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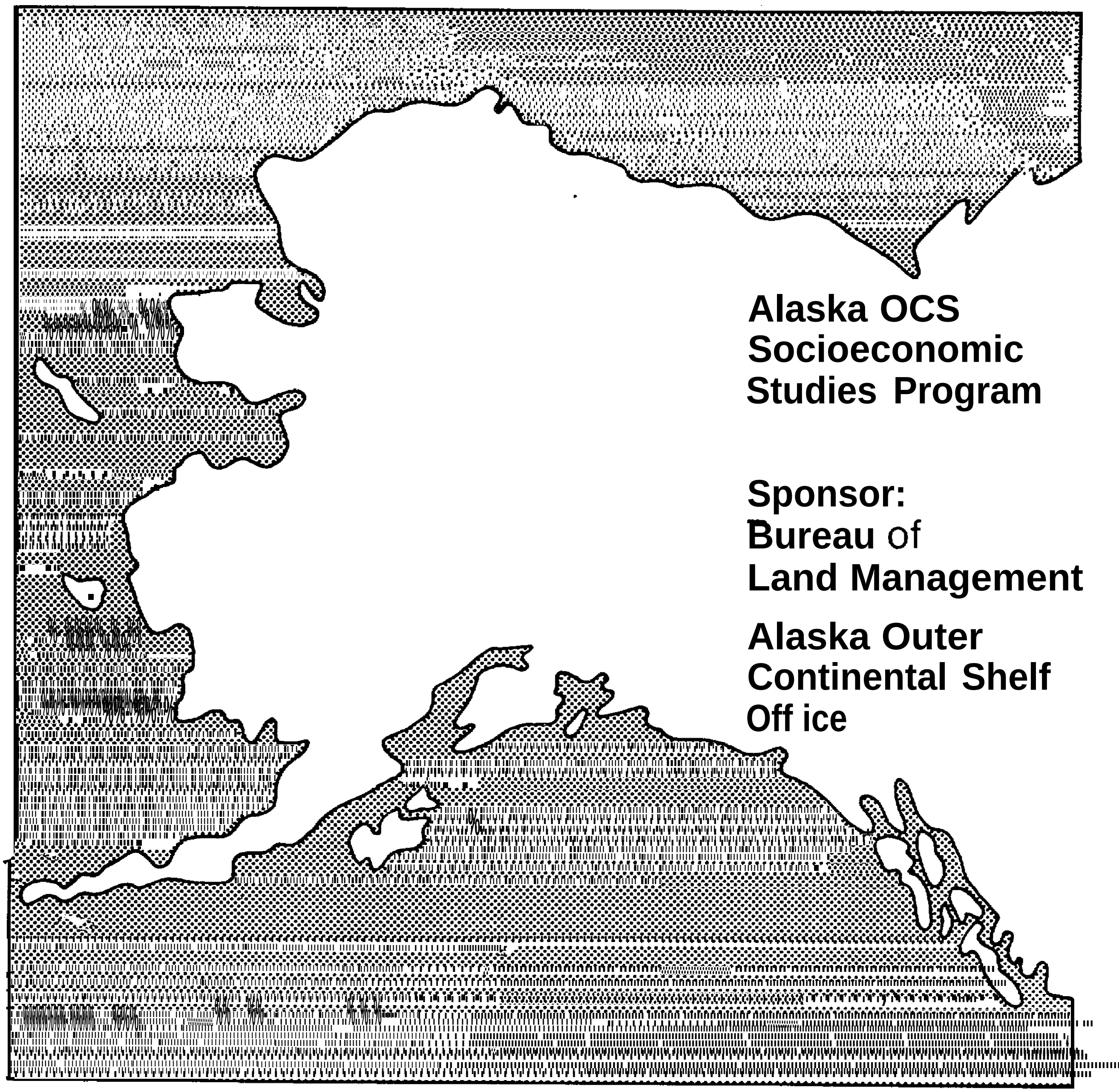

Alaska OCS
Socioeconomic
Studies Program

Sponsor:
Bureau of
Land Management

Alaska Outer
Continental Shelf
Office

Design of a Population Distribution Model

The United States Department of the Interior was designated by the Outer Continental Shelf (OCS) Lands Act of 1953 to carry out the majority of the Act's provisions for administering the ❑ineral leasing and development of offshore areas of the United States under federal jurisdiction. Within the Department, the Bureau of Land Management (BLM) has the responsibility to meet requirements of the National Environmental Policy Act of 1969 (NEPA) as well as other legislation and regulations dealing with the effects of offshore development. In Alaska, unique cultural differences and climatic conditions create a need for developing additional socioeconomic and environmental information to improve OCS decision making at all governmental levels. In fulfillment of its federal responsibilities and with an awareness of these additional information needs, the BLM has initiated several investigative programs, one of which is the Alaska OCS Socioeconomic Studies Program (SESP).

The Alaska OCS Socioeconomic Studies Program is a multi-year research effort which attempts to predict and evaluate the effects of Alaska OCS Petroleum Development upon the physical, social, and economic environments within the state. The overall methodology is divided into three broad research components. The first component identifies an alternative set of assumptions regarding the location, the nature, and the timing of future petroleum events and related activities. In this component, the program takes into account the particular needs of the petroleum industry and projects the human, technological, economic, and environmental offshore and onshore development requirements of the regional petroleum industry.

The second component focuses on data gathering that identifies those quantifiable and qualifiable facts by which OCS-induced changes can be assessed. The critical community and regional components are identified and evaluated. Current endogenous and exogenous sources of change and functional organization among different sectors of community and regional life are analyzed. Susceptible community relationships, values, activities, and processes also are included.

The third research component focuses on an evaluation of the changes that could occur due to the potential oil and gas development. Impact evaluation concentrates on an analysis of the impacts at the statewide, regional, and local level.

In general, program products are sequentially arranged in accordance with BLM's proposed OCS lease sale schedule, so that information is timely to decisionmaking. Reports are available through the National Technical Information Service, and the BLM has a limited number of copies available through the Alaska OCS Office. Inquiries for information should be directed to: Program Coordinator (COAR), Socioeconomic Studies Program, Alaska OCS Office, P. O. Box 1159, Anchorage, Alaska 99510.

TECHNICAL REPORT NO. 24

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ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM

DESIGN OF A POPULATION DISTRIBUTION MODEL

PREPARED FOR

BUREAU OF LAND MANAGEMENT
ALASKA OUTER CONTINENTAL SHELF OFFICE

DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE
NATIONAL TECHNICAL INFORMATION SERVICE
5285 PORT ROYAL ROAD
SPRINGFIELD, VIRGINIA 22161

NOTICE

ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM
DESIGN OF A POPULATION DISTRIBUTION MODEL

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June 1979

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I. INTRODUCTION

Background

The oil and gas resources of the United States Outer Continental Shelf will play an increasingly important role in U.S. energy supplies. Progressive depletion of traditional U.S. petroleum reserves has left the United States increasingly dependent on foreign energy supplies. The questionable reliability of these foreign supplies has led the federal government to establish policies aimed at increasing domestic energy supplies. The high potential of the U.S. Outer Continental Shelf (OCS) as a source of oil and gas means the development of these resources will be an important part of the future U.S. energy program.

Alaska will play a significant role in the future U.S. energy supply. It has been projected that by 1985 over 25 percent of total domestic crude oil production could be from Alaska (Federal Energy Administration, 1976). A major reason for Alaska's increased role as a supplier of U.S. energy resources is the petroleum reserves in the Alaskan OCS. Alaska is important to the future U.S. energy program and the OCS program since over 60 percent of the estimated undiscovered OCS reserves in the United States are in Alaska (U.S. Geological Survey, 1975).

The OCS development program has already begun in Alaska. Two lease sales have already been held; the first sale was of leases in the Northern Gulf in 1976 and the second sale was of leases in the Lower Cook Inlet in 1978. Future sales are planned for the Beaufort Sea, the Northern Gulf of Alaska, the Western Gulf of Alaska, Lower Cook Inlet, and the Bering-Norton Sour-id, The lease sales are the first step in the exploration and development of petroleum-producing areas in the Alaska OCS.

The Purpose of the Study

The past development of Alaska's petroleum reserves has produced major changes. The development of Upper Cook Inlet and Prudhoe Bay brought rapid increases in the economy and population of the state. These changes not only strained the Alaska society and environment but also produced the most prosperous period of economic growth in the state's history. Development of the petroleum reserves in the Alaska OCS will also affect the economy and population of the state.

OCS development will cause changes on both the state and local levels. The nature of these changes may differ from those which resulted from past petroleum development. The purpose of this study is to provide an understanding of the nature of those changes which may result from OCS activity. The study is part of the Bureau of Land Management's Alaska OCS Socioeconomic Studies Program. The objective of this program is to assess the potential impacts of proposed lease sales in the federal offshore areas of Alaska. This study is one of a series of studies examining lease sale impacts.

The major objective of this study is to develop a methodology which can be used to estimate the population impact of OCS development on small Alaskan communities directly affected by OCS activity, OCS development in Alaska will take place off relatively undeveloped areas. The concentration of people and activity in these areas will have a major effect on the small communities chosen for service bases. The major impact on the state level will result from the increased demand for Alaskan goods and services and the increased state government expenditures which result from the OCS activity. On the local level, the major impacts will result from the direct OCS employment. Because of the underdeveloped support sectors in these areas, there will be little local secondary impact. The magnitude of this potential effect can be seen by comparing Yakutat, which is a proposed service base for Northern Gulf OCS development, with the level of projected peak employment connected with OCS development. In 1976, Yakutat had an estimated population of 550 (Alaska Consultants, 1976), while the maximum OCS employment in the Northern Gulf is projected to be over 10,000 (Dames and Moore, 1978).

Projections of the future serve two purposes. First, they are a means of determining future demands and needs for services. Secondly, they allow policy makers to test the alternative effects of various policies. The model developed in this report can be used to project the population impact in small communities of OCS development. These projections will allow decision makers in small areas to assess the need for public and private services which result from OCS development. Like all projections, those resulting from this model are probabilistic. The parameters and relationships described in this report are based on uncertain information about the future. The model is useful because it allows the most sensitive parameters to be adjusted so that the sensitivity of the results can be seen.

Overview

The remainder of this report will describe the modeling process and an application of the model to the Kenai petroleum boom in the 1960s. Part II will provide a review of models applicable to small area impact analyses. Part III presents the model design. The application of the model to the Kenai oil boom is presented in Part IV. That chapter also includes a description of the selection of parameters and the sensitivity of the results to these parameters. Finally, Part V summarizes the major findings and discusses the strengths and weaknesses of the model as well as the improvements and extensions which could be made to it.

II. REVIEW OF EXISTING MODELS

Introduction

The purpose of this chapter is to review existing population projection models which have promise for application in Alaska. The relevance of each of these models depends on their ability to provide forecasts at the community level. Determining the accuracy of these models is difficult for two reasons. First, all of the models identified for consideration are of recent vintage, for the most part since 1970. Consequently, the analysis of the long-term accuracy of these models is entirely a matter of conjecture, rather than an assessment, in the light of census enumeration or current population estimates. Secondly, several of the models identified are still of a hypothetical nature and have not been applied to actual areas.

