Population Estimates for Phase I Hanford Environmental Dose Reconstruction Project

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March 1992

Prepared for the Technical Steering Panel

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POPULATION ESTIMATES FOR PHASE I

Hanford Environmental Dose
Reconstruction Project

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Prepared for the
Technical Steering Panel

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

A handwritten signature in black ink, appearing to read "John E. Till", written over a horizontal line.

John E. Till, Chairman
Technical Steering Panel
Hanford Environmental
Dose Reconstruction Project

31 January 1992
Date

PREFACE

This report summarizes the population 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 F 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 which 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 in 1987 to estimate radiation doses that people could have received from nuclear operations at the Hanford Site since 1944. To achieve this objective, demographic information must be developed that describes the study population in enough detail to allow researchers to identify potentially exposed groups of people and the number of people in each of those groups. The Phase I study area consists of the ten-county area around the Hanford Site. The required demographic information for Phase I includes year-by-year estimates of county and subdivision populations by age, sex, and race.

Three methods were used to develop county population estimates: ratio correlation, component method II, and vital rates. When results using the three methods were compared with a special census of Benton County in 1944, the ratio-correlation estimates were far superior (3.3% deviation from actual census count with a standard addition for transient construction workers). The superiority of this method was also evident in comparisons with actual census data from 1950, 1960, and 1970. The ratio correlation estimates were, therefore, used as the control totals for developing intercensal age, sex, and race estimates for counties and county subdivisions.

15 A cohort-component model developed by Dr. Donald Pittenger for estimating intercensal county populations by age and sex was not run to produce Phase I estimates because of lack of data and time constraints. In addition, the level of additional accuracy potentially gained by using this model was not considered necessary for Phase I. Instead, Dr. Pittenger used a combination of cohort interpolation and age-group interpolation estimates to provide these county population estimates by age and sex (*Pittenger 1991*). Race-share estimates were interpolated. Intercensus population estimates for all county census divisions within the HEDR study area were then calculated for the years 1940 to 1970 by interpolating population shares between the two census counts bracketing a particular estimate year.

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INTRODUCTION

The objective of the Hanford Environmental Dose Reconstruction (HEDR) Project is to develop estimates of the radiation doses populations could have received from Hanford operations beginning in 1944. To achieve this objective, demographic, lifestyle, agricultural, and food consumption information will be needed. Demographic information must be developed that describes the study population in enough detail to allow researchers to identify potential exposure groups and to estimate the number of people in each of those groups. Not all the demographic needs of the HEDR Project can be identified at this phase of the project; however, existing dose models suggest that, at a minimum, information on the age, sex, and race composition of the study population will be needed, as well as information on population density, migration patterns, and residential location. Other demographic parameters, such as income level and occupation, may also be important because they are closely associated with lifestyle and food consumption.

Requirements for providing the detailed demographic information outlined above include accurate estimates of county populations and information on where within a county people resided. This information is essential because these factors influence the type of food people eat and whether or not their food is produced locally. This is particularly true for the earlier years of the study period. For example, if 1945 data for a particular county indicate that the population was widely scattered throughout the county with few incorporated areas, it is reasonable to assume that many of the residents were more self-sufficient in terms of food and milk production than their urban counterparts. As a result, the rural residents of the county were likely to have consumed homegrown vegetables and milk from backyard cows, behavior that may have increased their exposure to certain radioisotopes. The point here is that demographic information is crucial to a description of settlement patterns and lifestyles which, in turn, are critical for determining exposure rates for the different population groups living in the Phase I study area.

The Phase I study area consists of eight counties in central Washington and two counties in northern Oregon (Figure 1). The purpose of this report is

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

to report initial Phase I population estimates and to explain how they were developed. Three general steps were used to develop the Phase I estimates: 1) county population estimates were developed; 2) age, sex, and race details were developed for each county; and finally 3) populations for sub-county areas were developed by disaggregating county totals to county census divisions (CCDS). Sections of this report discuss the methods associated with each of the three steps and the results of county and subcounty population estimates. Appendices contain evaluations of the estimates by outside reviewers and detailed descriptions of certain sub-steps. Age/sex/race component estimates are contained in a separate HEDR report (Pittenger 1991).

Quality Assurance

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.

16 Results were reviewed by a QA representative to ensure that the results were traceable back to the raw data and that the work was performed in accordance with applicable QA requirements. The staff member entering the data into databases 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. *Through this informal QA check, it was determined that adequate data traceability existed.*

The ratio-correlation model and the county population estimates produced with it were submitted to Dr. David Swanson, a demographer specializing in

ratio-correlation estimates. He concluded that the model and corresponding estimates are accurate. A complete copy of his review is found in Appendix A.

All three models for estimating intercensal county population were submitted to Dr. Donald Pittenger, along with the estimates produced by these models. Dr. Pittenger is director of the Demographics Laboratory in Olympia, Washington and has extensive experience in preparing migration estimates for the state of Washington. He served as staff demographer for the Washington State Office of Financial Management, where he was responsible for developing the official state population estimates. Although he raised several minor issues, he concluded that the models produce accurate results. A complete copy of his review is contained in Appendix B.

Possible Steps to Refine Estimates

By combining the results from the methods discussed in this paper, accurate population estimates for the HEDR Phase I counties and CCDs have been developed. However, further refinement is always possible. Perhaps the most cost-effective refinement would be to run the cohort component II models developed by Dr. Pittenger but not used due to lack of data and time constraints. Another possible refinement would involve using aerial photographs available for the CCDs adjacent to the Hanford site to produce population estimates based on the housing unit procedure. However, as with all demographic estimates, the decision to refine estimates must balance the expected increase in accuracy against the level of activity associated with the methods. We expect to use the results from future sensitivity analyses to help determine the appropriate level of future effort this task warrants.

METHODOLOGY

To identify potential exposure groups within the HEDR Phase I study area and to estimate the number of people in each of those groups, researchers need subcounty population estimates by age, sex, and race for each year from 1944 to 1947 and 1964 to 1966. Estimates were prepared for 1940 to 1970 to ensure that estimates that may be needed for future HEDR work will be available. The following sections describe the steps and associated methods used to produce these estimates: 1) developing county population estimates, 2) developing county-level age, sex, and race component estimates, and 3) developing county census division estimates. An overview of the methodology is provided in Figure 2.

STEP 1: DEVELOPING COUNTY POPULATION ESTIMATES

The first step in reconstructing the demographic history of the HEDR study area is to prepare county population estimates. In the U.S., complete censuses are routinely conducted only the first year of every decade. Therefore, to map population change throughout a decade, inter-census estimates must be developed. Over the last several decades several estimation methods have evolved, and two (the component method II and ratio-correlation methods) have become the accepted standards in the demography discipline. Both of these methods were used for this project and are discussed later in this report.

All of the estimation methods address in one way or another the components of the most basic equation in demography, the balancing equation. This equation decomposes population change into its components and can be expressed as follows:

$$P_t - P_o = B - O + I - E$$

where P_t = the population at the end of the period

P_o = the population at the beginning of the period

B = births

STEP 1: Develop County Population Estimates:	STEP 2: Develop County-Level Age, Sex, and Race Estimates	STEP 3: Develop Estimates for County Census Divisions
<ul style="list-style-type: none"> • Produce estimates for each year 1940 to 1970 - using several methods: <ul style="list-style-type: none"> – ratio-correlation method – component method II – vital rates method. • Adjust Benton County estimates for influx of construction workers. • Compare estimates with available census counts. • Select set of estimates for use in subsequent steps. 	<ul style="list-style-type: none"> • Produce age/sex share estimates for each year 1940 to 1970 using several methods: <ul style="list-style-type: none"> – cohort component model – cohort interpolation – age-group interpolation. • Determine weighting for final age/sex estimates. • Determine race share estimates by interpolation. 	<ul style="list-style-type: none"> • Standardize CCDs for HEDR use • Calculate intercensus estimates for each CCD 1940 to 1970: <ul style="list-style-type: none"> – Interpolate population shares between the two census counts bracketing a particular year. – Multiply each CCD's county population share by the appropriate ratio-correlation intercensus estimate generated in Step 1. – Use age/sex/race distributions for the county as a whole to determine CCD distributions.

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FIGURE 2. Overview of Methodology Used to Develop HEDR Phase I Population Estimates

D = deaths

I = in-migration

O = out-migration.

The challenge for demographers is to gather information or develop estimates for each of the components of population change. By convention, most U.S. demographic databases are maintained on the county level. For instance, reliable annual birth and deaths records are maintained for all U.S. counties but are not generally available for subcounty areas such as cities and towns. Unlike birth and death data, no county-level migration database is maintained and updated yearly.

As a result, the real challenge for estimating population in the U.S. is to develop models that accurately estimate county in- and out-migration for a particular county. Migration is a particularly important component of population change for HEDR demographic work because the study area has historically been characterized by rapid in- and out-migration due to the effects of war mobilization. For instance, over 34,000 construction workers migrated into Benton County in 1944 alone.

To develop the needed estimates for the HEDR Project, many different information sources were researched. The most important information sources are briefly summarized below.

Information Sources for HEDR Population Estimation

HEDR staff collected a wide variety of demographic data to help prepare population estimates, including U.S. census data; public-use microdata; vital statistics (i.e., birth and death data); special censuses conducted by state or local agencies; independent estimates provided by state and federal agencies; and symptomatic indicator data (e.g., school enrollment and voter registration data). Each data source is described in the following sections.

U.S. Census Data

A vast amount of demographic information is available from the censuses conducted by the U.S. Census Bureau every 10 years. To date, we have collected the 1940, 1950, 1960, 1970, and 1980 census publications for the

states of Washington, Idaho, and Oregon. These documents provide total population counts for all U.S. counties broken down by age, sex, and race for census years. Thus, they provide the benchmark data needed for the various estimation techniques discussed later in this paper. Census statistics are also provided in these publications for census subdivisions and towns and cities with populations larger than 1000.

In addition to decennial information, we have obtained U.S. Census special reports on substate migration and subcounty estimation techniques. These U.S. Census data constitute the most comprehensive source of demographic information for the HEDR study area.

Public-Use Microdata Sample

These data collections were created through a joint effort of the U.S. Census Bureau and the Center for Demography and Ecology at the University of Wisconsin. The collections contain information from a stratified sample of 1% of the households represented in the census. These files contain information on location and composition of the households, including such variables as nativity, marital status, number of children, occupation, education, employment status, and income. Data from these files are available back to the 1940 census.

Vital Statistics Information

We have collected annual birth and death statistics for all counties in the Phase I HEDR study area. Birth and death data were taken from the annual vital rates summaries published by the U.S. government.

Federal and State Population Estimates

The states of Washington, Oregon, and Idaho have periodically published county and city population estimates. We have received documented estimates for Oregon counties dating back to 1930 and are currently collecting estimates for counties in Washington and Idaho. In addition to state estimates, the U.S. Census Bureau has routinely produced estimates of county population (using a variety of methods) since 1960. However, few county intercensus estimates for the time period 1940 through 1960 were located.

Symptomatic Information Sources

We collected symptomatic information sources required for the component method II and ratio-correlation methods discussed later in this document. More specifically, we gathered school enrollment, voter registration, auto registration, employment, and vital statistics data for every county in Washington State. The sources for these data varied by state, but generally they came from annual reports published by state agencies.

Evaluation of Existing Data

17 After reviewing all of the demographic information available, we determined that no reliable standardized county estimates were available for the HEDR Phase I study area for the years 1940 to 1960. Prior to the 1960s, demographic estimation efforts focussed on developing sound state estimates; county population estimates were routinely linearly interpolated from census year to census year. The intercensus estimates that did exist tended to be projections into the future from a particular time in history, and as a result they were unable to take into account pre-and post census information. Furthermore the estimates that were developed contained none of the age-sex-race detail needed for the HEDR Project. For this reason we deemed it necessary to produce our own county and sub-county estimates. Fortunately, as pointed out earlier, several techniques that have been refined over the last several decades produce accurate county-level population estimates by accurately modelling in- and out-migration. The sections below describe the three most commonly used methods *applied* to develop county population estimates (and the ones we adopted for the HEDR Project): ratio-correlation, component II, and vital rates.

Ratio-Correlation Population Estimation Method

This method involves the construction of a regression equation that models the relationship between symptomatic indicators (e.g., number of births, auto registrations, voter registration, etc.) and total population. For example, to estimate a county population, the regression equation expresses the relationship between 1) change over the previous intercensal period in the county's share of the state total for several symptomatic indicators and

2) the change in the county's share of the state population (Shryock and Siegel 1976). The ratio-correlation method uses observed temporal changes in the county proportions of symptomatic indicators to estimate county population totals (Swanson 1980). These steps may be represented symbolically as follows:

$$\frac{\text{Proportion of total state population in county } i, 1960}{\text{Proportion of total state population in county } i, 1950} = \frac{\left(\frac{P_c}{P_s}\right)^{1960}}{\left(\frac{P_c}{P_s}\right)^{1950}} \quad (1)$$

The independent variables, such as births, are expressed in the same manner:

$$\frac{\text{Proportion of total state population in county } i, 1960}{\text{Proportion of total state population in county } i, 1950} = \frac{\left(\frac{B_c}{B_s}\right)^{1960}}{\left(\frac{B_c}{B_s}\right)^{1950}} \quad (2)$$

The validity of this method is based on the assumption that the observed statistical relationship between the independent and dependent variables in the past intercensal period will persist in the postcensal period (Shryock and Siegel 1976). Once the ratio-correlation model is constructed, the known ratio of proportions for each of the symptomatic indicator variables is multiplied by the appropriate regression coefficient. This step results in unadjusted county population estimates for each county. Finally, these unadjusted estimates are controlled to an independent state population estimate resulting in adjusted county estimates [for further explanation, see Namboodiri (1972); Shryock and Siegel (1976, pp. 428-429); and Crosetti and Schmitt (1956)]. These steps are discussed in more detail in Appendix C.

The ratio-correlation method is routinely used by the U.S. Census Bureau and has been used by the state of Washington since the 1970s. Because this method makes use of such a wide variety of symptomatic indicators, we believe it produces the most accurate county population estimates for the HEDR study

area. In addition, because the estimates we produce are anchored by the post- and pre-census numbers, we can be confident the estimates will be fairly accurate. Estimates were prepared only for the years 1940-1970 because the Washington State Office of Financial Management began producing ratio correlation estimates for Washington counties in 1970.

19 In developing the ratio-correlation model, we decided to try to keep the model parsimonious and to use the same variables for all three decades to ensure model consistency. The predictor variables included county births, deaths, school enrollment, and registered voters. These variables were chosen because they were the only symptomatic indicators available for each of the three decades for which estimates were prepared. The ratio-correlation model used in preparing county estimates is reproduced in Table 1. Each of the models can be conceptualized as either estimating the parameters of a sample of a larger universe or as calculating actual population measures (since we have complete data for every county in Washington). For the purpose of this report we have chosen the former interpretation. The fact that the R^2 (the proportion of the original equation that is accounted for by the regression equation) for all three models is larger than 0.90 indicates that the models do an excellent job of explaining variance. Births, school enrollment, and registered voters proved to be significant predictors of population in all three models. Deaths were not a significant predictor, although the negative relationship reported for all three decades was expected (i.e., as the number of deaths increased, total population decreased). The standard errors are recorded in parenthesis and are interpreted to be low.

In summary, the statistics reported in Table 1 suggest that our models do an excellent job of predicting population. In reviewing the above results it is important to point out that, unlike most regression analyses, the purpose of constructing these models was to predict population, not to estimate parameters. Therefore, a comparison of the population estimates developed with the ratio-correlation models and actual census counts is the soundest indicator of how "good" the previously described models are. This type of comparison is provided in the "Results" section of this report.

TABLE 1. Ratio-Correlation Model (OLS) for Washington
Counties by Decade^{(a)(b)}

	1940-50	1950-60	1960-70
Intercept	0.015 (.049)	0.081 (.040)	0.037 (.062)
Births	0.153 (.048) ^(c)	0.139 (.040) ^(c)	0.259 (.052) ^(c)
Deaths	-0.035 (.063)	-0.005 (.048)	-0.033 (.043)
School Enrollment	0.366 (.060) ^(c)	0.254 (.061) ^(c)	0.197 (.079) ^(d)
Registered Voters	0.500 (.065) ^(c)	0.543 (.054) ^(c)	0.532 (.092) ^(c)
R ²	0.989	0.969	0.907
Adj R ²	0.988	0.965	0.896
SEE ^(e)	0.045	0.040	0.042

(a) The issue of multicollinearity is not addressed because the purpose of these models is prediction (i.e., population estimation), not explanation (see Berry and Feldman 1985:41).

(b) Technically, these independent variables are ratios of proportions of the various symptomatic indicators (See Equation 2).

(c) Significant to the 0.01 level.

(d) Significant to the 0.05 level.

(e) Standard error of estimate.

Component Method II Population Estimation Method

The component method II produces annual population estimates by adding an estimate for the general non-group quarters population under 65, the group quarters population, the military population, and the over-65 population. For the HEDR estimates, the methodology outlined below is used to calculate the general non-group quarters (i.e., dormitories, prisons, etc.) population. This methodology is primarily based on two references: "Component Method II Computational Procedure for Estimating the Population of Counties" (New York State Department of Commerce 1979) and the "United States Department of Commerce Bureau of the Census Memorandum" (U.S. Bureau of the Census 1978). A third reference, The Methods and Materials of Demography (Shyrock and Siegel 1976), is used to make adjustments to the component method II results.

The over-65 population is normally estimated using Medicare records. For the HEDR estimates, no separate estimate is made of the over-65 population because Medicare records are not available for the 1940s and 1950s. Estimates

of the military and group quarter populations for Benton County are obtained from Hanford archive records. The military and group quarters population for the other counties in the study area are obtained from the decennial censuses.

To estimate the general non-group quarters population, the natural increase and net migrants from a census date to the estimate date are added to the total population at the census date. The net migrants are calculated with a procedure that uses annual school enrollment data (Grades 1 through 8; Ages 6.5 through 14.49) to estimate a population migration rate. The natural increase for a population is the number of births minus the number of deaths. A detailed example of how this method was used to produce results for the HEDR Project is reproduced in Appendix D.

Vital Rates Population Estimation Method

The premise of the vital rates method is that the observed change (from census year to estimation year) in birth or death rates for a county will be roughly equivalent to the change experienced by the state as a whole, i.e., demographic change for a geographic subset mirrors change for the entire set (Rives and Serow 1984; p. 56). For the HEDR estimations, the birth and death rates for the state of Washington are used to estimate the State's county populations.

This procedure requires the following data:

- the number of births and deaths for the study area for the estimation year
- the number of births and deaths for the study area for the most recent census year
- the population of the study area in the most recent census year
- the number of births and deaths for the reference area for the most recent census year and the estimation year
- the population of the reference area for the most recent census year and the estimation year.

The general formula for these estimations is

$$X / [(Y) * (Z)] = POP$$

where X = number of births (deaths) in the study area for the estimation year

Y = ratio of census year birth (death) rate in study area to census year birth (death) rate in the reference area

Z = birth (death) rate of the reference area for the estimation year.

Six estimates are calculated for each year. The estimates are based on birth rates, death rates, average of birth and death rate estimates, centered births, centered deaths, and the average of the centered estimates. Centered births and centered deaths are used to stabilize the randomness that occurs with vital statistics. For centered data in any given year, the number of births or deaths used is an average of three annual numbers: the year preceding the estimation year, the estimation year, and the year following the estimation year. The "Results" section of this report contains all the vital rates estimates developed by this method.

