familiar with conditions in the dairy industry during the 1944-1947 time period. The best source of quantitative data near the 1944-1947 time period is contained in the 1951 Yakima County DHIA report (1952). This issue contains a table that includes for each member the average milk production per cow; the average fat content of the milk; the breed of cow; average quantities of succulent feed (silage), dry roughage (primarily alfalfa hay), and grain fed per cow; and the number of days the cows were placed on pasture. These data were used to derive estimates of the dry matter intake from the different feeds used in the study area.[a]

The conversion of grain and hay quantities to dry matter quantities is relatively straightforward because the moisture content of the feed types generally does not vary substantially. The following conversion factors were used: 1) one pound of grain contains 0.89 pounds of dry matter, and 2) one pound of dry roughage contains 0.876 pounds of dry matter. The Nutrient Requirements of Dairy Cattle, Fourth Revised Edition, 1971, National Academy of Sciences, National Research Council, Washington, D.C., as presented in

(a) Because the moisture content of different feeds varies, dry matter is used as a standard measure.

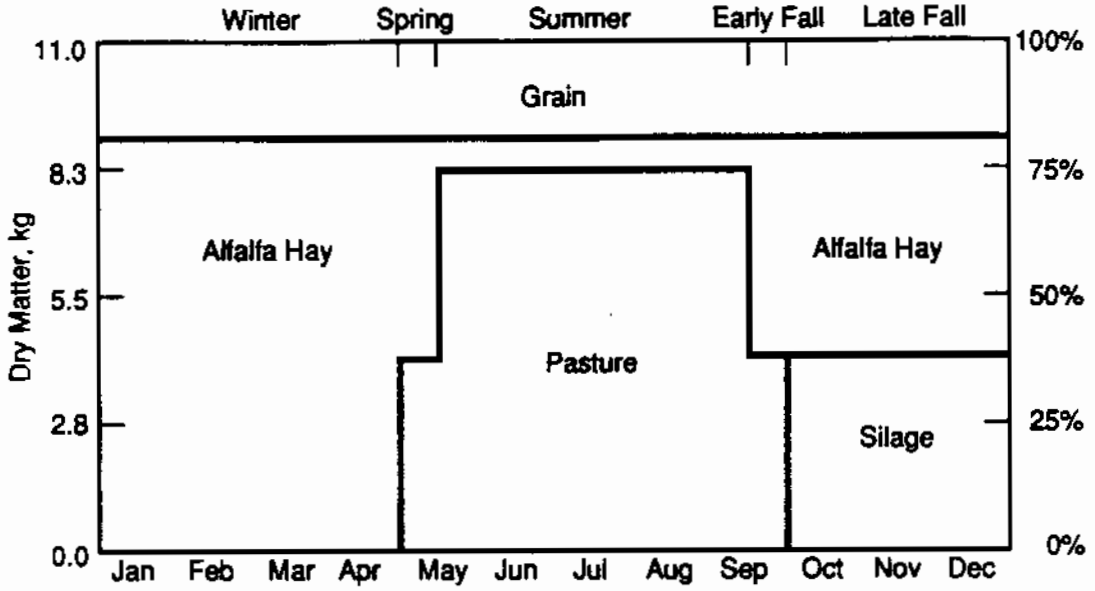

FIGURE 20. Typical Grain, Alfalfa Hay, Pasture, and Silage (GAPS) Feeding Regime used in the Hanford Environmental Dose Reconstruction Phase I Study Area, 1944-1947

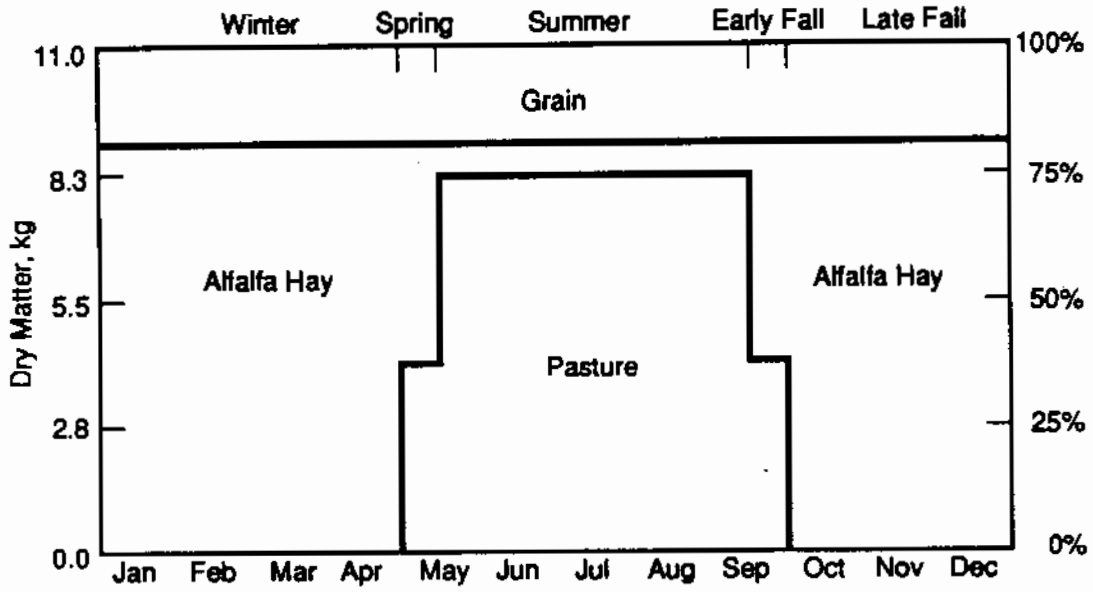

FIGURE 21. Typical Grain, Alfalfa Hay, and Pasture (GAP) Feeding Regime used in the Hanford Environmental Dose Reconstruction Phase I Study Area, 1944-1947

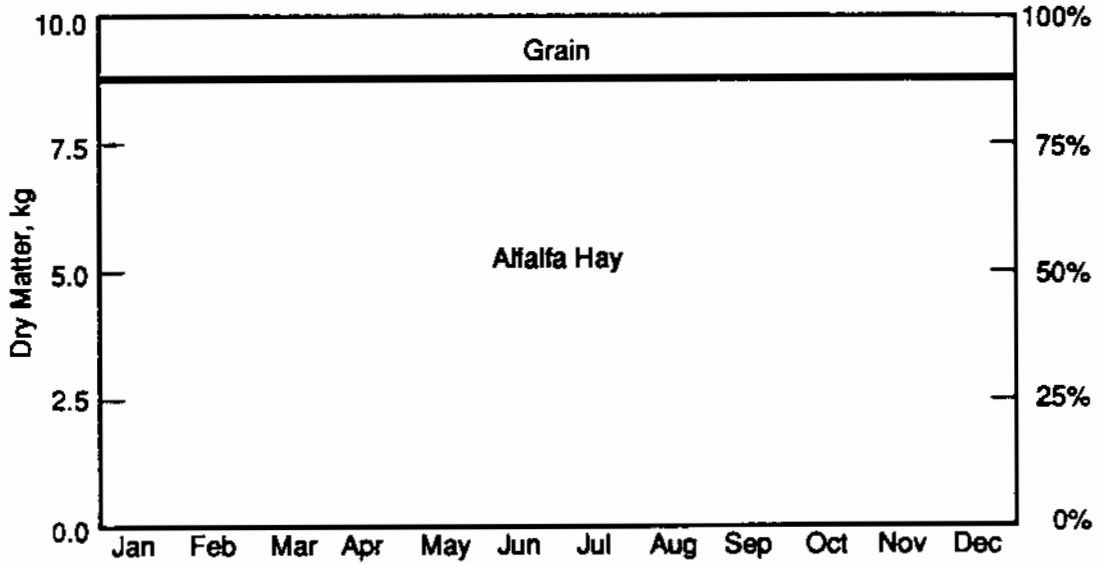

FIGURE 22. Typical Grain and Alfalfa Hay (GA) Feeding Regime used in the Hanford Environmental Dose Reconstruction Phase I Study Area, 1944-1947

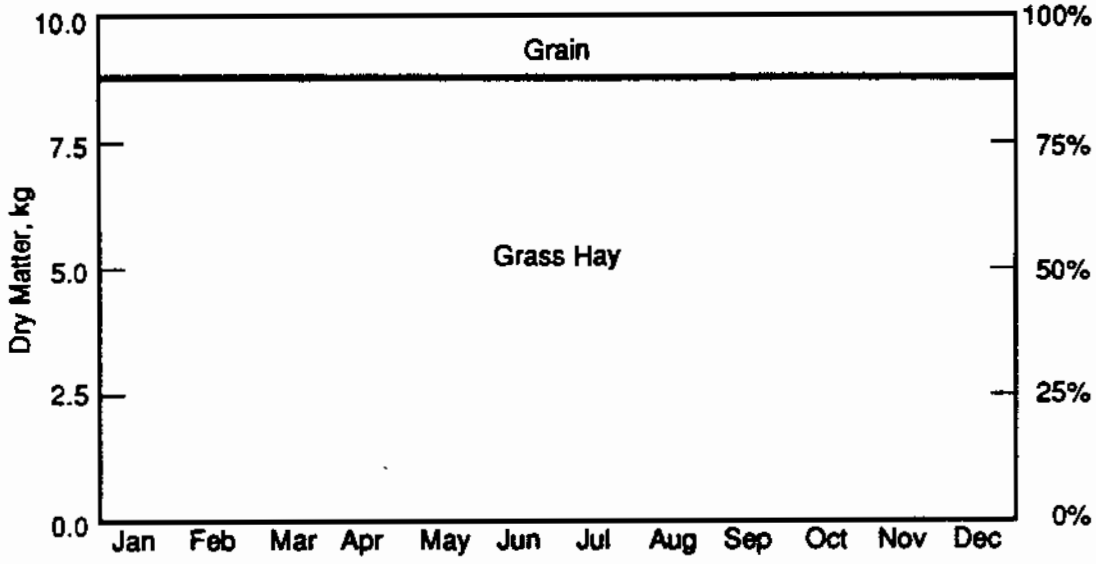

FIGURE 23. Typical Grain and Grass Hay (GG) Feeding Regime used in the Hanford Environmental Dose Reconstruction Phase I Study Area, 1944-1947

Foley, Bath, Dickinson, and Tucker (1972), was used to determine these conversion factors. These conversion factors were multiplied by the average quantities of grain and hay feed by the DHIA farmers to obtain yearly average totals for grain and hay matter intake.

The conversion of silage quantities and pasture days into dry matter intake is more difficult. The moisture content of silage, for example, depends on how the silage is made and stored.

The quantity of pasture consumed in a pasture day is even more variable. In this report, pasture intake refers to the quantity of fresh forage that cows actually consume. Pasture intake depends upon the quantity and quality of the forage composing the pasture and upon the quantity and quality of other feeds consumed by the cows. Pasture quantity and quality change both seasonally and from one day to the next as cows consume, trample, and otherwise modify its condition.

18,20 Pasture and succulent dry matter intakes were estimated by going backward from the amount of dry matter required for milk production and maintenance for the average cow in each herd *(See Appendix D for details)*. The first step was to assign average weights to the cows based on the breed information given. This assignment was made based on encyclopedic information on dairy cattle (Americana Corporation 1964). The second step was to determine the total average dry matter requirements for the cows owned by each DHIA member, given the weight of the cow, the amount of milk produced per cow, and the fat content of the milk. Information from the Nutrient Requirements of Dairy Cattle, Fourth Revised Edition, 1971, National Academy of Sciences, National Research Council, Washington, D.C., as presented in Foley et al. (1972), was used to make these determinations.

The third step was to determine the amount of dry matter intake obtained from grain and dry roughage and to subtract it from the total average requirements. The fourth step was to regress the remaining dry matter requirements on the quantities of succulent feed (lbs/cow) and pasture (days). The results of the regression are:

$$DV = 0.26\ SUC + 18.63\ PAST \qquad (1)$$

where *DV*, *SUC*, and *PAST* represent the dry matter requirements, the quantity of succulent feed, and number of pasture days, respectively. The results indicate that the succulent feeds contained approximately 0.26 pounds of dry matter per pound and that the dry matter intake of pasture per day per cow was on average about 19 pounds. Both parameters are reasonable and significant at the 0.001% level.

Finally, these parameters were combined with the average annual quantity of silage fed by those farmers feeding silage and the average number of pasture days to obtain yearly totals for silage and pasture dry matter intake.

22 DHIA dairy cows, however, are not representative of all dairy cows in a region. Thus, the information obtained from the Yakima Valley DHIA was modified using expert opinion combined with the Census of Agriculture data on average milk production for the region during that time (U.S. Bureau of the Census 1946, 1952). *As a result of this process, a set of average* feeding regimes was developed so as to provide enough variety to *generally* cover both the large commercial dairy operations located within the region's irrigated areas and the small family farm producers located throughout the non-irrigated grain-growing regions. Final descriptions of these regimes were derived at a working meeting with Dr. Gerald Ward on June 27, 1989.

In many instances, dairy cow diets change from one season to the next.[a] To mark these changes, the feeding regime year is divided into five "seasons" -- winter, spring, summer, early fall, and late fall. For the purposes of this study, these seasons are defined by when specific types and/or amounts of feed are fed. Thus, "winter" is defined as the period beginning on January 1 and ending on the day before the cows are first put on pasture. "Spring" is defined by the period during which cows are conditioned to fresh pasture, i.e., the period beginning on the first day the cows are placed on pasture and ending on the day before the cows are placed on full

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(a) The total quantity of feed intake also changes from one season to the next. For example, dairy cows consume more feed after they freshen. These changes in dry matter quantities are not accounted for in the feeding regimes depicted in Figures 20 through 24. If, however, we assume that dry matter quantities increase or decrease proportionally, then Figures 20 through 24 are accurate in percent terms.

pasture. The spring conditioning period is assumed to be 2 weeks. "Summer" is defined as the period during which the cows are on full pasture, i.e., the period beginning on the first day the cows are placed on full pasture and ending on the day before the cows are placed on fall conditioning. "Early fall" is defined by the transition period during which cows are removed from full pasture to no pasture, i.e., the period beginning on the first day of fall conditioning and ending on the day before the cows are removed from pasture entirely. The fall conditioning period, like the spring conditioning period, is assumed to be 2 weeks. "Late fall" is defined as the period beginning on the day the cows are completely removed from pasture and ending on December 31. Linking these seasons to specific dates is discussed in a later section on seasonal and year-to-year adjustments.

The feeding regimes depicted in Figure 20 through Figure 23 represent a set of average feeding regimes. Variability enters into these regimes along four interrelated dimensions. The first dimension pertains to how much feed was generally fed. The second dimension pertains to what proportions of milk were produced on specific feeding regimes. The third dimension pertains to how much of the feed was obtained locally. The fourth dimension pertains to how the seasonal pattern of dietary changes can vary both within a given year and from one year to the next. The remainder of this subsection focuses on the first dimension -- how much feed was generally fed.

The amount of feed consumed by cows on the same overall feeding regime varies from one cow to the next. First, although a group of dairymen may use the same overall feeding regime, no two dairymen will feed identical quantities of each specific component. Second, although a given dairyman may present each dairy cow in his herd with identical quantities of each component, no two cows will actually consume identical quantities. A number of assumptions were made to account for this variability. These assumptions are presented in Table 5.

Note that the ranges assumed in Table 5 reflect the variability of feed consumed by all individual cows on a particular feeding regime. These assumptions do not reflect the variability of the mean amount of feed consumed by the cows on a particular regime. This difference is similar to the

TABLE 5. Assumptions on the Variability of Feed Quantities Consumed by Dairy Cows in the Ten County HEDR Area, by Feeding Regime, 1944-1947

Feeding Regime/Feed	Season	(kg dry matter per cow per day) Average	Range
Grain, Alfalfa Hay, Pasture, and Silage Feeding Regime			
Grain	All	1.50	0.0 - 10.0
Alfalfa Hay	Winter	9.50	5.0 - 15.0
	Spring	5.25	2.0 - 10.0
	Summer	1.00	0.0 - 5.0
	Early Fall	5.25	2.0 - 10.0
	Late Fall	5.25	2.0 - 10.0
Pasture	Spring	4.25	1.0 - 10.0
	Summer	8.50	2.0 - 15.0
	Early Fall	4.25	1.0 - 10.0
Silage	Late Fall	4.25	1.0 - 10.0
Combined Total at Any One Time	All	11.0	8.0 - 20.0
Grain, Alfalfa Hay, and Pasture Feeding Regime			
Grain	All	1.50	0.0 - 10.0
Alfalfa Hay	Winter	9.50	5.0 - 15.0
	Spring	5.25	2.0 - 10.0
	Summer	1.00	0.0 - 5.0
	Early Fall	5.25	2.0 - 10.0
	Late Fall	9.50	5.0 - 15.0
Pasture	Spring	4.25	1.0 - 10.0
	Summer	8.50	2.0 - 15.0
	Early Fall	4.25	1.0 - 10.0
Combined Total at Any One Time	All	11.0	8.0 - 20.0
Grain and Alfalfa Hay Feeding Regime			
Grain	All	1.0	0.0 - 10.0
Alfalfa Hay	All	9.0	5.0 - 15.0
Combined Total at Any One Time	All	10.0	7.0 - 15.0
Grain and Grass Hay Feeding Regime			
Grain	All	1.0	0.0 - 10.0
Grass Hay	All	9.0	5.0 - 15.0
Combined Total at Any One Time	All	10.0	7.0 - 15.0

difference between the standard error of a population and the standard error of the mean of a population. The variability of the mean amount of feed consumed would be much smaller. Using the variability of feed consumed by individual cows, therefore, assures that more extreme cases will be picked up in the sensitivity analysis.