The models reviewed are economic-demographic interaction models. Both the concern with the effects of development on small areas and the development of economic-demographic interaction models to forecast population are recent. The concern with small area impacts arose with the recent development of large-scale energy projects in lightly populated areas. Population forecasting models which describe the interaction between changes in the economy and changes in the population arose primarily to provide a better explanation of migration. Demographically based models have usually given little attention to the migration component of population change, either assuming future migration to be functionally determined by its past levels or assuming uniform convergence to a predetermined level. Purely demographic models do not include migration induced by employment changes or linkages between labor markets and population growth. The recent interactive models have attempted to include these features.

There are five important characteristics of the models discussed in this section which differ. These characteristics are the models' flexibility, the level of the forecast, the ease of application, the treatment of baseline population, and the procedure used in developing the models. In the long run, the nature of uncertainties and structural changes make almost any projection unreliable. Changes in the demand for labor due to changes in technology and output levels and changes in the supply of labor which result from changes in labor force participation may result in different levels of migration. A primary consideration in evaluating the following models is the model's flexibility, the ease with which it can accommodate changes in either side of the labor market equation. The ease with which the sensitivity of the results can be examined influences model flexibility.

The level of the population forecast provided by a model includes the regional level of the forecast--whether it is state, regional, or local--and the level of population disaggregation--whether population is provided by race, age, sex, or aggregated. Although the model itself may be applied to a state, the important concern is whether the methodology is applicable at a local level. The most appropriate level of population disaggregation for small area impact analysis is by age, race, and sex. These components not only influence local labor supply, they also have varying influence on the level of demand for services such as schools and housing.

Rural Alaska has a shortage of data, and rapid growth in these small areas will mean a probable change in past relationships." Because of this, one measure of the model's usefulness will be its ease of application to these small areas. Models which require large amounts of data cannot be easily adapted to rural Alaska.

The type of model will influence its ease of application. Econometric models depend on continuing series of historical data and the assumption that measured historical trends will continue in the future. Parameters for accounting-type models are assumed, based on many types of information; but there is no need of a long historical series.

The models will differ in their treatment of the baseline population. The complexity of the models' treatment of non-impact population depends on the purpose of the models. Models which are forecasting models are concerned with population growth in general and can be used to assess impacts by comparing alternate forecasts. These models deal with economic growth. Impact models are mainly concerned with the impact population. Although some links to the baseline population are established, the major emphasis of the model is on the impact' population.

Summary of Existing Models

This section includes a synopsis of existing population forecasting models. Each model is summarized and its usefulness for projecting the impact of OCS development on small Alaskan communities is assessed.

LARGE-SCALE PROJECT IMPACT MODEL

Christopher Cluett, Michael T. Mertaugh, and Michaél Micklin. 1977. A Demographic Model for Assessing the Socioeconomic Impacts of Large-Scale Industrial Development Projects. Unpublished. Paper presented at the 1977 Annual Meeting of the Southern Regional Demographic Group, Virginia Beach, Virginia, Battelle Institute.

Summary

The demographic model described in this summary uses a component technique to produce two sets of population projections by age and sex for a county experiencing the impact of a new employment source. Projections are for the population at the end of the construction phase and for the end of the first five-year and subsequent five-year periods during the operations phase. The model is applied to a general case and not to a specific new employment source.

The initial step in projecting the population is the use of standard demographic techniques to project the beginning 1980 population from 1970 Census figures. The labor force available for the construction phase is then defined as the resident unemployed construction labor force, resident employed construction workers who may change jobs, and in-migrant construction workers. Each of these components is independently estimated under the assumption that project jobs will be filled first by the unemployed, second by the already employed, and finally by in-migrants.

The first migration component therefore consists of in-migrants who fill project positions and those who have migrated in the hopes of filling such positions but for some reason have failed to do so. Primary employment

expansion may be expected to produce a secondary expansion which, in turn, attracts further in-migration. The model applies a multiplier to estimate the labor force demand of such secondary employment opportunities. These opportunities are filled first by the resident unemployed and second by the spouses of primary employees and finally by in-migrants. The secondary in-migrants constitute the second migration component.

Having estimated in-migrants to both primary and secondary employment, a modified gravity model is next applied to allocate the number of in-migrants who will actually reside in the site county. Accompanying dependents are then estimated, and age and sex schedules are applied to produce a demographic profile of all "in-migrants and their dependents. Finally, the population at the end of the construction phase is estimated under the assumptions that a proportion of construction phase workers will remain and transfer to secondary employment, another group will remain without further project involvement, and a third group will leave. Dependents are assumed to continue to reside with family heads.

Unlike the construction phase, which is assumed to draw the initial segment of its labor force from the resident population, the primary operations phase labor force is assumed to be specialized and, therefore, wholly drawn from outside the region. In-migrants are therefore calculated from the number of positions available, a gravity model applied to allocate residents to the site county, and dependents estimated as in the construction phase. Since the assumed span of the operations phase is 25 to 35 years, the population projections for this phase take into account labor force turnover as a result of separation and retirement, replacement of these workers, projections of fertility, mortality, and migration during the period, and out-migration of a proportion of the separated labor force.

Assessment

Though the model lacks the sophisticated feedback and interactive aspects of some others, it has a number of advantages. "Input data should be relatively easy to obtain, and the logical structure is sound. Assumptions are, for the most part, standard ones used by demographers and labor force analysts. The mechanisms for estimating labor force take into consideration turnover, retirement, separation, and mortality factors omitted by some other models. The unit of analysis, the county, is small enough to be used in the Alaska situation and is not region-bound, while the broad definition of the project permits the application of the model to a wide variety of industrial developments, including offshore oil drilling. The parameters of the model are, in other words, sufficiently broad and the data requirements sufficiently narrow to permit the model to be used in a variety o-f situations.

This model has a number of advantages which include relative simplicity, ease of use in terms of data required, and flexibility. The breakdown of the projected population by age and sex permits the easy use of the figures as bases for the further projection of such services as classroom space, hospital beds, and recreational facilities.

BOOM1 MODEL

Andrew Ford. 1976. User's Guide to the BOOM1 Model. Los Alamos Scientific Laboratory.

Andrew Ford. 1977. Simulating the Effects of Boom Town Policies. LASL Mini-Review. Los Alamos Scientific Laboratory.

Andrew Ford. 1977. Breaking the Stalemate: An Analysis of Boom Town Mitigation Policies. Informal Report LA-7046-MS. Los A"lamos Scientific Laboratory.

Summary

The BOOM1 model is a computer simulation model specifically designed for use in the situation where a large energy-producing plant is established in the vicinity of a small, isolated town or community. It is designed to permit interruption of the model in order to assess the effects of policy alteration on five segments: housing, public construction and municipal financing, retail and services, the power plant, and migration.

The model is holistic in the sense that output detail within each of these sectors is sacrificed to comprehensiveness and recursive in the sense that it consists of a series of interlocking feedback loops. It is dynamic rather than static, since it simulates the evolution of the affected town over a period of time, beginning with the pre-construction period and ending with the operations phase. It is this latter characteristic which permits interruption in order to change any desired input parameter and to assess the effects of such changes on each of the five output segments.

BOOM1 requ res a considerable number of inputs of three types: town specifit, state specific, and constants. Of the latter; which constitute the majority o the inputs, a number of them must, necessarily, be the result of estimates, whether derived from judgment, opinion, or some mathematical technique. Although the author lists sources for many of these constants, these sources are specific to the example cited and may or may not be available for the particular area under study. Further, such inputs as "relative importance of community acceptance of new residents" are clearly attempts to quantify essentially qualitative data and are subject to all the pitfalls inherent in this process.

Assessment

This model, while comprehensive and certainly extremely sophisticated, is also extremely complex and may well be quite difficult to implement. In the present context, it is especially important that the model is not designed specifically to forecast or project population, although population size is one of the final outputs. Consequently, the large number of inputs and the difficulty of obtaining them may not be worth the effort, since much of the output will be extraneous. In addition, the approach yields a lack of detail in the population area, producing an estimate of size but lacking the estimates of age and sex categories produced by some of the other models reviewed in this bibliography. If the ultimate goal is population projection, there appear to be several models which are simpler and, in addition, provide more detailed forecasts than BOOM1.

GENERAL ENERGY IMPACT MODEL

Erik J. Stenejhem and James E. Metzger. 1976. A Framework for Projecting Employment and Population Changes Accompanying Energy Development. Argonne: Argonne National Laboratory, Energy and Environmental Systems Division.

Summary

This report is basically an application of the conventional economic base analysis to specified areas of energy development. The major value of the study is determination of the number of employees required to construct and operate actual or proposed energy development facilities. The eight specific areas of energy development for which data are provialed include offshore oi1 and gas extraction. Additionally, the report also provides estimates of three sorts of employment multipliers for all counties in the continental United States.

The report provides a set of planning factors (estimates and procedures) to quantify changes in population and employment which occur as the result of the construction and operation of specified types of energy development. The county is the basic unit of analysis. The first of these factors is the direct employment requirement; these are given for eight types of development during both the construction and operations phases. The second factor is the estimation of secondary or supporting employment changes induced by changes in direct employment. Three alternative multipliers are estimated for each county in the nation. The first is the simple ratio multiplier; that is, the ratio of total-to-basic employment. The second is the complex ratio multiplier where basic employment is reduced by the number of employees in the transportation, construction,

and public administration sectors whose jobs are not supported by receipts external to the region. The third multiplier is estimated through regression analysis; counties of similar size and in similar areas are grouped. Each of the three types of multiplier is then subjected to a lag factor in order to trace through the timing of secondary employment changes.

The final planning factor is a conventional, demographically based population projection model. Cohort survival techniques are employed to forecast total population by age and sex. A projection of labor supply is made with the application of age-sex specific labor force participation rates. By comparing this with labor demand projections, the number of unfilled jobs will be determined. The number of unfilled jobs determines the in-migration of workers. By applying a household factor (household size of construction and local workers divided by the average number of workers per household) to this result and adding the result to the previously determined population, a revised population forecast is provided.

Assessment

With the exception of the alternative forms of the employment multiplier and the introduction of lags into the estimating procedure, this model is simply the combination of conventional economic base and demographic forecasting methods. The major contribution of the overall report lies not in the introduction of any new methodology but rather in its provision of data on employment multipliers and direct employment requirements for specified sorts of energy development. The choice of the county as the area unit of analysis is probably appropriate in most portions of the nation

UTAH PROCESS ECONOMIC AND DEMOGRAPHIC IMPACT MODEL

Rodger Weaver and Ross Reeve. 1976. Economic-Demographic-Land Use Impact Projections: Utah Process Methodologies. Unpublished. Office of the Utah State Planning Coordinator.

Summary

This paper reports on two interrelated models designed to project economic and demographic impacts of potential major economic or policy events on on-going economic systems. These models are termed UPED (Utah Process Economic and Demographic Impact Model) and UPLAND (Utah Process Land Use and Tax Base impact Model). UPED provides projections of economic and demographic labor markets bounded by community limits. UPLAND, on the other hand, <u>allocates</u> these changes to subareas within the labor markets; these subareas may be viewed as communities.