Selection of Estimates for Use in Subsequent Steps

The results from all three of these methods are contained in the "Results" section. Plots of population estimated by each of the three methods (see "Results" section) clearly demonstrate the relative stability of ratio-correlation estimates compared with the vital rates and component method II estimates. This is partially explained by the fact that, unlike the other two methods, the ratio-correlation methods uses multiple indicators to model population change. The use of multiple indicators moderates the influence of a spurious fluctuation in any one indicator for any particular year.

Estimating Benton County population in the mid 1940s was a particularly difficult challenge because of the rapid in and out migration of large numbers of construction workers. Estimates for 1944 for all of the models include the addition of 34,315 construction workers to the numbers generated by the different methods. Without this addition, all three of the methods significantly underestimated the number of people residing in Benton County (70,987 based on a special county census conducted that year by the census bureau). The underestimates are to be expected since all of the estimation techniques were developed to estimate permanent residents and not transient construction workers. Discussions with local residents and representatives of Jaycor Incorporated (a military research organization) suggest that the Hanford

construction workforce was dominated by single males. None of the estimation methods discussed in this paper could have sensed the influx of this population because construction workers in the 1940s were likely childless (few births and school age children per capita), young and healthy (few deaths per capita), and mobile (unlikely to register to vote in Benton County). Therefore, in consultation with the demographics sub-committee of the HEDR Technical Steering Panel (TSP), the average number of construction workers for 1944 (34,315) was added to the 1944 population estimates. Adding these figures to the estimates results in numbers much closer to the Benton County population recorded in the 1944 special census.

It was initially suggested that estimates developed by the three methods be averaged to arrive at a best estimate. However, because several TSP members expressed concern over this procedure, we decided to choose a best estimate from among the three estimates developed. We believe the ratio-correlation estimates are the most accurate, based on theoretical and empirical evidence. Theoretically, the ratio-correlation method should produce better estimates than the other two methods because it uses the most information. Birth, death, voter registration, and school enrollment data are all used in the ratio-correlation models, while only school enrollment data are used in the component method II model, and only birth and death data are used in the vital rates estimates.

Furthermore, the superiority of the ratio-correlation estimates over the other two methods can be demonstrated empirically. The 1944 special census of Benton County allows us to compare estimates generated by the three different methods with census information for an intercensus year (1944). Table 2 summarizes the percent difference between the estimates and the number generated by the special census. As mentioned earlier the estimates include the addition of 34,315 construction workers recorded in monthly Hanford work reports. The ratio-correlation estimate deviated only 3.33 percent from the census figure; the component method II and vital rates estimate deviated 12.61 and 18.49 percent, respectively. Estimates using the three methods were also prepared for the decennial census years 1950, 1960, and 1970. Table 3 contains the results of this comparison. Once again, the ratio-correlation

TABLE 2. Comparison of 1944 Benton County Population Estimates and 1944 Benton County Special Census Population Total (70,987)

	<u>1944 Estimate</u>	<u>Absolute Difference Between Estimate and Special Census</u>	<u>Percent Difference</u>
Ratio Correlation	68,615	2,367	3.33
Component Method II	79,939	8,952	12.61
Vital Rates	57,815	13,123	18.49

TABLE 3. Deviation of Census Year Estimates from Actual Census Counts

County	Deviation from Actual Census Counts, %								
	1950			1960			1970		
	Ratio Correlation	Component II	Vital Rates	Ratio Correlation	Component II	Vital Rates	Ratio Correlation	Component II	Vital Rates
Adams	9.72	31.57	5.16	0.36	6.05	12.32	2.84	12.70	14.10
Benton	0.05	34.41	15.19	2.96	5.39	17.83	0.05	12.80	17.50
Franklin	0.25	29.37	4.36	1.75	2.36	14.41	1.60	12.66	7.08
Grant	3.17	14.23	2.56	1.50	6.11	3.66	3.12	11.27	7.04
Kittitas	1.73	24.62	0.97	3.69	2.03	7.54	8.06	11.84	13.31
Klickitat	2.72	28.92	10.20	3.97	5.81	.80	0.04	10.26	1.60
Walla Walla	1.18	28.93	4.88	0.71	2.78	6.07	2.73	5.26	4.67
Yakima	<u>6.24</u>	<u>25.99</u>	<u>1.18</u>	<u>3.25</u>	<u>2.96</u>	<u>2.33</u>	<u>6.00</u>	<u>10.72</u>	<u>11.61</u>
Average	3.13	27.26	5.6	2.27	4.19	8.12	3.06	10.94	9.6

estimates were more accurate than the estimates prepared by the other two methods. Ratio-correlation estimates deviated from the census numbers by 3.13 percent in 1950, 2.27 percent in 1960, and 3.06 percent in 1970.^(a) Component method II estimates deviated by large amounts: 27.26 percent, 4.19 percent, and 10.94 percent for the years 1950, 1960, and 1970. The vital rates estimates deviated by 5.6 percent, 8.12 percent, and 9.6 percent for the same years. The above comparisons clearly indicate the superiority of the

- (a) In the component II method, the difference between the census year estimate and the census count (referred to as the error of closure) is evenly spread out over the eight intercensus estimates. As a result, the intercensus year estimates are likely to be much more accurate than estimate prepared for a census year.

ratio-correlation estimates. Therefore, the ratio-correlation estimates are used as the control totals for the additional demographic work described below.

STEP 2: DEVELOPING COUNTY-LEVEL AGE, SEX, AND RACE ESTIMATES

Developing age, sex, and race estimates is a challenge because it requires that migration estimates be prepared by age group. At times, this requires judgement calls based on an intimate knowledge of local demographics. For this reason, we decided to sub-contract this piece of the work to Dr. Donald Pittenger.

Age and Sex Estimation Methods

Dr. Pittenger explored three models for estimating population by age-sex group: cohort-component estimation, cohort interpolation, and age-group interpolation. He used the ratio-correlation estimates developed in Step 1 as his control totals. The following discussion is taken from his report, which is published separately (Pittenger 1991).

Cohort-Component Estimation Model

This model was explored because it could potentially provide estimates of the population remaining in the study area over various time spans. It can keep track of populations by arrival year, and shows how many in each cohort (a group that arrives in the same year by migration or birth) are still in the area at each subsequent year. For instance, using this method it would be possible to estimate, by age and sex, the number of people who lived in Benton County throughout the period 1944-1947 as well as the number entering and leaving the county through birth, death, and migration over that span.

Unfortunately, after initial tests it was determined that it was not feasible to use this model for Phase I results even though it was developed, debugged, and tested. The reason it was not used was that initial test runs showed that 1) a retirement-age migration component was needed, and 2) calibrating the model to each county was prohibitively time consuming.

Cohort Interpolation

Although this method is less-sophisticated than the cohort-component model, we believe it produced accurate estimates suitable for Phase I purposes. This method entails interpolating inter-decade rates of change for single-year age-sex groups (birth cohorts). For instance, the Grant County ratio of males age 46 in 1960 to males age 36 in 1950 was computed, the 10th root taken, and interpolation was performed by raising the root to the first through ninth powers and multiplying the result by the 1950 population.

Once interpolations were made, the trial populations were reduced to age-sex shares of the totals. These shares were then multiplied by the intercensal total population estimates (ratio-correlation estimates) to provide provisional age-sex estimates.

Age-Group Interpolation

This method simply linearly interpolates between corresponding age-sex groups at the beginning and the end of each the decade. For instance, females who were age 27 in Benton County in 1960 would be subtracted from Benton County females who were age 27 in 1970, and the interpolation involved taking tenths of the amount of change. As with the cohort interpolation method, the resulting populations were transformed into age-sex shares and multiplied by the control totals (ratio-correlation estimates).

Final Age/Sex Estimates

Final estimates were made by weighing the results of the two methods. In most cases, the cohort interpolation model was given a weight of 0.8, and the age-group interpolation a weight of 0.2. In Dr. Pittenger's opinion, this seemed to offer more realistic age detail for intercensal years by preserving the "lumpiness" of age groups for small areas as they passed through time. The final age and sex estimates developed by Dr. Pittenger are contained in his report (Pittenger 1991).

Race Estimation Method

Race share estimates, by age and sex groups, were produced by interpolating between census years. These shares were multiplied by intercensal

population estimates. Race groups estimated were 1) whites, 2) non-whites, 3) Negroes/blacks, and 4) Indians. The age, sex, and race results developed by Dr. Pittenger are contained in his report (Pittenger 1991). It is important to note that due to serious census undercounting of Indians, Indian population estimates independent of census information are being prepared.

STEP 3: DEVELOPING POPULATION ESTIMATES FOR COUNTY CENSUS DIVISIONS

To provide finer resolution, HEDR estimates are reported by county sub-divisions. The county sub-divisions used for the HEDR Project are based on the county census divisions (CCDs) developed by the U.S. Census Bureau. The census bureau developed CCDs based on population density and regional economic organization. The HEDR county subdivision boundaries are identical to those developed by the U.S. Census Bureau 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 Division 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. For further discussion of the creation of HEDR CCDs, see Beck et al. (1990). Figure 3 illustrates the HEDR CCDs.

Intercensus population estimates were calculated for all CCDs within the HEDR study area for the years 1940 to 1970. Intercensus estimates were prepared by interpolating population shares between the two census counts bracketing a particular estimate year. Each CCD's county population share was then multiplied by the appropriate ratio-correlation intercensus estimate.

CCD boundaries changed several times during the 1940-1970 time span. To maintain consistency, the CCD boundaries reported in the 1970 census are used for all years. CCD boundaries for earlier decades were modified to make them consistent with the 1970 boundaries. Appendix E contains a description of how all the changes from census to census were addressed. The "Results" section

FIGURE 3. Hanford Environmental Dose Reconstruction County Census Divisions

of this report contains the population estimates for each HEDR CCD. Age, sex, and race distributions for the CCD were assumed to be identical to the distributions developed for the county as a whole.

of this report contains the most reliable estimates for each HEDS, and race distribution for the HEDS were drawn to be identical to the distribution reported for the county as a whole.

RESULTS

Phase I HEDR population estimates consist of the following: 1) estimates from each of three methods for each county in Washington for each year from 1940 to 1970, 2) population estimates for each CCD in the HEDR Phase I study area for each year, and 3) age/sex/race population component estimates for each county in the HEDR Phase I study area for each year.

The Washington County estimates and the HEDR study area CCD estimates are reported here. The age/sex/race component estimates were prepared by Donald Pittenger and are given in a separate report (Pittenger 1991).

COUNTY-LEVEL HEDR POPULATION ESTIMATES 1940 THROUGH 1970

The results from all three of the methods used to estimate county populations are presented in this section. Estimates were prepared for all counties in Washington for the years 1940 through 1970. We did not prepare estimates for Oregon counties because official historical estimates were available from the Oregon State Center for Population Research and Census. Oregon estimates were most likely developed by some combination of straight-line interpolation and component method II procedures.^(a)

Plots of the estimates from all three methods are given for each Washington county in the HEDR study area in Figures 4 through 11. Figures 12 and 13 depict the Morrow and Umatilla estimates supplied by the Oregon State Center for Population Research and Census.

A complete listing of estimates for all Washington counties is given in Tables 4a through 4e. The listing is divided by year as follows:

- 4a 1940 - 1946
- 4b 1947 - 1953
- 4c 1954 - 1960
- 4d 1961 - 1967
- 4e 1968 - 1970.

(a) This is based on a phone conversation with the director of the Oregon State Center for Population Research and Census.

FIGURE 4. Adams County Population Estimates 1940 through 1970

FIGURE 5. Benton County Population Estimates 1940 through 1970

FIGURE 6. Franklin County Population Estimates 1940 through 1970

FIGURE 7. Grant County Population Estimates 1940 through 1970

FIGURE 8. Kittitas County Population Estimates 1940 through 1970

FIGURE 9. Klickitat County Population Estimates 1940 through 1970

FIGURE 10. Walla Walla County Population Estimates 1940 through 1970

FIGURE 11. Yakima County Population Estimates 1940 through 1970

FIGURE 12. Morrow County Population Estimates 1940 through 1970

FIGURE 13. Umatilla County Population Estimates 1940 through 1970

TABLE 4a. Population Estimates for Washington Counties 1941 - 1946^(a)

		1940 ^(b)	1941	1942	1943	1944	1945	1946
ADAMS	VITAL ^(c)	6209	6000	6100	6300	7900	7700	6600
	RATIO	6209	6300	6600	6300	6600	6400	6700
	COMPONENT II	6209	6500	6800	6500	5900	5000	5000
ASOTIN	VITAL	8365	7300	9300	7200	8700	9100	8100
	RATIO	8365	8400	8500	7800	8300	9100	9400
	COMPONENT II	8365	10100	9700	9500	9300	7600	7700
BENTON	VITAL	12053	12300	11500	12800	70987	18109	28761
	RATIO	12053	12100	12300	24600	70987	30300	32900
	COMPONENT II	12053	8900	6800	26400	70987	21609	17861
CHELAN	VITAL	34412	34400	34000	31800	34500	38000	41900
	RATIO	34412	34200	34600	33100	34200	35300	38700
	COMPONENT II	34412	37300	37700	37200	37500	38600	39900
CLALLAM	VITAL	21848	21500	20800	20800	22100	22200	23900
	RATIO	21848	21800	22400	22000	21400	23300	24300
	COMPONENT II	21848	22000	22700	23500	20500	22200	22300
CLARK	VITAL	49852	55700	66500	92600	99900	97000	90500
	RATIO	49852	52800	67200	91500	96500	96400	92300
	COMPONENT II	49852	58600	95700	127400	135200	112300	93100
COLUMBIA	VITAL	5549	6300	5600	5000	6700	6500	5700
	RATIO	5549	5500	5300	4600	4600	4900	5200
	COMPONENT II	5549	5900	5500	5000	5000	5000	4700
COWLITZ	VITAL	40155	40600	41100	36300	38100	41600	43700
	RATIO	40155	41500	43500	40200	40400	44600	46600
	COMPONENT II	40155	46100	47500	45000	43500	45800	44500
DOUGLAS	VITAL	8651	8800	7000	8600	9100	8100	9300
	RATIO	8651	8400	8400	8000	8400	8400	9500
	COMPONENT II	8651	9200	8500	7800	8000	6200	6800
FERRY	VITAL	4701	4300	3700	3700	4000	2500	2900
	RATIO	4701	4100	4000	3300	3100	3600	4100
	COMPONENT II	4701	4800	4200	3500	3100	3200	3700
FRANKLIN	VITAL	6307	6800	6800	8700	9900	11200	9900
	RATIO	6307	6400	6700	8700	9500	9800	10100
	COMPONENT II	6307	7100	7200	11500	11700	8700	8300
GARFIELD	VITAL	3383	2600	2500	2600	2600	2600	2600
	RATIO	3383	3300	3100	3100	3200	3200	3400
	COMPONENT II	3383	3700	3000	2900	3000	2800	2900

TABLE 4a. (contd)

		1940 ^(b)	1941	1942	1943	1944	1945	1946
GRANT	VITAL	14668	9600	9100	9400	9100	8300	11800
	RATIO	14668	12100	12800	10200	9800	12000	15000
	COMPONENT II	14668	12700	13400	12200	10400	9500	12200
GRAYS HARBOR	VITAL	53166	52300	50400	45600	48800	51600	55800
	RATIO	53166	52300	52100	49400	49900	51700	55000
	COMPONENT II	53166	57600	53300	52600	51300	50400	51100
ISLAND	VITAL	6098	6100	6800	8200	8300	8900	8900
	RATIO	6098	6300	7000	7700	7700	8800	8800
	COMPONENT II	6098	6900	8200	8500	8500	8200	8100
JEFFERSON	VITAL	8918	9900	10100	10900	10600	9900	10000
	RATIO	8918	8800	9000	8400	8100	8900	9000
	COMPONENT II	8918	10100	9500	8900	8000	9200	9200
KING	VITAL	504980	547900	634500	676300	681200	741900	761800
	RATIO	504980	533600	579000	644100	667200	704900	726400
	COMPONENT II	504980	602200	647500	674900	703000	693400	659600
KITSAP	VITAL	44387	56100	75700	86100	91500	105600	93400
	RATIO	44387	54200	64700	89800	94400	101600	93200
	COMPONENT II	44387	65900	80800	105500	119000	136400	104700
KITITITAS	VITAL	20230	21800	17300	17100	21100	20400	22800
	RATIO	20230	19800	19600	19200	19400	20300	21300
	COMPONENT II	20230	22100	20300	21000	20300	20900	20900
KLICKITAT	VITAL	11357	10900	8500	8700	9200	10400	9300
	RATIO	11357	10600	10100	9600	9500	11200	12000
	COMPONENT II	11357	12400	10700	10800	10800	10400	10200
LEWIS	VITAL	41393	38600	41100	37300	40300	42400	43800
	RATIO	41393	40500	40800	38900	39800	41600	44800
	COMPONENT II	41393	45400	43500	42800	42000	42700	42800
LINCOLN	VITAL	11361	11200	9000	11500	11900	10900	10900
	RATIO	11361	11100	11000	9900	10000	10300	11100
	COMPONENT II	11361	11700	11100	10100	9800	9500	9900
MASON	VITAL	11603	10500	12400	13100	11900	11400	12700
	RATIO	11603	11900	12700	12000	12000	13500	14100
	COMPONENT II	11603	13600	14600	12300	12100	13900	13500

TABLE 4a. (contd)

		1940 ^(b)	1941	1942	1943	1944	1945	1946
OKANOGAN	VITAL	24546	21400	20200	21700	20600	22100	26500
	RATIO	24546	23800	24000	23200	24100	25400	27800
	COMPONENT II	24546	25700	25600	23000	24500	25500	27600
PACIFIC	VITAL	15928	14200	14500	13300	14400	15800	14800
	RATIO	15928	15700	15000	13500	14100	16000	17500
	COMPONENT II	15928	17400	14600	14500	15200	15200	16200
PEND ORIELLE	VITAL	7156	6500	5700	6200	5400	5200	5300
	RATIO	7156	6600	6700	6100	6000	6400	7200
	COMPONENT II	7156	7500	7400	6700	6200	6100	6700
PIERCE	VITAL	182081	195600	214100	240200	230300	241700	242000
	RATIO	182081	200400	215100	230700	232000	247000	254800
	COMPONENT II	182081	213800	236500	244100	255700	262700	251700
SAN JUAN	VITAL	3157	2400	2800	2600	2100	3200	3800
	RATIO	3157	2900	2800	2500	2500	2700	3000
	COMPONENT II	3157	3100	2800	2400	2100	2000	2400
SKAGIT	VITAL	37650	38900	38900	41900	46300	45000	49000
	RATIO	37650	37500	38700	37900	39600	41200	43000
	COMPONENT II	37650	41000	41900	40700	40100	42700	41700
SKAMANIA	VITAL	4633	4700	4900	5100	3300	4400	4500
	RATIO	4633	4700	4800	3800	3800	3900	4500
	COMPONENT II	4633	5200	5000	4100	3300	3600	3800
SNOHOMISH	VITAL	88754	87200	88700	91700	93800	99400	104700
	RATIO	88754	91700	95800	97600	99300	106900	111400
	COMPONENT II	88754	100600	103300	106000	103900	99700	98000
SPOKANE	VITAL	164652	163300	168800	182300	191200	201100	216900
	RATIO	164652	165600	181700	188600	194200	201500	209700
	COMPONENT II	164652	180000	208600	210200	210800	204000	192500
STEVENS	VITAL	19275	17500	16000	15400	14400	14200	15000
	RATIO	19275	18100	17400	16000	16000	15800	17100
	COMPONENT II	19275	19000	17300	15700	14700	17300	18200
THURSTON	VITAL	37285	41300	39000	44200	40200	40700	44000
	RATIO	37285	38500	39500	39600	38900	41000	42700
	COMPONENT II	37285	42500	43300	41200	40100	41300	39900
WAHIAKUM	VITAL	4286	3600	4200	3500	3400	3300	3800
	RATIO	4286	4500	4200	3800	3500	3900	4200
	COMPONENT II	4286	4400	4000	3700	2500	4000	3900

TABLE 4a. (contd)

		<u>1940^(b)</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>
WALLA	VITAL	30547	31100	29600	31600	36600	39600	40500
WALLA	RATIO	30547	30200	31100	32000	32100	35500	36600
	COMPONENT II	30547	32600	34300	34300	31800	33800	33800
WHATCOM	VITAL	60355	59100	61200	64400	65000	66600	71700
	RATIO	60355	59800	60500	59100	60400	62800	66400
	COMPONENT II	60355	64500	61300	60000	59600	57100	56700
WHITMAN	VITAL	27221	26800	26400	24700	27400	25300	29000
	RATIO	27221	26400	26500	24100	25600	26500	28200
	COMPONENT II	27221	29400	26900	26000	26700	25600	25300
YAKIMA	VITAL	99019	96000	88300	91900	104400	113200	120100
	RATIO	99019	96500	96100	96000	101500	112100	121400
	COMPONENT II	99019	104300	100100	106400	111100	125700	128300

(a) Intercensus estimates are rounded to nearest hundred.