ALLOCATING FEEDING REGIMES TO COUNTY CENSUS DIVISIONS

Once the four basic feeding regimes were defined, the next step was to determine what proportions of the milk produced by dairy cows in a particular CCD were linked to the various feeding regimes. Milk production, rather than number of dairy cows, is the appropriate standard. First, milk is the final dose carrier to humans, and second, milk production varies from one dairy cow to the next. Cows cared for by commercial dairymen, for example, produced, on average, greater quantities of milk for fresh, human consumption than cows kept to provide milk for single families. If the allocation were made to the number of cows, there would be no simple way to aggregate in terms of milk.

The underlying assumptions used to allocate the various feeding regimes are relatively straightforward. First, feeding regimes containing pasture, i.e., the GAPS and GAP feeding regimes, were assumed to be confined to CCDs with major irrigation projects. This also means that only feeding regimes without pasture were assumed to occur in non-irrigated CCDs. Second, the grain and alfalfa hay (GA) feeding regime may have been used in any of the CCDs. Alfalfa hay, then as now, was an export crop for many of the CCDs containing major irrigation projects. Third, the grain and grass hay (GG) feeding regime was confined to the dryland grain growing regions of the study area.

The feeding regimes were assigned to the CCDs by Dr. Ward during the June working meeting. To facilitate the assignment, information about major land uses prior to 1950 was transferred from the 1950 USDA land use map (USDA 1950) to Metsker county maps. The CCD boundaries also were transferred to the Metsker county maps. Each assignment consists of 1) an average percent and 2) the minimum and maximum percents of milk production in the CCD. The assignment results are presented in Appendix C.

This is as far back in the feed source chain as Phase I of the analysis goes. All of the feed components of the feeding regimes assigned to a CCD are assumed to originate locally, i.e., within the CCD. The validity of this assumption varies from one feed component to another. For example, with only a few exceptions, the pasture utilized by dairy cows producing milk within a CCD was assumed to be located within the CCD. The costs of moving cows more than a mile or two twice a day would have been too high for cows located in one CCD to graze in another except in the vicinity of a boundary. With a few more exceptions, the crops used to make silage were also grown within the CCD. Succulent feeds, too, were and remain relatively costly to transport.

The number of exceptions increases as the cost of transportation decreases. Thus, one would expect the proportion of hay or grain originating from outside a CCD to be larger than the proportion of silage crops or pasture. Also, alfalfa hay was an important export from irrigated areas of the region, while wheat, barley, oats, and other grains were important exports from non-irrigated dryland areas. Local specialization and trade of these crops, therefore, also contributed to cross-CCD movements of hay and grain. Information on which to quantify such movements has not as yet been collected. Fortunately, the most important link in the milk pathway for radioiodine is pasture. Silage, hay, and grain are relatively minor radioiodine sources. Thus, the assumption that all feed components originate within CCD should have relatively little effect on the results of the Phase I analysis.

SEASONAL AND YEAR-TO-YEAR ADJUSTMENTS

The major focus in this subsection is the seasons during which dairy cows in the study area consumed particular feeds. The main source of variability is local climate and weather conditions. Dairy cows can consume significant quantities of pasture, for example, only when pasture is available. Pasture only becomes available in the spring after temperatures have increased enough for the grasses, legumes, and other pasture forbs to begin their annual growth. As temperatures decrease in the fall, pasture crops return to a state of dormancy. The timing of the beginning and ending of significant pasture intake, therefore, is temperature dependent. Temperature changes also affect

the growth and readiness of silage, hay, and grain crops. The occurrence of these seasonal temperature changes in the study area varies by latitude and altitude and from one year to the next.

Thus, once the feeding regimes were assigned to the various CCDs, the next step was to link the seasonal patterns depicted in the feeding regimes to local climate and weather conditions. The basic approach is summarized as follows. First, data on the timing of major temperature phenomena were obtained from the local weather stations in the study area. Second, the information on the timing of temperature phenomena was interpolated to all of the CCDs. And third, the timing of the temperature phenomena in each CCD was linked to changes in dairy cow feed intake.

The temperature phenomena assumed to be the primary timing driver are 1) the average date that temperatures last reach 28°F in the spring, i.e., the "last day of frost," and 2) the average date that temperatures first reach 28°F in the fall, i.e., the "first day of frost." Data on these phenomena collected from the weather stations in the study area were used to create two "iso-day" plots by James V. Ramsdell, Jr., Senior Research Scientist, PNL, (see Figures 24 and 25). In these plots, the unit of measure is the number of days from the beginning of the calendar year, i.e., 90 represents March 31 and 290 represents October 17. Next, the iso-day plots were transferred to Metsker county maps, which also depicted the CCD boundaries. Finally, each CCD was assigned an average "last day of spring frost" and a "first day of fall frost" during a working meeting with Dr. Gerald Ward on June 28, 1989.

These data were compared with previously obtained estimates of the dates that dairy cows were usually placed on and removed from pasture. These estimates had been provided by various experts, i.e., Dr. Gerald Ward, Mr. Eddie Thomason, Mr. Bill McCaw, and Mr. Bob Duncan. Based on this comparison, two simple algorithms were devised for transforming last and first frost days into pasture start and finish days. The pasture start day in a CCD is equal to the last day of spring frost assigned to the subdivision plus 20 days. The pasture finish day in a CCD is equal to the first day of fall frost assigned to the CCD minus 20 days. These algorithms place the pasture start and finish

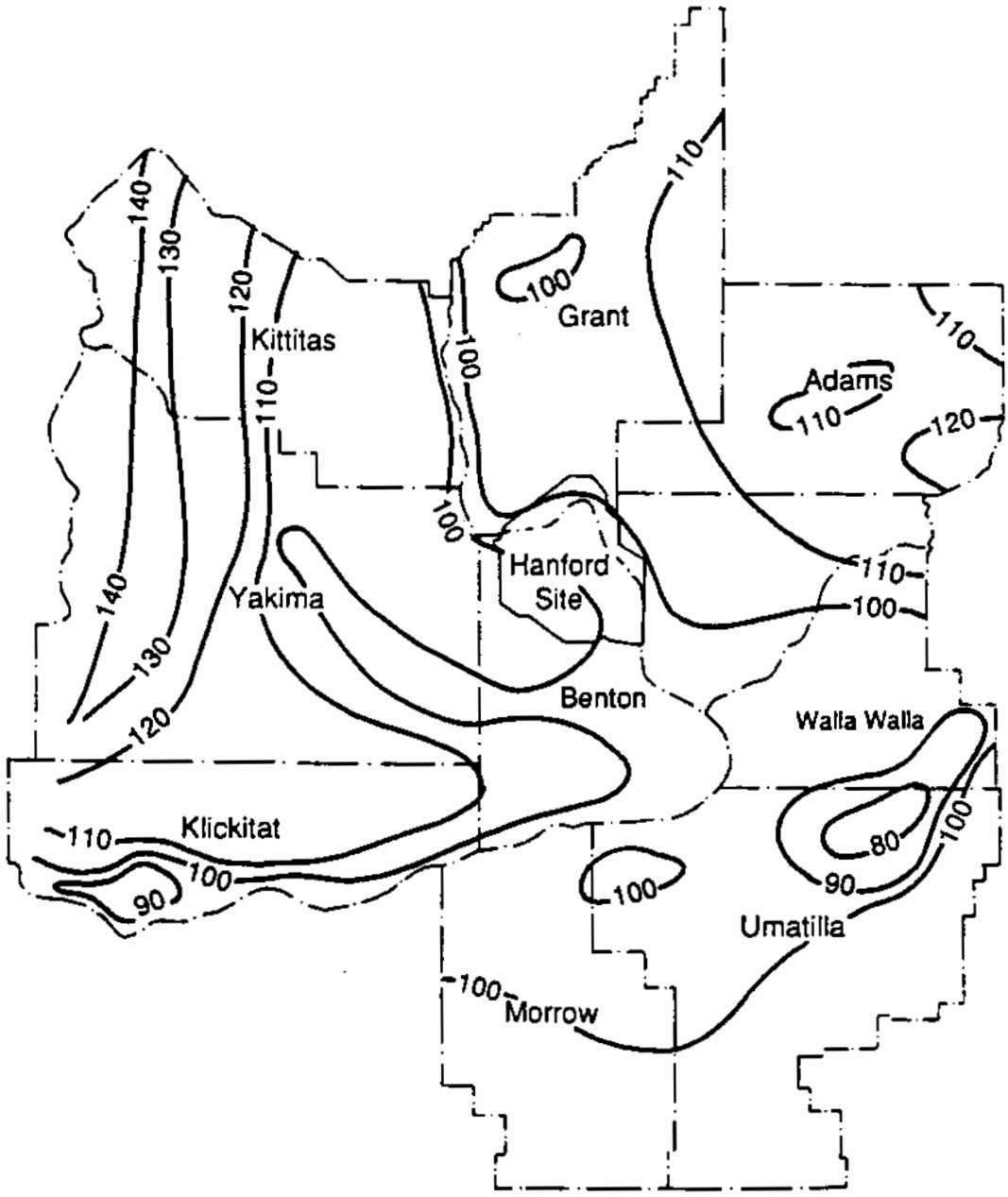

FIGURE 24. Iso-day Plot of the Average Last Day of Spring Frost. Units indicate number of days from the beginning of calendar year.

days in the vicinity of April 15 (day number 115) and October 1 (day number 274), respectively. The variability around pasture start days was estimated to be plus or minus 10 days, while the variability around pasture finish days was estimated to be plus or minus 20 days. These variability

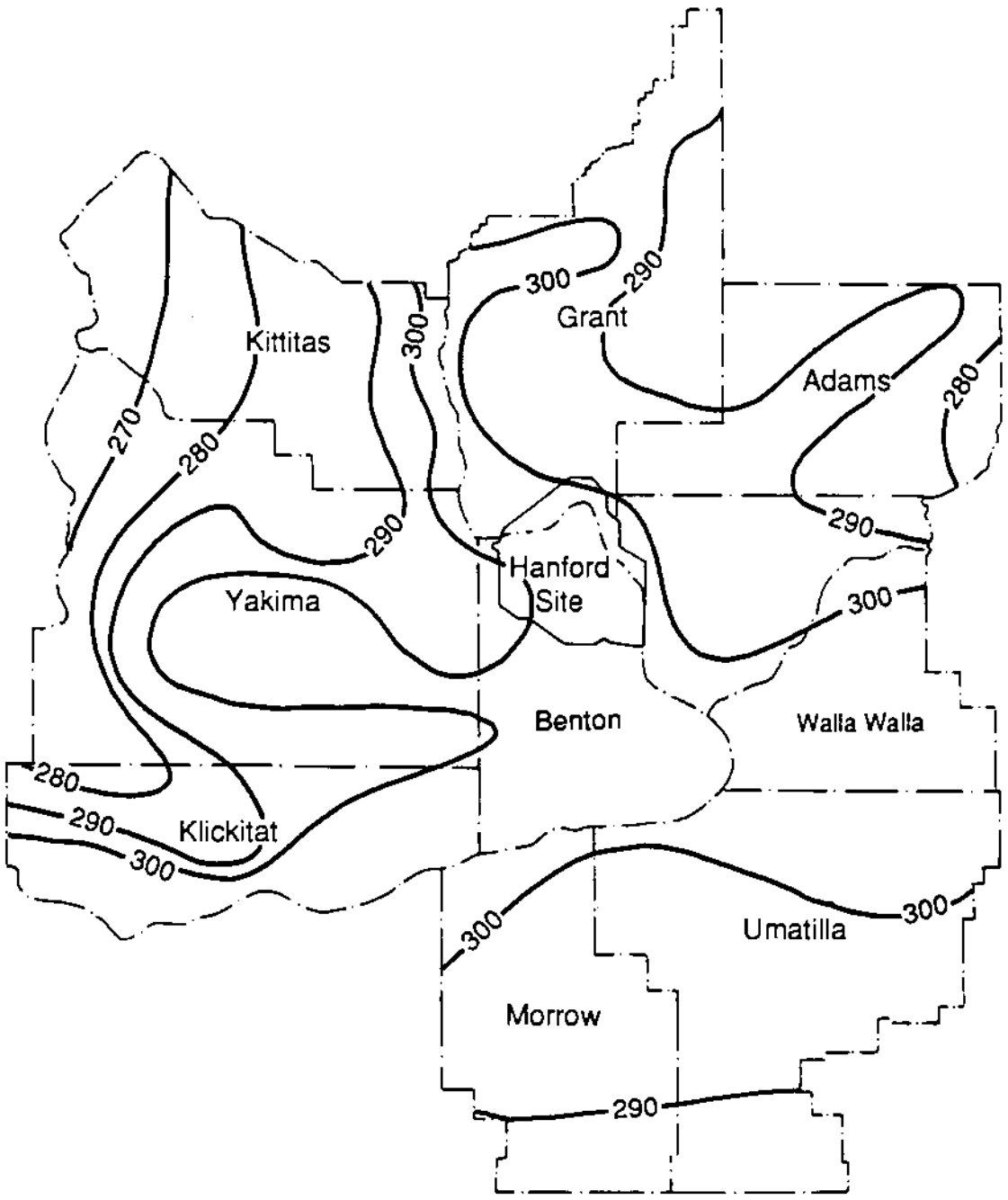

FIGURE 25. Iso-day Plot of the Average First Day of Fall Frost. Units indicate number of days from the beginning of calendar year.

estimates were provided by Dr. Gerald Ward during the June 28 working meeting. The results of this process are listed in Appendix Table C.2.

The days given in Table C.2 represent "average" start and finish days for pasture. In actuality, pasture becomes available earlier or later in the spring as the weather is warmer or cooler than normal. A similar process occurs in the fall. Pasture remains available for a longer or shorter period in the fall as the weather is warmer or cooler. To capture such year-to-year changes, additional adjustments are required (Appendix C). These estimates are based both on the occurrence of frost dates and on the three-month average daily temperature during the spring and fall at the Hanford weather station.

The weather data were compared also with information on when hay crops were usually harvested. Based on information previously obtained from various experts, i.e., Dr. Gerald Ward, Mr. Eddie Thomason, Mr. Bill McCaw, and Mr. Bob Duncan, an average alfalfa hay cutting schedule for the lower Yakima Valley was developed (Appendix Table C.3). The average first cutting date at Prosser (CCD BE6), for example, is June 5 (day number 156). The average last date of spring frost (28°F) for Prosser is March 30 (day number 90). Average first cutting dates for other CCDs were derived by simply adding 66 days to their average last date of spring frost. The average second and third cutting dates were assumed to occur 45 and 90 days, respectively, after the first cutting date (see Table C.3). Bob Duncan, an Extension Agent at Washington State University Irrigated Agriculture Research and Extension Center, Prosser, Washington, estimated the range around the average cutting dates to be plus or minus a week.

Weather also affects the dates at which hay crops mature. Warm or cold springs can move the date of the first alfalfa cutting two weeks sooner or later, respectively. To adjust the alfalfa hay cutting dates for specific years requires some additional calculation (Appendix C).

Once alfalfa hay has been cut, cured, and baled, some may be fed immediately to dairy cows and some may be stored for consumption later. As one cutting follows another, the proportions of hay originating from prior cuttings

change. For now, the mixture of alfalfa hay from prior cuttings that is fed to dairy cows during the course of a year (Figure 26) will be determined by the following:

- Immediately following the first cutting in a given year and continuing until the second cutting, the hay fed to dairy cows is 100% first cutting.
- Immediately following the second cutting and continuing until the third cutting, the mixture of hay fed to dairy cows is 50% first cutting and 50% second cutting.
- Immediately following the third cutting and continuing until the following year's first cutting, the mixture of hay fed to dairy cows is 33% first cutting, 33% second cutting, and 33% third cutting.

We did not locate any detailed information about how these proportions may actually have changed during the years of interest. These assumptions, therefore, are purely arbitrary.