UPED is a classic economic base model. Based on changes in the export sector, via employment and demographic multipliers, projections of population and total employment are made. The population component of the model begins with the conventional cohort-component technique. Migration is divided into two sectors. Nonemployment-related migration is exogenously determined and treated parametrically. Employment-related migration is determined by interaction of labor supply (from basic deomgraphic projections of population by age, race, and sex) and labor demand (from economic base projections). UPED is solved iteratively until net migration is at a sufficient level to be within a parametrically determined "normal" range of unemployment. The model permits population-dependent job opportunities to be dependent upon changes in the size and composition

of the local population, the level of local service relative to the nation, and changes in national economic demographic characteristics.

UPLAND is designed to extend and complement UPED by allocating economic and demographic change to communities within the labor market area. The primary mechanism for this is by use of the market for available land. The price of land in each community and the uses of that land are determined in UPLAND by access (complementarily) and competition (conflict) relationships. The former vary directly with the extent to which area provides access to input or output markets for given activity; the latter by the ability of the activity to pay land rent in the area.

Assessment

The interaction of regional and local models is an extremely desirable aspect of the approach taken here. The models are general enough to suit a variety of economic changes and are specifically intended for a variety of energy-related activities. The use of a land use model as an allocative mechanism from the regional to the community level is a novel concept, as far as we can determine. Because of this land-use orientation, though, UPLAND is lacking in demographic detail. The only population variable is total population. Further linkage between UPED and UPLAND would be required to allocate demographic characteristics (an output of UPED) to the community level. The overall approach is definitely geared to the pre-existence of a market-type economy which may or may not be the case for all communities in Alaska.

OBERS

Bureau of Economic Analysis, U.S. Department of Commerce and Economic Research Service, U.S. Department of Agriculture. 1974. 1972 OBERS Projections: Economic Activity in the United States. Washington: Government Printing Office.

Summary

This model is used to project economic activity for the nation, for functional (BEA) economic areas, for water resource regions, and for all states. Included are projections of population, personal income, employment, earnings of persons, and output; the last three variables are separately projected by sector. These projections are designed to serve as a baseline for the analyses of resource demands and development needs and for the evaluation of the costs, benefits, and economic impact of development and management programs and projects.

The overall framework of the model is a national one, with the regional models relating to it. There are three basic assumptions relating to population and employment at the regional level. First, workers are assumed to migrate toward areas of economic opportunity and away from slow-growth or declining areas. Secondly, regional earnings per worker and income per capita are assumed to continue to converge toward the national average. Finally, regional employment-population ratios are also assumed to converge to the national average. The second and third assumptions are essentially corollaries of the first.

Changes in employment are the primary driving force in the population projections. Initial differences between regions in terms of levels of unemployment and rates of labor force participation are recognized, but the model assumes that these will gradually disappear. Projected changes in employment are translated into population changes by applying the projected national population-employment ratio to employment changes. This step is done only for that segment of the population aged 15-64. Migration of the 0-14-aged population is a function of the migration of the working population and migration of persons aged 65 and over tied to previous levels of migration in that age group.

Regional employment projections are made for the basic and supporting sectors. Basic employment growth is modeled using a shift-share approach. Shift-share divides industrial growth into national growth and regional share effects. National growth is simply the result of applying projected national growth rates of employment at the regional level. The regional effect is designed to capture the region's comparative advantage (or disadvantage) in a given industrial sector. To project this component, the OBERS model uses the trend extension of the region's share of total national employment in each industry.

Employment in the supporting or residentiary sectors is a function of projected employment in the basic sectors. The levels of employment in each supporting industry are determined by the projected regional location quotient (regional share of an industry divided by national share of the same industry), the projected national ratio of the industry's employment to total national employment, and the projected basic employment in the region.

Assessment

These projections are designed to serve as a baseline against which to evaluate various programs. The framework for the model does not explicitly permit the introduction of new basic industries, or expansion of them beyond the level consistent with past trends. One could fairly easily input such an industry in an exogenous fashion to trace through possible effects. The population component in this model is more or less a by-product rather than being an integral component of the model. In a national model of this sort, it would seem highly useful to utilize a labor pool-type concept to ensure equilibrium in the overall flows of migration. In this model, there is an absence of interaction between labor supply and labor demand components. However, the lack of specificity to the Alaska case (and the failure of the model to go below the state level in Alaska) suggests that considerable data gathering and collecting would be needed to use the model for assessment of OCS petroleum development population distribution issues below the state level.

COLORADO POPULATION-EMPLOYMENT MODEL

Colorado Division of Planning. 1973. A Simulation Model for Forecasting Colorado's Population. Colorado Population Trends. Vol. 2, No. 4.

David E. Monarchi. 1974. Some Forecasts for Colorado in 1974 Using the CPE Model. Colorado Population Trends. vol. 3, No. 2. Colorado Division of Planning.

David E. Monarchi and Ken D. Prince. 1975. Forecasting with the CPE Model--Some Practical Experiences. Colorado Population Trends. Vol. 4, No. 4. Colorado Division of Planning.

Summary

The Colorado Population-Employment (CPE) model is an interactive model which forecasts population by age, race, and sex and employment for 54 industry groups. The model was used to produce forecasts for the state of Colorado and for 12 planning regions. Regional totals were allocated to the county level.

The basic model projects births, deaths, and three types of migration--retirement, military, and employment. Outputs include population by age, race, and sex and employment in the 54 industry groups. This is an interactive model consisting of two submodels, population and economic.

The model projects the births and deaths which will occur during the period for which the forecast is being made. Retirement and military migration are then added to produce an estimate of nonemployment-related population change. The final component of population change is estimated as a function of the change in employment.

Change in basic employment expected to occur during the period is assumed to reflect national growth rates. Changes in employment in household-serving industries are calculated as a function of changes in the population; and changes in business-serving employment are derived from changes in both population and basic employment. Total employment change is subtracted from the available labor force to yield an estimate of net migration resulting from changes in employment opportunity. This estimate is added to the births, deaths, and other migration estimates to produce a population estimate.

Assessment

This model has several major drawbacks for use in the Alaska situation. First, data inputs are complex and involve not only the inclusion of estimates of certain types of migration but also data which may well not be available at the local level. Second, the model assumes that basic industry growth reflects national trends, and it is not clear to what extent this assumption may easily be altered. Finally, in testing the model, it was found to perform well for Colorado during the 1970-73 period; but during this period, it performed least adequately in 1972, a year which the authors note was a time of substantial increase in jobs in the state. This finding certainly casts doubt on the ability of the model to perform adequately where the impact to be evaluated is that of a sudden increase in employment opportunity.

NATIONAL-REGIONAL IMPACT EVALUATION SYSTEM

Daniel H. Garnick, Charles E. Trott, Allan Olson, Henry Hertzfeld, and Vernon Fable. 1971. Toward Development of a National-Regional Impact Evaluation System and the Upper Licking Area Pilot Study. Staff Paper in Economics and Statistics, No. 18. U.S. Department of Commerce, Office of' Business Economics.

Summary

This model is designed to develop a generalized methodology for public project evaluation that includes both redistributive as well as national economic efficiency considerations. The approach, encompassing a regionally distributed and industrially detailed model, facilitates consistent balancing of regional costs and benefits and yields time-series specification of redistribution of population, labor force, earnings, and employment, at the regional level, that can be expected from a given investment.

The basic structure of the model provides separate projections of employment and labor force, and then utilizes migration to achieve equilibrium in the labor market. Two separate employment projections are carried out; one assumes the development of a water control project in the study area, and the other omits such a development (these are termed "with" and "without" conditions, respectively). The without projections are linked to the national and regional OBERS projections of economic activity. The with projections add water control project employment (these are manufacturing industries assumed to locate in the area after development) to basic employment, and induced service employment is derived from conventional multiplier effects. The model does not treat the short-run effects of the flood control activities.

The labor supply projections stem from demographic projections of population by age and sex. Projections are made using-a cohort-survival model with a fixed fertility assumption and three migration assumptions: closed population (no migration), previous (1950-60) migration rates halving every five years, and previous migration rates halving every ten years. Based on the population projections, estimates of potential labor supply are derived by application of national age-sex specific rates of labor force participation. The demand for labor is met from the indigenous, untapped supply of labor until it is fully employed (a rate of unemployment of four percent is equated with full employment). Additional labor must be imported to meet employment needs. In-migrant population is found by dividing the imported labor force into age groups according to the national age distribution. The labor force is divided by participation rates to arrive at total induced population in the area. Based on the population projection, projections of children and births in subsequent periods are derived.

Assessment

This model is the prototype of interactive evaluation efforts. It lacks many of the desirable refinements of subsequent models. The manner and degree of initially induced employment in the area is highly arbitrary. The supply of labor is treated as being homogeneous; but for some activities, the requisite level of specialization is such that migration might occur immediately. Additionally, the division of immigrants into national patterns of labor force by age and sex ignores the selectivity of migration by age and possibly understates the longer-run demographic effects. The major strength of this model is that the data requirements of the model are relatively simple.

MULTIREG1ONAL, MULTIINDUSTRY FORECASTING MODEL

Curtis C. Harris, Jr. 1973. The Urban Economies, 1985: A Multiregional, Multiindustry Forecasting Model. Heath.

Summary

This book presents a multiregional, multiindustry forecasting model for the metropolitan portion of the United States. The model forecasts the location of industry. Changes in industrial output in each region result from changes in input prices faced by the firms in their respective locations and agglomeration variables which explain a portion of industrial location behavior which is not explained by prices. The regional industrial output determines employment and population, earnings, and personal income.

For most industries, changes in the level of output are functionally determined by transportation costs for inputs and outputs, local wage rates, land values, lagged output and investment, population density, and the location of major buying and selling sectors for that industry. Since the model is recursive, total output is simply the previous period's output plus the change. This change in output also governs the current level of investment for most industries.

Employment is also recursive and is functionally determined by lagged output, changes in output, and lagged investment.

Total population is divided into two racial groups and four age groups. Natural increase is treated in the conventional manner, with birth rates being specific only to race and mortality rates being specific to both age and race. Births within racial groups are determined by the size of the 15-34-year-old age group.

Migration is determined differently for the working-age groups (15-34, 35-64) than for nonworkers (0-14, 65-I-). Those aged 0-14 are determined by migration of those aged 15-64; while for those aged 65 and over, net migration is simply a function of the previous population in this age group. Civilian migration for the working-age groups is a function of the base-year labor surplus, the change in employment, the change in military, and the average wage rate in the base year. (Surplus labor relates the region's unemployment rate to the national average.)

Assessment

Although this model contains many innovative features, particularly the attempt to project migration separately for age and race groups, its potential for utilization in the Alaska case must be regarded as being rather limited. The nature of the model is such that the data requirements are enormous and probably not available in many instances. While the model forecasts location based on price structures and nearness to markets, it does not permit the immediate reaction of induced changes in employment in other sectors stemming from a major industrial location. Although migration of the working population is determined, theoretically, by the interaction of supply and demand forces, the model performs poorly in this aspect. Furthermore, because the model is estimated cross-sectionally for the entire United States' metropolitan population, the prospect that the equations themselves will fit the Alaska case is unlikely.