(b) Actual census count.

(c) Average of birth and death estimates.

TABLE 4b. Population Estimates for Washington Counties 1947 - 1953^(a)

		1947	1948	1949	1950 ^(b)	1951	1952	1953
ADAMS	VITAL ^(c)	6700	8200	8500	6584	5700	7100	6600
	RATIO	6100	6400	6500	6584	6500	6900	7300
	COMPONENT II	5400	5800	5800	6584	7300	7800	8400
ASOTIN	VITAL	10000	7600	12400	10878	12000	10800	11100
	RATIO	9300	8900	10100	10878	11200	10900	11600
	COMPONENT II	7700	8800	9300	10878	11400	11400	12000
BENTON	VITAL	29096	54428	56248	57267	60000	66200	60900
	RATIO	42100	62400	57900	57267	58300	59900	62600
	COMPONENT II	31996	71928	53348	57267	57200	59400	66200
CHELAN	VITAL	43000	43300	42500	39301	34900	36500	35500
	RATIO	38800	38300	38500	39301	38400	39100	39800
	COMPONENT II	39800	43300	40300	39301	42500	44000	46100
CLALLAM	VITAL	24600	26400	23900	26396	29400	27900	29900
	RATIO	23900	24600	25400	26396	26600	27100	27200
	COMPONENT II	22900	26800	26300	26396	28900	30900	31400
CLARK	VITAL	86600	84900	85700	85307	88700	86700	84100
	RATIO	84900	86000	86900	85307	87300	86800	85100
	COMPONENT II	91500	108500	96800	85307	94200	91900	92600
COLUMBIA	VITAL	5800	6600	5600	4860	4300	5500	4400
	RATIO	4900	4800	4900	4860	4400	4600	4200
	COMPONENT II	4600	5100	5200	4860	4900	4800	4700
COWLITZ	VITAL	48200	52100	51200	53369	55300	57300	55700
	RATIO	46600	48300	49300	53369	55600	55800	56700
	COMPONENT II	46500	54400	54500	53369	58800	58100	58200
DOUGLAS	VITAL	8600	9600	10900	10817	11200	14500	13200
	RATIO	9200	9400	10300	10817	11500	11900	12900
	COMPONENT II	6800	7800	8500	10817	12600	12900	12700
FERRY	VITAL	2800	4100	3800	4096	4500	5200	4300
	RATIO	3800	3900	3900	4096	3700	3800	3800
	COMPONENT II	3500	3800	3600	4096	4200	4300	4300
FRANKLIN	VITAL	10500	11400	13000	13563	14300	17800	17200
	RATIO	11300	11900	12900	13563	14800	15300	16400
	COMPONENT II	11200	14300	12800	13563	15200	15900	18200
GARFIELD	VITAL	2800	3100	3400	3204	3600	3100	3500
	RATIO	3000	3100	3400	3204	3000	2800	2900
	COMPONENT II	2800	3200	3000	3204	3300	3300	3400

TABLE 4b. (contd)

		<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950^(b)</u>	<u>1951</u>	<u>1952</u>	<u>1953</u>
GRANT	VITAL	14900	14800	17000	24346	24300	23900	26600
	RATIO	16500	17000	21300	24346	26700	27200	30200
	COMPONENT II	12800	15100	20600	24346	26800	28200	30300
GRAYS HARBOR	VITAL	56400	61200	57500	53644	54000	49800	48000
	RATIO	54000	54600	54300	53644	52300	52000	50700
	COMPONENT II	51500	57800	54200	53644	55700	55300	55800
ISLAND	VITAL	9000	8700	9000	11079	12400	12100	16600
	RATIO	8400	8700	9300	11079	11500	11700	13800
	COMPONENT II	8300	10800	11500	11079	13000	13500	14300
JEFFERSON	VITAL	9500	10500	12900	11618	10600	12200	9900
	RATIO	8700	9400	10000	11618	11600	12000	11100
	COMPONENT II	9200	11300	11700	11618	13000	12500	10800
KING	VITAL	724100	740500	750700	732992	746000	755900	764600
	RATIO	695900	707700	716900	732992	760000	771200	772900
	COMPONENT II	662500	777500	767400	732992	794200	802200	825100
KITSAP	VITAL	74500	70500	69200	75724	87500	91000	86600
	RATIO	79700	78300	71700	75724	79100	80800	79600
	COMPONENT II	93000	102200	86500	75724	84300	88400	86700
KITITITAS	VITAL	21100	23200	22800	22235	21200	19900	20100
	RATIO	21000	21100	21800	22235	20700	20100	20100
	COMPONENT II	21300	23400	23500	22235	23200	21900	22200
KLICKITAT	VITAL	10300	12100	12800	12049	11400	12400	12200
	RATIO	11300	11700	12200	12049	12000	12100	12500
	COMPONENT II	10500	12100	12000	12049	13900	14500	16100
LEWIS	VITAL	40500	44400	44100	43755	42500	40900	39700
	RATIO	43100	43100	43800	43755	42000	41900	41300
	COMPONENT II	43100	48300	44900	43755	46200	46100	46900
LINCOLN	VITAL	12800	10300	11500	10970	10200	12400	10100
	RATIO	10100	10300	10900	10970	10400	10600	10500
	COMPONENT II	9800	10800	10600	10970	11600	11100	11300
MASON	VITAL	12700	13300	13100	15022	17100	17800	18300
	RATIO	13700	13800	14400	15022	15100	15300	15200
	COMPONENT II	13300	14800	15500	15022	16600	16700	17000
OKANOGAN	VITAL	24800	29100	26700	29131	25400	22600	22700
	RATIO	27100	26900	27400	29131	26900	26400	26400
	COMPONENT II	27400	29100	28800	29131	28800	27900	28800

TABLE 4b. (contd)

		1947	1948	1949	1950 ^(b)	1951	1952	1953
PACIFIC	VITAL	15000	18100	15700	16558	16400	18100	16700
	RATIO	17100	17300	17300	16558	16000	16100	15600
	COMPONENT II	16000	18000	16900	16558	17700	17700	17000
PEND ORIELLE	VITAL	6300	6300	6800	7413	8900	8900	9300
	RATIO	6900	6800	7300	7413	7100	7300	7600
	COMPONENT II	6400	6900	7400	7413	7800	8500	8600
PIERCE	VITAL	232000	222400	230000	275876	274100	278400	283100
	RATIO	240900	245800	253100	275876	280100	283100	287600
	COMPONENT II	250400	288600	285100	275876	294500	290200	297100
SAN JUAN	VITAL	3400	3700	3100	3245	3500	2600	3200
	RATIO	3000	3000	3200	3245	3100	3000	3000
	COMPONENT II	2500	3000	2900	3245	3500	3300	3300
SKAGIT	VITAL	47400	34900	36900	43273	45600	40800	42300
	RATIO	41500	42200	42300	43273	42000	42000	42200
	COMPONENT II	41600	46300	45200	43273	45500	46000	47400
SKAMANIA	VITAL	5500	6000	5100	4788	4600	5600	4900
	RATIO	4200	4200	4500	4788	4500	4500	4900
	COMPONENT II	4000	4300	4300	4788	5400	5200	5500
SNOHOMISH	VITAL	105500	112200	106200	111580	115200	114900	121700
	RATIO	108100	110000	110200	111580	116500	117400	120500
	COMPONENT II	97500	111900	112100	111580	122000	122600	127300
SPOKANE	VITAL	209500	211100	219000	221561	227400	236900	247500
	RATIO	205000	211800	215900	221561	229000	233700	236300
	COMPONENT II	193400	223700	224000	221561	247600	252600	258900
STEVENS	VITAL	15600	17900	17000	18580	19000	18500	19100
	RATIO	16700	17200	17100	18580	18000	17900	17800
	COMPONENT II	18300	21100	19500	18580	19800	19300	19300
THURSTON	VITAL	41500	43800	43800	44884	45600	45100	42600
	RATIO	41700	43000	44100	44884	44700	44200	44100
	COMPONENT II	39400	45800	45300	44884	46200	44900	46700
WAHAKIAKUM	VITAL	4100	3700	4100	3835	4100	4100	4200
	RATIO	3700	3800	3900	3835	3700	3600	3600
	COMPONENT II	3500	4100	4000	3835	4000	3800	3900
WALLA WALLA	VITAL	35800	37300	40900	40135	39800	38000	41300
	RATIO	36600	37200	38200	40135	40000	40100	40600
	COMPONENT II	35200	40200	40200	40135	42900	42900	42600

TABLE 4b. (contd)

		<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950^(b)</u>	<u>1951</u>	<u>1952</u>	<u>1953</u>
WHATCOM	VITAL	70700	71900	71100	66733	69800	62200	63200
	RATIO	62400	64000	65700	66733	64000	63500	64500
	COMPONENT II	55400	66200	66100	66733	68300	68600	71500
WHITMAN	VITAL	30900	32700	31300	32469	31400	30700	27600
	RATIO	28200	28200	29500	32469	31500	31000	30600
	COMPONENT II	26400	29300	30000	32469	33900	32500	32000
YAKIMA	VITAL	116400	119800	126100	135723	129000	134800	134900
	RATIO	124200	126200	125600	135723	134400	134600	132100
	COMPONENT II	129400	147600	138200	135723	148400	147500	156100

(a) Intercensus estimates are rounded to nearest hundred.

(b) Actual census count.

(c) Average of birth and death estimates.

TABLE 4c. Population Estimates for Washington Counties 1954 - 1960^(a)

		1954	1955	1956	1957	1958	1959	1960 ^(b)
ADAMS	VITAL ^(c)	6800	7600	8600	8300	8300	8900	9929
	RATIO	7900	8646	9100	9400	9600	9700	9929
	COMPONENT II	9500	9500	9900	8700	10000	9800	9929
ASOTIN	VITAL	12700	12400	12300	11900	11200	11100	12909
	RATIO	11800	12341	12600	13000	12700	12600	12909
	COMPONENT II	12400	14200	14200	13200	13600	12800	12909
BENTON	VITAL	68200	63800	60200	59300	61300	61900	62070
	RATIO	64000	61964	61800	62000	62700	62700	62070
	COMPONENT II	66500	64100	63900	57200	62800	64000	62070
CHELAN	VITAL	38800	35800	36600	35000	36300	37500	40744
	RATIO	40700	40024	40000	40400	41000	40000	40744
	COMPONENT II	45900	44500	41300	38500	44100	42700	40744
CLALLAM	VITAL	29600	29500	29300	30900	30300	31600	30022
	RATIO	27400	28107	28700	28100	28100	28100	30022
	COMPONENT II	31400	31700	31900	27700	30700	30300	30022
CLARK	VITAL	80800	86500	86300	82500	89000	88000	93809
	RATIO	85400	88550	90000	88700	89700	91400	93809
	COMPONENT II	92400	86900	88400	81000	91100	91700	93809
COLUMBIA	VITAL	4200	4400	4300	4700	4800	4100	4569
	RATIO	4300	4258	4300	4400	4400	4200	4569
	COMPONENT II	4800	4800	4600	4300	4800	4900	4569
COWLITZ	VITAL	54200	54500	57100	55600	54200	58900	57801
	RATIO	56900	57444	58600	57900	57600	57100	57801
	COMPONENT II	57900	59000	59800	54000	58600	57500	57801
DOUGLAS	VITAL	14700	11900	12700	12800	14300	14900	14890
	RATIO	12800	12701	12900	13400	14000	13700	14890
	COMPONENT II	12000	13100	12900	11500	14500	14700	14890
FERRY	VITAL	5000	4500	5100	5100	4900	5000	3889
	RATIO	3900	3583	3600	3700	3800	3700	3889
	COMPONENT II	4100	3600	3600	3400	3700	3900	3889
FRANKLIN	VITAL	17100	19300	18400	16900	18500	17500	23342
	RATIO	17000	19202	19700	20800	21300	22000	23342
	COMPONENT II	19000	22000	22200	20300	23600	23800	23342
GARFIELD	VITAL	3100	2900	2900	3200	3200	2800	2976
	RATIO	2900	2735	2700	2800	2800	2700	2976
	COMPONENT II	3400	3100	3100	2900	3100	3000	2976

TABLE 4c. (contd)

		<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960^(b)</u>
GRANT	VITAL	32800	37700	41000	41200	40000	40600	46477
	RATIO	33200	39964	41600	42200	42400	43600	46477
	COMPONENT II	37200	47000	50100	40100	45300	44600	46477
GRAYS HARBOR	VITAL	47400	48300	51300	50500	50900	51000	54465
	RATIO	51100	51410	53100	52600	53400	52400	54465
	COMPONENT II	55900	55000	55900	49000	54800	54100	54465
ISLAND	VITAL	17900	19100	18300	20600	21400	23300	19638
	RATIO	14900	14942	15600	16700	17800	18800	19638
	COMPONENT II	15200	12000	13000	12900	16200	17600	19638
JEFFERSON	VITAL	9800	10600	9600	10100	9500	8800	9639
	RATIO	11100	10913	11000	11200	11100	11200	9639
	COMPONENT II	10800	10400	10000	9300	9800	9800	9639
KING	VITAL	768200	807200	832500	863600	897000	919500	935014
	RATIO	789300	829585	855800	887000	907200	946400	935014
	COMPONENT II	834900	846700	865200	811700	922400	929500	935014
KITSAP	VITAL	86900	87300	86100	86500	83700	82700	84176
	RATIO	80200	80757	80800	79300	79800	77200	84176
	COMPONENT II	87600	94800	92400	81300	90500	87000	84176
KITITAS	VITAL	18000	20600	20800	20000	22000	20300	20467
	RATIO	20000	19744	19800	19500	20000	19900	20467
	COMPONENT II	21600	19400	19200	16900	18700	20200	20467
KLICKITAT	VITAL	13900	13700	11400	11900	11100	11800	13455
	RATIO	13100	13624	13000	12500	12400	12900	13455
	COMPONENT II	17000	16600	14000	12200	13600	13200	13455
LEWIS	VITAL	42200	41400	43000	42900	40400	42600	41858
	RATIO	41100	41065	41300	41600	41200	40200	41858
	COMPONENT II	46300	43600	43300	38200	40400	41300	41858
LINCOLN	VITAL	11000	11900	12200	10200	10600	10600	10919
	RATIO	10500	10408	10500	10700	10700	10800	10919
	COMPONENT II	11100	10100	9900	9500	10800	11300	10919
MASON	VITAL	18600	19300	21100	19500	20700	17100	16251
	RATIO	15400	15625	15800	15900	15800	15400	16251
	COMPONENT II	17000	16600	17100	15100	16800	16700	16251
OKANOGAN	VITAL	25500	23300	25500	26300	23200	25100	25520
	RATIO	27000	25920	26200	25800	25900	25400	25520
	COMPONENT II	27700	26900	25600	22800	25600	25400	25520

TABLE 4c. (contd)

		<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960^(b)</u>
PACIFIC	VITAL	15000	16800	15300	16000	15200	16700	14674
	RATIO	15600	15271	15400	15300	15400	14400	14674
	COMPONENT II	17000	15800	15700	14100	15500	14800	14674
PEND ORIELLE	VITAL	8300	8100	8400	9000	7700	7000	6914
	RATIO	7700	7286	7600	7400	7200	7000	6914
	COMPONENT II	9200	7400	8200	7500	7800	7400	6914
PIERCE	VITAL	284700	294800	317600	345600	338900	355300	321590
	RATIO	291700	298538	311400	318700	323700	330800	321590
	COMPONENT II	296500	288700	291900	260700	298500	304000	321590
SAN JUAN	VITAL	2700	2600	2900	3000	2200	3200	2872
	RATIO	2900	2823	2800	2800	2900	2800	2872
	COMPONENT II	2900	2700	2800	2500	2800	2800	2872
SKAGIT	VITAL	43900	47700	48400	47000	49700	47900	51350
	RATIO	43600	46202	46800	48500	49200	49700	51350
	COMPONENT II	51000	50700	49600	47900	53200	52300	51350
SKAMANIA	VITAL	4700	5000	5300	5500	4700	6000	5207
	RATIO	4800	4886	5000	4900	5000	5100	5207
	COMPONENT II	4800	5000	4900	4100	5000	5200	5207
SNOHOMISH	VITAL	129200	134700	144700	149000	155900	160300	172199
	RATIO	125700	136516	141300	147900	152700	161500	172199
	COMPONENT II	133800	136300	141500	133400	159400	165600	172199
SPOKANE	VITAL	259300	264900	275800	276800	274900	276500	278333
	RATIO	243700	253361	259900	266800	271500	273400	278333
	COMPONENT II	269400	264700	270900	250700	284100	281100	278333
STEVENS	VITAL	19400	19500	20000	18000	18600	19400	17884
	RATIO	17700	17845	18000	18000	18400	17600	17884
	COMPONENT II	18500	18400	18000	16500	19200	18900	17884
THURSTON	VITAL	47900	47000	52000	53600	55900	56500	55049
	RATIO	45000	45793	48000	49200	51000	50900	55049
	COMPONENT II	47800	48800	49900	45200	53100	53900	55049
WAHIAKUM	VITAL	4000	4600	3300	4300	3900	3500	3426
	RATIO	3700	3656	3500	3700	3700	3500	3426
	COMPONENT II	3600	3400	3100	3000	3400	3500	3426
WALLA WALLA	VITAL	38300	39500	37000	41200	42200	40100	42195
	RATIO	40600	40867	41200	41600	42100	41600	42195
	COMPONENT II	42100	41200	41500	37500	41300	41900	42195

TABLE 4c. (contd)

		<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960^(b)</u>
WHATCOM	VITAL	64200	67500	66000	62300	67800	66100	70317
	RATIO	66100	66317	66100	67100	68200	66400	70317
	COMPONENT II	71000	70100	68000	63200	71200	70300	70317
WHITMAN	VITAL	28500	31300	28900	31700	31200	31000	31263
	RATIO	31100	30902	31200	32000	32600	31800	31263
	COMPONENT II	32700	30800	29900	28700	31000	31200	31263
YAKIMA	VITAL	136300	145600	136400	138200	145300	146600	145112
	RATIO	134100	140223	140900	140600	143900	142400	145112
	COMPONENT II	157700	158900	154100	134500	151600	147700	145112

(a) Intercensus estimates are rounded to nearest hundred.