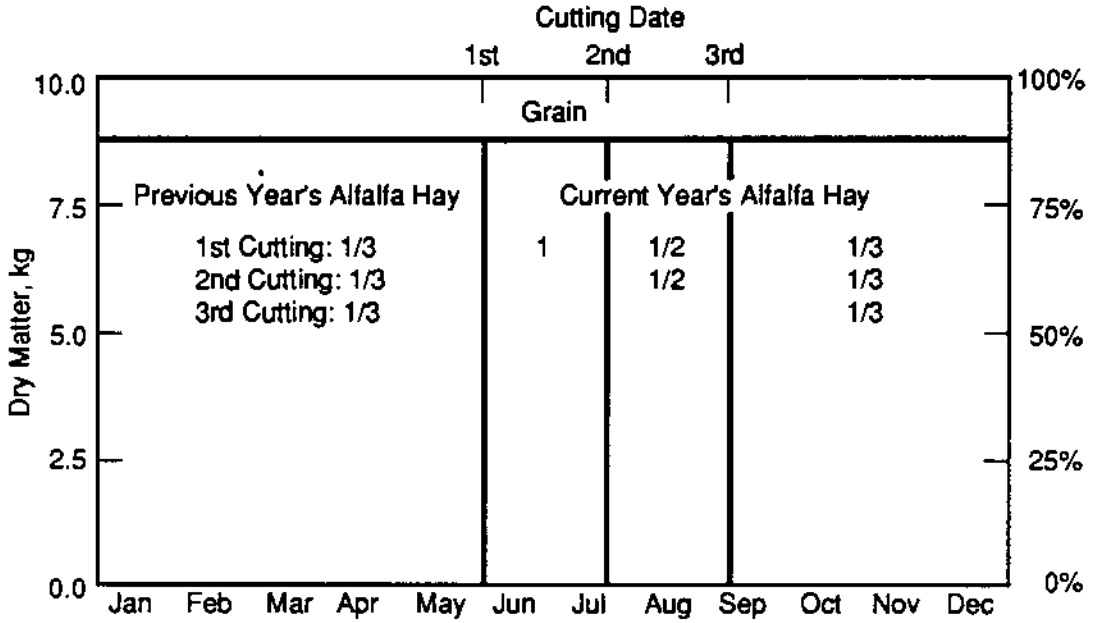

FIGURE 26. Cutting Dates and Feeding Proportions for Alfalfa Hay in the Hanford Environmental Dose Reconstruction Phase I Study Area, 1944-1947

Weather also affects the date at which grass hay crops (i.e., wheat or barley hay) mature. Bob Duncan estimated that wheat hay was probably harvested in early July in the Prosser area. Based on that limited information, grass hay harvest dates were assigned to the CCD in a manner similar to that used to assign alfalfa hay cuttings (see Appendix Table C.4). The average grass hay cutting date for a CCD is derived by adding 100 days to the last day of spring frost for the CCD. Cutting dates for specific years are calculated using the same procedure described for alfalfa hay. Only the most recently cut hay is assumed to have been fed to dairy cows at any one time.

Other assumptions made for the Phase I calculations pertain to grain and silage harvest dates. Grain is assumed to be harvested 14 days after the grass hay cutting date for a given CCD and year. We assume that the grain fed is from the most recent harvest. Silage crops are assumed to be harvested 14 days prior to the date at which silage begins to be fed. Thus, the silage harvest date would occur at the beginning of "early fall." As with grain, we assume that silage fed to animals is from the most recent harvest. The last day of silage feeding is always the last day of the year. This assumption is based on a comment made during the milk producers workshop, i.e., that silage was fed only until early winter.

FEED INTAKE SUMMARY

In summary, fresh forage was an important feed component of dairy cows in irrigated areas during the spring, summer, and fall months. These irrigated areas were the major sources of milk in the study area in the 1944-1947 period. If pasture lands in an irrigated area were contaminated by radioactive iodine during those months, then the milk produced in that area may have been an important source of radioiodine exposure for the human population consuming milk produced in that area.

Dairy cows kept in the study area's non-irrigated areas were fed primarily grain and hay. Based on the information currently available to us, pasture intake by dairy cows in these areas was negligible, at least on average. There may, however, have been small, isolated pockets of pasture land available in the non-irrigated areas that we do not know about. If such

pasture lands existed, they may have been utilized by some of the dairy cows owned by farm families living in the areas at the time. Some of the farm families also may have allowed their dairy cows to graze wheat, barley, oats, or other grain and legume crops during certain times of the year. The milk produced from such pasture lands, if contaminated, may have exposed some people to radioiodine.

DATA LIMITATIONS AND ADDITIONAL RESEARCH

There are inherent limitations to the methodology used to prepare these Phase I results. Although Dr. Gerald Ward is a recognized expert in the field, and he had access to all available information on the subject, the estimates are just one expert's judgement. Therefore, this document should be considered a living document that may be revised as new information surfaces. If results from the sensitivity analysis suggest refinements of these estimates are warranted, we would recommend the following steps be taken: 1) The report should be sent to as many knowledgeable people as possible for review. 2) A second milk market workshop should be held to reach consensus on exceptions to estimates presented in this report. 3) Attempts to locate individuals associated with the dairy industry during the time of interest shou`d be continued. 4) A systematic survey of milk producers should be conducted to refine the dairy cow feeding regimes.

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APPENDIX A

SOURCES OF COMMERCIAL MILK

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SOURCES OF COMMERCIAL MILK

77 A listing of all commercial milk producers gleaned from the Washington Dairy Products Commission *butterfat* records *(which were for Washington counties only)* is reproduced in Table A.1. The sources of milk supplied to the Hanford Site are recorded in Hanford Works Monthly Reports *(Blondin and Hattrup 1989)*. A summary of the information contained in these reports is reproduced in Table A.2.

TABLE A.1. Sources of Commercial Milk

PcD = Processor/Distributor PD = Producer/Distributor

County/Town	Type	Name of Processor/Distributor
Kittitas		
Ellensburg	PD	Bender's Independent Dairy
	PD	Blue Ribbon Dairy/Gregory
	PcD	Enfield Dairy
	PD	Faust
	PcD	Kittitas County Dairyman's Assn.
	PcD	Morning Milk/Carnation
	PD	Statton's Dairy
	PD	Winegar's Dairy
Cle Elum	PcD	Cle Elum Dairy Prod. Co./Sawyers
	PD	K.O. Lund
Roslyn	PD	Del Ducco Dairy
	PD	Kayner's Dairy
	PD	Model Dairy
	PD	Venera Dairy
Yakima		
Yakima	PD	H.C. Detloff
	PD	Lower Naches Dairy
	PcD	Mack's Creamery
	PD	Mary-O Dairy
	PD	Lloyd Meyer
	PD	Mountain View Dairy
	PD	Naches Dairy
	PD	Scudder Ranch Dairy
	PD	Spring Brook Dairy
	PD	Westlawn Dairy
	PD	Wiley City Dairy
	PcD	Yakima City Creamery
	PD	Yakima Poultry & Egg Co.
	PcD	Yakima Dairyman's Assn.
Zillah	PD	Clausing's Dairy
Sunnyside	PD	Golden Jersey Dairy
	PcD	Milk Products Co.
	PcD	Morning Milk Co./Carnation
Toppenish	PcD	Maple Leaf Dairy
	PcD	McColum's/Reeseman's Dairy
	PD	Thorp's Creamery
Selah	PcD	Selah Home Dairy
Union Gap	PD	Union Gap Dairy

TABLE A.1. (contd)

County/Town	Type	Name of Processor/Distributor
Walla Walla		
Walla Walla	PD	Calhoun's Dairy
	PD	Percy Clark's Dairy
	PcD	Duff's Creamery
	PD	Deboer Farm Dairy
	PD	Depping's Dairy
	PD	Mountain View Dairy
	PcD	Shady Lawn Creamery
	PD	Tomlinson's
	PD	Walla Walla College Dairy
	PcD	Walla Walla Dairyman's Assn.
	PD	Washington State Penn.
	PcD	Young's Dairy
Prescott	PD	Prescott Co.
Grant		
Moses Lake	PcD	Wilmot's Morning Sun Dairy
Grand Coulee	PD	Willow Point Dairy
Quincy	PD	Sweet Clover Dairy
Ephrata	PD	Sanson's Dairy
Benton		
Prosser	PD	Fairview Guernsey Dairy
Kennewick	PcD	Twin City Creamery
Pasco	PD	Diversity Farm Dairy
	PD	Ingram's Dairy
Benton City	PD	Hulbert Dairy
Franklin		
Connell	PD	Connell Dairy
Adams		
Othello	PD	May's Dairy
Ritzville	PD	Ritzville Dairy
Umatilla		
Hermiston	PcD	Mayflower

TABLE A.2. Report of Milk Sold to Hanford Contractor. Figures compiled from the Hanford Works Monthly Report (HWMR) from 1944 to 1949.

Date	Gallons of Milk and Cream Sold		
	Morning Milk	Darigold	Carnation[a]
5/44	18,865		
6/44	24,120		
7/44	25,436		
8/44	28,269		
9/44	36,485		
10/44	41,393		
11/44	42,435		
12/44	n/a		
1/45	n/a		
2/45	n/a		
3/45	n/a		
4/45	n/a		
5/45	n/a		
6/45	n/a		
7/45	50,698		
8/45	49,133		
9/45	46,152		
10/45	40,417[b]		
11/45	48,270		
12/45	47,203		
1/46	49,722		
2/46	50,241		
3/46	46,761		
4/46			52,102
5/46			46,720
6/46			49,504
7/46			38,981
8/46			55,545
9/46			n/a
10/46			49,862
11/46			48,217
12/46			48,896
1/47			52,263
2/47			47,353
3/47			51,909
4/47			50,956
5/47		13,000[c]	36,844
6/47		13,000	33,117
7/47		13,418	34,990

TABLE A.2. (contd)

Date	Gallons of Milk and Cream Sold		
	Morning Milk	Darigold	Carnation[a]
8/47		11,530	40,592
9/47		10,589	47,267
10/47		10,256	54,953
11/47		8,709	58,415
12/47		10,485	65,016
1/48		8,625	72,710
2/48		7,294	76,460
3/48		8,572	82,201
4/48		6,818	83,202
5/48		6,519	83,622
6/48		8,228	103,126
7/48		7,198	90,975
8/48		6,821	92,765
9/48		6,655	96,609
10/48		8,668	93,323
11/48		7,735	93,025
12/48		8,454	97,773
1/49		7,867	98,308
2/49		6,680	93,251
3/49		6,375	101,013
4/49		4,050	91,648
5/49		3,069	81,325

(a) In 4/46, the Morning Milk Co became Carnation (see entries for 3/46 and 4/46 in Blondin and Hattrup 1989).
(b) Total is for a 25-day period (see entries for 10/45).
(c) Due to a discrepancy in the totals, it is believed that Darigold began to deliver milk to the area in 5/47. The number 13,000 is arbitrary and used to assist in the coherency of the analysis. The first official date Darigold is mentioned is in 6/47. At this date, the HWMR stated that Darigold had not reported its monthly distribution (see HWMR 5/47, 6/47, 7/47).

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APPENDIX B

ESTIMATES OF MILK DISTRIBUTION

APPENDIX B

ESTIMATES OF MILK DISTRIBTION

The estimates in this appendix were developed by Dr. Gerald Ward. They represent his expert opinion as to where milk consumed in the study area originated. Table B.1 contains information on which processing plants and producer/distributors supplied milk to each of the HEDR county census divisions (CCDs). The estimates are percentage estimates and include mean, minimum, and maximum values. Estimates are presented for rural and urban areas where appropriate. For example, for rural residents (designated by the capital R) in CCD AD1, 90 percent (max 100%, min 75%) received milk from a backyard cow and 10 percent (max 25%, min 0%) received their milk from the Spokane milk pool. There are no estimates for urban residents in AD1 because there were no incorporated places in this CCD.

Table B.2 contains information on which CCDs provided milk to the various commercial processing plants. As in Table B.1, the estimates are percentages and include mean, minimum, and maximum values. The tables are read in a similar fashion to Table B.1.

TABLE B.1a. Adams County Census Division Milk Source

R = Rural
U = Urban

ADAMS COUNTY	FAMILY COW	RITZVILLE DAIRY, P.D.	MAY'S DAIRY, P.D.	MORNING SUN	SPOKANE MILK POOL
AD1	R:Mean=90% Min.=75 Max.=100				R:Mean=10% Min.=0 Max.=25
AD2 Ritzville	R:Mean=90% Min.=75 Max.=100	U:Mean=25% Min.=0 Max.=50			R:Mean=10% Min.=0 Max.=25 U:Mean=75% Min.=50 Max.=100
AD3	R:Mean=90% Min.=75 Max.=100				R:Mean=10% Min.=0 Max.=25
AD4	R:Mean=90% Min.=75 Max.=100				R:Mean=10% Min.=0 Max.=25
AD5	R:Mean=90% Min.=75 Max.=100	U:Mean=10% Min.=0 Max.=25			R:Mean=10% Min.=0 Max.=25 U:Mean=90% Min.=75 Max.=100
AD6	R:Mean=90% Min.=75 Max.=100				R:Mean=10% Min.=0 Max.=25
AD7	R:Mean=90% Min.=75 Max.=100				R:Mean=10% Min.=0 Max.=25
AD8	R:Mean=90% Min.=75 Max.=100	U:Mean=10% Min.=0 Max.=25			R:Mean=10% Min.=0 Max.=25 U:Mean=90% Min.=75 Max.=100

TABLE B.1a. (Contd)

ADAMS COUNTY	FAMILY COW	RITZVILLE DAIRY, P.D.	MAY'S DAIRY, P.D.	MORNING SUN	SPOKANE MILK POOL
AD9	R:Mean=90% Min.=75 Max.=100	U:Mean=10% Min.=0 Max.=25			R:Mean=10% Min.=0 Max.=25 U:Mean=90% Min.=75 Max.=100
AD10	R:Mean=90% Min.=75 Max.=100		R:Mean=5% Min.=0 Max.=12.5 *U:Mean=50% Min.=25 Max.=75	R:Mean=5% Min.=0 Max.=12.5 *U:Mean=50% Min.=25 Max.=75	

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1b. Benton County Census Division Milk Source

BENTON COUNTY	FAMILY COW	DARIGOLD	CARNATION	TWIN CITY	FAIRVIEW GUERNSEY PROSSER
BE1 Benton City	R:Mean=90% Min.=80 Max.=100		R:Mean=5% Min.=0 Max.=10 U:Mean=60% Min.=50 Max.=70	R:Mean=5% Min.=0 Max.=10 U:Mean=40% Min.=30 Max.=50	
BE2	R:Mean=5% Min.=0 Max.=10		*R:Mean=95% Min.=90 Max.=100		
BE3 Kennewick	*R:Mean=75% Min.=60 Max.=90	R:Mean=5% Min.=0 Max.=10 U:Mean=20% Min.=10 Max.=30	R:Mean=5% Min.=0 Max.=10 U:Mean=20% Min.=10 Max.=30	R:Mean=15% Min.=10 Max.=20 U:Mean=60% Min.=40 Max.=70	
BE4	R:Mean=80% Min.=70 Max.=90			R:Mean=20% Min.=10 Max.=30	
BE5	R:Mean=90% Min.=80 Max.=100				R:Mean=10% Min.=0 Max.=20
BE6 Prosser		U:Mean=25% Min.=0 Max.=50	U:Mean=25% Min.=0 Max.=50		U:Mean=50% Min.=40 Max.=60
	R:Mean=90% Min.=80 Max.=100				R:Mean=10% Min.=0 Max.=20
BE7 Richland	R:Mean=50% Min.=40 Max.=60 U:Mean=5% Min.=0 Max.=10		R:Mean=50% Min.=40 Max.=60 *U:Mean=95% Min.=90 Max.=100		

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1b. (Contd)

BENTON COUNTY	FAMILY COW	DARIGOLD	CARNATION	TWIN CITY	GUERNSEY PROSSER
BE8	*R:Mean=75% Min.=60 Max.=90	R:Mean=5% Min.=0 Max.=10	R:Mean=5% Min.=0 Max.=10	R:Mean=15% Min.=10 Max.=20	
BE9 West Richland	R:Mean=90% Min.=80 Max.=100		R:Mean=5% Min.=0 Max.=10 U:Mean=70% Min.=60 Max.=80	R:Mean=5% Min.=0 Max.=10 U:Mean=30% Min.=20 Max.=40	

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1c. Franklin County Census Division Milk Source

FRANKLIN COUNTY	FAMILY COW	LOCAL PROD/DIST	TWIN CITY SPREEN	CARNATION DIST.CTR. RICHLAND	DARIGOLD DST.CTR. KENNEWICK	CONNELL DAIRY CONNELL
FR1 Connell, Mesa	R:Mean=50% Min.=30 Max.=70		R:Mean=10% Min.=0 Max.=20 U:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=40	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=40	R:Mean=20% Min.=10 Max.=30 U:Mean=30% Min.=20 Max.=40
FR2 Kahlotus	R:Mean=50% Min.=30 Max.=70		*R:Mean=10% Min.=0 Max.=20	R:Mean=20% Min.=10 Max.=30 U:Mean=40% Min.=30 Max.=50	R:Mean=20% Min.=10 Max.=30 U:Mean=40% Min.=30 Max.=50	U:Mean=20% Min.=10 Max.=30
FR3 Pasco, Pasco West	*R:Mean=91% Min.=70 Max.=100		R:Mean=3% Min.=0 Max.=10 U:Mean=40% Min.=20 Max.=60	R:Mean=3% Min.=0 Max.=10 U:Mean=30% Min.=20 Max.=40	R:Mean=3% Min.=0 Max.=10 U:Mean=30% Min.=20 Max.=40	
FR4	*R:Mean=75% Min.=45 Max.=90		R:Mean=5% Min.=0 Max.=15	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20	
FR5	*R:Mean=75% Min.=45 Max.=90		R:Mean=5% Min.=0 Max.=15	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20	

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1d. Grant County Census Division Milk Source