INTRA-II

Stephen H. Putnam. 1975. An Empirical Model of Regional Growth with an Application to the Northeast Megalopolis. Regional Science Research Institute.

Summary

This book presents two econometric models of regional economic and population growth, INTRA-I and INTRA-II. INTRA-II is presented as a refined version of the former and is the basis for the discussion that follows. INTRA-II is a large-scale econometric model with separate employment, population, income, and land-use components. The model is based on 1960 and 1965 data for the Northeastern portion of the United States. Subregional analysis is conducted at the Standard Metropolitan Statistical Area or State Economic Area level. Projections are provided for the years 1980, 1985, and 1990.

Changes in employment by major industrial sector are the most important major determinants of net migration to a region. Employment changes are functionally determined by changes in market potential for intermediate and final goods, access, degree of agglomeration, degree of scale of operation, level of unemployment, land value, potential labor force, and

average wage rates. The population model is a rather simple and conventional component-type model ; migration is determined endogenously. Although attention is paid to the desirability of separate estimates of in- and out-migration (and the fact that behavior response varies in these circumstances), only net migration is explicitly included in the model . Net migration is assumed to be a function of wage rate differentials, employment opportunities, the degree of labor surplus in the region (or subregion), and current levels of natural increase (disaggregate into birth and death components). No effort is made to disaggregate either projected population or net migration into age, race, or sex groups.

The model also includes estimating equations for the number of births, crude birth rates, the number of deaths, and crude death rates. The attempt to estimate both vital rates as a function of population density and per capita income were unsuccessful, explaining only about one-fourth of all variance in each case. The results for number of events were much better, explaining almost all of the variance, but this variance was almost entirely explained by the previous level of the respective event.

Assessment

Like many other regional econometric models, INTRA-II is not primarily concerned with demographic aspects and any demographic results tend to be cursory and secondary. This is perhaps best illustrated here by the failure to include any level of demographic detail. The attempt to determine fertility and mortality rates endogenously is worthy of attention, although the results indicate that the model in its present form is not well-specified. The size of areas treated in this model is also substantially larger than that relevant to the Alaska situation.

MAP MODEL

Daniel A. Seiver. 1975. The Use of an Econometric Model in Population Projections in Alaska. Paper presented at the annual meeting of the Population Association of America, Seattle. Institute of Social and Economic Research.

Daniel A. Seiver. 1975. Alaskan Economic Growth: A Regional Model with Induced Migration. Paper presented at the annual meeting of the Regional Science Association, Cambridge. Institute of Social and Economic Research.

David T. Kresge. 1976. Alaska's Growth to 1990: Economic Modelling and Policy Analysis for a Rapidly Changing Northern Frontier Region. Alaska Review of Business and Economic Conditions, Vol. 13. Institute of Social and Economic Research.

Summary

These papers collectively describe the Man-in-the-Arctic program (MAP) modeling effort of the University of Alaska's Institute of Social and Economic Research (ISER). The model is designed to project the various growth paths which Alaska might follow as a result of alternative policy choices. The effect of specific policy actions on personal income, industrial output, employment, and population can be projected by the model.

Like other demographic-economic models, the MAP model contains separate, interrelated economic and demographic submodels. The economic model projects output by industrial sector. In some sectors, output and/or employment is projected outside the model; these include mining, federal government, agriculture-forestry-fisheries, and manufacturing. The other sectors are determined endogenously; these sectors include trade, services, finance, and transportation-communication-utilities. A portion of construction is determined endogenously, and a portion is determined exogenously. The demand for output is a function of real disposable income. The outputs of all sectors are functionally transformed into employment levels. Wage rates are a function of U.S. wage rates and relative prices in Alaska, and when applied to employment, they yield the total wage bill.

The population submodel employs conventional cohort survival techniques to determine the level of natural increase among the civilian population. Net civilian migration is a function of employment growth in Alaska and the lagged (one-year) ratio of real per capita income in Alaska to that of the entire nation. For the 1960-1973 period, the equation explained 95 percent of the variance in net migration to Alaska. Net migration is allocated by age and sex using two sets of 1965-1970 data-actual Alaska data for those 40 and over and data for California and noncontiguous states for those aged 0 to 39. This latter is necessary due to the severely distorting effects of military migration to Alaska among males aged 20 to 29. There does not exist a feedback mechanism in the model between labor supply and labor demand. Net migration to or from Alaska is solely determined by employment change and relative income so that there is no possibility for increasing labor force participation absorbing migration increases.

The model also contains a regional feedback mechanism. For the demographic sector, total population is controlled to the projected state total, and then allocated to the regions of the state by means of separate regression equations which are based on 1965-1973 employment-population relationships by region. The regional submodel also contains an economic component similar to that for the entire state. Initially, by processes analogous to those described above, regional employment is projected, and then through the regional employment-population equation, a "first-round" population projection at the regional level is obtained. Each of these is divided by the sum of all regional populations, and this ratio is multiplied by the separately projected state total to obtain the final regional projection.

Assessment

The fact that this model is built for the Alaska economy, is sensitive to petroleum development, and contains a set of regional submodels makes its potential utility very high. The nature of the migration model is such that it is able to forecast a boom and bust situation resulting from pipeline construction; the estimated regional equations clearly show the tendency for relatively greater import of any development to ultimately occur in the urban areas, particularly Anchorage and Fairbanks.

The model is not without some drawbacks in its present form. The regional population models vary greatly in their accuracy. Additionally, these models could be refined to make them more analogous to the statewide population model so that local variations in fertility and mortality could be employed. Also, as noted previously, the lack of feedback between labor supply and labor demand could lead to overstatement of both net in- and out-migration.

Finally, in its present form, the model is not suited for use at the community level. At the state and regional level, the MAP model is almost ideally suited for evaluation of OCS petroleum development population distribution issues. A community-type model with linkages to the regional and statewide MAP models is needed to complete the task at hand.

INPUT-OUTPUT MODEL

Mathematical Sciences Northwest, Inc., and Human Resources Planning Institute, Inc. 1976. A Social and Economic Impact Study of Off-Shore Petroleum and Natural Gas Development in Alaska: Phase I. Report submitted to Bureau of Land Management, U.S. Department of the Interior.

Mathematical Sciences Northwest, Inc., and Alaska Consultants, Inc. 1976. A Social and Economic Impact Study of Off-Shore Petroleum and Natural Gas Development in Alaska: Phase II. Report submitted to Bureau of Land Management, U.S. Department of the Interior.

Summary

These reports describe an effort to determine and assess the socioeconomic impact of OCS energy development for selected areas in Alaska. Phase I develops and tests two sorts of models, economic base and input-output (I-O) for the Kenai Peninsula. The data used here represent simulated and actual outcomes over the 1961-1972 period. Phase II builds on Phase I in that it incorporates the calibrated I-O model from Phase I to project impacts for the Yakutat, Dillingham-Naknek-Bristol Bay, and Kotzebue areas.

I-O models are frequently suggested for the assessment of economic impacts; this project is one of the few where actual implementation occurs. Conceptually, I-O analysis can be extremely useful in assessing economic impact, given its nature as a research tool showing changes in all sectors induced by change in any specified sector(s).

Phase II which deals exclusively with projections of impacts utilizes I-O analysis alone. The areas studied in Phase II are all small and isolated (in contrast to the study area of Phase I). It was assumed that the same model would apply to all three communities due to the basic similarities in their economic structure. Through specified changes in OCS sectors, forecasts of employment in all other sectors are generated. This is accomplished by the use of inverse I-O coefficients. These latter state changes in direct, indirect, and induced output requirements in each industry required per dollar of expenditure in the OCS sector. The total output requirements, by sector, are then multiplied by each sector's employment-output ratio to obtain projected total employment by sector. There is no effort made to project changes in the employment-output ratio that might accrue through increased productivity or economies of scale.

The model does not contain an explicit demographic component. The only demographic variable included as an output is total population, which is obtained simply by multiplying total employment by an employment-population ratio

Assessment

The use of I-O analysis is perhaps the project's strongest point. As noted above, this technique is well suited to assess economic impact stemming from any change in local economic structure. Whether the technique is appropriately applied for very small areas is, however, another question. Data requirements for such a model are quite large and, therefore, heavily demanding upon scarce time and monetary resources. The availability and quality of data at the local level would seem to be a very real constraint for present purposes, so the degree of accuracy added by I-O is difficult to assess.

The demographic component of the model is secondary at best. It would require extensive modification before the model could project changes in population distribution and basic demographic characteristics.

Summary and Conclusions

Of the models reviewed in this section, the Large-Scale Project Impact Model of Cluett, Mertaugh, and Micklin is most appropriate for assessing the OCS impact in small Alaskan communities. The logical structure of the model emphasizes the important link between the local labor supply response to the project and in-migration. The model is designed for community-level impacts. The model is an accounting model which does not require large amounts of data; the simple structure of the model makes it easily applicable to rural Alaskan communities. The ability to change parameters dealing with both the labor supply response and the secondary employment multiplier makes the model flexible. The basic structure of the model described in the next section is based on this model. Alterations to the model have been made to allow the model's application in rural Alaska.

III. THE DESIGN OF A POPULATION IMPACT MODEL FOR SMALL ALASKAN COMMUNITIES

Introduction

The development of this population impact model evolved from the need to assess the general impacts of OCS development. Small, rural Alaskan communities may become the sites of the service bases used in Alaskan OCS development. Because the level of employment is large relative to the size of these communities, the in-migration associated with OCS activity is the major source of impact. The increased population will affect the demand for services from both the private sector, such as housing, and the public sector, such as schools. The effect of increased population on the community services necessitates an estimate of the future level of the total population impact associated with a given level of direct OCS employment.

The concern of this report with OCS-associated population growth dictated the design of the model; however, the basic model can easily be expanded beyond our present concerns. Although the model is formulated to describe the population effect of OCS activity, it can be used to discuss the impact of any major special project. The model is community oriented, designed to accommodate the lack of data and need for flexibility at the local level. The community in this context can be interpreted as the labor market area; the labor market area is the area from which we would reasonably expect the majority of the workers to commute. The model, with different parameters, can explain activity at any level--state, regional, or local --although more appropriate tools exist for the higher levels (ISER, 1979). Because of their importance in determining the demand for services, the model projects the age-sex structure of the population. In order to provide projections at this level, a cohort-component approach is central to the model.

The model presented is an interactive one which divides the projection period into shorter cycles and projects separately the three demographic events--births, deaths, and migration--which determine population change. The population in each cycle is adjusted for each event and serves as the base for the subsequent cycle where the whole process is repeated. The model actually includes three separate projections, each with unique characteristics. The baseline population is treated separately from the project-related population, except that the degree of response to project job opportunities of local labor partially determines the number of in-migrants attracted to the community.

In-migrant workers are divided into two separate phases, development and operations. Each phase has different demographic characteristics as well as differences in tenure. The development phase is assumed to last for a short time and occur independently in each cycle. The operations phase is assumed to last throughout the projection period. Because of the length of this phase, the operations population becomes a more permanent part of community population. Operation phase population in one cycle is subject to fertility, mortality, and out-migration and influences the level of migration in future cycles. The remainder of this chapter will address the model's treatment of each phase of activity and the interaction between the baseline and impact phases. (Appendix A contains flow charts describing the general process of the model.)