(b) Actual census count.

(c) Average of birth and death estimates.

TABLE 4d. Population Estimates for Washington Counties 1961 - 1967^(a)

		1961	1962	1963	1964	1965	1966	1967
ADAMS	VITAL ^(b)	8800	8800	8500	9800	8700	9500	10100
	RATIO	10400	10900	10500	10700	10400	10800	10900
	COMPONENT II	9400	9700	9800	9900	10000	10100	10200
ASOTIN	VITAL	11300	11200	12500	13500	12600	12000	12500
	RATIO	12300	12400	12500	12600	12700	12900	13200
	COMPONENT II	11500	11500	11400	11100	11100	11300	12100
BENTON	VITAL	62200	64000	67000	65100	63800	68900	66300
	RATIO	62300	62700	64400	64100	64600	65400	65800
	COMPONENT II	56900	57800	55600	53400	52500	52300	54200
CHELAN	VITAL	42400	40200	43700	46000	41900	43800	47300
	RATIO	40300	39600	40000	40000	39100	39400	40200
	COMPONENT II	35700	35700	34800	34200	31700	31100	31700
CLALLAM	VITAL	29800	29500	26600	28800	32400	29800	31500
	RATIO	30800	30500	30600	30700	31500	31300	32600
	COMPONENT II	27500	28400	28700	29300	29600	28900	29900
CLARK	VITAL	98500	99400	97300	107000	106100	116400	117600
	RATIO	93600	95300	97500	99000	100100	105600	111200
	COMPONENT II	84200	84800	84000	83800	84500	87700	93000
COLUMBIA	VITAL	5600	5800	6100	5300	5300	6000	6100
	RATIO	4800	4800	5000	4900	4700	5100	5600
	COMPONENT II	4200	4100	4300	4000	4300	4900	4900
COWLITZ	VITAL	56500	57300	59400	61700	67900	62000	64100
	RATIO	56600	57500	57500	59000	61000	62300	63700
	COMPONENT II	52500	52700	52500	52100	53200	54800	56500
DOUGLAS	VITAL	14600	14000	15000	15600	17400	19600	18800
	RATIO	15500	15100	14900	14800	15400	15900	15600
	COMPONENT II	13000	12500	12300	12500	12400	12000	12800
FERRY	VITAL	4100	4200	4200	4100	3900	3600	3400
	RATIO	3800	3800	3700	3700	3600	3500	3400
	COMPONENT II	3300	3400	3400	3400	3300	3200	3200
FRANKLIN	VITAL	25000	23100	23300	23800	26000	28100	26800
	RATIO	23800	24300	25700	25100	25100	25800	25200
	COMPONENT II	21500	21600	21000	20700	21000	21200	20700
GARFIELD	VITAL	3400	3000	2200	2800	2100	2800	3300
	RATIO	3300	3000	2800	2900	2700	3100	3400
	COMPONENT II	2600	2600	2600	2400	2600	3200	3500

TABLE 4d. (contd)

		<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>
GRANT	VITAL	51500	52500	48200	48500	44500	38900	41700
	RATIO	47900	48500	46800	45500	41900	39600	40300
	COMPONENT II	45600	41100	40000	39100	37600	33600	35200
GRAYS HARBOR	VITAL	54600	53400	55300	58200	62000	59900	58800
	RATIO	52900	54600	53300	55000	55700	56800	55800
	COMPONENT II	48600	48100	49300	49600	48700	48300	49200
ISLAND	VITAL	20000	19800	20100	21500	19900	20000	23400
	RATIO	20700	21400	22300	22200	21900	22900	25900
	COMPONENT II	19200	19600	20700	19800	20000	21400	22700
JEFFERSON	VITAL	9300	9300	8100	8500	9200	8800	9500
	RATIO	9600	9800	8900	9500	9400	9700	9900
	COMPONENT II	8300	8600	8800	8300	8000	8200	8200
KING	VITAL	942500	968700	970900	947600	952800	1030100	1072900
	RATIO	953600	979200	993500	985200	986800	1033900	1093500
	COMPONENT II	868600	885300	882100	878400	898500	926000	983500
KITSAP	VITAL	87200	87000	90300	89000	93600	94400	102100
	RATIO	83600	85600	84900	86400	87800	89900	93700
	COMPONENT II	77000	80600	78700	79300	78300	83000	85400
KITITITAS	VITAL	20800	19100	19000	18800	19500	19600	19800
	RATIO	21200	20600	19900	19200	19900	20800	20600
	COMPONENT II	19500	19000	19000	19100	19100	19900	20600
KLICKITAT	VITAL	12600	13100	14000	13200	12000	14000	11500
	RATIO	13400	13500	13600	13500	13700	13800	12200
	COMPONENT II	12300	12000	12000	12200	11500	10500	10000
LEWIS	VITAL	41200	44600	42300	45400	45600	44300	48400
	RATIO	42500	44100	41900	42200	43500	45500	44200
	COMPONENT II	37200	37500	36500	35500	36200	36300	36300
LINCOLN	VITAL	10000	9700	10700	9200	9000	10200	9600
	RATIO	10900	10500	10300	9800	9700	9800	9600
	COMPONENT II	9700	9500	8900	8500	8300	8300	8200
MASON	VITAL	17100	17300	17600	17800	18200	17800	18400
	RATIO	16500	16400	16500	17000	17800	17400	18100
	COMPONENT II	14600	14800	15000	15200	15200	15200	15800
OKANOGAN	VITAL	24800	23000	25500	23800	25400	22700	23400
	RATIO	25400	25000	25000	24700	25200	25500	24300
	COMPONENT II	22100	21900	22100	23000	21500	20800	21200

TABLE 4d. (contd)

		<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>
PACIFIC	VITAL	13500	15500	13400	15700	17700	17800	18800
	RATIO	13900	14900	13400	14200	14700	14600	14800
	COMPONENT II	12900	12700	12100	11900	12000	11500	11900
PEND ORIELLE	VITAL	6900	6500	7100	6900	7900	8200	7800
	RATIO	6900	6700	7100	7300	7800	7900	6700
	COMPONENT II	6400	6400	6800	7200	7600	7300	5300
PIERCE	VITAL	320600	334600	339200	344100	333000	341300	359800
	RATIO	329200	338500	340700	345300	345200	353800	377100
	COMPONENT II	302000	304100	313000	312900	310500	327600	337600
SAN JUAN	VITAL	3000	2900	3200	3800	3600	3300	2700
	RATIO	3100	3000	3100	3100	3300	3300	3100
	COMPONENT II	2400	2400	2200	2000	1800	1800	2100
SKAGIT	VITAL	52700	53600	50400	51100	50100	52100	55700
	RATIO	50600	50900	49600	49600	49100	51000	51100
	COMPONENT II	45800	45500	45100	43500	42500	42000	43300
SKAMANIA	VITAL	4500	4800	5000	5200	5200	4700	5100
	RATIO	5100	5400	5300	5500	5500	5500	5200
	COMPONENT II	4600	4700	4900	4900	4900	4400	4400
SNOHOMISH	VITAL	174300	188000	190100	193300	193500	201300	216900
	RATIO	180400	187400	196200	199100	202900	209700	224000
	COMPONENT II	161200	166700	166400	165800	167700	177700	190900
SPOKANE	VITAL	276200	274500	274600	273800	275200	269900	272300
	RATIO	272600	273900	268800	267400	264800	269800	272200
	COMPONENT II	248200	246300	239500	236800	234200	235500	242100
STEVENS	VITAL	18000	16200	15400	16000	17000	16900	16700
	RATIO	17200	17300	15700	16200	16900	17000	16200
	COMPONENT II	15600	15400	15300	14500	14200	13600	13400
THURSTON	VITAL	58100	64200	61300	65700	62400	67100	70900
	RATIO	56100	59000	58700	60500	61000	62100	66500
	COMPONENT II	53000	52800	52600	53600	54000	57000	60400
WAHKIAKUM	VITAL	3700	3800	4200	3600	4000	3700	4700
	RATIO	3700	3500	3300	3500	3700	3300	3600
	COMPONENT II	3000	3100	2800	3100	2600	2700	2800
WALLA WALLA	VITAL	43600	43800	42400	44400	44400	44300	45400
	RATIO	41700	42700	42000	43300	41300	42900	42500
	COMPONENT II	37600	37600	38700	37100	37500	38000	39000

TABLE 4d. (contd)

		<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>
WHATCOM	VITAL	74500	72600	70900	74300	74200	73600	74800
	RATIO	70600	72200	70900	70700	70900	71000	74500
	COMPONENT II	62700	64700	63700	63300	64400	64400	68900
WHITMAN	VITAL	30100	31300	31000	27600	30000	27800	28600
	RATIO	31400	32100	32100	31400	31700	31900	33300
	COMPONENT II	29500	30300	31200	31400	31700	31500	32200
YAKIMA	VITAL	149200	151800	158300	150700	152200	152000	154700
	RATIO	143900	145300	146100	146000	143900	146100	144400
	COMPONENT II	133900	133800	132500	132800	129600	132000	133600

(a) Intercensus estimates are rounded to nearest hundred.

(b) Average of birth and death estimates.

TABLE 4e. Population Estimates for Washington Counties 1968 - 1970^(a)

		<u>1968</u>	<u>1969</u>	<u>1970^(b)</u>
ADAMS	VITAL ^(c)	9200	9300	12014
	RATIO	11100	10900	12014
	COMPONENT II	10800	12100	12014
ASOTIN	VITAL	13200	13100	13799
	RATIO	13100	13200	13799
	COMPONENT II	12600	13500	13799
BENTON	VITAL	65400	71200	67540
	RATIO	66600	66600	67540
	COMPONENT II	61200	67700	67540
CHELAN	VITAL	42300	40600	41355
	RATIO	39800	39200	41355
	COMPONENT II	38400	40200	41355
CLALLAM	VITAL	32300	33100	34770
	RATIO	33300	33800	34770
	COMPONENT II	31800	34600	34770
CLARK	VITAL	121900	125900	128454
	RATIO	116500	121300	128454
	COMPONENT II	109500	124200	128454
COLUMBIA	VITAL	4700	5500	4439
	RATIO	4900	4800	4439
	COMPONENT II	5000	4600	4439
COWLITZ	VITAL	66200	73300	68616
	RATIO	65500	65900	68616
	COMPONENT II	62900	68100	68616
DOUGLAS	VITAL	16800	18600	16787
	RATIO	16800	16600	16787
	COMPONENT II	13800	15200	16787
FERRY	VITAL	3600	3500	3655
	RATIO	3600	3500	3655
	COMPONENT II	3300	3700	3655
FRANKLIN	VITAL	25200	27200	25816
	RATIO	25000	26200	25816
	COMPONENT II	24200	25700	25816
GARFIELD	VITAL	3100	3100	2911
	RATIO	3400	3100	2911
	COMPONENT II	2800	3000	2911

TABLE 4e. (contd)

		<u>1968</u>	<u>1969</u>	<u>1970^(b)</u>
GRANT	VITAL	42200	43400	41881
	RATIO	41000	41500	41881
	COMPONENT II	39700	42200	41881
GRAYS HARBOR	VITAL	61200	62100	59553
	RATIO	57100	58700	59553
	COMPONENT II	55100	59600	59553
ISLAND	VITAL	24100	22700	27011
	RATIO	26500	28400	27011
	COMPONENT II	25300	27300	27011
JEFFERSON	VITAL	9000	10400	10661
	RATIO	9900	10600	10661
	COMPONENT II	10200	10800	10661
KING	VITAL	1116500	1112900	1156633
	RATIO	1129000	1140400	1156633
	COMPONENT II	1106800	1193900	1156633
KITSAP	VITAL	106700	109300	101732
	RATIO	97300	100000	101732
	COMPONENT II	92600	101500	101732
KITITITAS	VITAL	20300	20500	25039
	RATIO	21800	22100	25039
	COMPONENT II	23400	24900	25039
KLICKITAT	VITAL	11600	12800	12138
	RATIO	12400	12100	12138
	COMPONENT II	11100	12100	12138
LEWIS	VITAL	46800	48700	45467
	RATIO	45500	46600	45467
	COMPONENT II	41200	45600	45467
LINCOLN	VITAL	9600	10500	9572
	RATIO	10000	9600	9572
	COMPONENT II	9000	9400	9572
MASON	VITAL	19500	22100	20918
	RATIO	18800	20000	20918
	COMPONENT II	18700	20300	20918
OKANOGAN	VITAL	24300	25800	25867
	RATIO	24400	25300	25867
	COMPONENT II	23600	26100	25867

TABLE 4e. (contd)

		<u>1968</u>	<u>1969</u>	<u>1970^(b)</u>
PACIFIC	VITAL	17900	18200	15796
	RATIO	14800	15400	15796
	COMPONENT II	14100	15900	15796
PEND OREILLE	VITAL	6000	5700	6025
	RATIO	6400	6200	6025
	COMPONENT II	5300	5800	6025
PIERCE	VITAL	372000	386900	411027
	RATIO	388600	402500	411027
	COMPONENT II	389400	418400	411027
SAN JUAN	VITAL	2800	3500	3856
	RATIO	3200	3600	3856
	COMPONENT II	2500	3300	3856
SKAGIT	VITAL	55700	57800	52381
	RATIO	52000	54200	52381
	COMPONENT II	47800	52500	52381
SKAMANIA	VITAL	4700	5300	5845
	RATIO	5400	5600	5845
	COMPONENT II	6200	6400	5845
SNOHOMISH	VITAL	229700	245800	265236
	RATIO	233800	248900	265236
	COMPONENT II	239900	267500	265236
SPOKANE	VITAL	284800	289900	287487
	RATIO	279800	285700	287487
	COMPONENT II	260800	286600	287487
STEVENS	VITAL	16200	16700	17405
	RATIO	16600	17400	17405
	COMPONENT II	14500	16900	17405
THURSTON	VITAL	73200	74500	76894
	RATIO	70200	74500	76894
	COMPONENT II	68200	76000	76894
WAHKIAKUM	VITAL	3800	4000	3592
	RATIO	3500	3800	3592
	COMPONENT II	3300	3500	3592
WALLA WALLA	VITAL	44500	44800	42176
	RATIO	42900	42500	42176
	COMPONENT II	38200	43000	42176

TABLE 4e. (contd)

		<u>1968</u>	<u>1969</u>	<u>1970^(b)</u>
WHATCOM	VITAL	79500	84500	81950
	RATIO	77000	81300	81950
	COMPONENT II	72600	79300	81950
WHITMAN	VITAL	29800	30800	37900
	RATIO	34500	34700	37900
	COMPONENT II	35700	38200	37900
YAKIMA	VITAL	159800	157800	144971
	RATIO	148300	146400	144971
	COMPONENT II	134500	146400	144971

(a) Intercensus estimates are rounded to nearest hundred.

(b) Actual census count.

(c) Average of birth and death estimates.

SUBCOUNTY HEDR POPULATION ESTIMATES

Population estimates for each county census division in the HEDR study area are given for each year by county in Tables 5a through 5j.

TABLE 5a. Adams County Population by Division

	<u>1940</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>	<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950</u>	<u>1951</u>
AD1	40	40	42	40	42	41	43	39	41	42	42	39
AD2	2974	3020	3170	2998	3180	3050	3204	2939	3063	3126	3154	2992
AD3	135	137	144	136	144	138	145	133	139	142	143	136
AD4	157	160	168	159	168	161	170	156	162	166	167	163
AD5	1145	1163	1220	1154	1224	1174	1233	1131	1179	1203	1214	1147
AD6	98	100	105	99	105	101	106	97	101	103	104	97
AD7	270	274	287	272	288	277	291	267	278	283	286	271
AD8	620	629	660	624	662	635	667	612	638	651	657	623
AD9	117	119	125	118	125	120	126	116	120	123	124	120
AD10	654	664	696	659	699	670	704	646	673	687	693	887
COUNTY ESTIMATE	6209	6305	6617	6258	6639	6367	6688	6136	6395	6525	6584	6474
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
AD1	39	39	40	41	40	38	35	33	30	30	31	29
AD2	3051	3146	3268	3410	3423	3382	3302	3184	3075	3109	3179	2970
AD3	139	144	150	157	158	157	154	149	145	144	145	132
AD4	170	181	193	208	216	221	224	224	226	230	238	224
AD5	1165	1196	1237	1284	1282	1258	1220	1168	1118	1135	1165	1093
AD6	97	98	99	101	98	94	88	82	75	76	78	74
AD7	275	283	293	305	305	300	292	280	269	267	267	244
AD8	635	654	679	708	711	701	684	659	636	648	668	630
AD9	125	132	140	150	154	157	158	157	157	158	161	150
AD10	1157	1473	1846	2283	2682	3072	3453	3812	4198	4553	4991	4998
COUNTY ESTIMATE	6854	7346	7945	8646	9069	9380	9609	9747	9929	10352	10924	10545
	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>					
AD1	29	28	28	27	27	25	27					
AD2	2915	2746	2745	2659	2608	2449	2599					
AD3	127	117	113	107	101	91	93					
AD4	222	211	214	209	208	198	213					
AD5	1077	1020	1024	998	985	930	994					
AD6	73	69	69	68	67	63	68					
AD7	234	215	209	196	185	167	169					
AD8	623	593	599	586	582	553	595					
AD9	147	138	138	133	130	121	128					
AD10	5254	5304	5682	5899	6206	6254	7128					
COUNTY ESTIMATE	10701	10440	10820	10881	11098	10853	12014					

TABLE 5b. Benton County Population by Division

	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
BE1	968	972	992	1675	1775	695	791	981	1157	1255	1289	1476
BE2	1000	1000	1000	4414	34315	2660	58	72	84	92	94	104
BE3	3815	3830	3900	7493	15688	7242	8244	10220	12056	13076	13424	15697
BE4	1114	1118	1141	1973	2634	1030	1173	1454	1715	1860	1910	2281
BE5	1686	1692	1725	3141	6006	2345	2670	3309	3904	4235	4347	4945
BE6	1284	1290	1315	2321	3627	1422	1619	2007	2367	2568	2636	2954
BE7	240	240	240	240	3336	13517	16746	22069	38729	32253	30950	27880
BE8	833	837	855	1400	980	385	438	544	641	696	714	761
BE9	1113	1117	1140	1970	2627	1028	1170	1450	1710	1855	1905	2233
COUNTY ESTIMATE	12053	12097	12308	24627	70987	30325	32908	42105	62365	57889	57267	58330

* For the years 1944-1950, BE2 population reflects the number of construction workers.