GRANT COUNTY	FAMILY COW	LOCAL PROD/DIST	MORNING SUN	WILLOW PT. DAIRY G. COULEE	SWEET CLOVER DAIRY QUINCY
GR1 Elect.City, Cooke	R:Mean=75% Min.=50 Max.=90			R:Mean=12.5% Min.=0 Max.=25 *U:Mean=50% Min.=20 Max.=80	
GR2 Hartline, CouleeCity	R:Mean=75% Min.=50 Max.=90			R:Mean=12.5% Min.=0 Max.=25 U:Mean=25% Min.=0 Max.=50	
GR3	*R:Mean=75% Min.=60 Max.=90				
GR4 Grupp, Wilson	*R:Mean=75% Min.=60 Max.=90 *U:Mean=75% Min.=60 Max.=90		*R:Mean=25% Min.=10 Max.=40 U:Mean=25% Min.=10 Max.=40		
GR5 Soap Lake	R:Mean=75% Min.=50 Max.=90		R:Mean=12.5% Min.=0 Max.=25 *U:Mean=50% Min.=25 Max.=75		

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1d. (Contd)

GRANT COUNTY	FAMILY COW	LOCAL PROD/DIST	MORNING SUN	WILLOW PT. DAIRY G. COULEE	SWEET CLOVER DAIRY QUINCY
GR6 Quincy	R:Mean=75% Min.=50 Max.=90		R:Mean=12.5% Min.=0 Max.=25 U:Mean=50% Min.=25 Max.=75		R:Mean=12.5% Min.=0 Max.=25 U:Mean=50% Min.=25 Max.=75
GR7 MosesLake, WestLake	*R:Mean=75% Min.=60 Max.=90		R:Mean=25% Min.=10 Max.=40 U:Mean=100% Min.=100 Max.=100		
GR8 Moses Lake N.	*R:Mean=75% Min.=60 Max.=90		R:Mean=25% Min.=10 Max.=40 U:Mean=100% Min.=100 Max.=100		
GR9	*R:Mean=75% Min.=60 Max.=90		R:Mean=25% Min.=10 Max.=40		
GR10 Warden	R:Mean=75% Min.=60 Max.=90 U:Mean=25% Min.=0 Max.=50		R:Mean=25% Min.=10 Max.=40 U:Mean=75% Min.=50 Max.=100		

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1d. (Contd)

GRANT COUNTY	FAMILY COW	LOCAL PROD/DIST	MORNING SUN	WILLOW PT. DAIRY G. COULEE	SWEET CLOVER DAIRY QUINCY
GR11 George	*R:Mean=75% Min.=60 Max.=90		*R:Mean=25% Min.=10 Max.=40 *U:Mean=100% Min.=100 Max.=100		
GR12 Royal City	*R:Mean=75% Min.=60 Max.=90		R:Mean=25% Min.=10 Max.=40 U:Mean=100% Min.=100 Max.=100		
GR13 Mattawa	*R:Mean=75% Min.=60 Max.=90 *U:Mean=75% Min.=60 Max.=90		R:Mean=25% Min.=10 Max.=40 U:Mean=25% Min.=10 Max.=40		
GR14 Ephrata			U:Mean=50% Min.=25 Max.=75		

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1d. (Contd)

	SWANSON'S DAIRY EPHRATA	SPOKANE MILK POOL
GR1 Elect.City, Cooke		R:Mean=12.5% Min.=0 Max.=25 *U:Mean=50% Min.=20 Max.=80
GR2 Heartline, Coulee City		R:Mean=12.5 Min.=0 Max.=25 U:Mean=75% Min.=50 Max.=100
GR3	R:Mean=25% Min.=10 Max.=40	
GR4 Grupp, Wilson		
GR5 Soap Lake	R:Mean=12.5% Min.=0 Max.=25 U:Mean=50% Min.=25 Max.=75	
GR6 Quincy		
GR7 Moses Lake, West Lake		
GR8 Moses Lake N.		

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1d. (Contd)

	SWANSON'S DAIRY EPHRATA	SPOKANE MILK POOL
GR9		
GR10 Warden		
GR11 George		
GR12 Royal City		
GR13 Mattawa		
GR14 Ephrata	U:Mean=50% Min.=25 Max.=75	

TABLE B.1e. Kittitas County Census Division Milk Source

KITTITAS COUNTY	FAMILY COW	GREGORY	ENFIELD	CARNATION	FAUST	VENERRA
KI1	R:Mean=80% Min.=70 Max.=90		*R:Mean=20% Min.=10 Max.=30			
KI2	R:Mean=50% Min.=30 Max.=70					
KI3	R:Mean=50% Min.=30 Max.=70					
KI4	R:Mean=50% Min.=30 Max.=70					
KI5 Cle Elum, Roslyn						*R:Mean=5% Min.=0 Max.=10 *U:Mean=5% Min.=0 Max.=10
KI6						
KI7	R:Mean=80% Min.=70 Max.=90		*R:Mean=20% Min.=10 Max.=30			
KI8	R:Mean=80% Min.=70 Max.=90		*R:Mean=20% Min.=10 Max.=30			
KI9	R:Mean=80% Min.=70 Max.=90		*R:Mean=20% Min.=10 Max.=30			
KI10	R:Mean=80% Min.=70 Max.=90		*R:Mean=20% Min.=10 Max.=30			
KI11		U:Mean=25% Min.=10 Max.=40	U:Mean=50% Min.=25 Max.=75		U:Mean=25% Min.=10 Max.=40	

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1e. (Contd)

	KAYNER'S DAIRY ROSLYN	DEL DUCCO ROSLYN	SAWYER'S	SPENSER	LUND	SNOWWHITE
KI1						
KI2			R:Mean=50% Min.=30 Max.=70			
KI3			R:Mean=50% Min.=30 Max.=70			
KI4			R:Mean=50% Min.=30 Max.=70			
KI5 Cle Elum, Roslyn	R:Mean=10% Min.=0 Max.=20 U:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20 U:Mean=10% Min.=0 Max.=20	*R:Mean=75% Min.=50 Max.=100 *U:Mean=75% Min.=50 Max.=100			
KI6	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20	*R:Mean=65% Min.=50 Max.=100	*R:Mean=5% Min.=0 Max.=10	*R:Mean=5% Min.=0 Max.=10	*R:Mean=5% Min.=0 Max.=10
KI7						
KI8						
KI9						
KI10						
KI11 Ellensburg						

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1f. Klickitat County Census Division Milk Source

KLICKITAT COUNTY	FAMILY COW	LOCAL PRDD/DIST	PORTLAND MILK SHED
KL1	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
KL2	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
KL3 Goldendale	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20 U:Mean=50% Min.=25 Max.=75	R:Mean=10% Min.=0 Max.=20 U:Mean=50% Min.=25 Max.=75
KL4	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
KL5	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
KL6	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
KL7 White Salmon	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20 U:Mean=100% Min.=100 Max.=100
KL8	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
KL9	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
KL10	*R:Mean=80% Min.=60 Max.=100	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1g. Morrow County Census Division Milk Source

MORROW COUNTY	FAMILY COW	PORTLAND MILK SHED	LOCAL PROD/DIST	MAYFLOWER HERMISTON
M01	R:Mean=60% Min.=30 Max.=90	R:Mean=10% Min.=0 Max.=20 *U:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20 U:Mean=20% Min.=10 Max.=30	R:Mean=20% Min.=0 Max.=40 U:Mean=70% Min.=50 Max.=80
M02 Heppner	R:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50	R:Mean=25% Min.=0 Max.=50	
M03	R:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50	R:Mean=25% Min.=0 Max.=50	

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1h. Umatilla County Census Division Milk Source

UMATILLA COUNTY	FAMILY COW	LOCAL PROD/DIST	MAYFLOWER HERMISTON	PENDLETON
UM1	R:Mean=50% Min.=25 Max.=75	R:Mean=20% Min.=10 Max.=30		
UM2	R:Mean=50% Min.=25 Max.=75	R:Mean=20% Min.=10 Max.=30 U:Mean=10% Min.=5 Max.=15		
UM3 Hermiston	R:Mean=50% Min.=25 Max.=75 U:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50 U:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50	
UM4	R:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50	R:Mean=15% Min.=0 Max.=30	*R:Mean=10% Min.=5 Max.=15
UM5 Milton Freewater		U:Mean=10% Min.=5 Max.=15		
UM6 Pendleton				U:Mean=70% Min.=50 Max.=90
UM7	R:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50	R:Mean=15% Min.=0 Max.=30	*R:Mean=10% Min.=5 Max.=15
UM8 Reserva-tion	R:Mean=50% Min.=25 Max.=75	R:Mean=10% Min.=0 Max.=20		R:Mean=40% Min.=20 Max.=60

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1h. (Contd)

UMATILLA COUNTY	FAMILY COW	LOCAL PROD/DIST	MAYFLOWER HERMISTON	PENDLETON
UM9	R:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50	R:Mean=25% Min.=0 Max.=50	
UM10	R:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50	R:Mean=15% Min.=0 Max.=30	*R:Mean=10% Min.=5 Max.=15
UM11	R:Mean=50% Min.=25 Max.=75	R:Mean=20% Min.=10 Max.=30 U:Mean=10% Min.=5 Max.=15		
UM12 Umatilla	R:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50 U:Mean=50% Min.=25 Max.=75	R:Mean=25% Min.=0 Max.=50 U:Mean=50% Min.=25 Max.=75	
UM13	R:Mean=50% Min.=25 Max.=75	R:Mean=20% Min.=10 Max.=30		
UM14	R:Mean=50% Min.=25 Max.=75	R:Mean=20% Min.=10 Max.=30		

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1h. (Contd)

	WALLA WALLA DAIRYMAN'S	YOUNG'S	SHADY LAWN
UM1	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
UM2	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=50	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=50	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=50
UM3 Hermiston			
UM4			
UM5 Milton Freewater	U:Mean=30% Min.=10 Max.=50	U:Mean=30% Min.=10 Max.=50	U:Mean=30% Min.=10 Max.=50
UM6 Pendleton	U:Mean=30% Min.=10 Max.=50		
UM7			
UM8 Reservation			
UM9			
UM10			
UM11	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=50	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=50	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=50
UM12 Umatilla			

TABLE B.1h. (Contd)

	WALLA WALLA DAIRYMAN'S	YOUNG'S	SHADY LAWN
UM13	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20
UM14	R:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20	*R:Mean=10% Min.=0 Max.=20

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1i. Walla Walla County Census Division Milk Source

WALLA WALLA COUNTY	FAMILY COW	PRESCOTT CO.	WALLA WALLA DUFF'S	DAIRYMAN'S	YOUNG'S
WA1 Prescott	R:Mean=50% Min.=40 Max.=60	R:Mean=40% Min.=30 Max.=50 U:Mean=70% Min.=60 Max.=80		R:Mean=5% Min.=0 Max.=10 U:Mean=15% Min.=10 Max.=20	R:Mean=5% Min.=0 Max.=10 U:Mean=15% Min.=10 Max.=20
WA2	R:Mean=50% Min.=40 Max.=60	R:Mean=20% Min.=10 Max.=30		R:Mean=5% Min.=0 Max.=10	R:Mean=5% Min.=0 Max.=10
WA3	R:Mean=50% Min.=40 Max.=60				
WA4 Touchet	R:Mean=75% Min.=50 Max.=100 U:Mean=15% Min.=5 Max.=20		R:Mean=5% Min.=0 Max.=10 U:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20 U:Mean=40% Min.=30 Max.=50	R:Mean=5% Min.=0 Max.=10 U:Mean=10% Min.=0 Max.=20
WA5	R:Mean=50% Min.=25 Max.=75		R:Mean=10% Min.=5 Max.=15	R:Mean=20% Min.=10 Max.=30	R:Mean=10% Min.=5 Max.=15
WA6 Waitsburg	R:Mean=50% Min.=25 Max.=75	U:Mean=15% Min.=10 Max.=20	R:Mean=10% Min.=5 Max.=15 U:Mean=10% Min.=5 Max.=15	R:Mean=20% Min.=10 Max.=30 U:Mean=20% Min.=10 Max.=30	R:Mean=10% Min.=5 Max.=15 U:Mean=20% Min.=10 Max.=30
WA7	R:Mean=50% Min.=25 Max.=75		R:Mean=10% Min.=5 Max.=15	R:Mean=20% Min.=10 Max.=30	R:Mean=10% Min.=5 Max.=15

TABLE B.1i. (Contd)

WALLA WALLA COUNTY	FAMILY COW	PRESCOTT CO.	WALLA WALLA DUFF'S	DAIRYMAN'S	YOUNG'S
WA8 Walla Walla East	R:Mean=75% Min.=70 Max.=80 U:Mean=10% Min.=5 Max.=15		U:Mean=15% Min.=10 Max.=20	R:Mean=5% Min.=0 Max.=10 U:Mean=30% Min.=20 Max.=40	R:Mean=5% Min.=0 Max.=10 U:Mean=20% Min.=10 Max.=30
WA9 Garret	R:Mean=75% Min.=70 Max.=80 U:Mean=10% Min.=5 Max.=15		U:Mean=15% Min.=10 Max.=20	R:Mean=5% Min.=0 Max.=10 U:Mean=30% Min.=20 Max.=40	R:Mean=5% Min.=0 Max.=10 U:Mean=20% Min.=10 Max.=30
WA10 College Place	U:Mean=10% Min.=5 Max.=15		U:Mean=15% Min.=10 Max.=20	U:Mean=30% Min.=20 Max.=40	U:Mean=20% Min.=10 Max.=30
WA11 Walla Walla	U:Mean=10% Min.=5 Max.=15		U:Mean=15% Min.=10 Max.=20	U:Mean=30% Min.=20 Max.=40	U:Mean=20% Min.=10 Max.=30

TABLE B.1i. (Contd)

	SHADY LAWN	TWIN CITY	CARNATION	DARIGOLD	LOCAL PROD/DIST
WA1 Prescott					
WA2		R:Mean=20% Min.=10 Max.=30			
WA3		R:Mean=40% Min.=30 Max.=50	R:Mean=5% Min.=0 Max.=10	R:Mean=5% Min.=0 Max.=10	
WA4 Touchet	R:Mean=5% Min.=0 Max.=10 U:Mean=10% Min.=0 Max.=20				U:Mean=15% Min.=5 Max.=20
WA5	R:Mean=10% Min.=5 Max.=15				
WA6 Waitsburg	R:Mean=10% Min.=5 Max.=15 U:Mean=20% Min.=10 Max.=30				U:Mean=15% Min.=10 Max.=20
WA7	R:Mean=10% Min.=5 Max.=15				
WA8 WallaWalla East	R:Mean=5% Min.=0 Max.=10 U:Mean=15% Min.=10 Max.=20				R:Mean=10% Min.=5 Max.=15 U:Mean=10% Min.=5 Max.=15

TABLE B.1i. (Contd)

	SHADY LAWN	TWIN CITY	CARNATION	DARIGOLD	LOCAL PROD/DIST
WA9 Garret	R:Mean=5% Min.=0 Max.=10 U:Mean=15% Min.=10 Max.=20				R:Mean=10% Min.=5 Max.=15 U:Mean=10% Min.=5 Max.=15
WA10 College Place	U:Mean=15% Min.=10 Max.=20				U:Mean=10% Min.=5 Max.=15
WA11 WallaWalla	U:Mean=15% Min.=10 Max.=20				U:Mean=10% Min.=5 Max.=15

TABLE B.1j. Yakima County Census Division Milk Source

YAKIMA COUNTY	FAMILY COW	SELAH HOME DAIRY	CASCADE	YAKIMA CITY	DARIGOLD	MACK'S
YA1 Terrace Heights		R:Mean=5% Min.=0 Max.=10 U:Mean=5% Min.=0 Max.=10	R:Mean=10% Min.=5 Max.=15 U:Mean=10% Min.=5 Max.=15	R:Mean=55% Min.=40 Max.=60 U:Mean=55% Min.=40 Max.=60	R:Mean=30% Min.=20 Max.=35 U:Mean=30% Min.=20 Max.=35	
YA2 Selah, Tieton	R:Mean=40% Min.=30 Max.=50	R:Mean=30% Min.=20 Max.=40 U:Mean=50% Min.=40 Max.=60	R:Mean=10% Min.=0 Max.=20 U:Mean=16% Min.=6 Max.=26	R:Mean=10% Min.=0 Max.=20 U:Mean=16% Min.=6 Max.=26	R:Mean=10% Min.=0 Max.=20 U:Mean=18% Min.=8 Max.=28	
YA3 Naches	R:Mean=40% Min.=30 Max.=50			R:Mean=10% Min.=0 Max.=20 U:Mean=5% Min.=0 Max.=10	R:Mean=10% Min.=0 Max.=20 U:Mean=5% Min.=0 Max.=10	
YA4	R:Mean=40% Min.=30 Max.=50			R:Mean=30% Min.=20 Max.=40	R:Mean=30% Min.=20 Max.=40	
YA5 Yakima, Union Gap, Fairview	R:Mean=40% Min.=30 Max.=50	R:Mean=5% Min.=0 Max.=10 U:Mean=5%	R:Mean=10% Min.=5 Max.=15 U:Mean=10%	R:Mean=30% Min.=20 Max.=40 *U:Mean=50%	R:Mean=15% Min.=5 Max.=25	
*U:Mean=30%*U:Mean=5%		Min.=0 Max.=10	Min.=5 Max.=15	Min.=40 Max.=60	Min.=20 Max.=35	Min.=0 Max.=10

TABLE B.1j. (Contd)