The Baseline Population

The impact community will experience demographic changes in the absence of OCS development. The size and age-sex structure of the population will determine the natural change in the population through births and deaths. Changes in employment opportunities and community amenities will influence migration both into and out of the community. Changes in the level of indigenous population are important to the analysis of OCS impact for two reasons. First, the indigenous population and its non-OCS growth serve as a comparative baseline for OCS development. The relative size of the impact population and its relative effect on growth rates will determine the ease with which the service demands of this population can be met. Secondly, the indigenous population is a source of supply for project employment.

For each cycle, the model determines the number of people who would reside in the community without OCS development. Baseline population is projected using a straightforward cohort-survival approach. The cohort-survival approach begins with the previous period population disaggregate by age, sex, and race and provides estimates for the same cohorts at the end of the period.

The natural increase of the community population is estimated using age-sex-race specific fertility and survival rates. Survival rates are equal to the probability of surviving over the cycle for each cohort. Fertility rates are applied to a subset of the female-cohorts, so births are determined by the population in these cohorts and the assumed fertility rate. Assumptions must be made concerning the future fertility and mortality rates. The model assumes that the rates remain constant throughout the projection period, so a change in overall rate for the population is a function of the changing age-sex-race structure.

The application of fertility and mortality rates to the base population provides an estimate of the survived population at the end of the period. The possibility that this population may be increased or decreased through migration must also be considered. Migration rates are assumed for each age-race-sex cohort. The migration rates determine the net migration in each cohort as a function of the survived population in that cohort. Migration rates are chosen to reflect an assumed rate of growth in the economy without any OCS activity. These rates are assumed to remain constant throughout the projection period. Equations B.1 through B.5 describe the demographic component of the baseline phase.

B.1. $$\text{BIRTHS}(T,R) = \sum_{A} \left(\text{POP}(T-1,A,S,R) * \text{FR}(A,R)\right)$$

B.2. $$\text{SPOP}(T,1,S,R) = \text{BIRTHS}(T,R) * \text{SXR}(S)$$

B.3. $$\text{SPOP}(T,A,S,R) = \text{POP}(T-1,A-1,S,R) * \text{SR}(A-1)$$

B.4. $$\text{POP}(T,A,S,R) = \text{SPOP}(T,A,S,R) * \text{MIGR}(A,S,R)$$

B.5. $$\text{POP}(T) = \sum_{A} \sum_{S} \sum_{R} \text{POP}(T,A,S,R)$$

where POP = baseline population

BIRTHS = survived births

FR = fertility rate

SXR = sex ratio of births

SPOP = survived population

SR = survival rate

MIGR = migration rates

T = time period

A = age cohort

s = sex cohort

R = race cohort

The previous set of equations provides the projection of the baseline, non-OCS population to which the relative impact of OCS development can be compared. The baseline population also serves as a source of OCS labor supply. The labor supply response of the population to OCS development depends on the projected labor force status of the population. The model projects the population's three mutually exclusive labor force status groups--employed, unemployed, and the population not in the labor force. The willingness of members in each of these groups to work on an OCS project is assumed to differ. The population in each labor force status group is determined by application of age-sex-race specific labor force participation and unemployment rates to the projected population. The employed population is projected as the difference between the labor force and unemployed. As in the demographic component, changes in overall rates of unemployment and labor force participation are assumed to reflect only changes in the age-race-sex composition of the population. The labor force and unemployment rates are assumed to remain constant throughout the projection period. This assumes that employment opportunities are expanding at a rate equal to the expansion of the labor force. Equations B.6. through B.10. describe the labor force status portion of the model.

B*6. $$BLF(T,A,S,R) = POP(T,A,S,R) * LFPR(A,S,R)$$

B.7. $$UNEMPLY(T,A,S,R) = BLF(T,A,S,R) * UR(A,S,R)$$

B*8. $$EMPLY(T) = \sum_A \sum_S \sum_R (BLF(T,A,S,R) - UNEMPLY(T,A,S,R))$$

B.9. $$UNEMPLY(T) = \sum_A \sum_S \sum_R UNEMPLY(T,A,S,R)$$

B.10. $$NLF(T) = \sum_A \sum_S \sum_R (POP(T,A,S,R) - BLF(T,A,S,R))$$

where BLF = the baseline labor force

UNEMPLY = the baseline unemployed population

EMPLY = the baseline employed population

NLF = the baseline population not in the labor force

LFPR = the labor force participation rate

UR = the unemployment rate

The product of the baseline phase is a description of the non-OCS, baseline population at the end of each projection cycle. Population projections are provided by age, sex, and race cohorts.' The combination of these population projections and assumed rates of unemployment and labor force participation allows the projection of the population by labor status groups. These projections serve as a point of comparison for OCS impacts. More importantly, the determination of local labor supplied to the project depends on the projected labor force status of the population.

The Development Phase

OCS-induced population growth is treated in two distinct phases, development and operations. The distinction between these phases is necessary because of assumed differences in the demographic characteristics and tenure of in-migrants of each phase. Although these differences result in subtle model differences in each phase, the major determinants of migration are the same. In-migration is determined by the interaction of the local labor supply and project labor demand. Demand for labor is increased because of the project, both directly and through increased secondary employment. The local community supplies labor to the project. In-migration occurs to clear the labor market.

To project the population impact of an OCS project during its development phase, the model requires certain information about the project. Data is required on the size of the work force in this phase and the skill levels associated with it. The model assumes two skill levels, skilled and unskilled. Information is also required on the proportion of employment the contractor will bring with him. A certain proportion of the jobs is assumed to be filled by outsiders with previous contact with the contractor or by workers with specialized skills not found in the local economy.

The model also requires information on the interaction of the OCS employment with the local economy. An important consideration in Alaskan resource development is the enclave nature of much resource development. Enclave development limits the interaction OF project workers with the local economy. The model requires information on the extent development phase employment will be enclave employment.

Once project labor demand and its various components are known, the model matches project demand with the local labor supply. The local labor supply is a function of the size of the community and the willingness of its population to take OCS jobs. The willingness to take OCS jobs is assumed to differ across. labor status groups--employed, unemployed, and those not in the labor force. The number of local workers on the project will also depend on the characteristics of the project labor demand. Most important of these considerations is the matching of skills possessed by local labor and the skills required on the project.

The intricate labor-market interaction is described in the model by a series of labor-market response rates. These rates describe the response of each labor status group to OCS employment opportunities; each group responds to both skilled and unskilled employment opportunities. The labor-market response rates are determined external to the model. Labor-market response rates for each group and skill category are presently assumed to equal the joint probability that labor will be supplied to the project and demanded by the project. The rates in each labor status group are determined as follows:

1. The willingness of locally employed workers to switch to OCS employment is assumed to equal the probability that these workers could increase their incomes. This probability is assumed to equal the proportion of workers in industries with incomes less than the project industry (construction or mining). Only workers less than 50 are assumed to be willing to move. The probability that the employed will be demanded by the project depends on the match between skills supplied and demanded. Skills are assumed to be described by occupational distribution. The probability that an occupation will be supplied and demanded equals the proportion of the employed population in the occupation times the proportion of employment in project industry (mining or construction) in the occupation. The sum of these probabilities across occupations equals the probability that employed population will be demanded by the project.

2. All of the unemployed population is assumed to be willing to accept jobs on the project. The constraint on this response depends on the skill match. The probability that unemployed labor will be employed on the project equals the joint probability that an occupation required by the project occurs within the unemployed population.

3. It is assumed that some of those not in the labor force would be willing to enter the labor force to work on the project. This population was assumed to enter until the age-sex specific labor force participation rates equal led the state rates. The match of skills possessed by those not in the labor force and demanded by the project constrain the response.

The labor-market response rates are multiplied by the potential supply to determine labor supplied to the project.

In-migration of direct construction workers occurs to fill the gap between labor supply and demand. In-migration equals the sum of total imported labor, the excess of skilled demand over skilled supply, and the excess of unskilled demand over unskilled supply. Equations D.1. through D.3. describe the determinants of direct development in-migration.

D.1. PSUPPLY(T,1) = EMPLY(T); PSUPPLY(T,2) = NLF(T) ;
PSUPPLY(T,3) = UNEMPLY(T)

D.2. CONSUPPLY(T,i,j) = CONSLBR(i,j) * PSUPPLY(T,i)

D.3. IMGW(T) = BETA1 * CONDEM(T, 1) + BETA2 * CONDEM(T,2)
+ LOCAL(t,1) + LOCAL(T,2)

where PSUPPLY(T,i) = the population in labor force status group i

CONSUPPLY(T,i,j) = the labor supply in skill group j from labor status group i

CONSLBR(i,j) = the market response rate from labor status group i for skill group j

IMGW(T) = direct development phase in-migration

BETAj = the proportion of labor demand in skill group j which is imported

CONDEM(T,j) = project development labor demand for skill group j

LOCAL(T,j) = excess of project demand over local supply for skill group j. Where LOCAL(T,j) cannot be less than zero.

Once direct development in-migration is determined, the associated family in-migration is calculated. The model projects both in-migrant spouses and in-migrant dependents using a series of age-sex specific multipliers which describe the number of dependents and spouses in each cohort per worker. All in-migrant workers are assumed to be non-Natives. An age-sex distribution is also applied to direct worker in-migrants. Prior to projecting the dependents and spouses, two adjustments to the work force are made. First, the enclave employment is separated. It is assumed that neither dependents nor spouses accompany enclave workers. The second adjustment is to account for in-migrant workers that take up residence in other communities. This is only possible when other areas are within commuting distance. The model assumes that a proportion of in-migrants will live in other communities. The proportion of resident in-migrants is not found internal to the model but is assumed. The present assumption applies a gravity model to distribute the in-migrants to alternate areas. The dependent/spouse multipliers are applied to the adjusted nonenclave resident worker in-migrants. Equations D.4. through D.8. describe the demographic portion of the model.

D.4. $$EIMGW(T) = ENCLV * \sum_j CONDEM(T,j)$$

D.5. $$RIMGW(T) = (IMGW(T) - EIMGW(T)) * GRV$$

D.6. $$SPIMGW(T,A,S) = RIMGW(T) * CSPAS(A,S)$$

D.7. $$DPIMGW(T,A,S) = RIMGW(T) * CDPAS(A,S)$$

D.8. $$LIMGW(T,A,S) = (RIMGW(T) + EIMGW(T)) * IMGWAS(A,S)$$

where EIMGW(T) = the enclave in-migrants

ENCLV = the proportion of enclave employment

RIMGW(T) = the resident in-migrants

GRV = the proportion of direct nonenclave in-migrants residing in the community

SPIMGW(T,A,S) = the number of spouses in age cohort A and sex cohort S

CSPAS(A,S) = the number of spouses in age cohort A and sex cohort S per direct resident in-migrant worker

DPIMG(T,A,S) = the number of dependents in age cohort A and sex cohort S

CDPAS(A,S) = the number of dependents in age cohort A and sex cohort S per direct resident in-migrant worker

LIMGW(T,A,S) = the number of local resident in-migrant workers in age cohort A and sex cohort S

IMGWAS(A,S) = the proportion of local resident in-migrant workers in age cohort A and sex cohort S

The second important component of migration in each phase includes migrants responding to secondary employment opportunities. Increases in direct project employment lead to increases in the support employment which serves primary workers. Two sources of secondary employment are explicit in the model. The first is increased local government employment. This employment is considered separately, since it may not depend on the level of primary employment but on the extra revenues generated by the project. The more traditional source of secondary employment is the expansion of the local support sector to serve the increased primary workers. This relationship is described by a multiplier. In the model, secondary employment opportunities are computed by applying multipliers to the level of primary project employment. Different multipliers are applied to the enclave and nonenclave components of primary employment. Since enclave employment has little interaction with the local economy, the multiplier is assumed to be lower than for the nonenclave sector. The final component of secondary employment demand is replacement of those residents who left jobs to work on the project.