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
BE1	1528	1611	1660	1620	1629	1647	1678	1691	1689	1724	1764	1845
BE2	103	105	104	98	94	91	89	86	82	81	80	81
BE3	16582	17827	18716	18606	19043	19573	20282	20766	21057	21426	21860	22785
BE4	2458	2692	2875	2904	3016	3144	3301	3421	3510	3408	3316	3292
BE5	5087	5329	5456	5294	5291	5314	5384	5393	5353	5241	5143	5154
BE6	2991	3085	3110	2969	2920	2885	2875	2831	2763	2767	2779	2853
BE7	28040	28710	28716	27204	26535	25999	25681	25065	24229	24302	24445	25126
BE8	730	710	671	597	543	491	443	390	333	323	314	311
BE9	2365	2549	2683	2673	2741	2823	2931	3007	3054	3001	2955	2973
COUNTY ESTIMATE	59884	62619	63990	61964	61813	61967	62664	62650	62070	62273	62658	64419

	1964	1965	1966	1967	1968	1969	1970
BE1	1865	1910	1965	2008	2064	2096	2158
BE2	80	79	79	78	78	76	76
BE3	22969	23461	24074	24528	25157	25478	26168
BE4	3157	3065	2985	2882	2797	2676	2592
BE5	4992	4897	4823	4714	4635	4496	4420
BE6	2832	2849	2880	2892	2923	2917	2954
BE7	24981	25172	25485	25623	25938	25931	26295
BE8	298	289	281	271	262	250	242
BE9	2891	2848	2818	2767	2734	2666	2635
COUNTY ESTIMATE	64065	64571	65390	65762	66587	66587	67540

TABLE 5c. Franklin County Population by Division

	<u>1940</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>	<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950</u>	<u>1951</u>
FR1	363	368	387	503	544	562	582	648	683	740	781	918
FR2	338	342	359	467	506	522	541	603	635	688	726	756
FR3	4756	4819	5063	6585	7129	7357	7627	8491	8943	9696	10228	10953
FR4	70	71	75	97	105	109	113	125	132	143	151	244
FR5	780	790	830	1080	1169	1206	1251	1392	1466	1590	1677	1912
COUNTY ESTIMATE	6307	6391	6713	8732	9454	9756	10114	11259	11859	12858	13563	14784
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
FR1	1018	1167	1289	1538	1669	1853	1991	2163	2396	2522	2670	2910
FR2	745	760	748	796	771	762	728	702	687	706	730	779
FR3	11129	11723	11954	13213	13311	13761	13794	13999	14522	15059	15718	16906
FR4	335	448	557	731	857	1016	1154	1314	1518	1447	1383	1355
FR5	2066	2310	2497	2922	3114	3402	3601	3857	4219	4022	3843	3765
COUNTY ESTIMATE	15294	16406	17045	19202	19721	20795	21269	22035	23342	23756	24343	25714
	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>					
FR1	2931	3012	3192	3212	3269	3516	3556					
FR2	768	773	803	793	793	838	833					
FR3	16809	17064	17876	17789	17914	19070	19100					
FR4	1220	1114	1041	914	802	733	616					
FR5	3390	3095	2892	2541	2230	2036	1711					
COUNTY ESTIMATE	25117	25057	25804	25250	25009	26193	25816					

TABLE 5d. Grant County Population by Division

	<u>1940</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>	<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950</u>	<u>1951</u>
GR1	3236	2666	2814	2244	2154	2644	3302	3649	3744	4697	5371	5390
GR2	1036	854	901	719	690	847	1058	1169	1199	1504	1720	1763
GR3	124	102	107	86	82	101	126	139	143	179	205	219
GR4	542	447	472	376	361	443	553	611	627	787	900	938
GR5	1744	1436	1516	1209	1161	1425	1779	1966	2017	2531	2894	3060
GR6	848	698	737	588	564	693	865	956	981	1230	1407	1680
GR7	2942	2423	2559	2040	1958	2404	3002	3317	3404	4270	4883	5724
GR8	774	637	673	536	515	632	789	872	895	1123	1284	1593
GR9	243	201	212	169	162	199	248	274	282	353	404	486
GR10	236	194	205	163	157	192	240	266	273	342	391	489
GR11	81	67	71	56	54	66	83	92	94	118	135	170
GR12	92	75	80	64	61	75	93	103	106	133	152	215
GR13	7	5	6	5	4	5	7	7	8	10	11	44
GR14	2765	2277	2405	1917	1840	2259	2821	3118	3199	4013	4589	4900
COUNTY ESTIMATE	14668	12083	12757	10171	9763	11986	14969	16540	16972	21289	24346	26671
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
GR1	4987	4993	4862	5119	4562	3840	3078	2356	1652	1801	1923	1953
GR2	1673	1726	1742	1918	1809	1641	1459	1302	1177	1212	1226	1182
GR3	217	236	252	295	299	294	287	286	295	303	305	293
GR4	906	954	987	1117	1089	1026	956	904	880	890	884	837
GR5	3003	3218	3391	3920	3911	3785	3632	3551	3593	3668	3678	3517
GR6	1851	2219	2605	3346	3702	3967	4212	4554	5096	5287	5387	5235
GR7	6211	7343	8518	10826	11865	12608	13282	14262	15858	16312	16480	15878
GR8	1811	2228	2675	3501	3939	4282	4605	5036	5693	5689	5578	5211
GR9	539	649	766	987	1096	1178	1254	1360	1525	1575	1598	1545
GR10	559	691	833	1094	1233	1344	1449	1587	1797	1908	1988	1974
GR11	196	244	296	390	442	483	522	573	650	704	746	753
GR12	269	355	449	614	716	802	885	989	1139	1297	1438	1508
GR13	77	122	173	256	316	370	423	487	574	564	543	497
GR14	4861	5269	5620	6582	6659	6543	6381	6350	6548	6672	6677	6371
COUNTY ESTIMATE	27160	30247	33166	39964	41639	42165	42424	43596	46477	47882	48452	46756
	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>					
GR1	1995	1926	1901	2020	2136	2250	2358					
GR2	1150	1059	1000	1018	1033	1046	1055					
GR3	284	260	245	248	251	253	254					
GR4	799	722	669	667	664	658	650					
GR5	3391	3096	2897	2922	2939	2948	2947					
GR6	5130	4760	4527	4641	4745	4838	4916					
GR7	15428	14196	13386	13612	13801	13955	14065					
GR8	4903	4365	3977	3901	3811	3707	3588					
GR9	1508	1393	1319	1346	1371	1391	1408					
GR10	1975	1870	1813	1895	1972	2047	2116					
GR11	766	735	723	765	806	845	883					
GR12	1586	1570	1585	1718	1851	1982	2109					
GR13	458	398	353	336	318	298	277					
GR14	6130	5585	5214	5248	5266	5270	5255					
COUNTY ESTIMATE	45502	41935	39607	40338	40964	41488	41881					

TABLE 5e. Kittitas County Population by Division

	<u>1940</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>	<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950</u>	<u>1951</u>
K11	749	732	727	709	720	750	789	778	781	808	823	764
K12	350	342	340	332	337	351	369	364	365	378	385	351
K13	115	112	111	109	110	115	121	119	120	124	126	112
K14	28	28	27	27	27	28	30	29	29	30	31	29
K15	4737	4631	4601	4485	4553	4748	4989	4922	4942	5112	5207	4750
K16	679	663	659	643	652	680	715	705	708	732	746	678
K17	662	647	643	627	637	664	698	688	691	715	728	670
K18	2276	2225	2211	2155	2188	2281	2397	2365	2375	2456	2502	2387
K19	1687	1649	1638	1597	1621	1691	1777	1753	1760	1820	1854	1709
K110	1276	1248	1240	1208	1227	1279	1344	1326	1332	1377	1403	1295
K111	7670	7497	7448	7261	7372	7687	8078	7969	8002	8276	8430	7923
COUNTY ESTIMATE	20230	19775	19645	19153	19444	20275	21306	21018	21105	21829	22235	20668
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
K11	744	742	738	727	727	717	734	729	750	773	750	719
K12	334	327	318	307	300	290	290	281	282	295	291	284
K13	105	100	95	89	84	79	76	71	68	77	81	83
K14	28	28	28	27	27	27	27	27	28	29	27	26
K15	4538	4447	4339	4191	4110	3972	3981	3870	3896	3922	3718	3478
K16	646	631	613	590	577	555	554	536	537	549	528	502
K17	646	639	630	615	609	595	603	593	604	633	625	609
K18	2384	2442	2490	2513	2575	2600	2723	2765	2908	2909	2739	2544
K19	1651	1636	1615	1578	1567	1534	1557	1534	1566	1574	1489	1391
K110	1253	1243	1229	1203	1196	1172	1193	1177	1203	1238	1201	1150
K111	7803	7882	7931	7903	7997	7977	8257	8291	8625	9179	9199	9098
COUNTY ESTIMATE	20132	20118	20026	19744	19771	19518	19995	19873	20467	21177	20650	19885
	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>					
K11	690	714	745	731	772	779	879					
K12	277	291	308	307	330	338	387					
K13	86	95	106	110	123	131	156					
K14	25	25	26	25	26	26	29					
K15	3252	3277	3324	3171	3252	3180	3476					
K16	478	490	506	492	515	514	575					
K17	594	625	663	661	710	727	834					
K18	2360	2359	2371	2241	2275	2199	2375					
K19	1298	1305	1321	1257	1286	1254	1367					
K110	1102	1139	1186	1163	1227	1236	1393					
K111	8996	9591	10292	10396	11292	11701	13568					
COUNTY ESTIMATE	19157	19912	20847	20555	21809	22085	25039					

TABLE 5f. Klickitat County Population by Division

	<u>1940</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>	<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950</u>	<u>1951</u>
KL1	316	295	281	267	263	311	335	314	325	339	335	331
KL2	193	181	172	163	161	190	205	192	199	208	205	212
KL3	3250	3040	2889	2746	2709	3201	3444	3235	3350	3493	3448	3439
KL4	12	11	11	10	10	12	13	12	13	13	13	20
KL5	600	562	534	507	500	591	636	598	619	645	637	628
KL6	532	497	473	449	443	524	563	529	548	571	564	557
KL7	3701	3462	3290	3128	3085	3646	3922	3685	3815	3979	3927	3877
KL8	876	819	778	740	730	862	928	872	903	941	929	911
KL9	874	817	777	738	728	861	926	870	901	939	927	933
KL10	1003	938	892	847	836	988	1063	998	1034	1078	1064	1046
COUNTY ESTIMATE	11357	10622	10096	9596	9466	11186	12034	11306	11706	12208	12049	11952
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
KL1	333	342	355	369	349	336	331	340	354	351	353	356
KL2	223	239	258	279	274	274	281	299	322	309	301	293
KL3	3506	3636	3822	4007	3832	3730	3721	3865	4064	4045	4080	4129
KL4	27	35	44	54	59	64	71	81	92	83	75	68
KL5	632	648	672	696	658	632	623	639	664	655	655	657
KL6	562	576	600	622	589	567	560	576	599	594	597	602
KL7	3912	4016	4178	4336	4104	3954	3905	4015	4179	4192	4262	4347
KL8	912	930	961	989	930	889	871	888	917	913	921	933
KL9	959	1004	1064	1125	1084	1064	1069	1119	1186	1193	1217	1245
KL10	1050	1073	1111	1147	1081	1036	1018	1041	1078	1045	1025	1009
COUNTY ESTIMATE	12116	12498	13065	13624	12958	12546	12449	12864	13455	13381	13485	13637
	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>					
KL1	351	354	358	314	319	310	310					
KL2	279	271	263	222	216	200	191					
KL3	4093	4142	4203	3702	3775	3677	3697					
KL4	59	51	43	30	23	15	7					
KL5	645	647	650	568	573	553	551					
KL6	594	599	605	531	539	523	524					
KL7	4342	4428	4527	4017	4127	4050	4101					
KL8	925	937	951	838	855	833	838					
KL9	1246	1275	1307	1163	1197	1178	1196					
KL10	971	954	939	801	790	745	723					
COUNTY ESTIMATE	13505	13657	13846	12184	12414	12083	12138					

TABLE 5g. Walla Walla County Population by Division

	<u>1940</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>	<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950</u>	<u>1951</u>
WA1	690	682	701	723	725	802	825	826	840	863	906	902
WA2	134	133	136	140	141	156	160	160	163	168	176	173
WA3	674	667	685	706	708	784	806	807	821	843	885	898
WA4	612	606	622	641	643	712	732	733	746	766	804	796
WA5	397	392	403	416	417	461	475	475	483	496	521	516
WA6	1458	1443	1483	1528	1533	1697	1745	1747	1777	1825	1916	1898
WA7	508	503	517	533	534	591	608	609	619	636	668	652
WA8	2744	2716	2791	2876	2884	3192	3283	3287	3343	3433	3605	3662
WA9	2571	2545	2615	2695	2703	2991	3077	3080	3132	3217	3378	3341
WA10	2416	2391	2457	2532	2540	2810	2891	2894	2943	3023	3174	3232
WA11	18344	18156	18661	19226	19284	21341	21952	21979	22349	22952	24102	23963
COUNTY												
ESTIMATE	30547	30234	31074	32015	32112	35538	36554	36599	37216	38219	40135	40031
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
WA1	902	911	908	913	919	926	935	921	932	902	907	872
WA2	170	169	166	164	162	160	159	154	153	147	147	141
WA3	915	941	955	977	1001	1026	1054	1057	1087	1083	1120	1109
WA4	792	794	788	787	787	788	791	775	779	760	770	746
WA5	513	515	511	511	511	512	515	504	507	494	501	485
WA6	1890	1898	1884	1883	1887	1891	1901	1863	1875	1829	1855	1799
WA7	639	631	616	605	596	586	578	556	548	540	552	541
WA8	3739	3849	3915	4009	4114	4223	4344	4358	4489	4482	4650	4616
WA9	3323	3333	3303	3298	3299	3302	3313	3242	3258	3238	3343	3303
WA10	3307	3412	3477	3568	3668	3772	3888	3907	4031	4049	4226	4219
WA11	23954	24155	24065	24153	24292	24449	24667	24279	24536	24135	24671	24129
COUNTY												
ESTIMATE	40143	40610	40589	40867	41236	41636	42145	41616	42195	41660	42744	41960
	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>					
WA1	881	823	837	810	798	773	749					
WA2	141	131	132	127	125	120	115					
WA3	1154	1111	1164	1161	1181	1180	1181					
WA4	760	716	735	718	714	699	684					
WA5	494	466	477	466	464	454	444					
WA6	1833	1728	1772	1732	1725	1687	1653					
WA7	556	529	548	542	545	538	533					
WA8	4814	4644	4877	4880	4973	4981	4995					
WA9	3430	3294	3444	3431	3482	3473	3469					
WA10	4425	4292	4531	4557	4667	4698	4734					
WA11	24800	23580	24408	24073	24185	23884	23619					
COUNTY												
ESTIMATE	43289	41315	42927	42498	42858	42486	42176					

TABLE 5h. Yakima County Population by Division

	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
YA1	2165	2110	2100	2099	2218	2451	2654	2715	2758	2746	2967	2968
YA2	8704	8483	8444	8439	8920	9853	10672	10918	11091	11041	11930	11715
YA3	2303	2244	2234	2233	2360	2607	2823	2888	2934	2921	3156	3088
YA4	236	230	229	228	241	267	289	296	300	299	323	306
YA5	46170	45000	44794	44767	47316	52268	56611	57914	58834	58571	63284	62704
YA6	2130	2076	2066	2065	2182	2411	2611	2671	2714	2702	2919	2842
YA7	22490	21920	21820	21806	23048	25460	27576	28210	28659	28530	30826	30371
YA8	840	819	815	815	861	951	1031	1054	1071	1066	1152	1150
YA9	11548	11255	11204	11197	11834	13073	14159	14485	14715	14649	15828	15910
YA10	1536	1498	1491	1490	1575	1739	1884	1927	1958	1949	2106	2090
YA11	899	876	872	872	921	1018	1102	1127	1145	1140	1232	1226
YA12	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY ESTIMATE	99019	96509	96069	96011	101477	112096	121413	124207	126180	125615	135723	134371
	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
YA1	3002	2976	3053	3223	3271	3295	3404	3400	3498	3554	3672	3777
YA2	11636	11324	11404	11821	11779	11652	11822	11593	11712	11687	11867	12002
YA3	3057	2964	2974	3072	3049	3004	3036	2965	2983	2964	2997	3019
YA4	293	274	265	263	250	235	226	210	199	203	210	217
YA5	62851	61732	62745	65648	66029	65936	67337	66871	68211	68029	69044	69794
YA6	2798	2698	2692	2764	2727	2670	2681	2601	2599	2588	2622	2646
YA7	30270	29562	29875	31078	31079	30855	31421	30930	31365	30744	30663	30456
YA8	1161	1149	1176	1240	1256	1263	1303	1299	1334	1248	1184	1114
YA9	16175	16110	16601	17606	17945	18157	18840	18893	19516	19304	19431	19481
YA10	2099	2065	2102	2204	2220	2221	2279	2260	2309	2256	2244	2221
YA11	1234	1218	1243	1306	1319	1323	1361	1353	1386	1368	1374	1375
YA12	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY ESTIMATE	134576	132073	134132	140223	140924	140611	143910	142375	145112	143944	145309	146102
	1964	1965	1966	1967	1968	1969	1970					
YA1	3861	3887	4034	4070	4267	4299	4340					
YA2	12067	11955	12214	12137	12536	12450	12394					
YA3	3023	2983	3035	3004	3091	3058	3032					
YA4	222	224	233	236	248	250	253					
YA5	70138	69459	70926	70445	72731	72198	71840					
YA6	2655	2625	2676	2654	2736	2712	2694					
YA7	30070	29253	29340	28619	29014	28277	27621					
YA8	1037	947	885	799	743	657	575					
YA9	19417	19072	19317	19031	19489	19190	18941					
YA10	2186	2120	2119	2059	2080	2020	1965					
YA11	1367	1340	1354	1331	1360	1336	1316					
YA12	0	0	0	0	0	0	0					
COUNTY ESTIMATE	146043	143865	146132	144385	148295	146446	144971					

TABLE 5i. Morrow County Population by Division

	<u>1940</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>	<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950</u>	<u>1951</u>
M01	1029	1020	997	973	949	949	997	949	1020	1115	1135	1138
M02	2331	2311	2258	2204	2150	2150	2258	2150	2311	2526	2571	2570
M03	977	968	946	923	901	901	946	901	968	1058	1077	1092
COUNTY ESTIMATE	4337	4300	4200	4100	4000	4000	4200	4000	4300	4700	4783	4800
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
M01	1208	1159	1139	1150	1118	1134	1072	1151	1145	1183	1141	1083
M02	2720	2603	2551	2567	2489	2515	2370	2537	2517	2533	2379	2201
M03	1172	1137	1130	1153	1133	1161	1108	1202	1209	1229	1166	1089
COUNTY ESTIMATE	5100	4900	4820	4870	4740	4810	4550	4890	4871	4945	4686	4373
	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>					
M01	1177	1216	1197	1209	1228	1255	1237					
M02	2332	2348	2253	2218	2198	2191	2107					
M03	1166	1186	1150	1143	1145	1154	1121					
COUNTY ESTIMATE	4675	4750	4600	4570	4570	4600	4465					