YAKIMA COUNTY	FAMILY COW	SELAH HOME DAIRY	CASCADE	YAKIMA CITY	DARIGOLD	MACK'S
YA6 Moxee	R:Mean=40% Min.=30 Max.=50		*R:Mean=10% Min.=0 Max.=20 U:Mean=10% Min.=0 Max.=20	R:Mean=10% Min.=0 Max.=20 U:Mean=20% Min.=10 Max.=30	*R:Mean=10% Min.=0 Max.=20 U:Mean=20% Min.=10 Max.=30	
YA7 Toppenish, Wapato, Harrah, Zillah, Granger	*R:Mean=75% Min.=60 Max.=85			R:Mean=5% Min.=0 Max.=10 U:Mean=10% Min.=0 Max.=20	R:Mean=5% Min.=0 Max.=10 U:Mean=30% Min.=20 Max.=40	
YA8 Yakima Ind.			*R:Mean=25% Min.=15 Max.=35	U:Mean=25% Min.=15 Max.=35 *R:Mean=50% Min.=40 Max.=60	U:Mean=50% Min.=40 Max.=60 *R:Mean=25% Min.=15 Max.=35	U:Mean=25% Min.=15 Max.=35
YA9 Sunnyside	*R:Mean=75% Min.=60 Max.=85			U:Mean=5% Min.=0 Max.=10	U:Mean=5% Min.=0 Max.=10	
YA10	R:Mean=75% Min.=60 Max.=85					
YA11			U:Mean=25% Min.=15 Max.=35 *R:Mean=25% Min.=15 Max.=35	U:Mean=50% Min.=40 Max.=60 *R:Mean=50% Min.=40 Max.=60	U:Mean=25% Min.=15 Max.=35 *R:Mean=25% Min.=15 Max.=35	

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1j. (Contd)

YAKIMA COUNTY	FAMILY COW	SELAH HOME DAIRY	CASCADE	YAKIMA CITY	DARIGOLD	MACK'S
YA12			U:Mean=25% Min.=15 Max.=35 *R:Mean=25% Min.=15 Max.=35	U:Mean=50% Min.=40 Max.=60 *R:Mean=50% Min.=40 Max.=60	U:Mean=25% Min.=15 Max.=35 *R:Mean=25% Min.=15 Max.=35	

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1j. (Contd)

	NACHES LOCAL PROD/DIST	MOXEE LOCAL PRODUCERS	CARNATION	LOCAL PROD.YA7	LOCAL PROD.YA9
YA1 Terrace Heights					
YA2 Selah, Tieton					
YA3 Naches	*R:Mean=50% Min.=30 Max.=40 U:Mean=90% Min.=80 Max.=100				
YA4					
YA5 Yakima, Union Gap, Fairview					
YA6 Moxee		R:Mean=30% Min.=20 Max.=40 *U:Mean=50% Min.=40 Max.=60			
YA7 Topperish, Wapato, Harrah, Zillah, Granger			R:Mean=5% Min.=0 Max.=10 U:Mean=30% Min.=20 Max.=40	R:Mean=10% Min.=0 Max.=20 U:Mean=30% Min.=20 Max.=40	
YA8 Yakima Ind.					

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.1j. (Contd)

	NACHES LOCAL PROD/DIST	MOXEE LOCAL PRODUCERS	CARNATION	LOCAL PROD.YA7	LOCAL PROD.YA9
YA9					
Sunnyside			R:Mean=15% Min.=10 Max.=20 U:Mean=75% Min.=60 Max.=85		R:Mean=10% Min.=0 Max.=20 U:Mean=15% Min.=10 Max.=20
YA10			R:Mean=15% Min.=10 Max.=20		R:Mean=10% Min.=0 Max.=20
YA11					
YA12					

TABLE B.2. Processor/Distributor Milk Source by Census Division

ENFIELD	SPENCER CleElum	P.D. LUND	P.D. SNOWWHITE	P.D. VENERRA	GREGORY Ellensburg
KI8 Mean=22% Min.=17 Max.=27	KI6 Mean=100% Min.=100 Max.=100	KI6 Mean=100% Min.=100 Max.=100	KI6 Mean=100% Min.=100 Max.=100	KI5 Mean=100% Min.=100 Max.=100	*KI10 Mean=50% Min.=25 Max.=75
KI7 Mean=78% Min.=73 Max.=83					*KI9 Mean=50% Min.=25 Max.=75

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.2. (Contd)

YAKIMA CITY CREAMERY	CARNATION Sunnyside	DARIGOLO	CASCADE	MACK'S	MAPLE LEAF	MCCOLUM'S
YA2 Mean=28% Min.=23 Max.=33		YA2 Mean=28% Min.=18 Max.=38	YA2 Mean=28% Min.=18 Max.=38			
YA5 Mean=19% Min.=14 Max.=24		YA5 Mean=21% Min.=11 Max.=31	YA5 Mean=21% Min.=11 Max.=31	YA5 Mean=100% Min.=100 Max.=100		
YA7 Mean=37% Min.=32 Max.=42	*YA7 Mean=25% Min.=20 Max.=30	YA7 Mean=40% Min.=30 Max.=50	YA7 Mean=40% Min.=30 Max.=50		YA7 Mean=100% Min.=100 Max.=100	YA7 Mean=100% Min.=100 Max.=100
YA9 Mean=12% Min.=7 Max.=17	YA9 Mean=59% Min.=54 Max.=64	YA9 Mean=11% Min.=1 Max.=21	YA9 Mean=11% Min.=1 Max.=21			
BE5 Mean=4% Min.=0 Max.=9	KI1 Mean=3% Min.=0 Max.=8					
	KI7 Mean=2% Min.=0 Max.=7					
	KI8 Mean=7% Min.=2 Max.=12					
	KI10 Mean=4% Min.=0 Max.=9					

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.2. (Contd)

SELAH	MAYFLOWER Hermiston	Pendleton	MORNING SUN Moses Lake	SWEET WILLOW POINT	CLOVER Quincy	SWANSON'S	CONNELL DAIRY
YA2	MO1	*UM4	*GR7	GR1	GR6	GR5	FR1
Mean=100%	Mean=100%	Mean=35%	Mean=75%	Mean=100%	Mean=100%	Mean=100%	Mean=100%
Min.=100	Min.=100	Min.=25	Min.=60	Min.=100	Min.=100	Min.=100	Min.=100
Max.=100	Max.=100	Max.=45	Max.=90	Max.=100	Max.=100	Max.=100	Max.=100
		*UM7	*KI1				
		Mean=35%	Mean=5%				
		Min.=25	Min.=0				
		Max.=45	Max.=10				
		*UM8	*KI7				
		Mean=30%	Mean=3%				
		Min.=20	Min.=0				
		Max.=40	Max.=8				
			*KI8				
			Mean=10%				
			Min.=5				
			Max.=15				
			*KI10				
			Mean=7%				
			Min.=2				
			Max.=12				

* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

TABLE B.2. (Contd)

MAY'S Othello	RITZVILLE DAIRY Ritzville	YOUNG'S	WALLA WALLA DAIRYMAN'S	PRESCOTT CREAMERY Prescott	DUFF'S	SHADY LAWN
AD10 Mean=100% Min.=100 Max.=100	AD2 Mean=100% Min.=100 Max.=100	WA4 Mean=40% Min.=30 Max.=50	WA4 Mean=40% Min.=30 Max.=50	WA1 Mean=100% Min.=100 Max.=100	WA4 Mean=40% Min.=30 Max.=50	WA4 Mean=40% Min.=30 Max.=50
		WA9 Mean=40% Min.=30 Max.=50	WA9 Mean=40% Min.=30 Max.=50		WA9 Mean=40% Min.=30 Max.=50	WA9 Mean=40% Min.=30 Max.=50
		WA8 Mean=10% Min.=0 Max.=20	WA8 Mean=10% Min.=0 Max.=20		WA8 Mean=10% Min.=0 Max.=20	WA8 Mean=10% Min.=0 Max.=20
		UM11 Mean=5% Min.=0 Max.=15	UM11 Mean=5% Min.=0 Max.=15		UM11 Mean=5% Min.=0 Max.=15	UM11 Mean=5% Min.=0 Max.=15
		UM2 Mean=5% Min.=0 Max.=15	UM2 Mean=5% Min.=0 Max.=15		UM2 Mean=5% Min.=0 Max.=15	UM2 Mean=5% Min.=0 Max.=15

TABLE B.2. (Contd)

FAIRVIEW Prosser	TWIN CITY/SPREAN	FAUST YOUNG'S	KAYNER'S Roslyn	DEL DUCCO Roslyn	SAWYER'S
BE5 Mean=100% Min.=100 Max.=100	BE4 Mean=10% Min.=5 Max.=15	*KI9 Mean=50% Min.=25 Max.=75	*KI5 Mean=100% Min.=100 Max.=100	*KI5 Mean=100% Min.=100 Max.=100	*KI5 Mean=50% Min.=25 Max.=75
	BE1 Mean=16% Min.=11 Max.=21	*KI10 Mean=50% Min.=25 Max.=75			*KI6 Mean=50% Min.=25 Max.=75
	BE5 Mean=37% Min.=32 Max.=42				
	FR4 Mean=19% Min.=14 Max.=24				
	FR5 Mean=18% Min.=13 Max.=23				

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* This cell has been changed from the first release of the Census Division Milk Source Matrix dated July 1989.

APPENDIX C

MILK COW FEED INTAKE ASSIGNED VALUES

APPENDIX C

MILK COW FEED INTAKE ASSIGNED VALUES

To generate milk cow feed intake values, estimates of feeding regimes, pasture start and finish days, and hay cutting dates were required. These values were assigned based on expert opinion regarding dairy practices and recorded weather information.

Values for the percent of milk production associated with each of four feeding regimes were assigned for each census subdivision in the Phase I area. Dr. Gerald Ward assigned these values during a working meeting on June 27, 1989. The values, including a mean and a range for each feeding regime, are shown in Table C.1.

Values were also assigned for the average dates that milk cows were placed in pastures in the spring and removed from pasture in the fall in each census subdivision. These values were based on weather station information on the last day of frost in the spring and the first day of frost in the fall and estimates provided by various experts, i.e., Dr. Gerald Ward, Mr. Eddie Thomason, Mr. Bill McCaw, and Mr. Bob Duncan. The pasture start day in a census subdivision is equal to the last day of spring frost assigned to the subdivision plus 20 days. The pasture finish day is equal to the first day of fall minus 20 days. Variability estimates were provided by Dr. Gerald Ward The results are listed in Table C.2.

The information presented in Table C.2 represent "average" start and finish days for pasture. In actuality, pasture becomes available earlier or later in the spring as the weather is warmer or cooler than normal. A similar process occurs in the fall. To capture such year to year changes, additional adjustments are required. The adjustments are as follows. For 1945, use the average pasture start days as is, but add 3 days to the average pasture finish days. For 1946, subtract 8 days from the average pasture start days and subtract 3 days from the average pasture finish days. For 1947, subtract 14 days from the average pasture start days and add 14 days to

TABLE C.1. Percentage of Milk Production Assigned to Various Feeding Regimes for the County Census Divisions of the Phase I Study Area, 1944-1947

(Percent Milk Production)

Census Subdivision	Feeding Regime: Grain, Alfalfa Hay, Pasture, and Silage		Grain, Alfalfa, Hay and Pasture		Grain and Alfalfa Hay		Grain and Grass Hay	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Adams County								
AD1					5	0-10	95	90-100
AD2					5	0-10	95	90-100
AD3					5	0-10	95	90-100
AD4					5	0-10	95	90-100
AD5					5	0-10	95	90-100
AD6					5	0-10	95	90-100
AD7					5	50-10	95	90-100
AD8					5	50-10	95	90-100
AD9					5	50-10	95	90-100
AD10					5	50-10	95	90-100
Benton County								
BE1	45	20-65	45	20-65	10	0-15		
BE2	45	20-65	50	20-65	5	0-15		
BE3	45	20-65	50	20-65	5	0-15		
BE4	45	20-65	50	20-65	5	0-15		
BE5	45	20-65	50	20-65	5	0-15		
BE6					95	90-100	5	0-10
BE7	45	20-65	50	20-65	5	0-15		
BE8			5	0-10			95	90-100
BE9			5	0-10			95	90-100
Franklin County								
FR1	45	20-65	45	20-65			10	0-15
FR2					5	0-10	95	90-100
FR3	45	20-65	45	20-65	10	0-15		
FR4	45	20-65	45	20-65			10	0-15
FR5	45	20-65	45	20-65	10	0-15		

TABLE C.1. (contd)

(Percent Milk Production)

Census Subdivision	Feeding Regime: Grain, Alfalfa Hay, Pasture, and Silage Mean	Range	Grain, Alfalfa, Hay and Pasture Mean	Range	Grain and Alfalfa Hay Mean	Range	Grain and Grass Hay Mean	Range
Grant County								
GR1					5	0-10	95	90-100
GR2					5	0-10	95	90-100
GR3					5	0-10	95	90-100
GR4					5	0-10	95	90-100
GR5					5	0-10	95	90-100
GR6					5	0-10	95	90-100
GR7	45	20-65	50	25-70	5	0-10		
GR8	45	20-65	50	25-70	5	0-10		
GR9					5	0-10	95	90-100
GR10					5	0-10	95	90-100
GR11					5	0-10	95	90-100
GR12					5	0-10	95	90-100
GR13					5	0-10	95	90-100
GR14					5	0-10	95	90-100
Kittitas County								
KI1	45	20-65	45	20-65	10	0-15		
KI2					5	0-10	95	90-100
KI3					5	0-10	95	90-100
KI4					5	0-10	95	90-100
KI5					5	0-10	95	90-100
KI6	45	20-65	45	20-65	10	0-15		
KI7	45	20-65	45	20-65	10	0-15		
KI8	45	20-65	45	20-65	10	0-15		
KI9	45	20-65	45	20-65	10	0-15		
KI10	45	20-65	45	20-65	10	0-15		
KI11	45	20-65	45	20-65	10	0-15		

TABLE C.1. (contd)

(Percent Milk Production)

Census Subdivision	Feeding Regime: Grain, Alfalfa Hay, Pasture, and Silage Mean	Range	Grain, Alfalfa, Hay and Pasture Mean	Range	Grain and Alfalfa Hay Mean	Range	Grain and Grass Hay Mean	Range
Klickitat County								
KL1					5	0-10	95	90-100
KL2					5	0-10	95	90-100
KL3					5	0-10	95	90-100
KL4					5	0-10	95	90-100
KL5			90	50-100	10	0-15		
KL6			90	50-100	10	0-15		
KL7					5	0-10	95	90-100
KL8					5	0-10	95	90-100
KL9					5	0-10	95	90-100
KL10					5	0-10	95	90-100
Walla Walla County								
WA1					5	0-10	95	90-100
WA2					5	0-10	95	90-100
WA3					5	0-10	95	90-100
WA4	45	20-65	45	20-65	10	0-15		
WA5					5	0-10	95	90-100
WA6					5	0-10	95	90-100
WA7					5	0-10	95	90-100
WA8	45	20-65	45	20-65	10	0-15		
WA9	45	20-65	45	20-65	10	0-15		
WA10	45	20-65	45	20-65	10	0-15		
WA11	45	20-65	45	20-65	10	0-15		

TABLE C.1. (contd)

(Percent Milk Production)

Census Subdivision	Feeding Regime: Grain, Alfalfa Hay, Pasture, and Silage Mean	Range	Grain, Alfalfa, Hay and Pasture Mean	Range	Grain and Alfalfa Hay Mean	Range	Grain and Grass Hay Mean	Range
Yakima County								
YA1					5	0-10	95	90-100
YA2	45	20-65	45	20-65	10	0-15		
YA3	45	20-65	45	20-65	10	0-15		
YA4	45	20-65	45	20-65	10	0-15		
YA5	45	20-65	45	20-65	10	0-15		
YA6	45	20-65	45	20-65	10	0-15		
YA7	45	20-65	45	20-65	10	0-15		
YA8					5	0-10	95	90-100
YA9	45	20-65	45	20-65	10	0-15		
YA10	45	20-65	45	20-65	10	0-15		
YA11					5	0-10	95	90-100
YA12					5	0-10	95	90-100
Morrow County								
MO1	45	20-65	45	20-65	10	0-15		
MO2	45	20-65	45	20-65	10	0-15		
MO3	45	20-65	45	20-65	10	0-15		
Umatilla County								
UM1					5	0-10	95	90-100
UM2	45	20-65	45	20-65	10	0-15		
UM3	45	20-65	45	20-65	10	0-15		
UM4					5	0-10	95	90-100
UM5					5	0-10	95	90-100
UM6					5	0-10	95	90-100
UM7	45	20-65	45	20-65	10	0-15		
UM8					5	0-10	95	90-100
UM9	45	20-65	45	20-65	10	0-15		
UM10					5	0-10	95	90-100
UM11	45	20-65	45	20-65	10	0-15		
UM12	45	20-65	45	20-65	10	0-15		
UM13					5	0-10	95	90-100
UM14					5	0-10	95	90-100

Assignments made by Dr. Gerald Ward during a working meeting, June 27, 1989.