The migratory component of the secondary labor force is computed in a residual fashion like direct migration. The local labor supplied to the secondary sector is determined by the potential supply and labor market response rates of each labor status group. Potential labor supply is adjusted to account for those residents from each labor status group employed in direct development employment. Potential labor supply for secondary employment includes the dependents and spouses of the direct project in-migrant workers. Labor market response rates for each labor status group are applied to the potential supply to determine the local labor supplied to the project. These rates are estimated in a manner similar to that described for direct development employment. The distribution of occupations demanded is assumed to equal the distribution for the entire economy in the last census. Employed residents are not assumed to be able to improve their income positions by taking secondary jobs, so their response rate is assumed to be zero. The response rates of dependents and spouses is assumed to equal the weighted average of their age-specific labor force participation rates.

Once supply is determined, the residual labor demand is met by migration. There is assumed to be no enclave secondary employment, and all in-migrants are assumed to live in the community. The number and age-sex distribution of dependents and spouses are determined in a manner similar to the project in-migrants. Equations D.9. through D.18. describe the secondary migration response of the model.

D.9.
$$PSCSPPLY(T,1) = EMPLY(T) - X1 - X2;$$
$$PSCSPPLY(T,3) = UNEMPLY(T) - Y1 - Y2;$$
$$PSCSPPLY(T,2) = NLF(T) - Z1 - Z2;$$
$$PSCSPPLY(T,4) = \sum_{A}\sum_{S} SPIMG(T,A,S); \quad PSCSPPLY(T,5) = \sum_{A}\sum_{S} DPIMG(T,A,S)$$

D.10.
$$SCONSPPLY(T) = \sum_{i} (PSCSPPLY(T, i) * SCONLBR(i))$$

D.11.
$$LOCGOVT(T) = EMPPCT * REV(T)$$

D.12.
$$SCONDEM(T) = CNEMULTi * [CONDEM(T,1) + CONDEM(T,2) - EIMGW(T) - (IMGW(T) - RIMGW(T))] + CEMULTi * EIMGW(T) + LOCGOVT(T) + X1 + X2$$

D.13.
$$SIMGW(T) = SCONDEM(T) - SCONSPPLY(T)$$

D.14.
$$SPS\ MG(T,A,S) = SIMGW(T) * SCSPAS(A,S)$$

D.15.
$$DPS\ MG(T,A,S) = SIMGW(T) * SCDPAS(A,S)$$

D.16.
$$SIMG(T,A,S) = SIMGW(T) * SIMGWAS(A,S)$$

D.17.
$$CIMG(T,A,S) = LIMGW(T,A,S) + SPIMG(T,A,S) + DPIMG(T,A,S) + SIMGW(T,A,S) + SPSIMG(T,A,S) + DPSIMG(T,A,S)$$

D.18.
$$CIMG(T) = \sum_{A}\sum_{S} CIMG(T,A,S)$$

where PSCSPPLY(T,i) = the population available for employment in labor status group i

SCONSPPLY(T) = the labor supply available for secondary employment

SCONLBR(i) = the labor market response rate of labor status group i

SCONDEM(T) = the secondary employment demand from the development phase

CNEMULTi = the multiplier for the nonenclave project employment

CEMULTi = the multiplier for the enclave project employment

EMPPCT = the local government employment per dollar of revenue

REV(T) = local government revenue due to the project

LOCGOVT(T) = local government employment

SIMGW(T) = secondary employment in-migrants

SPSIMG(T,A,S) = the number of spouses in age cohort A and sex cohort S

SCSPAS(A,S) = the number of spouses in age cohort A and sex cohort S per secondary employment in-migrant

DPSIMG(T,A,S) = the number of dependents in age cohort A and sex cohort S

SCDPAS(A,S) = the number of dependents in age cohort A and sex cohort S per secondary employment in-migrant

SIMG(T,A,S) = the number of in-migrant workers in age cohort A and sex cohort S

SIMGWAS(A,S) = the proportion of in-migrant workers in age cohort A and sex cohort S

CIMG(T) = total in-migrant population for the development phase

Xj = local labor of skill j from employed labor status group hired for project development

Yj = local labor of skill j from unemployed labor status group hired for project development

Zj = local labor of skill j from not-in-labor-force labor status group hired for project development

The result of this phase of the model is an age-sex profile of the migrant development population in each cycle of the projection period. These migrants and their dependents are assumed to leave the community after each cycle. If development occurs in the following cycle, the same process is repeated to determine the development phase in--migrants. Other products of this phase include the total worker in-migrants, both primary and secondary, and the secondary supply of and demand for labor.

The Operations Phase

Operations employment will usually follow development employment, although these phases may overlap. Operations employment is assumed to last throughout the projection period. The long time span and the relative stability of the operations phase mean that not only will the demographic characteristics of these in-migrants differ from those in the development phase but also new in-migrants cannot be assumed to fill jobs each period. The long time span will necessitate the consideration of social, economic, and demographic forces which alter the composition of the labor force over time. The migrant operations population must be subject to turnover and out-migration as well as fertility and mortality. The long-term stability of operations phase employment is taken into account by incorporating the migrant operations and secondary employees into the potential labor force for the next period.

The process by which the model determines in-migrant population is the same as in the development phase. In-migration occurs to fill the gap between local labor supplied to the project and the project labor demand. These primary migrants bring dependents and spouses. The increased employment opportunities increase the necessary secondary employment opportunities which generate a new round of worker, spouse, and dependent migration.

Operations demand is provided exogenous to the model. Information required about operations project demand is the same as the construction phase requirements. It is necessary to know the import component of this labor demand, the portion of demand associated with the project operation or having skills not supplied locally. Information on the skill composition of the labor demand is also necessary since differences in the proportion of skilled and unskilled workers needed will determine the possibility of local labor taking jobs. The final information required concerns the proportion of the employment which is enclave.

The local labor supplied to the project is determined by the potential supply and the labor market response of this component of supply. Potential labor supply is defined as the population in each labor status group--employed, unemployed, and not in the labor force--minus the local population employed in construction or secondary employment connected with construction. An additional component of potential labor supply is the members of the operations phase in-migrants who have remained since the last cycle. The in-migrant workers from the last cycle are subject to mortality and turnover. Mortality is described by a series of survival rates which equal one minus the probability of dying during the cycle; these rates are age-sex specific. Turnover occurs when an in-migrant worker leaves an operations phase job in the projection cycle. In-migrant workers who leave operations employment are assumed by the model to leave the site county. Those workers from the previous cycle who do survive and who do not out-migrate are a source of supply in the following cycle.

Labor response rates for the local labor supply are determined in a manner exactly the same as in the development phase. The response of the employed population is determined by the joint probability that they can increase their incomes and that skills demanded and supplied match. The response of unemployed is determined by the probability that skills supplied match those in demand. The response of those not in the labor force is determined by assuming the age-specific labor force participation rates increase to the state rates and that skills match. All previous operations employees are assumed to respond to project employment opportunities.

Migration is determined by the difference between local labor supply and project labor demand. Migration equals the sum of the imported project labor, the difference between skilled project demand and local supply, and the difference between unskilled project demand and local supply. The major difference in this phase is that it is possible for out-migration to occur. If supply exceeds demand, in-migrant workers from the previous period will leave the community. Equations 0.1. through 0.5. describe the determinations of the level of primary operations migration.

0.7. $$SROIMGW(T,A,S) = OIMGW(T1,A1,S) * SR(A1,S) * OMR(A,S)$$

0.2. $$POSPPLY(T,1) = EMPLY(T) \quad X1 \quad X2 \quad \tilde{X};$$

$$POSPPLY(T,3) = UNEMPLY(T) - Y1 - Y2 - \tilde{Y};$$

$$POSPPLY(T,2) = NLF(T) - Z1 - Z2 - \tilde{Z};$$

$$POSPPLY(T,4) = \sum_{A} \sum_{S} SROIMGW(T,A,S)$$

$$0.3. \quad OPSPPLY(T,i,j) = OPLBR(i,j) * POSPPLY(T,i)$$

$$0.4. \quad OPSPPLY(T,j) = \sum_i OPSPPLY(T,i,j)$$

$$0.5. \quad NOIMGW(T) = ALPHA1 * OPDEM(T,1) + ALPHA2 * OPDEM(T,2) + OLOCAL(T,1) + OLOCAL(T,2)$$

where SROIMGW(T,A,S) = survived in-migrant operations workers

OIMGW(T,A,S) = in-migrant operations workers

OMR(A,S) = age-sex specific turnover rate

POSPPLY(T,i) = potential operations phase supply of employment status group i

$\tilde{X}$ = local labor from employed labor status group hired as secondary development employment

$\tilde{Y}$ = local labor from unemployed labor status group hired as secondary development employment

$\tilde{Z}$ = local labor from not-in-labor force labor status group hired as secondary development employment

OPSPPLY(T,i,j) = local labor supplied to project from status group i and skill group j

NOIMGW(T) = change in in-migrant operations workers in period T

ALPHAj = proportion of project labor demand for skill j which is imported

OPDEM(T,j) = project labor demand skill level j

OLOCAL(T,j) = project demand for local labor of skill j minus local supply

Equations 0.6. through **0.20.** describe the determination of family in-migration associated with primary operations employment in-migration. Family in-migration is determined by applying age-sex specific multipliers for both spouses and dependents to the resident in-migrant labor. Resident in-migrant labor is found by subtracting that portion of in-migrant workers who reside in enclaves and outside the community from the total. The families of workers are also subject to fertility, mortality, and out-migration. Births are determined by the application of age-specific fertility rates to in-migrant females. Deaths and out-migration are determined by age-sex specific survival and migration rates. Dependents and spouses are also assumed to out-migrate when workers out-migrate.