TABLE 5.j. Umatilla County Population by Division

	<u>1940</u>	<u>1941</u>	<u>1942</u>	<u>1943</u>	<u>1944</u>	<u>1945</u>	<u>1946</u>	<u>1947</u>	<u>1948</u>	<u>1949</u>	<u>1950</u>	<u>1951</u>
UM1	1251	1259	1326	1389	1422	1427	1567	1667	1687	1980	2004	2044
UM2	1175	1183	1246	1305	1337	1341	1472	1567	1585	1860	1883	1899
UM3	4103	4130	4351	4556	4666	4682	5139	5470	5533	6495	6574	6837
UM4	1711	1722	1814	1900	1946	1952	2143	2281	2307	2708	2741	2746
UM5	2071	2085	2196	2299	2355	2363	2594	2761	2793	3278	3318	3502
UM6	7349	7397	7792	8159	8357	8385	9204	9797	9910	11632	11774	12412
UM7	996	1002	1056	1105	1132	1136	1247	1327	1342	1576	1595	1854
UM8	614	618	651	682	698	701	769	819	828	972	984	1086
UM9	1028	1035	1090	1141	1169	1173	1287	1370	1386	1627	1647	1742
UM10	1560	1571	1655	1732	1774	1780	1954	2080	2104	2470	2500	2634
UM11	524	527	555	581	596	598	656	698	706	829	839	961
UM12	1999	2012	2120	2220	2273	2281	2504	2665	2696	3164	3203	3145
UM13	1003	1010	1064	1114	1141	1144	1256	1337	1353	1588	1607	1565
UM14	645	650	684	717	734	736	808	860	870	1022	1034	1074
COUNTY ESTIMATE	26030	26200	27600	28900	29600	29700	32600	34700	35100	41200	41703	43300
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>
UM1	2202	2167	1935	1909	1948	1848	1749	1811	1757	1757	1700	1668
UM2	2022	1965	1732	1685	1695	1583	1474	1500	1429	1480	1483	1505
UM3	7511	7539	6872	6919	7212	6987	6760	7155	7102	7321	7298	7376
UM4	2902	2798	2446	2358	2349	2171	1999	2009	1888	1840	1733	1654
UM5	3904	3974	3674	3750	3962	3890	3813	4088	4110	4139	4033	3986
UM6	13820	14055	12978	13234	13967	13700	13417	14371	14434	14414	13927	13646
UM7	2251	2473	2449	2661	2976	3079	3168	3552	3723	3823	3797	3824
UM8	1262	1335	1280	1351	1474	1491	1503	1655	1706	1728	1693	1682
UM9	1947	1986	1840	1882	1992	1960	1925	2067	2082	2083	2017	1980
UM10	2493	2321	1950	1798	1702	1483	1275	1180	1004	995	954	927
UM11	1152	1253	1230	1327	1474	1517	1553	1734	1810	1823	1776	1755
UM12	3252	3060	2604	2436	2346	2086	1838	1756	1555	1571	1536	1522
UM13	1602	1491	1253	1155	1093	952	818	757	644	644	622	610
UM14	1180	1183	1077	1084	1129	1093	1056	1117	1108	1110	1075	1056
COUNTY ESTIMATE	47500	47600	43320	43550	45320	43840	42350	44750	44352	44726	43643	43193
	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>					
UM1	1643	1636	1636	1633	1648	1661	1630					
UM2	1533	1577	1630	1680	1749	1820	1841					
UM3	7482	7666	7892	8102	8406	8714	8788					
UM4	1582	1527	1479	1427	1389	1348	1271					
UM5	3955	3966	3997	4019	4086	4152	4105					
UM6	13423	13344	13330	13283	13382	13472	13197					
UM7	3865	3947	4050	4145	4288	4432	4457					
UM8	1678	1692	1715	1734	1772	1811	1800					
UM9	1951	1944	1946	1943	1962	1979	1943					
UM10	905	892	883	872	870	868	842					
UM11	1742	1747	1761	1770	1800	1829	1808					
UM12	1515	1525	1541	1555	1586	1616	1603					
UM13	601	598	598	596	601	606	594					
UM14	1042	1039	1041	1041	1052	1062	1044					
COUNTY ESTIMATE	42917	43100	43500	43800	44590	45370	44923					

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APPENDIX A

REVIEW OF RATIO-CORRELATION (REGRESSION)

MODELS AND RESULTS BY D. A. SWANSON

Regression Model Review

In terms of the three models, I find that using the same four symptomatic variables for three distinct decennial period model offers several advantages. First, the ratio-correlation form appears to be preferred over certain alternatives (i.e., the difference-correlation form) because the estimates are not affected by the presence of zero values (Swanson, 1976). Second, the four variables selected are an optimal choice in that they are the only ones available for each year beginning in 1940. Third, the accuracy of the annual estimates for each intercensal period is maximized by using three distinct models, one for each of the three intercensal periods. Fourth, by not adding different symptomatic indicators as they became available over the years (e.g., registered automobiles, sales tax receipts, state liquor store sales, covered employment, marriages, marital dissolutions, etc.), the changes in model characteristics can be examined in a manner that enhances one's ability to detect data input errors. This is not a minor issue. Tayman and Shafer (1982) have demonstrated that measurement errors affecting the input data have a far greater potential for creating subsequent errors in the final population estimates than does the "temporal instability" of model coefficients. Fifth, this approach avoids the temptation of simply including all available symptomatic indicators in a given regression, which has been found to be even less accurate than using the average of univariate regressions (Namboodiri and Lalu, 1971). Sixth, as has been noted elsewhere (National Research Council, 1980: 10-12), it is generally not possible to produce a set of population estimates that will minimize all accuracy criteria simultaneously, so it is necessary to make choices among different estimation techniques; By using the same symptomatic variables, these choices and their subsequent problems can be minimized.

Taking into consideration the preceding comments, I find that each of the three regression models conforms to the standard criteria for evaluating ratio-correlation regression models. First, each of the three models appears to be adequate in terms of the standard statistical and demographic criteria for evaluating ratio-correlation models: the explained variance for each model exceeds 90% and the sum of the coefficients for each model is approximately 1.00. Second, following a verification of the input data, each model was replicated in a second construction run.

In terms of criticism, there are several issues worth considering. First, it would be useful to conduct a residual analysis. Given the high values of the

coefficients of determination, ~~extreme~~ specification error is not likely but it would be useful to have the added assurance of a verification from an analysis of residuals. It would also be useful to know if other OLS assumptions are violated. Second, it would be useful to state if each model is constructed from a data set conceptualized as a population or a sample. If the former is the case, then it would be appropriate to eliminate the standard errors and significance tests from Table 1. If the latter is the case, then it would be appropriate to examine the issue of collinearity (Belsley, Kuh, and Welsch, 1980). Third, it may be useful to consider the effect of changing census accuracy on the estimates. At the national level, the U.S. Bureau of the Census has found that net undercount error declined from 1940 to 1970 (Brown, 1970). The sensitivity of the models and their estimates to net undercount error may be a factor to consider before placing final approval on any population estimates.

Population Estimates

Following the verification of each of the models, population estimates were developed for each year ending in "5" (1945, 1955, and 1965) in accordance with each model using the procedures outlined in the report. These procedures resulted in population estimates that, when rounded to the nearest hundred, matched those given in Appendix A of the report. Each county's intercensal estimates were also found to merge with the decennial census figures for each county. Thus, it appears that the models given in Table 1 are producing the estimates in Appendix A.

As a critical comment, it would be useful to display the state population figure for each year in Appendix A. Also, it would be useful to cite the source of the independently - estimated state population figures for each non-census year.

General Comments on The Report

In Appendix B, the report accurately describes the process of developing county population estimates using the ratio-correlation method. You may want to consider moving Appendix B to the section of the report labelled "Explanation of the Ratio-Correlation Technique." A few minor typographical and other errors are in the report. Those that I found are noted in the copy that I have enclosed.

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APPENDIX B

REVIEW OF HEDR MODELS AND RESULTS BY D. B. PITTENGER

Review and Comments on Population Estimates Report
for Hanford Environmental Dose Reconstruction Project

Prepared for Battelle Pacific Northwest Laboratories
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April 28, 1989

Aside from a little editing, the March, 1980 working report titled "Population Estimates for the Hanford Environmental Dose Reconstruction Project" needs little in the way of corrections.

However, there are several places where material needs to be added to make the report both complete and more defensible against legal or other challenge.

The points that I think need to be addressed are presented below.

SELECTION OF ACTUAL ESTIMATES

The writers present several series of estimates of total populations for counties in Washington state, but failed to produce one "final" series to be used for the balance of dosage study research. On Page 4, they suggest that the "ratio-correlation" technique yields the best result, but fail to commit themselves completely.

What is missing here is an analysis of the estimates produced by the various techniques.

If nothing else, they could have prepared a series of graphs--perhaps using a semi-log scale--for Benton and Franklin counties showing how the series compared. Just scanning the numerical output, I found the 1940-1950 period particularly interesting for Benton County.

Besides Benton and Franklin, they also could graph other counties that have experienced impacts from World War II or perhaps the construction of dams along the Columbia River between 1945 and 1970. Such counties might include Clark, Chelan, Douglas, Grant, King, Kitsap, Island, and Okanogan.

From such graphs, it might be possible to get an impression as to which technique tends to handle sudden population changes best.

Another test is to compare the estimates against actual census counts. Besides the July 15, 1944 Benton County census, there were some county-wide censuses in Washington during the 1970s which might be used as a check if test estimates were prepared for that decade. (These censuses are: Cowlitz, September 13, 1973; San Juan, September 22, 1975; Stevens, September 25, 1975; and Pend Oreille, October 31, 1978.)

Instead of selecting a set of estimates resulting from one methodology, there are other options. For example, the estimates could be averaged across all methods. Or, averaging might be done using a judgmental weighting scheme (for instance, ratio-corellation could have a weight of 0.5, Component 11 could be 0.35, and vital rates 0.15).

ANONYMOUS STATE POPULATION CONTROL NUMBERS

Even though all the estimates were forced to sum to state population totals for each year, these totals are not reported. Furthermore, no source is given for the control totals.

These anonymous statewide data also come into play in establishing statewide vital rates for the vital rates method (see last paragraph, p. 16).

Clearly, the source of these data must be identified and the numbers justified.

MINOR CRITICISMS

The two subjects above are considered highly important, and should be dealt with as soon as possible. Below are notes on lesser issues taken in the sequence found in the report.

Rural Populations

The U.S. Census Bureau tabulates county populations by "rural" and "rural-farm" status, so these might be as good a proxy for the likelihood of drinking milk from backyard cows as simple dispersion. (See Page 2, last paragraph.)

Fix Equation

The second equation on Page 3 should have "symptomatic variable" or some such label substitute for "population".

Post-1970 Estimates

Paragraph 2, Page 4 indicates that OFM estimates are used after 1970. Although this may be reasonable, I think you need a stronger justification statement here to forestall

criticism.

Ratio-Correlation Variables

The question of variables used in the ratio-correlation estimates is fairly important, and I think the decision to use the same set over the entire 1940-1970 period (last paragraph, Page 4) needs stronger justification.

I (and an expert hired by, say, opposition lawyers should there be lawsuits concerning radiation doses), might argue that you should have chosen the sets of independent variables that yielded the best fit for each decade. After all, isn't the purpose of this project to derive the best possible data that can reasonably gotten? Accepting only those data available for the 30-year period makes some sense for an academic exercise--but this is the real world.

Therefore, if the present symptomatic data are to be used, I think it should be shown (through r-squares of regression fits for actual decade changes, etc.) that any improvement using other variables would be negligible.

Over-65 Populations

The treatment of the population over age 65 in the Component-II (C-II) method may require more thought.

The reason why over-65s are broken out is because net migration of the retired population can be in the opposite direction from net migration of the rest of the population. From the report, it seems that no explicit treatment for over-65s was made at all; this raises questions as to how good the C-II estimates were.

Granted that Medicaide data did not exist until the late 1960s. One way around this problem would be to estimate decade net migration rates for the over-65 population using a cohort-survival procedure, and use the following formula to derive net migration rates for intercensal years:

40
$$\text{RATEYRn} = (((1+\text{DECADERATE})^{**1/10})^{**n})-1$$

where ** denotes exponentiation.

Estimates of Births by Race

Estimating births by race (pp. 7-8) might be overkill, given the small non-white populations involved. The C-II method

uses race because, in some parts of the country, there are large black populations that have significantly higher mortality and fertility than the balance of the population

On the other hand, if data might be brought into future litigation, perhaps it is best to follow the accepted C-II procedures as far as possible.

Please note that the equations at the top of Page 8 are not needed. Since the denominators are identical, the share can be computed as follows:

$$.9585 = 8274/8632$$

Also, the phasing in the last three sentences of the second paragraph is repetitious--just state that you used U.S. total and white life tables for the years covering the census dates.

Group Quarters

The 1940 census presents some definitional problems because it followed rules for treating college students that were changed in 1950; the 1950 procedures essentially have been followed ever since. My 1940 census file for Washington counties has no group quarters tabulation, and the report states (Page 9) that none was reported for Yakima county--so probably nothing much can be done to clean up this aspect of 1940-1950 change.

I'm not sure how college students were handled for the other two decades. The New York State report uses total students rather than just those students living in group quarters. I suppose this is not a mistake, although it seems to be so at first glance. One can argue that not all in-migrating students live in dorms, so it is simplest to make all students (regardless of origin) honorary group quarters residents. Check with Dave Swanson or the Census Bureau on this point. In any case, state explicitly how student group quarters populations were defined in the estimation technique used.

Grade School Adjustment Ratios

Ratios used to estimate population from enrollment data (Page 10) are applied uniformly for approximately five years on either side of each census point. This can create a marked "stairstep" effect--particularly as shown between 1954 and 1955 for Yakima County. Why not interpolate between these ratios so that the result is a smoother (and

probably more realistic) intercensal progression. (On the other hand, if the cause for a lurch in the ratio can be found and its date established, that information should be incorporated in the procedure.)

Use of Life Tables for Entire Decades

A similar problem crops up on Page 12. The paragraph in the middle of the page states that life tables calculated around a census year are used for the for the balance of the decade.

This can be justified when making post-censal estimates; it's hard to make reliable sub-national life tables. This is why census-centered life tables are specified in the methodology.

But the Hanford study is an exercise in historical demography. Life tables for both ends of each decade in the study can be found. Therefore, it makes sense to interpolate between the endpoint life tables, since it is easy to do so and because the results are clearly more realistic.

Benton County Construction Workers

The report suggests (bottom of Page 17) that recorded numbers of military personnel and construction workers for the period 1944-1950 be added to the estimates resulting from the various techniques. A table presents these numbers.

It might save the reader time and trouble if these additions were performed and the results displayed in a table and on a graph.

NOTE ON ESTIMATES THEMSELVES

Although a complete set of estimation series came with the report, these data are not easy to evaluate.

First, the data used to compute the estimates were not sent with the report, so it was not possible to confirm that the computations were done correctly--though I understand that this indeed was done by another authority.

Second, the data were not graphed, so it is difficult to digest the data and understand how the numbers generated by

the various techniques correspond to one another.

Ideally, the writers of the report should have prepared graphs for the study area counties as well as other counties of interest. Then they should have presented an analysis of what the data meant. And they should have drawn conclusions as to which single method was best or else proposed a weighting scheme for averaging the data from the various methods into a single set of estimates.

FINAL THOUGHTS

My present role in the HEDR project is to critique the work of Battelle staff, presumably with the goal of keeping the study results as defensible as reasonably possible. Since there is no sure way of determining historical populations in years where no censuses were taken, the final estimates can only be evaluated on the basis of appeals to logic or on the performance of techniques in other times and places. The role of Battelle staff is to make the strongest possible case for the selected technology, and my task is to evaluate their case.

Most of the work they have done up to this point is sound. But they must make their final technical decision. The bullet is not yet bitten.

And they must give their decision proper supporting arguments before I can present my own final judgment. They must convince me. Me and the lawyers and juries, if it comes to that.

APPENDIX C

STEPS IN DEVELOPING RATIO-CORRELATION ESTIMATES

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STEPS IN DEVELOPING RATIO-CORRELATION ESTIMATES

Example Year 1941

Step 1: Construct Appropriate Regression Model for 1941-1949 Time Period

a) Develop appropriate ratio of proportions for each symptomatic indicator. For example, for births the ratio is expressed

$$\frac{\left(\frac{Bi}{\sum Bi} \right) 1950}{\left(\frac{Bi}{\sum Bi} \right) 1940} \quad (1)$$

where Bi = the number of births in county i

$\sum Bi$ = the total number of births for all counties in the State

b) Regress the appropriate symptomatic indicator variables on the dependent variable. The dependent variable is the ratio of change in the proportion of each county population relative to the state population total. This can be symbolized as

$$\begin{aligned} \left\{ \frac{\left(\frac{Pi}{\sum Pi} \right) 1950}{\left(\frac{Pi}{\sum Pi} \right) 1940} \right\} &= a + b1 \left\{ \frac{\left(\frac{Bi}{\sum Bi} \right) 1950}{\left(\frac{Bi}{\sum Bi} \right) 1940} \right\} + b2 \left\{ \frac{\left(\frac{Di}{\sum Di} \right) 1950}{\left(\frac{Di}{\sum Di} \right) 1940} \right\} \\ &+ b3 \left\{ \frac{\left(\frac{SEi}{\sum SEi} \right) 1950}{\left(\frac{SEi}{\sum SEi} \right) 1940} \right\} + b4 \left\{ \frac{\left(\frac{RVi}{\sum RVi} \right) 1950}{\left(\frac{RVi}{\sum RVi} \right) 1940} \right\} \end{aligned} \quad (2)$$

where P_i = the census number in county i

B_i = the number of births in county i

D_i = the number of deaths in county i

SE_i = the number of children enrolled in school in county i

RV_i = the number of registered voters in county i

ΣP_i = the census total for all counties in the State

ΣB_i = the total number of births for all counties in the State

ΣD_i = the number of deaths for all counties in the State

ΣSE = the number of children enrolled in school for all counties in the State

ΣRV = the number of registered voters for all counties in the State

Step 2: Develop for each county and for each year an estimated ratio of population proportion. For 1941 the equation is

$$\begin{aligned} \frac{\left(\frac{P_i}{\Sigma P_i}\right) 1941}{\left(\frac{P_i}{\Sigma P_i}\right) 1940} = & .015 + .153 \left\{ \frac{\left(\frac{B_i}{\Sigma B_i}\right) 1941}{\left(\frac{B_i}{\Sigma B_i}\right) 1940} \right\} - .035 \left\{ \frac{\left(\frac{D_i}{\Sigma D_i}\right) 1941}{\left(\frac{D_i}{\Sigma D_i}\right) 1940} \right\} \\ & + .366 \left\{ \frac{\left(\frac{SE_i}{\Sigma SE_i}\right) 1941}{\left(\frac{SE_i}{\Sigma SE_i}\right) 1940} \right\} + .500 \left\{ \frac{\left(\frac{RV_i}{\Sigma RV_i}\right) 1941}{\left(\frac{RV_i}{\Sigma RV_i}\right) 1940} \right\} \end{aligned} \quad (3)$$

Step 3: Produce unadjusted population estimates for each county and each year by taking the estimated ratio of population proportion for each county (derived in Step 2) and multiplying it by an independent state population total and by the county population proportion recorded in 1940.