TABLE C.2. Average Pasture Start and Finish Days in Phase I Study Area, 1944-1947

(Number of days from the beginning of the calendar year)

Census Subdivision	Pasture Start Day		Pasture Finish Day	
	Mean	Range	Mean	Range
Benton County				
BE1	110	100-120	280	260-300
BE2	105	95-115	280	260-300
BE3	105	95-115	280	260-300
BE4	105	95-115	280	260-300
BE5	110	100-120	280	260-300
BE6	110	100-120	280	260-300
BE7	105	95-115	280	260-300
BE8	105	95-115	280	260-300
BE9	105	95-115	280	260-300
Franklin County				
FR1	105	95-115	280	260-300
FR2				
FR3	105	95-115	280	260-300
FR4	105	95-115	280	260-300
FR5	105	95-115	280	260-300
Kittitas County				
KI1	130	120-140	270	250-290
KI2				
KI3				
KI4				
KI5				
KI6	140	130-150	260	240-280
KI7	130	120-140	260	240-280
KI8	130	120-140	270	250-290
KI9	130	120-140	260	240-280
KI10	130	120-140	260	240-280
KI11	130	120-140	260	240-280

TABLE C.2. (contd)

(Number of days from the beginning of the calendar year)

Census Subdivision	Pasture Start Day Mean	Pasture Start Day Range	Pasture Finish Day Mean	Pasture Finish Day Range
Klickitat County				
KL1				
KL2				
KL3				
KL4				
KL5	130	120-140	270	250-290
KL6	130	120-140	270	250-290
KL7				
KL8				
KL9				
KL10				
Walla Walla County				
WA1				
WA2				
WA3				
WA4	110	100-120	280	260-300
WA5				
WA6				
WA7				
WA8	105	95-115	280	260-300
WA9	105	95-115	280	260-300
WA10	105	95-115	280	260-300
WA11	105	95-115	280	260-300
Yakima County				
YA1				
YA2	120	110-130	270	250-290
YA3	120	110-130	270	250-290
YA4	120	110-130	270	250-290
YA5	115	105-125	270	250-290
YA6	115	105-125	270	250-290
YA7	115	105-125	270	250-290
YA8				
YA9	110	100-120	280	260-300
YA10	110	100-120	280	260-300
YA11				
YA12				

TABLE C.2. (contd)

(Number of days from the beginning of the calendar year)

Census Division	Pasture Start Day		Pasture Finish Day	
	Mean	Range	Mean	Range
Morrow County				
MO1	105	95-115	280	260-300
MO2	115	105-125	275	255-295
MO3	120	110-130	280	260-300
Umatilla County				
UM1	100	90-110	285	265-305
UM2	100	90-110	285	265-305
UM3	120	110-130	280	260-300
UM4				
UM5				
UM6				
UM7	120	110-130	275	255-295
UM8				
UM9	120	110-130	280	260-300
UM10				
UM11	100	90-110	285	265-305
UM12	105	95-115	280	260-300
UM13				
UM14				

NOTE: To adjust these data for specific years requires some additional calculation. For 1945, use the average pasture start days as is, but add 3 days to the average pasture finish days. For 1946, subtract 8 days from the average pasture start days and subtract 3 days from the average pasture finish days. For 1947, subtract 14 days from the average pasture start days and add 14 days to the average pasture finish days. Make similar adjustments to the minimum and maximum values as well.

the average pasture finish days. Make similar adjustments to the minimum and maximum values as well. These adjustment estimates are based both on the occurrence of frost dates and on the three-month average daily temperature during the spring and fall at the Hanford weather station.

Milk cow intake was also affected by the date that hay crops were harvested. The average first cutting dates for alfalfa hay (Table C.3) and grass hay (Table C.4) were assigned by simply adding 66 days (for alfalfa) or 100 days (for grass) to the average last day of spring frost for the census subdivision. These algorithms are based on estimates provided by various experts. The average second and third cutting dates for alfalfa were assumed to occur 45 and 90 days, respectively, after the first cutting date (Table C.3).

The date of the first cuttings varies from year to year depending on how warm or cold the spring is that year. To adjust the alfalfa hay or grass hay cutting dates for 1945, use the appropriate hay average cutting day as is. For 1946, subtract 4 days from the average hay cutting day. For 1947, subtract 7 days from the average hay cutting day.

TABLE C.3. Average Alfalfa Hay Cutting Dates in the Phase I Study Area, 1944-1947

(Number of days from the beginning of the calendar year)

Census Subdivision	Cutting Number			
	First	Second	Third	Range
Adams County				
AD1	166	211	256	±7
AD2	166	211	256	±7
AD3	166	211	256	±7
AD4	166	211	256	±7
AD5	166	211	256	±7
AD6	166	211	256	±7
AD7	176	221	266	±7
AD8	176	221	266	±7
AD9	166	211	256	±7
AD10	166	211	256	±7
Benton County				
BE1	156	201	246	±7
BE2	151	196	241	±7
BE3	151	196	241	±7
BE4	151	196	241	±7
BE5	156	201	246	±7
BE6	156	201	246	±7
BE7	151	196	241	±7
BE8	151	196	241	±7
BE9	151	196	241	±7
Franklin County				
FR1	151	196	241	±7
FR2	151	196	241	±7
FR3	151	196	241	±7
FR4	151	196	241	±7
FR5	151	196	241	±7

TABLE C.3. (contd)

(Number of days from the beginning of the calendar year)

Census Subdivision	Cutting Number			
	First	Second	Third	Range
Grant County				
GR1	156	201	246	±7
GR2	161	206	251	±7
GR3	166	211	256	±7
GR4	166	211	256	±7
GR5	156	201	246	±7
GR6	156	201	246	±7
GR7	161	206	251	±7
GR8	166	211	256	±7
GR9	166	211	256	±7
GR10	166	211	256	±7
GR11	161	206	251	±7
GR12	161	206	251	±7
GR13	156	201	246	±7
GR14	151	196	241	±7
Kittitas County				
KI1	176	221	266	±7
KI2	186	231	276	±7
KI3	186	231	276	±7
KI4	186	231	276	±7
KI5	176	221	266	±7
KI6	186	231	276	±7
KI7	176	221	266	±7
KI8	176	221	266	±7
KI9	176	221	266	±7
KI10	176	221	266	±7
KI11	176	221	266	±7
Klickitat County				
KL1	176	221	266	±7
KL2	166	211	256	±7
KL3	171	216	261	±7
KL4	176	221	266	±7
KL5	176	221	266	±7
KL6	176	221	266	±7
KL7	171	216	261	±7
KL8	176	221	266	±7
KL9	166	211	256	±7
KL10	166	211	256	±7

TABLE C.3. (contd)

(Number of days from the beginning of the calendar year)

Census Subdivision	Cutting Number			
	First	Second	Third	Range
Walla Walla County				
WA1	161	206	251	±7
WA2	161	206	251	±7
WA3	156	201	246	±7
WA4	156	201	246	±7
WA5	156	201	246	±7
WA6	156	201	246	±7
WA7	161	206	251	±7
WA8	151	196	241	±7
WA9	151	196	241	±7
WA10	151	196	241	±7
WA11	151	196	241	±7
Yakima County				
YA1	166	211	256	±7
YA2	166	211	256	±7
YA3	166	211	256	±7
YA4	166	211	256	±7
YA5	161	206	251	±7
YA6	161	206	251	±7
YA7	161	206	251	±7
YA8	166	211	256	±7
YA9	156	201	246	±7
YA10	156	201	246	±7
YA11	156	201	246	±7
YA12	176	221	266	±7

TABLE C.3. (contd)

(Number of days from the beginning of the calendar year)

Census Subdivision	Cutting Number			
	First	Second	Third	Range
Morrow County				
MO1	151	196	241	±7
MO2	161	206	251	±7
MO3	166	211	256	±7
Umatilla County				
UM1	146	191	236	±7
UM2	146	191	236	±7
UM3	166	211	256	±7
UM4	156	201	246	±7
UM5	146	191	236	±7
UM6	166	211	256	±7
UM7	166	211	256	±7
UM8	166	211	256	±7
UM9	166	211	256	±7
UM10	166	211	256	±7
UM11	146	191	236	±7
UM12	151	196	241	±7
UM13	166	211	256	±7
UM14	166	211	256	±7

NOTE: To adjust these data for specific years requires some additional calculation. For 1945, use the average alfalfa hay cutting days as is. For 1946, subtract four (4) days from the average alfalfa hay cutting days. For 1947, subtract seven (7) days from the average alfalfa hay cutting days. Make similar adjustments to the minimum and maximum values as well.

TABLE C.4. Average Grass Hay Cutting Dates in the Phase I Study Area, 1944-1947.

(Number of days from the beginning of the calendar year)

Census Subdivision	Day Number	Range
Adams County		
AD1	200	±7
AD2	200	±7
AD3	200	±7
AD4	200	±7
AD5	200	±7
AD6	200	±7
AD7	210	±7
AD8	210	±7
AD9	200	±7
AD10	200	±7
Benton County		
BE1	190	±7
BE2	185	±7
BE3	185	±7
BE4	185	±7
BE5	190	±7
BE6	190	±7
8E7	185	±7
BE8	185	±7
BE9	185	±7
Franklin County		
FR1	185	±7
FR2	185	±7
FR3	185	±7
FR4	185	±7
FR5	185	±7

TABLE C.4. (contd)

(Number of days from the beginning of the calendar year)

Census Subdivision	Day Number	Range
Grant County		
GR1	190	±7
GR2	195	±7
GR3	200	±7
GR4	200	±7
GR5	190	±7
GR6	190	±7
GR7	195	±7
GR8	200	±7
GR9	200	±7
GR10	200	±7
GR11	195	±7
GR12	195	±7
GR13	190	±7
GR14	185	±7
Kittitas County		
KI1	210	±7
KI2	220	±7
KI3	220	±7
KI4	220	±7
KI5	210	±7
KI6	220	±7
KI7	210	±7
KI8	210	±7
KI9	210	±7
KI10	210	±7
KI11	210	±7
Klickitat County		
KL1	210	±7
KL2	200	±7
KL3	205	±7
KL4	210	±7
KL5	210	±7
KL6	210	±7
KL7	205	±7
KL8	210	±7
KL9	200	±7
KL10	200	±7

TABLE C.4. (contd)

(Number of days from the beginning of the calendar year)

Census Subdivision	Day Number	Range
Walla Walla County		
WA1	195	±7
WA2	195	±7
WA3	190	±7
WA4	190	±7
WA5	190	±7
WA6	190	±7
WA7	195	±7
WA8	185	±7
WA9	185	±7
WA10	185	±7
WA11	185	±7
Yakima County		
YA1	200	±7
YA2	200	±7
YA3	200	±7
YA4	200	±7
YA5	195	±7
YA6	195	±7
YA7	195	±7
YA8	200	±7
YA9	190	±7
YA10	190	±7
YA11	190	±7
YA12	210	±7
Morrow County		
MO1	185	±7
MO2	195	±7
MO3	200	±7

TABLE C.4. (contd)

(Number of days from the beginning of the calendar year)

Census Subdivision	Day Number	Range
Umatilla County		
UM1	180	±7
UM2	180	±7
UM3	200	±7
UM4	190	±7
UM5	180	±7
UM6	200	±7
UM7	200	±7
UM8	200	±7
UM9	200	±7
UM10	200	±7
UM11	180	±7
UM12	185	±7
UM13	200	±7
UM14	200	±7

NOTE: To adjust these data for specific years requires some additional calculation. For 1945, use the average grass hay cutting days as is. For 1946, subtract four (4) days from the average grass hay cutting days. For 1947, subtract seven (7) days from the average grass hay cutting days. Make similar adjustments to the minimum and maximum values as well.

APPENDIX D

ESTIMATING PASTURE INTAKE

APPENDIX D

ESTIMATING PASTURE INTAKE

In this appendix, the procedure used to estimate pasture intake per day per cow is presented in detail.

D.1 DEPENDENT VARIABLE

The dependent variable used in the regression analysis is equal to the total dry matter requirement per average cow per year less the dry matter obtained from grain and less the dry matter obtained from dry roughage:

$$DV = TDM - DMG - DMH \quad (1)$$

where DV = the dependent variable

TDM = the total dry matter required by the average cow per year

DMG = the dry matter obtained from grain by the average cow per year

DMH = the dry matter obtained from dry roughage by the average cow per year

The unit of measure for the dependent variable is *pounds of* dry matter per cow per year. The usual approach is to consider feed requirements only in terms of net energy, i.e., one million calories (Mcal) per cow per year. Although the dependent variable could have been formulated in some net energy unit, the dry matter unit of measure was chosen to obtain a direct estimate of the dry matter equivalent of an average day of pasture. If formulated in terms of net energy, then the problem of converting a net energy equivalent of pasture to a dry matter equivalent of pasture would still remain. That is not an easy problem to resolve.

D.2 TOTAL DRY MATTER (TDM)

TDM is equal to the dry matter requirement for milk plus the dry matter requirement for maintenance during the lactation period plus the dry matter requirement for maintenance during the last 60 days of pregnancy:

$$TDM = DMK + DMMK + DMMP \quad (2)$$

where DMK is the dry matter required by the average cow per year for milk production, DMMK is the dry matter required by the average cow per year for maintenance during the lactation period, and DMMP is the dry matter required by the average cow per year for maintenance during the last 60 days of pregnancy.

D.3 DRY MATTER REQUIREMENT FOR MILK (DMK)

The DMK depends on how much milk is produced by the average cow, as well as the proportion of milk that is cream. The basic steps required for calculating DMKs for the Yakima County DHIA herds include 1) determining the fat content of the milk, 2) estimating the net energy requirement for milk, and 3) converting the net energy requirement to a dry matter requirement.

The average fat content (in percent) of the milk of each herd was derived by dividing the average pounds of fat per cow per year by the average pounds of milk per cow per year and multiplying by 100:

$$\%FAT = 100 * (FAT/MILK) \quad (3)$$

The net energy requirement for a pound of milk was estimated by use of the following equation:

$$NEK/lb = 0.159571428 + (0.043571428 * \%FAT) \quad (4)$$

where NEK/lb is the net energy requirement for a pound of milk. This equation was derived from data presented in Foley et al. (1972) (see Section D.9).

Next, the NEKs were used to calculate the daily net energy requirement for the amount of milk produced by the average cow in the herds:

$$NEK/day = (NEK/lb * MILK)/305 \quad (5)$$

where 305 represents the number of days that the average cow is assumed to be producing milk.

The NEK/day is converted to dry matter requirements per day by

$$DMK/day = -0.115188 + (1.623063 * NEK/day) \quad (6)$$

where DMK/day is the daily dry matter requirement for the amount of milk produced by the average cow in the herds. This equation also was derived from data presented in Foley et al. (1972) (see Section D.10). DMK is then calculated by multiplying DMK/day by 305:

$$DMK = DMK/day * 305 \quad (7)$$

D.4 DRY MATTER FOR MAINTENANCE DURING LACTATION (DMMK)

DMMK depends primarily on the weight of the cow. The weight of the cow, in turn, depends upon the breed of cow. Estimating DMMKs, therefore, includes the following two steps: 1) estimating the weight of the average cow in the Yakima County herds and 2) determining the DMMKs given the estimated weights.

Table D.1 contains the algorithms used to convert the breed information (i.e., the abbreviations) given for the Yakima DHIA herds into estimated cow weights. The algorithms, in turn, are based on encyclopedic information (see Americana Corporation 1964), which is presented in Table D.2.

Once the body weights were estimated, daily DMMKs could be assigned directly from Table III-A in Foley et al. (1972). DMMKs were then calculated as

$$DMMK = 305 * DMMK/day \quad (8)$$

where DMMK/day is the daily dry matter required by the average cow during the lactation period.

TABLE D.1. Estimated Weights of Average Cows in Yakima County DHIA Herds During 1951

Breed	Abbreviation	Estimated Weight of Average Cow (lbs)
Registered and General Jersey	R&GJ	1,000
Registered Jersey	RJ	1,000
Registered Jersey and Mixed	RJ&M	1,100
Registered Guernsey	RG	1,100
Registered Ayrshire	RA	1,150
Registered Guernsey and Mixed	RG&M	1,200
Registered Holstein and Registered Jersey	RH&RJ	1,250
Registered Jersey and General Holstein	RJ&GH	1,250
Mixed	MIX,M	1,250
Registered Holstein, Registered Jersey and Mixed	RH&RJ&M	1,250
Registered Brown Swiss and Mixed	RBS&M	1,350
General Holstein and Mixed	GH&M	1,400
Registered Milking Shorthorn	RMS	1,400
General Holstein	GH	1,500
Registered Holstein	RH	1,500
Registered and General Holstein	R&GH	1,500

TABLE D.2. Typical Weights For Mature Cows Circa 1964

Breed	Weight (lbs)
Ayrshire	1,150
Brown Swiss	1,400
Holstein	1,500
Guernsey	1,100
Jersey	1,000
Milking Shorthorn	1,200 to 1,600

D.5 DRY MATTER FOR MAINTENANCE DURING THE LAST 60 DAYS OF PREGNANCY (DMMP)

DMMP like DMMK, depends primarily on the weight of the cow. And, like daily DMMKs, daily DMMPs could be assigned directly from Table III-A in Foley et al. (1972), once the body weights were estimated. DMMPs were then calculated as

$$DMMP = 60 * DMMP/day \quad (9)$$

where DMMP/day is the daily dry matter required by the average cow during the last 60 days of pregnancy.