0.6. NEOIMGW(T) = OENCLV * [OPDEM(T,1) + OPDEM(T,2)]

0.7. NORIMGW(T) = NOIMGW * (1-OENCLV) * GRAVO

0.8. NOSPIMG(T,A,S) = NORIMGW(T) * OSPAS(A,S)
0.9. NODPIMG(T,A,S) = NORIMGW(T) * ODPAS(A,S)
0.10. NOIMGW(T,A,S) = NOIMGW(T) * OIMGWAS(A,S)

} IF NOIMGW <0 THEN OSPAS(A-1,S), ODPAS(A-1 OIMGWAS(A-1 ,S}

0.11. SROIMGW(T,A,S) = OIMGW(T-1,A-1,S) * SR(A-1,S) * OMR(A,S)

0.12. OIMGW(T,A,S) = SROIMGW(T,A,S) + NOIMGW(T,A,S)

0.13. SRSPIMG(T,A,S) = OSPIMG(T-1,A-1,S) * SR(A-1,S) * OMR(A,S)

0.14. OSPIMG(T,A,S) = SRSPIMG(T,A,S) + NOSPIMG(T,A,S)

0.15. $\text{BBIRTHS}(T,1) = \sum_{A} \left([\ \text{OSPIMG}(T-1,A,2) + \text{ODPIMG}(T-1,A,2)\ ] * \text{FR}(A) \right)$

0.16. SRDPIMG(T,1,S) = BBIRTHS(T,1) * SR(S)

0.17. SRDPIMG(T,A,S) = ODPIMG(T-1,A-1,S) * SR(A-1,S) * OMR(A,S)

0.18. ODPIMG(T,A,S) = SRDPIMG(T,A,S) + NODPIMG(T,A,S)

0.19. $$TOPIMG(T,A,S) = OIMGW(T,A,S) * [(1-OENCLV) * GRAVO + OENCLV] + OSPIMG(T,A,S) + ODPIMG(T,A,S)$$

0.20. $$TOPIMG(T) = \sum_A \sum_S TOPIMG(T,A,S)$$

where NEOIMGW(T) = the enclave in-migrants

OENCLV = the proportion of employment in enclaves

NORIMGW(T) = the change in resident in-migrants

GRVO = the proportion of direct nonenclave in-migrants residing in the community

NOSPIMGW(T,A,S) = the change in the number of spouses in age cohort A and sex cohort S

OSPAS(A,S) = the number of spouses in age cohort A and sex cohort S per direct resident in-migrant

NODPIMG(T,A,S) = the change in the number of dependents in age cohort A and sex cohort S

ODPAS(A,S) = the number of dependents in age cohort A and sex cohort S per direct in-migrant employment

NOIMGW(T,A,S) = the change in the number of in-migrant workers in age cohort A and sex cohort S

OIMGWAS(A,S) = the proportion of in-migrant workers in age cohort A and sex cohort S

SROIMGW(T,A,S) = survived in-migrant workers

OIMGW(T,A,S) = total in-migrant workers

SRSPIMG(T,A,S) = survived spouses

OSPIMG(T,A,S) = total spouses

BBIRTHS(T,1,S) = births from in-migrant population

SRDPIMG(T,A,S) = survived dependents

ODPIMG(T,A,S) = total dependents

TOPIMG = total resident in-migrants from the operations phase

A change in operations employment changes the demand for employees in the support sector. The change in secondary employment may also result in migration. There are four components to secondary employment demand. The first component is the support sector employment which serves resident nonenclave employment. The second component is the support employment which serves the enclave sector. Each of these components is determined by applying a multiplier to nonenclave and enclave components of project employment. Because of the assumed nature of enclave employment, the enclave multiplier is assumed to be lower. The third component of secondary employment is any increased local government employment generated by increased revenues resulting from the project. The final component of secondary employment demand replaces those local employees who took jobs on the project.

The potential labor supply for secondary employment in the operations phase has three major components. First, the local baseline population supplies labor to the support sector. This potential supply equals that supplied to the project operations minus those actually employed on the project. The response differs across each labor force status group. The second major component of potential labor supply consists of the dependents and spouses of project operations workers. The response rate of these groups equals the weighted average of their labor force participation rates. The final component of potential labor supply equals those secondary in-migrant workers from the previous cycle who have not died or left the community.

Migration is assumed to eliminate the difference between labor demanded and supplied. Migration may be negative if the local supply of labor exceeds demand. The family migration accompanying direct worker migration is determined by a series of age-sex specific multipliers. Dependents and spouses of secondary migrants are also subject to births, deaths, and out-migration. Equations 0.21. through 0.35. describe the determinants of secondary migration in the operations phase.

0.21. $SRSOIMGW(T,A,S) = SOIMGW(T-1,A-1,S) * SR(A-1,S) * SOMR(A,S)$

0.22. $PSOSPPLY(T,1) = EMPLY(T) - X1 - X2 - \tilde{X} - \hat{X}1 - \hat{X}2$

$PSOSPPLY(T,3) = UNEMPLY(T) - Y1 - Y2 - \tilde{Y} - \hat{Y}1 - \hat{Y}2$

$PSOSPPLY(T,2) = NLF(T) - Z1 - Z2 - \tilde{Z} - \hat{Z}1 - \hat{Z}2$

$PSOSPPLY(T,4) = \sum_A \sum_S OSPIMG(T,A,S)$

$PSOSPPLY(T,5) = \sum_A \sum_S ODPIMG(T,A,S)$

$PSOSPPLY(T,6) = \sum_A \sum_S SRSOIMGW(T,A,S)$

0.23. $SOPSPPLY(T,i) = \sum_i (PSOSPPLY(T,i) * SOPLBR(T))$

0.24. $SOPDEM(T) = NEMULTi * [OPDEM(T,1) + OPDEM(T,2) - NEOIMGW(T) - (1 - GRVO) * (1 - OENCLV) * OIMGW(T)] + EMULTi * NEOIMGW(T) + OLOGOVT(T) + \hat{X}1 + \hat{X}2$

0.25. $NSOIMGW(T) = SOPDEM(T) - SOPSPPLY(T)$

0.26. $NSOSPIMG(T,A,S) = NSOIMGW(T) * SOSPAS(A,S)$

0.27. $NSODPIMG(T,A,S) = NSOIMGW(T) * SODPAS(A,S)$

0.28. $NSOIMGW(T,A,S) = NSOIMGW(T) * SOIMGWAS(A,S)$

0.29. SOIMGW(T,A,S) = SRSOIMGW(T,A,S) + NSOIMGW(T,A,S)

0.30. SRSSPIMG(T,A,S) = SOSPIMG(T-1,A-1,S) * SR(A-1,S) * SOMR(A,S)

0.31. SOSPIMG(T,A,S) = SRSSPIMG(T,A,S) + NSOSPIMG(T,A,S)

0.32. $BBBIRTHS(T,1) = \sum_{A}$ [(SOSPIMG(-1 ,A,2) + SODPIMG(T,A,F,2) * FR(A)]

0.33. SOSDPIMG(T,1,S) = BBBIRTHS(T,) * SXR(S)

0.34. SRSDPIMG = SODPIMG(T-1,A-1 ,S) * SR(A-1 ,S) * SOMR(A,S)

0.35. SODPIMG(T,A,S) = SRDPIMG(T,A,S) + NSODPIMG(T,A, S)

where NSOSPIMGW(T,A,S) = the change in the number of spouses in age cohort A and sex cohort S

SOSPAS(A,S) = the number of spouses in age cohort A and sex cohort S per direct resident in-migrant

NSODPIMG(T,A,S) = the change in the number of dependents in age cohort A and sex cohort S

SODPAS(A,S) = the number of dependents in age cohort A and sex cohort S per direct in-migrant employment

NSOIMGW(T,A,S) = the change in the number of local resident in-migrant workers in age cohort A and sex cohort S

SOIMGWAS(A,S) = the proportion of local resident in-migrant workers in age cohort A and sex cohort S

SRSOIMGW(T,A,S) = survived in-migrant workers

SOIMGW(T,A,S) = total in-migrant workers

SRSSPIMG(T,A,S) = survived spouses

SOSPIMG(T,A,S) = total spouses

BBBIRTHS(T,1,S) = births from in-migrant population

SRSDPIMG(T,A,S) = survived dependents "

SODPIMG(T,A,S) = total dependents

SRSOIMGW = survived secondary in-migrants

SOIMGW = total secondary in-migrants

SOMR = age-sex specific turnover rates

PSOSPPLY(T,i) = potential supply in labor status group i

$\ddot{X}j$ = local labor of skill j from employed labor status group hired for project operations

$\hat{Y}j$ = local labor of skill j from unemployed labor status group hired for project operations

$\hat{Z}j$ = local labor of skill j from not-in-labor-force labor status group hired for project operations

SOPSPPLY(T,i) = local labor supplied to secondary operations from labor status group i

SOPLBR(i) = labor market response rate of group i

SOPDEM = secondary operations phase demand

NEMULTi = nonenclave multiplier

EMULTi = enclave multiplier

OLOGOVT = local government employment response to project generated revenues

NSOIMGW = change in migrant secondary workers

Equations T.1. through T.3. describe the determination of population totals by the model.

T.1. $TSOPIMG(T,A,S) = SOIMGW(T,A,S) + SOSPIMG(T,A,S) + SODPIMG(T,A,S)$

T.2. $TIMG(T,A,S) = TOPIMG(T,A,S) + TSOPIMG(T,A,S)$

T.3. $TPOP(T,A,S) = TIMG(T,A,S) + CIMG(T,A,S) + POP(T,A,S)$

where TSOPIMG = total secondary operations phase in-migration

TIMG = total operations phase in-migration

TPOP = total population

The product of the operations phase is the cumulative total of in-migrant population connected with the operations phase of an OCS project. In-migrant population is any nonbaseline population which comes to the community during the projection period. In-migrant population is disaggregated by age and sex. Operations in-migrant population is assumed to form a permanent component of the community population which is subject to births, deaths, and out-migration. The in-migrant population in one cycle forms part of the potential labor supply in the following cycle. Other products of the operations phase are total worker in-migrants, the change during the current period in worker in-migrants, and the secondary demand for and supply of labor. The final product of the model is a projection of the total community population; this is disaggregate by age, race, and sex.

IV. TEST OF THE MODEL: KENAI, 1960-1975

Small community impact models have rarely been tested. The main reason for this is the recent vintage of most of these models. These models are designed to project the long-term impact of major project development and operations; and in most areas where they have been applied, the projects have not been completed. For accounting models, the main test of accuracy is the comparison of projected and actual populations. The equations of an econometric model can be assessed for their ability to explain the historical period; since accounting models are not statistically derived, the statistical accuracy of the equations cannot be assessed. Without a. predictive comparison, accounting models can only be assessed on their logical structure.

We are fortunate in Alaska to have a historical case which is similar to prospective OCS development. Petroleum exploration and development between 1960 and 1975 in the Upper Cook Inlet used the Kenai area for a service base. This caused a boom in Kenai similar to that expected with OCS-connected development. This chapter will describe the application of the model to the Kenai Census Division during this period. The application is designed to provide not only a comparison of projected and actual populations but also a test of the sensitivity of the results to the important parameter assumptions.

Forecasting the historical period may appear to make the selection of parameters easy. Parameters could be solved for from the historical data.

There are two reasons why this approach is not the best. First, the direct effects from petroleum development are not easily "separated from the general effects of growth, so parameters cannot easily be determined. Secondly, parameter selection is a most important part of the model application. A test of this selection process is also necessary. For these reasons, the parameters selected for the historical tests were not derived from historical data but were selected as if the knowledge of the projection period were unavailable. Parameters were selected as if the historical forecast were a projection of future project activity.