Unadjusted Population Proportion 1941 =

$$\frac{\left(\frac{\Pi}{\Sigma P_i} \right)_{1941}}{\left(\frac{P_i}{\Sigma P_i} \right)_{1940}} * \frac{P_i}{\Sigma P_i}_{1940} * \left(\frac{\text{Independent State Population}}{\text{Population}} \right)$$

Estimate^(a)

Step 4: Produce adjusted county population estimates by dividing each county unadjusted population estimate by the sum of those estimates and then multiplying is number by the independent state population estimate for the estimate year

$$\frac{\text{Adjusted Population Estimate}_{1941}}{\text{Estimate}} = \left(\frac{\text{Unadjusted } P_i}{\Sigma \text{Unadjusted}} \right)_{1941} * \left(\frac{\text{Independent State Population Estimate}_{1941}}{\text{Population Estimate}_{1941}} \right)$$

(a) Independent State Population Estimates were taken from official numbers provided by the U.S. Census.

REFERENCES

United States Department of Commerce, Bureau of the Census, Population Division, Estimates of the Population of the States: 1940-1980, Washington, D.C. "State Ranking" File.

APPENDIX D

USE OF COMPONENT METHOD II PROCEDURE TO ESTIMATE
1947 YAKIMA COUNTY POPULATION

APPENDIX D

USE OF COMPONENT METHOD II PROCEDURE TO ESTIMATE 1947 YAKIMA COUNTY POPULATION

The following paragraphs detail the component method II procedure using Yakima County data for estimating the 1947 Yakima County population. Annual estimates from 1940 to 1970 produced by this method are presented in the Results section of this report.

PRELIMINARY DATA PREPARATION

Calculating the expected population of school-age children requires single-year census population counts and vital statistics data broken down by race by county. This level of historical data was not available for the entire time-frame of the HEDR study for the entire study area.

Single-year census counts are required for the population age 6 to 14, but are directly available for the 1960 and 1970 censuses only. For the 1940 and 1950 censuses, single-year census counts are obtained using Karup-King interpolation coefficients. An expansion of the theory behind this interpolation method is beyond the scope of this documentation, but for a reference please refer to Shyrock and Siegel (1976 p. 542 to 544).

Total statistics for the number of births and deaths by county for the 1940 to 1970 time frame were obtained. Racial breakdowns of these statistics were not readily available. The Vital Statistics of the United States^(a) was checked for the needed information. The data in these publications were tabulated in such a way that the actual number of white and nonwhite births and deaths for each county could not be ascertained. For this reason, the total number of births and deaths for the counties were allocated to white and nonwhite categories using fertility ratios based on the decennial censuses and national life tables.

(a) Published annually by the National Office of Vital Statistics,
U.S. Department of Health, Education and Welfare, Public Health Service.

The general fertility ratio of a county calculated from census data is the total number of children under 5 divided by the number of females of child bearing age, 15 to 44 (Shryock and Siegel 1976; p. 297). The general fertility ratio for a county is the ratio of the total number of white children (0 to 4) to the total number of child-bearing females (15 to 44) plus the ratio of the total number of nonwhite children to the total number of child-bearing females. Of total births, the percent of white births for a county is assumed to be the same as the percent that the white fertility ratio is of the total fertility ratio. The percent of white births is calculated for each census year according to Example 1 (for white births in Yakima County, 1940), and a linear interpolation is used to estimate the percent of white births for intercensal years.

The total number of deaths for a county is made up of white and nonwhite deaths. The number of white and nonwhite deaths for a census year can be estimated using national life tables and the census count. The percent of white deaths is calculated for the census years according to Example 2 (for white deaths in Yakima County 1940), and a linear interpolation is used to estimate the percent of white deaths for intercensal years. For 1940, 1939 to 1941 U.S. Life Tables for the total population and the white population are used. For 1950, 1949 to 1951 U.S. Life Tables for the total population and the white population are used. For 1960, 1959 to 1961 U.S. Life Tables for the total population and the white population are used. For 1970, the 1969 to 1971 U.S. Life Tables for the total population and the white population are used.

EXAMPLE 1. Calculating the Percent of White Births for 1940, Yakima County

$$\begin{aligned}
 \frac{(0 - 4 \text{ yrs tot.})}{(15 - 44 \text{ females})} &= \frac{(0 - 4 \text{ yrs white})}{(15 - 44 \text{ females})} + \frac{(0 - 4 \text{ yrs nonwhites})}{(15 - 44 \text{ females})} \\
 \frac{8,632}{22,955} &= \frac{8,274}{22,955} + \frac{358}{22,955} \\
 0.3760 &= 0.3604 + 0.0156 \\
 \frac{0.3604}{0.3760} &= \frac{\text{white fertility ratio of}}{\text{total fertility ratio}} \\
 .9584 &= \text{percent of white births}
 \end{aligned}$$

EXAMPLE 2. Calculating Percent of White Deaths for 1940, Yakima County

(total deaths) = (white deaths) + (nonwhite deaths)

(total pop.) * (tot. death rt.) = (white pop.) * (white death rt.) +
(nonwht pop.) * (nonwht death rt.)

$$\frac{(\text{white pop.}) * (\text{white death rt.})}{(\text{total pop.}) * (\text{tot. death rt.})} = \frac{\text{white deaths}}{\text{total deaths}}$$

$$\frac{95399 * (0.01484)}{99019 * (0.01510)} = .9471 = \text{percent of white deaths}$$

HEDR COMPONENT METHOD II POPULATION ESTIMATES

As already mentioned, the historical data available for HEDR population estimates varies from the data used by the U. S. Census Bureau for more recent estimations. The historical data obtained also varies across time periods. For this reason, the component method II methodology has been altered to accommodate the available data. The following paragraphs use data for Yakima County to estimate the 1947 population. It is pointed out where the component method II methodology has been altered to accommodate the available data.

1. Calculating the Non-Group Quarters Population Base
(New York Department of Commerce 1979; p. 3)

Group quarter populations consist primarily of institutional inmates and college students living away from home. These numbers are reported as group quarter population in the decennial censuses. Intercensal estimates of group quarter populations are made by linearly interpolating the group quarters population documented in the two censuses that bracket the estimate year. These annual group quarter estimates are added to the annual non-group quarter population estimates.

The non-group quarters population base used to estimate an intercensal year population is the total population of a county in a census year minus the reported group-quarters population in that year. For example, the 1940 U.S. Census reports the population of Yakima County to be 99,019. It also reports no group quarter population for 1940. So the total non-group quarters population base used to produce a 1947 estimate is 99,019.

Within the HEDR study area, Benton County is an exception. Between the years of 1944 to 1950, Benton County experienced a large in-migration, and subsequently a large out-migration, of military and construction workers who were housed in group quarters. Since the migration occurred between census years, this population is not represented in the decennial censuses. The size of the group quarter population has been estimated through historical records.

2. Adjusting School Enrollment Data to Match the Census School-Age Population (New York Department of Commerce 1979; p. 7)

Since the enrollment for grades 1 to 8 rarely matches the census count for ages 6 to 14 in any given census year, the school enrollment numbers must be adjusted to match the census count for the appropriate ages. For the HEDR estimates from 1940 to 1967, end-of-the-year public school enrollment numbers were available. For 1968, fall public school enrollment was available. For 1969 and 1970, combined public and private school fall enrollment numbers were available. The variety of data types available necessitates the use of slightly different formulas for these later years.

The annual enrollment numbers are first adjusted using the ratio of the ages 6 to 14 census count to the grades 1 to 8 enrollment for that census year. The relationship of the school enrollment data to the census count is used to adjust the enrollment data closest to that census year (1940 ratio is used to adjust the 1940 to 1944 enrollment; 1950 ratio is used to adjust the 1945 to 1954 enrollment data). Adjusting the enrollment data (end of year data or fall data) to match the census count (April) is implicit in this ratio method. Whether end of year data or fall data are used, the relationship of the census count to either type of enrollment data is maintained for similar enrollment data used in the annual estimates. No extra adjustment is made to adjust fall or end of year enrollment to April enrollment.

14.42

The annual enrollment numbers are then adjusted with an independent state control. This state control is the ratio of the state total for grades 1 to 8 to an independently derived estimate for the state's age 6 to 14 population (U.S. Census data). Two ratios are used for the 1970 data because both public enrollment and public with private enrollment data were available. Table D.1 shows how the state control adjustment ratios are calculated and for which years they are used.

Example 3 illustrates the process of adjusting the school enrollment data to match the census data. The procedure presented in Example 3, varies according to the type of school enrollment data that is available. For 1940 to 1964, the procedure remains the same. For 1965 to 1967, 1960 public end of school year ratios are used. For 1968, 1970 public fall ratios are used. For 1969 to 1970, 1970 public-private fall ratios are used.

EXAMPLE 3. Adjustment of School Enrollments for Yakima County, 1947

a.	Population age 6.5 to 14.49 on April 1, 1950	20,284
	0.75 x (no. age 6) + (no. age 7 to 13) + 0.25 x (no. age 14)	
b.	Number enrolled in 1950 (Grades 1 to 8) .	22,630
c.	Ratio of school-age to enrollment (a/b) .	0.8963
d.	Number enrolled in 1947	22,466
e.	Estimated school-age population in 1947 . (c x d)	20,137
f.	Adjustment of number derived in c to independent state control (Item c) x ratio of estimated state school-age population (which is the sum of the county school enrollments) to an independent Census Bureau state school-age population estimate (U.S. Census) 1950 Public Enrollment / age 6 - 14 census count 1.0933 (Varies depending on year of the estimate) (c x 1.0933)	0.9799
g.	Adjusted school enrollment for 1947 (f x d)	22,017

TABLE D.1. State Control Adjustment Ratios (for Yakima County 1947)

Year		Grades 1 to 8 State Enrollment	Age 6 to 14 State Census Population	Ratio	Years Ratio Is Used
1940	Public	215,352	195,123	1.10367	1940-44
1950	Public	312,684	285,988	1.09335	1945-54
1960	Public	433,435	465,244	0.93163	1955-67
1970	Public	520,097	549,453	0.94657	1968
	Public & Private	555,206		1.01047	1969-70

3. Expected Population of School-Age Assuming No Migration, 1947
(New York Department of Commerce 1979; p. 7-8)

The expected population of school-age children, assuming no migration, on April 1, 1947, is the cohort of the population 6.5 to 14.49 years old on the estimate date minus deaths to the cohort. The cohort is obtained from the appropriate age group in the 1940 Census. The cohort age group, the population age 6.5 to 14.49 on April 1, 1947, is the group 0 to 7.24 old on April 1, 1940, plus 3/4 of the 1940 births. The number of survivors from this cohort is determined using national U.S. Life Tables, 1939 to 1941. Since the white and nonwhite populations have different death rates, the number of white survivors in this cohort was determined using national U.S. Life Tables for the white population, and the number of non-white survivors was determined using non-white life tables (Example 4).

The HEDR methodology differs from the component method II technique with respect to calculating the expected population. Where the HEDR method uses national mortality factors, the component method II uses age-specific death data for the county to calculate mortality factors. Age-specific death data were not found for the entire time frame of interest for the HEDR study.

EXAMPLE 4. Calculating the Expected School-Age Population
for Yakima County, 1947

	<u>White</u>	<u>Nonwhite</u>
a. (no. age 0 to 6) + 0.25 x (no. age 7) in 1940	11,941	524
b. Survival rate for age 0 to 7 from 1940-47	.9907	.9954
c. Number of age 0 to 7 survivors from 1940-47 (a x b)	11,830	516
d. 3/4 of 1940 births	1,483	64
e. Survival rate of 1940 births to 1947 . . .	.9812	.9658
f. Number of 1940 birth survivors (d x e) .	1,455	62
g. Expected population in 1947 (c + f) . . .	13,285	578
h. Total expected population (white + nonwhite)		13,863

The life tables used to calculate deaths change from decade to decade. The U.S. Life Tables are published for the three-year period at the beginning of every decade, beginning with 1939 to 1941. The life table used for a particular decade is the life table for the beginning of that decade. For the 1940 decade, the 1939 to 1941 national life tables are used. For the 1950 decade, the 1949 to 1951 national life tables are used. For the 1960 decade, 1959 to 1961 national life tables are used.

4. Net School-Age Migration from 1940 to 1947
(New York Department of Commerce 1979; p. 8-9)

The net migration from 1940 to 1947 is equal to the adjusted school enrollment for 1947 minus the expected enrollment for 1947 (Example 5).

EXAMPLE 5. Net Migration for the School-Age Population,
Yakima County, 1947

a. 1947 adjusted school enrollment	22,017
b. 1947 total expected school enrollment	13,863
c. Net school-age migration, 1940-47 (a - b)	8,154

5. School-Age Migration Rate, 1940 to 1947 (New York, 1979; p. 8-9)

The school-age migration rate is the net migrants divided by a school-age population base. The school-age migration rate is calculated in Example 6.

EXAMPLE 6. 1947 School-Age Migration Rate, Yakima County 1947

a. Net school-age migration, 1940-47 (7c)	8,154
b. Population base is equal to the 1940 school-age cohort plus 1/2 the change between 1940 and 1947. Births became part of the cohort in 1947. A factor to adjust for the different length of exposure for births versus the existing 1940 cohort is multiplied times the number of births and subtracted from the school-age base as follows:	

1. 1940 school-age cohort plus 3/4 1940
births 14,012 14,012
(Example 4: a + d)
2. 1/2 change in 1940 school-age cohort 74
{(Example 4: a + d) - (Example 4: a)} x 0.5
3. 3/4 1940 births 1,547
4. Migration Exposure factor = $\frac{1/2 * [9 \text{ months} + ((\text{est. yr} - \text{beginning school age} - 1) * 12)]}{(\text{est. yr} * 12 \text{ months})}$
 $\frac{1/2 * [9 + ((7 - 6 - 1) * 12)]}{(7 * 12)} 0.0535714$
5. Population base 14,003
(b1 + b2 - {b4 * b3})
- c. School-age migration rate (a / b5) 0.5823

6. Converting School-Age Migration Rate into Population Migration Rate
(U.S. Census Bureau Memorandum 1978; p.5)

The school-age migration rate is converted into a total population migration rate with the following formula:

$$\text{School Migration Rate} + [(0.10 \times n) \times \text{Residual Migration Factor}]$$

where n = the number of years between the 1940 census and the estimate date. The residual migration factor for a decade is the difference between the school-age migration rate for that decade and the under-65 female migration rate for that decade. County-specific residual migration factors for a specific decade are calculated as in Example 7.

**EXAMPLE 7. County-Specific Residual Migration Adjustment
Factor, Yakima County 1947**

Mortality rates are calculated using national U. S. Life Tables.

	<u>Whites</u>	<u>Non-Whites</u>
a. School-age population, April 1, 1950 (0.75 * no. age 6) + (no. age 7 to 13) + (0.25 * no. age 14)	19,521	764
b. Population 0 to 4, April 1, 1940 (no. age 0 to 3) + (0.25 * no. age 4)	7,048	304
c. Sum of births from April 1, 1940 to December 31, 1943 (use 3/4 of 1940 births instead of births by month)	7,490	330
d. Deaths to age 0-to-4 cohort from 4-1-40 to 4-1-50 plus deaths to births (4-1-40 to 12-31-43). Total deaths to school-age cohort are calculated using life table survival rates (see Table D.2)	254	19
e. Total school-age migration (a - b - c + d)	5,386	
f. Factor for underexposure of school-age population to migration	1.0963	
g. Total School-age migration rate (e / (b + c)) * f	0.3892	
	<u>Whites</u>	<u>Non-Whites</u>
h. Females under 65 years old, April 1, 1950	59,763	2,151
i. Females under 55 years old, April 1, 1940	39,499	1,473
j. Female births, April 1, 1940 - March 31, 1950 (3/4 x 1940 births + 1941-49 births + 1/4 x 1950 births) * (state % females)	3,383	627
k. Deaths to female 0 to 55 cohort and 1940-50 female births (see Table D.3)	1,812	162

- l. Total migration for females under 65 on
 April 1, 1950 8,906
 (h - i - j + k)
- m. Factor for underexposure of population
 under 65 to migration 1.0833
- n. Total migration rate for females under
 65 years on April 1, 1950 0.1755
 (l / (i + j)) * m
- o. Residual migration adjustment factor
 (10-year rate) -0.2138
 (n - g)
- p. Population migration rate 0.4326
 (school migration rate +
 [(0.10 x n) x residual factor])

TABLE D.2. Deaths to School-Age Cohort

<u>Cohort</u>	<u>White Pop</u>	<u>Death Rate</u>	<u>White Deaths</u>	<u>Non-White Pop</u>	<u>Death Rate</u>	<u>Non-White Deaths</u>
1940 0 - 4	7,048	0.01365	96	304	0.02161	7
3/4 1940 Births	1,483	0.02249	33	64	0.03912	3
1941 Births	2,002	0.02164	43	88	0.03797	3
1942 Births	1,902	0.02077	39	84	0.03681	3
1943 Births	2,102	0.01982	42	94	0.03558	3

TABLE D.3. Female Deaths

		<u>Cohort</u>	<u>White Females</u>	<u>Death Rate</u>	<u>White Female Deaths</u>	<u>Non- White Females</u>	<u>Death Rate</u>	<u>Non- White Deaths</u>			
		1940 0-55	39,499	0.04096	1,618	1,473	0.09865	145			
		<u>White Births</u>	<u>% White Females</u>	<u>White Female Births</u>	<u>Death Rate</u>	<u>White Female Deaths</u>	<u>Non- White Births</u>	<u>% Non- White Females</u>	<u>Non- White Births</u>	<u>Death Rate</u>	<u>Non- White Deaths</u>
3/4	1940	1483	0.4971	737	0.02029	15	86	0.5085	33	0.03589	1
	1941	2002	0.4971	995	0.01960	20	88	0.5085	45	0.03489	2
	1942	1902	0.4971	945	0.01887	18	84	0.5085	43	0.03388	1
	1943	2102	0.4971	1,045	0.01807	19	94	0.5085	48	0.03276	2
	1944	2353	0.4971	1,170	0.01719	20	106	0.5085	54	0.03146	2
	1945	2358	0.4971	1,172	0.01617	19	107	0.5085	55	0.02991	2
	1946	3089	0.4971	1,535	0.01502	23	142	0.5085	72	0.02808	2
	1947	3612	0.4971	1,795	0.01360	24	168	0.5085	85	0.02587	2
	1948	3579	0.4971	1,779	0.01175	21	168	0.5085	86	0.02290	2
	1949	3588	0.4971	1,783	0.00884	16	170	0.5085	87	0.01775	2
1/4	1950	855	0.4971	425	0.00000	0	41	0.5085	21	0.00000	0

7. Estimating Total Population

(New York Department of Commerce 1979; p. 14)

The total population estimate is derived by adding the natural increase and the number of net migrants from the census to the estimate date to the census count (Example 8). The natural increase is the difference between the births and deaths during the estimate period. The number of net migrants is calculated using the population migration rate that was calculated in the preceding section.

EXAMPLE 8. Preliminary Population Estimate for Yakima County, 1947

a. Non Group Quarters Population on April 1, 1940	99,019
b. 1/2 the births, 1940-47	8,460
c. 1/2 the deaths, 1940-47	3,616
d. Net migration base (a + b - c)	103,863
e. Net migrants (d x 7p)	44,938
f. Natural Increase, (1940-47 Births - 1940-47 Deaths)	9,687
g. 1947 Population (a + e + f)	153,638

8. Adjusting Population Estimate According to the Error of Closure

The error of closure is the percent difference between an estimated census year population and the census count. For each county, the error of closure is calculated and the error is linearly interpolated and added to the intercensal estimates. The procedure illustrated above is used to calculate a census year estimate (1950). This 1950 estimate of the non-group quarters population is compared with the census count for the non-group quarters population in 1950. The difference distributed evenly to all of the inter-census estimates. Example 9 illustrates this procedure.