D.6 DRY MATTER OBTAINED FROM GRAIN (DMG)

The amount of dry matter obtained from grain by the average cow per year can be derived by multiplying the amount of grain fed to the average cow in a year by the appropriate dry matter conversion factor. The amount of grain fed to the average cow in Yakima County DHIA herds during 1951 was obtained from the Yakima County DHIA Annual Report for that year. The conversion factor of 0.890 dry matter per pound of grain was obtained from Table III-D in Foley et al. (1972). This conversion factor is appropriate for oats, barley, and wheat. Thus, we have

$$DMG = 0.890 * GRAIN \quad (10)$$

where GRAIN is the amount of grain fed to the average cow in a year.

D.7 DRY MATTER OBTAINED BY DRY ROUGHAGE (DMH)

The amount of dry matter obtained from dry roughage by the average cow per year can be derived by multiplying the amount of dry roughage fed to the average cow in a year by the appropriate dry matter conversion factor. The amount of dry roughage fed to the average cow in Yakima County DHIA herds during 1951 was obtained from the Yakima County DHIA Annual Report for that year.

The primary source of dry roughage during the 1951 period was assumed to be various types of hay. The conversion factor of 0.876 dry matter per pound of dry roughage was obtained by averaging the various dry matter values for the hay crops listed in Table III-D in Foley et al. (1972). The values are as follows: alfalfa hay, pre-bloom - 0.845; alfalfa hay, early bloom - 0.900; alfalfa hay, mature - 0.912; alfalfa-bromegrass hay - 0.825; barley hay -

0.873; oat hay - 0.882; sudangrass hay - 0.889; timothy hay, early bloom - 0.877; and timothy hay, late bloom - 0.880. Thus, we have

$$DMH = 0.876 * HAY \qquad (11)$$

where HAY is the amount of dry roughage fed to the average cow in a year.

D.8 INDEPENDENT VARIABLES

The independent variables in the regression are 1) the amount of succulent feed fed to the average cow per year and 2) the average number of days that the cows were on pasture. These variables were taken directly from the data presented in the Yakima County DHIA report. The model equation is

$$DV = (\beta_1 * SUC) + (\beta_2 * PAST) + \epsilon \qquad (12)$$

where β_1 = the proportion of succulent feed that is dry matter

SUC = a vector of the amounts of succulent feed fed to the average cow per year

β_2 = the dry matter equivalent of pasture day in lbs/day

PAST = a vector of the average number of days that the cows were on pasture

ϵ = a vector of error terms.

The estimated model, which was calculated in a Lotus spreadsheet, is presented in Table D.3.

TABLE D.3. Regression Model Indicating the Dry Matter Content of Succulent Feed (decimal fraction) and the Dry Matter Equivalent of an Average Pasture Day (lbs)

Dependent Variable	DV or (TDM - DMG - DMH)
Constant	0
Std Err of Y Est	1481.028002
R Squared	0.191313
No. of Observations	47
Degrees of Freedom	45

Independent Variables	Parameter Estimates	Standard Errors	T-values
SUCCULENT FEED	0.257256	0.068397	3.761218
PASTURE DAYS	18.631754	1.516957	12.282319

Note that no intercept term is used (the constant is equal to zero). This was done to obtain parameter values that more closely reflect average, rather than marginal, dry matter contents. The lack of an intercept term, however, also means that the R-squared value calculated by Lotus is not a reliable measure of closeness-of-fit.

D.9. NET ENERGY OF LACTATION REGRESSION

TABLE D.4. Net Energy of Lactation and Fat Data from Foley et al. (1972)

Net Energy (Mcal/lb Milk)	Fat (%)
0.268	2.5
0.290	3.0
0.313	3.5
0.336	4.0
0.354	4.5
0.376	5.0
0.399	5.5
0.422	6.0

TABLE D.5. Regression Model of the Net Energy of Lactation

Dependent Variable	NET ENERGY OF LACTATION
Std Err of Y Est	0.001389
R Squared	0.999420
No. of Dbservations	8
Degrees of Freedom	6

	Intercept	Fat
X Coefficient(s)	0.159571428	0.043571428
Std Err of Coef.	0.001886444	0.000428571

D.10. DRY FEED REGRESSION

TABLE D.6. Dry Feed and Net Energy Data from Foley et al. (1972)

Dry Feed (lbs)	Net Energy (Mcal)
11.3	7.1
12.3	7.7
13.3	8.4
14.3	9.0
14.6	9.0
15.3	9.5
16.1	9.9
16.3	10.2
17.3	10.7
17.5	10.8
18.3	11.3
18.9	11.6
19.3	11.9
20.3	12.5
23.0	14.1
24.3	14.9
25.7	15.8
25.9	16.5

TABLE D.7. Regression Model of Dry Matter

Dependent Variable		DRY MATTER
Std Err of Y Est		0.244229
R Squared		0.997139
No. of Observations		18
Degrees of Freedom		16
	Intercept	Net Energy
X Coefficient(s)	-0.115188	1.623063
Std Err of Coef.	0.249341	0.021737

D.11 DATA

FARMER	BREED	COWS (#)	MILK (LBS)	FAT (LBS)	FAT (%)
CARPENTAR, D.	RG	13.2	10356	55B.7	5.39
BARIGAR, K. G.	GH	29.58	13974	534.8	3.83
CAREY, B. T.	RH	24.1	14092	507.2	3.60
ROBERTS, SANDY	RJ	40.96	9047	503.8	5.57
HALL, ALLEN	R&GJ	16.98	9376	474.1	5.06
PAUL, ALLEN	RH	16.33	13470	469.5	3.49
QUESINBERRY, W.	RH&RJ&M	25.28	10660	467.4	4.38
MARVIN, K.	R&GH	10.88	13133	466.8	3.55
BELCHER, M.	R&GH	29.4	12644	465.8	3.68
HAZEN	GH&M	23.5	11367	462.9	4.07
ALDERMAN, H.	R&GJ	12.96	8753	459.4	5.25
SHRDDE, S.J.	R&GH	12.1	13288	459.3	3.46
PRITZL, F.	RG	10.55	8806	450.7	5.12
KOTTWITZ, O.	RJ&M	23.33	8292	440.0	5.31
DIXON, C.	M	14.33	10950	439.8	4.02
SCHWARZWALTER	R&GJ	28.08	8007	439.1	5.48
RUSSELL, E.M.	RG	19.2	8185	438.5	5.36
RHOADES, O.M.	RH&RJ	24.73	7877	437.6	5.56
GANO, L.W.	R&GH	27.3	11454	432.3	3.77
NIMS	RH&RJ	19.4	10155	428.4	4.22
WINTERS, A.	RG	37.4	8439	425.9	5.05
BAGLEY, C.	RG&M	16.4	8916	425.2	4.77
THURMAN, A.	RJ&GH	9.41	11295	423.9	3.75
BAK, J.	RJ	15.4	7985	422.7	5.29
LAMB, L.	GH	18.31	12422	417.5	3.36
	MIX	20.9	9090	413.3	4.55
	RJ	17.41	7621	412.8	5.42
	R&GH	69.92	11451	410.1	3.58
	GH	18.9	9853	397.3	4.03
	RA	1.25	10941	393.4	3.60
	R&GH	21	11383	388.4	3.41
	RG	13.08	7711	386.5	5.01
	RBS&M	15.57	9236	384.8	4.17
	RG	41.5	7489	37B.9	5.06
	RJ	27.83	6792	376.2	5.54
	GH	13.42	10715	372.6	3.48
	RJ&M	20.88	7480	364.5	4.87
	RJ	25.8	6854	356.2	5.20
	RH	16	901B	353.8	3.92
	GH	21.5	9463	351.7	3.72
	R&GH	27.1	9814	349.3	3.56
	R&GH	11.08	9755	345.4	3.54
	RJ	28.5	6685	343.9	5.14
	RG&MIX	21.58	8564	336.9	3.93
	RJ	15.29	6955	334.3	4.81
	MIX	29.6	6851	312.6	4.56
	RMS	15	7730	301.5	3.90

D.11 DATA (Cont.)

NET ENERGY REQUIRED LB MILK (NEK/lb)	NET ENERGY MILK PROD PER YEAR (NEK)	NET ENERGY MILK PROD PER DAY (NEK/day)	POUNDS DRY MATTER FOR MILK/MDAY (DMK/day)	POUNDS DRY MATTER FOR MILK/MYEAR (DMK)
0.395	4087	13.4	21.6	6598
0.326	4560	15.0	24.2	7366
0.316	4459	14.6	23.6	7201
0.402	3639	11.9	19.2	5871
0.380	3562	11.7	18.8	5746
0.311	4195	13.8	22.2	6774
0.351	3738	12.3	19.8	6031
0.314	4130	13.5	21.9	6667
0.320	4047	13.3	21.4	6534
0.337	3831	12.6	20.3	6182
0.388	3398	11.1	18.0	5481
0.310	4122	13.5	21.8	6655
0.383	3369	11.0	17.8	5433
0.391	3240	10.6	17.1	5224
0.335	3664	12.0	19.4	5911
0.399	3191	10.5	16.9	5144
0.393	3217	10.5	17.0	5186
0.402	3164	10.4	16.7	5100
0.324	3711	12.2	19.6	5989
0.343	3487	11.4	18.4	5625
0.379	3202	10.5	16.9	5162
0.367	3275	10.7	17.3	5281
0.323	3649	12.0	19.3	5888
0.390	3116	10.2	16.5	5022
0.306	3801	12.5	20.1	6135
0.358	3251	10.7	17.2	5242
0.396	3015	9.9	15.9	4858
0.316	3614	11.8	19.1	5831
0.335	3303	10.8	17.5	5326
0.316	3460	11.3	18.3	5581
0.308	3509	11.5	18.6	5660
0.378	2914	9.6	15.4	4695
0.341	3150	10.3	16.6	5078
0.380	2846	9.3	15.0	4584
0.401	2723	8.9	14.4	4384
0.311	3333	10.9	17.6	5375
0.372	2782	9.1	14.7	4480
0.386	2646	8.7	14.0	4259
0.331	2981	9.8	15.7	4803
0.322	3042	10.0	16.1	4903
0.315	3088	10.1	16.3	4977
0.314	3062	10.0	16.2	4934
0.384	2565	8.4	13.5	4128
0.331	2834	9.3	15.0	4565

D.11 DATA (Cont.)

NET ENERGY REQUIRED LB MILK (NEK/lb)	NET ENERGY MILK PROD PER YEAR (NEK)	NET ENERGY MILK PROD PER DAY (NEK/day)	POUNDS DRY MATTER FOR MILK/MDAY (DMK/day)	POUNDS DRY MATTER FOR MILK/MYEAR (DMK)
0.369	2566	8.4	13.5	4130
0.358	2455	8.1	13.0	3950
0.330	2547	8.4	13.4	4099

D.1. DATA (Cont.)

ESTIMATED WEIGHT OF AVERAGE COW	POUNDS DRY MATTER FOR MAINT/MDAY (DMMK/day)	POUNDS DRY MATTER FOR MAINT/NMDAY (DMMP/day)	POUNDS DRY MATTER FOR MAINT/MYEAR (DMMK)	POUNDS DRY MATTER FOR MAINT/NMYEAR (DMMP)	POUNDS DRY MATTER FOR MAINT/YEAR (DMMK+DMMP)
1100	14.3	18.9	4362	1134	5496
1500	18.3	24.3	5582	1458	7040
1500	18.3	24.3	5582	1458	7040
1000	13.3	17.5	4057	1050	5107
1000	13.3	17.5	4057	1050	5107
1500	18.3	24.3	5582	1458	7040
1250	15.8	21.0	4819	1260	6079
1500	18.3	24.3	5582	1458	7040
1500	18.3	24.3	5582	1458	7040
1400	17.3	23.0	5277	1380	6657
1000	13.3	17.5	4057	1050	5107
1500	18.3	24.3	5582	1458	7040
1100	14.3	18.9	4362	1134	5496
1100	14.3	18.9	4362	1134	5496
1250	15.8	21.0	4819	1260	6079
1000	13.3	17.5	4057	1050	5107
1100	14.3	18.9	4362	1134	5496
1250	15.8	21.0	4819	1260	6079
1500	18.3	24.3	5582	1458	7040
1250	15.8	21.0	4819	1260	6079
1100	14.3	18.9	4362	1134	5496
1200	15.3	20.3	4667	1218	5885
1250	15.8	21.0	4819	1260	6079
1000	13.3	17.5	4057	1050	5107
1500	18.3	24.3	5582	1458	7040
1250	15.8	21.0	4819	1260	6079
1000	13.3	17.5	4057	1050	5107
1500	18.3	24.3	5582	1458	7040
1500	18.3	24.3	5582	1458	7040
1150	13.8	19.6	4209	1176	5385
1500	18.3	24.3	5582	1458	7040
1100	14.3	18.9	4362	1134	5496
1350	16.8	22.3	5124	1338	6462
1100	14.3	18.9	4362	1134	5496
1000	13.3	17.5	4057	1050	5107
1500	18.3	24.3	5582	1458	7040
1100	14.3	18.9	4362	1134	5496
1000	13.3	17.5	4057	1050	5107
1500	18.3	24.3	5582	1458	7040
1500	18.3	24.3	5582	1458	7040
1500	18.3	24.3	5582	1458	7040
1500	18.3	24.3	5582	1458	7040
1000	13.3	17.5	4057	1050	5107
1200	14.3	20.3	4362	1218	5580

D.11 DATA (Cont.)

ESTIMATED WEIGHT DF AVERAGE COW	POUNDS DRY MATTER FOR MAINT/MDAY (DMMK/day)	POUNDS DRY MATTER FOR MAINT/NMDAY (DMMP/day)	PDUNDS DRY MATTER FOR MAINT/MYEAR (DMMK)	POUNDS DRY MATTER FOR MAINT/NMYEAR (DMMP)	POUNDS DRY MATTER FOR MAINT/YEAR (DMMK+DMMP)
1000	13.3	17.5	4057	1050	5107
1250	15.8	21.0	4819	1260	6079
1400	17.3	23.0	5277	1380	6657

D.11 DATA (Cont.)

POUNDS DRY MATTER FOR MILK&MAINT (TDM)	LBS. DRY ROUGHAGE (HAY)	LBS. GRAIN (GRAIN)	TOTAL - [GRAIN(=.89) +DRY(=.876)] (DV)	LBS. SUCCULENT FEED2 (SUC)	AVE. DAYS PASTURE (PAST)
12094	7988	2950	2471	4517	166
14406	4115	5959	5497	4713	195
14241	4812	3502	6909	5074	175
10977	5119	3381	3484	337	195
10852	4549	2532	4614	1548	162
13813	5691	2571	6540	7304	148
12110	3891	5456	3846	4845	181
13707	8452	3773	2945	2002	182
13573	5325	2623	6574	11020	193
12839	4315	3447	5991	13132	231
10587	5616	3599	2464	0	189
13694	4008	2475	7980	6268	164
10928	4230	1471	5914	3016	170
10720	4880	3188	3607	1372	154
11990	5780	2515	4688	3342	171
10250	4971	2570	3609	3347	184
10681	5727	3458	2587	0	215
11179	2351	3504	6001	0	249
13028	5719	2256	6010	4396	144
11704	4205	2088	6162	1696	227
10658	3482	3088	4859	4697	195
11166	5241	2786	4095	3652	168
11967	7016	2745	3378	1482	232
10129	3481	3000	4409	0	192
13174	3331	3940	6750	0	222
11321	5173	4009	3221	0	197
9964	3718	2014	4915	4848	159
12870	5678	3318	4943	7793	167
12366	4974	4339	4147	0	191
10966	2404	4973	4434	0	317
12699	11163	1754	1359	0	166
10191	4723	2182	4111	4190	180
11540	4590	3880	4066	554	199
10080	6096	3375	1736	5056	157
9491	3149	1775	5153	2486	171
12414	7021	1976	4505	3899	176
9975	3788	3159	3846	0	185
9366	4193	3366	2697	0	203
11842	6399	3533	3092	0	190
11942	5194	2688	5000	1859	184
12016	8271	4021	1192	0	182
11973	8529	3656	1248	6466	154
9235	3324	2157	4403	2979	194
10145	3451	2984	4466	5823	139

D.11 DATA (Cont.)

POUNDS DRY MATTER FOR MILK&MAINT (TDM)	LBS. DRY ROUGHAGE (HAY)	LBS. GRAIN (GRAIN)	TOTAL - [GRAIN(=.89) +DRY(=.876)] (DV)	LBS. SUCCULENT FEED2 (SUC)	AVE. DAYS PASTURE (PAST)
9237	6433	3087	854	3165	145
10029	4311	1474	4051	1730	220
10756	4623	1644	5243	0	194

D.12 REFERENCES

Americana Corporation. 1964. The Encyclopedia Americana: Volume VI Caste-Civil Law. International Edition, New York.

Foley, R. C., D. L. Bath, F. N. Dickinson, and H. A. Tucker. 1972. Dairy Cattle: Principles, Practices, Problems, Profits. Lea & Febiger, Philadelphia.

Yakima County Dairy Herd Improvement Association. 1952. Twenty-Fifth Annual Report (January 1, 1951 to December 31, 1951). Naches Publishing Company, Naches, Washington.