EXAMPLE 9. Final Population Estimate for Yakima County, 1947

a.	1950 estimated population	170,356
b.	1950 non-group quarters census count . .	135,216
c.	Difference (b - a)	-35,140
d.	Annual increment (c / 10)	-3,514
e.	Preliminary 1947 non-group quarters . . .	153,638
f.	1947 group quarters population	355
g.	Final 1947 (e + (7 * d)) + f	129,395

REFERENCES

Shyrock, H. S., and J. S. Siegel. 1976. The Methods and Materials of Demography. Academic Press, New York.

New York State Department of Commerce. 1979. Component Method II Computational Procedure for Estimating the Population of Counties. Albany, New York.

Bureau of the Census. 1978. Calculation of Rates and Factors in the Component Method II. Memorandum to Federal State Cooperative Program Participants dated September 28, 1978, Bureau of the Census, Washington, D.C.

U.S. Census Bureau Memorandum 1978

APPENDIX E

ESTIMATING COUNTY CENSUS DIVISION POPULATIONS

APPENDIX E

ESTIMATING COUNTY CENSUS DIVISION POPULATIONS

To produce population estimates for county census divisions (CCDs), total county population estimates were disaggregated to their respective CCDs. This was done by interpolating the CCD's proportional share of the county population recorded in the census years bracketing the estimate year. This procedure is symbolized as:

$$P_N = [((Y - X) / 10) * N] + X$$

where P_N = CCD's share of county population for intercensal year N

X = CCD's share of county population in earlier census year

Y = CCD's share of county population in later census year

N = Number of years from earlier census

The CCD's share of the county population for each intercensal year is then multiplied by the total population estimate for the relevant county (ratio-correlation estimate) to produce an intercensus estimate. This interpolation technique was used for the years 1950 to 1970.

For the 1940, decade CCD population shares were assumed to be equal to the shares reported in the 1950 census. This assumption was deemed necessary because of the radical demographic change that occurred from 1943 to 1950 as a result of World War II. Relatively large populations moved into lightly populated areas as the result of military base construction. This demographic change drastically altered the settlement patterns within the HEDR study area. As a result, we believe 1950 CCD population shares are more representative of the likely CCD population shares for the HEDR Phase I time span 1944 to 1950. Stated differently, population distribution in 1943 to 1945 was much more like that recorded in 1950 than the distribution recorded in the 1940 census.

CCD boundaries changed over the time period 1944 to 1970 for which estimates were prepared. To facilitate comparisons across decades, we standardized CCD boundaries to those reported in the 1970 census. This required the aggregation of some CCDs and parts of CCDs for the earlier decades. Table E.1

indicates which CCDs for each county were combined to standardize all CCDs to the 1970 boundaries. For the purpose of the HEDR study, some of the CCD boundaries were modified into HEDR county divisions. Annual population estimates for each HEDR county division are reproduced in the Results section of this report. Age, sex, and race distributions for the HEDR county divisions are assumed to be identical to those reported for the county as a whole.

TABLE E.1. Aggregation of CCD Boundaries to 1970

1970	1960	1940 & 1950
ADAMS COUNTY		
Division 1	Division 1	Division 1
Division 2	Division 2	Division 2
Division 3	Division 3	Division 3
Division 4	Division 4	Division 4
Division 5	Division 5	Division 5
Division 6	Division 6	Division 6
Division 7	Division 7	Division 7
Division 8	Division 8	Division 8
Division 9	Division 9	Division 9
Division 10	Division 10	Division 10
BENTON COUNTY		
Benton City Division	.25(Div.12-BC-WR)+BC	.25(Div.12-BC)+BC
Federal Reservation Division	Division 1	Division 1
Kennewick Division	Kenn.+Div.17+.5(Div.16)+.5(Div.18)	Kenn.+Div.17+.5(Div.16)+.5(Div.18)
Kennewick South Division	Div.19+.5(Div.16)+.5(Div.18)	Div.19+.5(Div.16)+.5(Div.18)
Northwest Benton Division	Div.13+Div.14+.5(Div.12-BC-WR)	Div.13+Div.14+.5(Div.12-BC)
Prosser Division	Prosser	Prosser
Richland Division	Richland & Div. 2	Divisions 2 - 10
South Benton Division	Divisions 15 & 20	Divisions 15 & 20
West Richland Division	Div.11+WR+.25(Div.12-BC-WR)	Div.11+.25(Div.12-BC)
FRANKLIN COUNTY		
Connell Division	Division 2	Division 2
Kahlotus Division	Divisions 1 & 4	Divisions 1 & 4
Pasco Division	Pasco	Pasco
Pasco North Division	Division 3 & 5	Division 3 & 5
GRANT COUNTY		
Division 1	Division 1	Division 1
Division 2	Division 2	Division 2
Division 4	Divisions 3 & 4	Divisions 3 & 4
Division 5	Divisions 5 & 13	Divisions 5 & 13
Division 7	Division 7	Division 7
Division 9	Division 8 & 9	Division 8 & 9
Division 10	Division 10	Division 10
Division 11	Division 6 & 11	Division 6 & 11
Division 12	Division 12	Division 12
Division 14	Division 14	Division 14
Division 15	Division 15	Division 15

TABLE E.1. (contd)

1970	1960	1940 & 1950
Division 16	Division 16	Division 16
Division 17	Division 17	Division 17
Ephrata Division	Ephrata	Ephrata
KITITITAS COUNTY		
Division 1	Division 1	Division 1
Division 2	Division 2	Division 2
Division 3	Division 3	Division 3
Division 4	Division 4	Division 4
Division 5	Division 5	Division 5
Division 6	Division 6	Division 6
Division 7	Division 7	Division 7
Division 8	Division 8	Division 8
Division 9	Division 9	Division 9
Division 10	Division 10	Division 10
Ellensburg Division	Ellensburg Division	Ellensburg Division
KLiCKiTiTAT COUNTY		
Division 1	Division 1	Division 1
Division 2	Division 2	Division 2
Division 3	Division 3	Division 3
Division 4	Division 4	Division 4
Division 5	Division 5	Division 5
Division 6	Division 6	Division 6
Division 7	Division 7	Division 7
Division 8	Division 8	Division 8
Division 9	Division 9	Division 9
Division 10	Division 10	Division 10
WALLA WALLA COUNTY		
Division 1	Division 1	Division 1
Division 2	Division 2	Division 2
Division 3	Division 3	Division 3
Division 4	Division 4	Division 4
Division 5	Division 5	Division 5
Division 6	Division 6	Division 6
Division 7	Division 7	Division 7
Division 8	Division 8	Division 8
Division 9	Division 9	Division 9
College Place	College Place	College Place
Division	Division	Division
Walla Walla Division	Walla Walla Division	Walla Walla Division
YAKIMA COUNTY		
Division 1	Division 1	Division 1
Division 2	Division 2	Division 2
Division 3	Division 3	Division 3

TABLE E.1. (contd)

1970	1960	1940 & 1950
Division 4	Division 4	Division 4
Division 5	Division 5	Division 5
Division 6	Division 6	Division 6
Division 7	Division 7	Division 7
Division 8	Division 8	Division 8
Division 11	Division 11	Division 11
Division 12	Division 12	Division 12
Division 13	Division 13	Division 13
Division 14	Division 14	Division 14
Division 15	Division 15	Division 15
Division 16	Division 16	Division 16
Division 17	Division 17	Division 17
Division 18	Division 18	Division 18
Division 19	Division 19	Division 19
Division 20	Division 20	Division 20
Division 21	Division 21	Division 21
Division 22	Division 22	Division 22
Division 23	Division 23	Division 23
Division 24	Division 24	Division 24
Division 25	Division 25	Division 25
Division 26	Division 26	Division 26
Division 27	Division 27	Division 27
Division 28	Division 28	Division 28
Division 29	Division 29	Division 29
Division 30	Division 30	Division 30
Division 31	Division 31	Division 31
Division 32	Division 32	Division 32
Division 33	Division 33	Division 33
Division 34	Division 34	Division 34
Division 35	Division 35	Division 35
Division 36	Division 36	Division 36
Division 37	Division 37	Division 37
Division 38	Division 38	Division 38
Division 39	Division 39	Division 39
Division 40	Division 40	Division 40
Selah Division	Selah	Selah
Sunnyside Division	Sunnyside	Sunnyside
Toppenish Division	Toppenish	Toppenish
Wapato Division	Wapato	Wapato
Yakima Division	Yakima & Div. 9 & 10	Yakima & Div. 9 & 10
MORROW COUNTY		
Boardman Division	Boardman & Irrigon	Boardman & Irrigon
Heppner Division	Eightmile, Hardman, N. Heppner, Pine City, S. Heppner	Eightmile, Hardman, N. Heppner, Pine City, S. Heppner

TABLE E.1. (contd)

1970	1960	1940 & 1950
Ione-Lexington Division	Ione-Lexington	Ione-Lexington
UMATILLA COUNTY		
Athena Division	Athena Division	Precinct 10,11,13
Crockett Division	Crockett Division	Precinct 2,2A
Hermiston Division	Hermiston Division	Precinct 38, 32, 32A, 33,33A
Holdman Division	Holdman Division	Precinct 27,28,29,37,14
Milton-Freewater Division	Milton-Freewater Division	Precinct 4,4A,5,5A
Pendleton Division	Pendleton Division	Pendleton
Pilot Rock-Echo Division	Pilot Rock-Echo Division	Precinct 30,35
Reservation Division	Reservation Division	Precinct 16
Stanfield Division	Stanfield Division	Precinct 31
Ukiah-Meachem Division	Ukiah-Meachem Division	Precinct 15,36,12,39,40
Umapine Division	Umapine Division	Precinct 3
Umatilla Division	Umatilla Division	Precinct 34,41
Upper Walla Walla Division	Upper Walla Walla Division	Precinct 1,6
Weston Division	Weston Division	Precinct 7,8,9

APPENDIX F

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7263 HEDRDocument Title Population Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
1.	J. Stohr (JS)	Page 15, para. 1	Does a review of the school enrollment records for 1944 support the assumption that the work force was likely childless?	NA - Only county-level school enrollment records were used in Phase I. These numbers do not allow us to disaggregate the fertility of construction workers.
2.	JS	Page B.2, last para.	Census estimates should be compared against actual census counts to give a handle on sudden population changes, as recommended by Dr. Pittenger.	This was done and summarized on page 16. Additional work may be done in the future. State population estimates are those produced by the U.S. Census Bureau.
3.	JS	Page B.2-B.3	Have the issues of "Selection of Actual Estimates" and "Anonymous State Population Control Numbers" identified by Pittenger as highly important received an adequate level of attention? If not in Phase I, then when will they?	NA - Several options for selecting actual estimates were considered by the TSP Demography Subcommittee and were discarded. It was decided that the ratio-correlation method would be used.
4.	JS		The report should describe how uncertainty will be estimated for the population numbers used. If sensitivity analyses identify the location and time of reference as key contributors to overall dose estimate uncertainty, how will these census predictors be used or adjusted?	NA - At this point, uncertainty of population estimates is not being addressed.
5.	Al Conklin		Even though the estimates were said to include age, sex, and race distributions, they are not included in this report. Age is particularly important, and should be included.	See Pittenger (1991): "Letter Report: Population Estimates by Age, Sex and Race for 10-County Study Area."
NA = No action.				

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7263 HEDRDocument Title Population Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
6.	R.L. Morrill (RLM)		Tackle the estimation of age-specific migration for 1944-1950, for Benton, Franklin, and Walla Walla counties.	NA - Not in current scope of work authorized by the TSP.
7.	RLM		At least for the close, more affected counties, age, sex, and race distributions must be specific to county census division, and not rely on county-wide averages.	NA - Not in currently approved scope of work.
8.	RLM		The drastic population change in Benton County from 1944 to 1945 to 1946 suggests the need for a finer time breakdown than yearly for Benton.	NA - Not in currently approved scope of work.
9.	RLM		Evaluate the impact of major dam construction projects and the openness of the Columbia Basin project on population estimates (probably just for close-in counties or census units).	NA - Not in currently approved scope of work.
10.	Glyn G. Caldwell (GGC)	Page v, para. 3, lines 1-3	What data are missing? How much effort will be needed to collect it? What are the advantages/disadvantages of this method?	Missing data include age-specific migration rates for surrogate counties. Approximate estimate to collect these data is 180 hours. This work was proposed, but the TSP decided it was not necessary. The advantage of this method is refined estimates resulting from the inclusion of age-specific migration data. The disadvantage is the amount of time and effort
NA = No action.				

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7263 HEDRDocument Title Population Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
11.	GGC	Page 3, para. 4, lines 7-8	Who checked the calculations? List the calculators and checkers and each person's responsibility.	needed to reconstruct the migration information. 1. Donald M. Beck, Principal Investigator; 2. Steve Harkreader, Technician; 3. Battelle QA Staff, QA.
12.	GGC	Page 11, para. 1	Can Washington data after 1970 be used to validate/verify the estimates made by the models used for 1940-1970?	Yes, but the results would be less convincing than those for the census years used in the report.
13.	GGC	Page A.2, line 4	What does "OLS" mean?	Ordinary Least Squares.
14.	GGC	Page D.4, para. 4, lines 5-6	Illegible due to overprinting.	Problem has been corrected.
15.	John E. Till (JET)	Page v, para. 3, line 1	Reference to Dr. Donald Pittenger's work should be cited appropriately.	Reference added.
16.	JET	Page 3, para. 4	Be more specific about the results of the QA checks.	Paragraph on QA checks was clarified.
17.	JET	Page 9, para. 2	Third line from bottom: "...most commonly used methods <u>applied</u> to develop..."	Change made.
NA = No action.				

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7263 HEDRDocument Title Population Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
18.	JET	Page 10, eq. 1-2	The years at the top of the () to the right are confusing. Also, typically equation numbers are in the right margin.	They need to be to the right of the parentheses to indicate the appropriate year for each variable. The equation numbers were moved to the right margin.
19.	JET	Page 11, para. 2	Fourth line from bottom: "Deaths <u>were</u> not a significant..."	Change made.
20.	JET	Page 12, Table 1	Footnotes c and d: "Significant <u>to</u> ..."	Change made.
21.	JET	Page 18, para. 1	Would an equation not be helpful here?	NA - Text was based on write-up of contractor.
22.	JET	Appendix A	Did we consider the 3 recommendations suggested in Swanson's review, and what were the results?	1) Residual analysis completed; no significant error. 2) The model is conceptualized of a sample of possible demographic universes. The issue of collinearity was not explored because the model was constructed only for prediction and not explanation. 3) Exploring the effects of changing census accuracy was recommended for FY 1992 work but was postponed at TSP direction.
NA = No action.				

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

Document Number PNL-7263 HEDRDocument Title Population Estimates for Phase I

Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
23.	R.L. Morrill	Page 4	Further refinement of numbers in Phase II is far less important than what will be urgent: a sense of the distribution of how long people lived in the area (including by age).	NA - Not in currently approved scope of work.
24.	RLM	Pages 6, 21, E.2	Use of age/sex and race distributions of the county as a whole to determine CCD distributions is (barely) acceptable for Phase I, but unacceptable for Phase II.	NA - Not in currently approved scope of work.
25.	RLM	Pages 9-11, 14-16	The subcommittee has already endorsed the <u>ratio-correlation</u> methodology.	NA - Agreed. (See response to comment 3.)
26.	RLM	Page 17	Cohort-component modeling may need to be used in Phase II because we need to know how many people remained how long. The extrapolation methods are OK for Phase I.	NA - Not currently in approved scope of work.
27.	RLM	Page 29, Table 4a	Since the 1944-45 period is so overwhelmingly important, can we, for Phase II, attempt <u>monthly</u> estimates for Benton County? We need a sense of precisely <u>when</u> the big changes occurred.	NA - Not currently in approved scope of work.
28.	RLM	Page E.3	The apportioning of parts of Divisions, 1940 through 1960, needs narrative justification. Suggest tables/maps of populations by 1950 divisions (as well as 1970) for 1950, and 1944 through 1949.	NA - Future work.
NA = No action.				

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

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Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
29.	RLM		AD2 (Ritzville) and 1,3,4,5,7, and 8 obviously didn't grow 1954-1958, since they didn't get irrigation. The entire year-to-year growth should be allocated to AD10 (Othello and vicinity)--part of the Columbia Basin Project.	Agree in principle but need to determine in future work.
30.	RLM		I would like some narrative discussion of the 1944-1949 breakdowns for Benton County. What are the sources?	The estimates are based solely on the gross methods described in the report. Refinement of these methods is not in currently approved scope of work.
31.	RLM		We need a little more narrative justification for Franklin County, since you should have separate information on the pace of opening of different sections of the Columbia Basin Project.	Same response as for comment 30.
32.	RLM		For Grant County, 1954-1955, the numbers are clearly wrong. We need more precision for south Grant County, GR 10, 12, and 13. Again, you should take advantage of Columbia Basin Project data.	Same response as for comment 30.
33.	RLM	Appendix A	Did you do any residual analysis? If so, what did it show?	Yes; no significant specification error. (See response to comment 22.)
34.	RLM	Page B.2	Identify when the major construction projects occurred and where; i.e., dams on the Columbia River, the Columbia Basin Project.	NA - Future work.
NA = No action.				

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

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Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
35.	RLM	Page E.1	The simple interpolation method is usually OK, but not for areas affected by episodic construction and land opening. Phase II will need some refinement here.	Agree.
36.	RLM		Some close-in but large census sub-divisions should be divided, while some far-away divisions can be combined.	NA - Not in currently approved scope of work.
37.	RLM		The study area should probably be extended somewhat to the east and perhaps to the south for Phase III, but counties could be the units of analysis.	TSP decision.
38.	M.A. Robkin (MAR)	Page 18	Cohort Interpolation: The number of males of age 46 in 1960 are divided by the number at age 36 in 1950 in Grant County. This is not logical and one of these ages should be corrected.	NA - This ratio is appropriate for determining change from 1950 to 1960 for this age category.
39.	MAR	Page 19	Top of page: The racial categories are white, non-white, negroes/blacks, and Indians. This is a bizarre categorization.	The categories are provided by the U.S. Census Bureau.
40.	MAR	Page B.4	In the expression for RATEYRn: as written the value is always negative. Should the "minus sign" be a "plus sign"?	Equation was revised.
41.	MAR	Page C.1	In the section on <u>Step 1</u> : There are two typos. In the ratio itself, the lower date should be 1940. In the line below, "bi" should be "Bi".	Changes made.
NA = No action.				

SUMMARY OF TSP COMMENTS AND BATTELLE RESPONSES

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Comment Number	Commenter	Page, Paragraph	Comment Summary	Resolution
42.	MAR	Page D.4	The 10th line from the bottom of the page is garbled.	Problem has been corrected.
43.	MAR	Page E.1	Was the Hanford area construction boom of 1944-1947 over by 1950 with large relocation of construction workers out of the area? Will the error of using 1950 CCD population share be very large?	No, because we have detailed counts of number of Hanford employees.
NA = No action.				

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