APPENDIX E

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7227 HEDR Document Title Milk Cow Feed Intake and Milk Production and Distribution Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
1.	John E. Till (JET)		I am struck by the heavy weight given to a few experts, particularly Dr. Ward. Although his recommendations may be accurate, I am not convinced that we have taken all possible steps to collect the data ourselves.	NA - Additional experts will be used to provide expert judgement for milk model development in FY 1992.
2.	JET	Page vii, para. 1	Consumption of dairy products in the dominant pathway only when the subject consumes milk. This should be clarified by stating "for individuals who drank milk, consumption of dairy products..."	Change was made in text.
3.	JET	Page 5, para. 4	Last sentence: It would be helpful to describe the results of the QA check, i.e., the number of errors found, etc.	Information was added.
4.	JET	Page 6, line 2	Phase I should begin with a capital letter.	Change was made.
5.	JET	Page 7, para. 2, line 6	If milk production and distribution evolved dramatically, we need more data. I think this is a key point that should be substantiated.	NA - Will be addressed in future work.

NA = No action.

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7227 HEDR Document Title Milk Cow Feed Intake and Milk Production and Distribution Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
6.	JET	Page 9, para. 2	First sentence: I have never heard a farmer refer to feed as "fodder." We are talking about pasture, silage, and green chop (in addition to concentrates added to these feeds).	Change was made.
7.	JET	Page 20, para. 3	Two points. First, an excerpt from the land use map should be added to the report. Second, this line does not continue on the following page.	Change was made. An excerpt from the map appears as Figure 6.
8.	JET	Page 25, para. 3	Change the first sentence to read "The U.S. consumption estimate is typically reported in pounds (hundred weight). (Delete the rest of the sentence.)	Sentence was changed.
9.	JET	Page 26, para. 2	Last sentence: We are assuming "none of the milk was shipped outside the area." I am a little concerned that we have not done all we can to verify this assumption.	NA - Will be addressed in future work.
10.	JET	Page 32, para. 3	Last sentence: We state that small amounts of milk were shipped out of Klickitat County for processing.	The paragraph stated Klickitat milk was shipped out for processing, not for consumption of fresh milk.
11.	JET	Page 31, para. 2 line 1	Be specific with data instead of stating that milk production more than doubled.	Change made.

NA = No action.

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7227 HEDR Document Title Milk Cow Feed Intake and Milk Production and Distribution Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
12.	JET	Page 33, para. 3	Last sentence: Do we have any evidence that milk was "probably marketed in Adams County"? It should be referenced.	Reference added.
13.	JET	Page 34, para. 1	"in-flux"	Text was deleted and replaced with new text.
14.	JET	Page 35, para. 1	Last sentence: Change "secured" to "obtained."	Change was made.
15.	JET		Relied too heavily on milk workshop and advice of Dr. Ward. Further, I doubt we have level of detail needed to develop dosimetry for CDC.	Additional experts will be used for milk model development in FY 1992.
16.	JET		Is Dr. Ward our best source for milk distribution data? Have we attempted to get another, independent judgement?	Level of detail to be addressed in future work.
17.	JET	Page 48, para. 1	You must recognize the person who developed the concept of feeding regimes the way we now use them in models, Dr. Ward Whicker of Colorado State University. His work should be cited.	Change was made.
18.	JET	Page 51, para. 4	There is insufficient information on dairy feeding to guide the reader through the rationale behind our approach. A section needs to be added that does this.	See new Appendix D (reference to appendix was added on page 43).

NA = No action.

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7227 HEDR Document Title Milk Cow Feed Intake and Milk Production and Distribution Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
19.	JET	Page 48, para. 3	The NRC publication has been updated several times since the 1971 edition. You need to use the 1989 edition as well as older editions in developing input data.	NA - Revisions will be made in subsequent report.
20.	JET	Page 47	This explanation is demeaning.	Explanation was replaced with a reference to details in Appendix D.
21.	JET	Page 52, para. 1	Need more investigating on variabilities. Also, I doubt that these parameters are reasonable and significant to the 0.001% level. This is just too shallow a discussion to be making these sweeping statements.	See the material added in response to comments 18 and 23.
22.	JET	Page 52, para. 3	State that there were about as many feeding regimes as there were farmers, then consider the extremes and variability. Data demonstrating this variability should be included.	Paragraph revised. Also see explanation on page 51.
23.	JET		Did we conduct a survey on feeding practices and distribution? How many persons were included in the survey? Where are the results? This information must be included in its original form.	We did not conduct a survey on feeding practices and distribution (see new paragraph on page 47). On page 65, we recommend that such a survey be conducted.
24.	JET		The report needs a conclusion.	NA - The summary beginning on page v serves as a conclusion.

NA = No action.

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25.	JET	Appendix B	Again, do we have an explanation why Dr. Ward was used to estimate distribution rather than a local "expert"?	NA - At the time the report was written, Dr. Ward was, in our judgement, the most qualified to provide estimates; he did his graduate work at Washington State University and served as a dairy extension agent in the study area during the 1950s. In a sense, then, he can be considered a "local expert."
26.	Joe Stohr (JS)		Fallout of radioiodine onto hay stored in the field and drinking water for cows in ditches, etc., will incrementally increase the amount transferred to milk. I didn't see any recognition of this occurrence in the report.	NA - Could be considered by the TSP in future work.
27.	JS	Page 65	I agree with the statements made under the heading of "Data Limitations and Additional Research." I would also be interested in seeing how uncertainty was assigned to the various parameters discussed, especially milk production, distribution, delay times, etc.	NA - Will be considered in future work.
28.	Al Conklin		The summary says that 100% of the commercial milk consumed by Richland residents was from Sunnyside. This seems to be contradicted later in the report.	NA - The summary states "100% of the commercial milk consumed by Richland residents came from the Carnation Plant in Sunnyside." The Carnation Plant in turn

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				received some of its milk from Benton County, as indicated in the report. Hence the potential exposure to Richland residents from Benton County milk is accounted for in the dose estimates.
29.	Richard Morrill (RM)		The major issue here is the risk of depending on one expert for vital distributions on feeding regimes, production and distribution of milk.	NA - Will be addressed in future work.
30.	RM		Specific concerns about the reasonableness of figures for Benton County need to be evaluated by sensitivity analysis.	NA - Will be considered for future work.
31.	RM		The question of the duration of time on pasture, especially in the fall, needs resolution. This can be considered as part of activities 60101 and 60103.	NA - Will be addressed in future work.
32.	RM		I have the feeling of an odd mixture of great precision and attention to detail on some aspects of parameters, and then utter guesswork on others. I don't yet have a feeling for how serious the latter may be.	NA - Will be addressed in future work and sensitivity analysis.
33.	RM	Page 27, Figure 5	It would be useful to translate the "per capita surplus and deficit" also to total surplus and deficit by counties.	NA - Will be addressed in future work.

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34.	RM	Page 42, Table 3	At least one other source/judgement should be presented for this extremely important distribution.	NA - Will be addressed in future work.
35.	RM	Page 49, Fig 20-21	I want to be sure that the 5 months of pasture is accurate; that the last day of frost + 20 days and first day of frost = 20 days isn't far too conservative.	NA - Will be addressed in future work.
36.	RM	Page 52	Are DHIA cows consuming more or less than others? Does it matter?	NA - Will be addressed in future work.
37.	RM	Page 55, para. 3	Is hay important or not? Justify its exclusion.	NA - Will be addressed in future work. This was a feasibility study, not a final report; see the introduction.
38.	RM	Page 65	It is indefensible, and of extreme risk to Dr. Ward, as well as ourselves and the whole study, to have major results and possible decisions based on one person's judgement, no matter how expert.	Additional experts will be used in FY 1992.
39.	RM	Appendix C	I would like some narrative justification of the 20-65 range. Why these numbers? The probabalistic interpretation of the numbers is confusing.	Provided on p. C.1 - they are Dr. Ward's estimates.

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40.	RM	Page 1 para. 3	OK for cheese and butter, but what about cottage cheese?	NA - Sources for cottage cheese are assumed to be the same as those for fresh, liquid milk.
41.	RM	Appendix B	I went over these for logic and consistency. It looks good, but it is important that others review it.	NA - Will be addressed in future work.
42.	RM	Page B.2	How do we estimate the Ritzville dairy supplying only 25% of Ritzville needs? (This is a generic question about all the small local dairies.)	Dr. Ward's estimates - other estimates will be published in a future report.
43.	RM	Pages B.4 - B.6	Especially for these most important places, Kennewick, Pasco, Prosser, and West Richland, we need a little narrative discussion and justification of the allocation among dairies.	NA - Will be addressed in future work.
44.	RM		I wonder about the meaning of "urban," e.g., minuscule Kahlotus (FR2) while Mabton (YA10) isn't included.	NA - We defined any incorporated area as "urban." Mabton was not incorporated, according to the 1950 census.
45.	RM	Page B.15	Evidence of Portland milk in the Hermiston area?	There was no hard evidence. It was based entirely on expert judgement.

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46.	RM		The tendency to treat all data as of equal importance. Differentiate milk from other foods and put more effort into it. Similarly, be more sure about these close cities than far-away ones.	Additional information for Benton and Franklin Counties will be included in future work.
47.	Dave Price (DP)	Page 1, last lines	A half-life of 8 days does not imply that the radioactivity disappears in 8 days.	Wording was changed.
48.	DP	Page 8, para. 5	"Several days" is misleading. This should be more specific.	Wording was changed.
49.	DP	Page 26, para. 1	Butter, which was an important dairy product in those days, should be included.	Butter was added to sentence and was included in the study.
50.	DP	Page 26, para. 2	This fails to explain how the calculation was made. Fluid equivalent of all manufactured dairy products? Butter? Milk produced or milk sold?	NA - Described on p. 19.
51.	DP	Page 26, para. 3	Counties in balance should be listed.	Counties added.
52.	DP	Page 31, para. 2	The doubling of milk sales from Yakima County was due to more than one cause.	Wording added in response to comment 11 applies here.
53.	DP	Page 31	This implies that all milk sold in Richland was produced in Yakima County. This is contradicted later in the report.	NA - While some of the milk produced in Benton County was processed in Yakima, very little was processed by Carnation; therefore, only small amounts of milk

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				produced in Benton County were sold as Carnation milk and hence available for commercial sell in the city of Richland.
54.	DP	Page 33, para. 3	I can't follow the reasoning. The population of Grant County declined between 1940 and 1945.	NA - The large increase in milk demand was due to the influx of military personnel. Most of the military operations were eliminated or drastically scaled back before the 1950 census was taken. As a result, the population estimates based on census counts and symptomatic indicators fail to capture the influx and out migration of military personnel who resided in Grant County between 1945 and 1950.
55.	DP	Page 33	A producer distributor is shown for Connell. Thus, all Franklin County milk sales did not go to Twin Cities.	NA - At the time the report was written, it was assumed that the Connell Dairy was a very small dairy because no one we talked to knew anything about it. Hence we assumed it did not produce milk on a commercial scale but rather was a local small-scale dairy. We assumed that all commercial milk was shipped to Twin City.

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				However, in January 1990 we did locate and interview the owner of the Connell Dairy. He indicated that his dairy and another one located in Connell provided all the milk for Connell dairies (none was shipped out of Connell). Based on this information, our data base was modified to reflect that 100% of the milk consumed in Connell was produced in Connell. Dose estimates for Connell residents were based on this most recent information.
56.	DP	Page 34, para. 1	"Much of the milk" should be replaced by "some of the milk." Figure 13 doesn't show any Carnation producers in Benton County.	Text was revised. There were no Carnation producers in Benton County.
57.	DP	Page 8.6	There are no estimates for local producers/ distributors; however, Connell Dairy is listed in Appendix A.1.	See response to comment 55.
58.	DP	Page 42, bullet 2	The dates should be specified.	Dates were added.
59.	DP	Page 42, bullet 1	Connell Dairy has been ignored.	Changes were made to the Benton and Franklin descriptions. Also see new text on p. 32-34.

NA = No action.

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60.	DP	Page 51, eq. 1	R^2 and t values should be reported.	See new Appendix D.
61.	DP		Overall, the milk sources for Benton and Franklin Counties are not clear. Information presented appears contradictory.	Changes made to description of Benton and Franklin Counties address this comment. Also see new text on p. 32-34.
62.	DP		The opinions of Dr. Ward should be verified. In addition, more analysis of the existing data should be made.	NA - Will be addressed in future work.
63.	DP		One problem is the disappearance of the milk produced in Benton County. Don Beck informs me that much of this milk went into processing. This needs to be checked very thoroughly.	Changes made to description of Benton and Franklin Counties address this comment.
64.	DP	Appendix tables	From the census data, it is difficult to believe that so little milk supplied to the Tri-Cities came from Benton County.	See response to comment 63.
65.	DP		According to the extension service, good pasture for the lower Yakima valley starts in mid to late April and ends in mid to late October.	NA - As stated in the report, the mean dates used in the Phase I analysis were 1) October 10 in 1945, 2) October 4 in 1946, and 3) October 21 in 1947. Different dates could be chosen in the future.

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66.	Glyn Caldwell (GGC)	Page 48, para. 2	Who are the "experts," how many were there, and how much did their opinions/remembrances differ?	NA - The few recollections and opinions on which we based this work are supplementary, not contradictory. If more information is collected, then ways to report and resolve conflicts can be developed.
67.	GGC	Page 51, para. 4	How accurate, precise, and representative are the encyclopedic data?	NA - Do not know.
68.	GGC	Pages 51-52	Has the uncertainty of these remembered and encyclopedic data been estimated?	NA - Do not know.
69.	GGC	Page 56, para. 2	What is the basis and evidence that silage, hay, and grain are minor radioiodine sources?	NA - The basis is elapsed time between time of harvest and time of ingestion. Measurements have been made and we have some of the literature in house. Measurements have also been made with regard to contamination of stored grain, silage, and hay. Bruce Napier can provide more information on how radioiodine from these sources was incorporated into the study.

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70.	GGC	Page 57, para. 4	Did any dairymen or experts interviewed document in either log or diary when cows started and stopped using pasture?	NA - We do not know of any log or diary in existence today that contains pasture start and stop dates.
71.	GGC	Page 61	Do we have any estimates of uncertainty for these arbitrary assumptions?	NA - No estimates available.
72.	Bernie Shleien (BS)		Perhaps river pathway plays a greater role than we thought for iodine-131 in early years.	NA
73.	BS		Rural families using backyard cows in area north of Pasco could be most sensitive population regarding milk pathway.	NA
74.	Mary Lou Blazek (MLB)	Page 48	Little information is available for Morrow County, Oregon, in this report. A list of experts contacted is needed.	NA - Will be addressed in future work.
75.	MLB	Page 48	Did expert opinions/recollections vary?	NA - No contradictions have been identified to date (see also comment 66).
76.	MLB	Page 48	If recollections varied, how were differences resolved?	NA - See response to comment 66.
77.	MLB	Appendix A	Should include Morrow County or describe why it is omitted.	No Morrow County processing plants were identified. See p. A.1.

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78.	MLB	Appendix A	Research into Oregon milk processing/distribution for Umatilla and Morrow counties should be included.	NA - Information gathered in Phase I was included. Additional data will be gathered in FY 1992.
79.	MLB	Page B.16	Should include family cow statistics for Pendleton.	NA - Dr. Ward assumed that there were no family cows in Pendleton.
80.	MLB	Page 65	One expert's judgment is completely inadequate given the complexity of the task. At a minimum, the recommended steps should be taken as soon as possible.	NA - Will be addressed in future work.
81.	MLB	Page 65	Attempts at finding other dairy experts to fill information gaps about Umatilla and Morrow Counties should be a high priority before the report is released.	NA - Will be addressed in future work.
82.	Tim Connor (TC)		A great deal more milk was produced in Benton-Franklin County during 1945 than could be consumed by the rural population. About half of the milk produced was reported to have been sold. Where did the rest go?	Explanatory text was added beginning on page 11.
83.	TC		71,101 gallons in milk sales from Franklin County vs. 276,000 gallons produced in Franklin County in the same year. Where did the 200,000 gallons go?	See response to comment 82.

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84.	TC		If the "deficit" that PNL finds as a difference between milk sales and total county milk consumed does exist, it does not exist for the rural subset of the counties' population.	NA - It is important to distinguish between the number of people living in "rural" areas and those living on farms. While I believe it reasonable to assume that all the people who lived on farms drank local milk, many of those living in rural areas but not on farms could easily have gotten milk through home delivery services or in grocery stores. Of the estimated 9,800 people in Franklin County in 1945, only 1,114 lived on farms. In light of this information, I find Dr. Ward's estimates very reasonable. For instance, he estimated that, on average, 75% (with a minimum of 45% and a maximum of 90%) of rural residents of Franklin County (CCD 4) received their milk from backyard cows. In my opinion, these seem to be reasonable ranges. Similar ranges are reported for other rural areas.

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85.	TC		Would like to see more specific information on which milk companies were serving Pasco and Kennewick during the mid- to late-1940s and whether the shipments were of sufficient size for the populations.	NA - We have found no records that detail how much milk was shipped by milk plants. However, from our interviews with milk dealers delivering in the Tri-Cities during this time period, we know Carnation, Darigold, and Twin City Creamery all delivered to small towns throughout Benton and Franklin Counties.
86.	TC		If farmers were under-reporting milk production and herd size, might it also be possible that milk sales were being under-reported for the same reason? Of particular interest would be those towns (Pasco among them) nearest the herds.	See response to comment 82.

NA = No action.

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