Kenai, 1960-1975

The Kenai oil boom began with the discovery of the Swanson River field in 1957. The discovery of this field assured Kenai of Alaska's first modern petroleum complex and identified the area as one of prime potential for additional discoveries. The exploration effort in the Kenai area eventually yielded six oil fields and fifteen natural gas fields. Production reached 82.4 million barrels by 1970. Development of a petrochemical industry using the area's oil and gas contributed to the boom; five petrochemical plants were constructed between 1960 and 1970 (Math Sciences Northwest, 1976).

The development led to increased employment and population. Both mining and construction employment rose rapidly to peak in 1968; mining had 1,098 employees and construction had 1,209 in 1968. This increased mining and construction employment led to an increase in economic activity and population. The population of the Kenai Census Division increased at a rate of 9 percent per year between 1960 and 1970. After 1970, population fell slightly. The major exploration, development, and petrochemical plant construction was over by 1968. The growth of Kenai during this period exhibits the pattern of growth associated with OCS development. The most rapid growth occurs during the development phase of activity when platforms, pipelines, and petrochemical plants are constructed. After development, employment declines as production occurs and plants are put into operations. The ability of the model to project the pattern of development is a good test of its usefulness for OCS impact analysis.

Parameter Assumptions

The purpose of this section is to describe the parameters used in the Kenai projections and the assumptions behind those parameters. The Kenai projection will test the logic of our methods of selecting parameters and provide insight into appropriate methods for selecting them in the future uses of the model. We approached the Kenai forecast, as in any projection, not solving for parameters from historical data, but selecting them from available sources.

The parameters used in the model can be easily divided into three types. The three types of parameters are those describing the baseline population, both its nonproject growth and labor supply response; those describing the project demand; and finally those describing the in-migrant population. Each of these sets provides interesting problems, particularly in the historical period with only limited data availability. There were three primary sources of data used in selecting the appropriate parameters: the census, Alaska state statistics, and national energy impact studies. This section will discuss each-set of-parameters.

BASELINE POPULATION

Assumptions about the baseline population growth and its supply response to the project are important for the impact assessment since they determine the level of in-migrant population needed to close the gap between project labor demand and supply. There are three important age-sex-race-specific parameters used to determine the growth of the base population: survival rates, fertility rates, and migration rates. Table 1 shows the survival rates used for each age and sex cohort in the two race cohorts used, Native and non-Native. Survival rates were based on statewide information on the number of deaths by age, race, and sex in 1970. These were divided by population in 1970 in each cohort to determine rates. Census years were used since population by age-sex-race cohorts is available only for Census years. These one-year mortality rates were adjusted to five-year cycles and subtracted from one to determine the probability that a person in a cohort would survive five years. Fertility rates are also based on statewide information on births by age and race of mother in 1970; rates are derived by dividing by the number of women in these cohorts in ?970. (See Table 2.) Both survival and ferti 1 ity rates are age-adjusted to account for the change in cohorts over a cycle; rates are averaged between beginning and ending cohorts. State rates were used since they provide more stability; one-year estimates in a particular community may reflect important singular events. Since appropriate birth and death data was not available for 1960, 1970 was used to determine the appropriate rates.

TABLE 1. KENAI SURVIVAL RATES
PROJECTION ASSUMPTIONS

	Non-Native		Native	
Age Cohort	Male	Female	Male	Female
0 - 4	.984	.985	.972	.980
5 - 9	.997	.998	.995	.997
10 - 14	.992	.997	.988	.996
15 - 19	.987	.996	.963	.989
20 - 24	.985	.995	.959	.986
25 - 29	.985	.996	.977	.982
30 - 34	.984	.996	.982	.971
35 - 39	.979	.992	.966	.959
40 - 44	.965	.989	.946	.905
45 - 49	.951	.979	.946	.901
50 - 54	.936	.967	.937	.945
55 - 59	.894	.955	.869	.900
60 - 64	.794	.878	.758	.833
65 +	.723	.806	.699	.810

$$\text{Survival Rate} = 1 - \left(\frac{\text{Death by age, race, sex (1970)}}{\text{Population by age, race, sex (1970)}} \times 5\right)$$

SOURCE: U.S. Department of Commerce, Bureau of Census, 1970 Census of Population, Vol. 1, Part 3.

U.S. Department of Health, Education, and Welfare, Health Resources Administration for the National Center for Health Statistics, Vital Statistics of the U.S., 1970, and Special Tabulations, 1970.

TABLE 2. KENAI BIRTH RATES
PROJECTION ASSUMPTIONS

Age Cohort	Non-Native	Native
0 - 4	0	0
5 - 9		0
10 - 14	.230	.272
15 - 19	.732	1.023
20 - 24	.894	1.408
25 - 29	.577	.986
30 - 34	.247	.545
35 - 39	.090	.312
40 - 44	.022	.095
45 - 49	0	0
50 - 54	0	0
55 - 59	0	0
60 - 64	0	0
65 +	0	0

$$\text{Fertility Rate} = \frac{\text{1970 births by race and age of mother}}{\text{1970 female population by age}} \times 5$$

SOURCE: U.S. Department of Commerce, Bureau of Census, *1970 Census of Population*, Vol. 1, Part 3.

Alaska Department of Health and Social Services, Data Services, Special Tabulations.

In small, rapidly growing communities, migration is the most important source of growth. Kenai was experiencing rapid growth not connected with oil development during this period; migration rates must capture this growth. The usual approach to migration rates is to select them from the historical period. Migration rates are determined by adjusting a beginning period population by births and deaths to determine a survived population; the comparison of the survived and real population determines net migration. Net migration rates are determined by dividing net migration by the survived population. The period 1960 and 1970 was used to derive migration rates. Using this period to determine migration rates presented a problem since growth in this period was partially a reflection of the oil development boom. The age-sex-race-specific rates were adjusted to reflect difference between aggregate migration in the first part of the period (1960-65} prior to the boom period in an attempt to eliminate the major portion of this effect. (See Table 3.)

Once the growth of population is determined, its labor supply response must be determined; this requires information on the potential supply and labor market response rates. The potential supply is determined by applying age-sex-specific labor force participation and unemployment rates to the population. In this application, the racial disaggregation was dropped because of the small proportion of Natives in the Kenai population. Labor force participation rates for Kenai in 1960 Census were used. The age-sex-specific unemployment rates were based on state rates which were adjusted to reflect aggregate differences between the state and Kenai. Table 4 presents these rates.

TABLE 3. KENAI NET MIGRATION RATES
PROJECTION ASSUMPTIONS

Age Cohort	Non-Native Male	Non-Native Female	Native Male	Native Female
0 - 4	1.332	1.283	.808	.947
5 - 9	1.540	1.484	1.112	1.053
10 - 14	1.390	1.353	1.023	1.024
15 - 19	1.158	1.161	.852	.906
20 - 24	1.146	1.130	.012	.679
25 - 29	1.382	1.712	.933	1.038
30 - 34	1.339	1.822	.037	1.005
35 - 39	1.414	1.385	.048	1.206
40 - 44	1.242	1.192	.124	1.081
45 - 49	1.141	1.105	.007	.844
50 - 54	1.146	1.168	.000	.875
55 - 59	1.083	1.059	.009	1.020
60 - 64	1.056	1.014	.153	1.018
65 +	.992	.992	1.020	1.020

SOURCE: U.S. Department of Commerce, Bureau of Census, 1960 and 1970, Census of Population.

TABLE 4. KENAI LABOR FORCE PARTICIPATION RATES AND UNEMPLOYMENT RATES PROJECTION ASSUMPTIONS"

Age Cohort	Labor Force Participation Rates All Races		Unemployment Rates All Races	
	Male	Female	Male	Female
o - 4	0	0	0	0
5 - 9	0	0	0	0
10 - 14			0	
15 - 19	.254°	.165°	.244	.130°
20 - 24	.895	.186	.203	.127
25 - 29	.802	.234	.147	.086
30 - 34	.802	.234	.125	.092
35 - 39	.832	.353	.154	.092
40 - 44	.832	.353	.155	.052
45 - 49	.766	.369	.142	.066
50 - 54	.766	.369	.174	.079
55 - 59	.766	.369	.226	.065
60 - 64	.766	.369	.193	.094
65 +	.256	.152	.167	.064

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SOURCE: U.S. Department of Commerce, Bureau of Census, 1960 Census of Population, Vol. 1, Part 3.

The labor market response rates were also determined using census information; The derivation of these rates was described in Chapter 111. Table 5 illustrates the rates used in this projection.

DEMAND PARAMETERS

The model requires assumptions about the level of project employment by phase for each cycle of the projection. Assumptions about the disaggregation of this employment into imported labor, enclave labor, and skill groups are also necessary. Project employment estimates were derived from employment totals for the period (Alaska Department of Labor). It was assumed that construction employment and exploration mining employment were development and other mining and petrochemical manufacturing employment were operations. The disaggregation of mining and manufacturing was based on previous work on the Kenai oil development (Math Sciences, 1976). It was assumed that the development phase ended in 1970 and all mining employment after that was included in operations. Five-year averages for each of these phases were used to represent employment during the cycle. The alternative would have been to use the peak levels. The Kenai projection assumed no enclave development. It was assumed that 25 percent of skilled workers and 10 percent of the unskilled would be reported. Employment totals for each cycle are shown in Table 6.

The second component of project-connected demand is the demand for support sector employment generated by the project. This demand is described by a multiplier. Multipliers were assumed for both the development and operations phases Multipliers in small, rural areas cannot be simply computed from

TABLE 5. KENAI LABOR MARKET RESPONSE RATES
PROJECTION ASSUMPTIONS

	Construction Phase			Operations Phase		
	Project Skilled	Project Unskilled	Secondary	P].eject Skilled	Project Unskilled	Secondary
Labor Status Group	.031	.034	0	.029	.025	0
Not in Labor Force	.009	.022	.018	.005	.023	.018
Unemployed	.074	.113	.084	.040	.102	.084
In-migrant Dependents	--	--	.125	--	--	.125
In-migrant Spouses	--	--	.365	--	--	.365

SOURCE: U.S. Department of Commerce, Bureau of the Census, 1960 Census of Population, Vol. 1, Part3.

TABLE 6. KENAI PROJECT EMPLOYMENT PROJECTION ASSUMPTIONS

Cycle	construction Phase		Operations Phase	
	Skilled	Unskilled	Skilled	Unskilled
1: 1960-1965	119	178	0	0
2: 1965-1970	542	812	88	149
3: 1970-1975	0	0	282	479

SOURCE: Alaska Department of Labor, Statistical Quarterly, various issues.

existing basic to nonbasic employment ratios. The relative importance to the local economy of these major projects means the local economy will probably undergo some structural change, changing the relationship. Instead of using multipliers generated from the historical data, we attempted to use multipliers generated outside of Kenai to test the generality of this concept. The Northern Great Plains region of the United States is also undergoing population impact from energy development. Much work has been done to determine a method of projecting population impact, including the estimation of general multipliers for rural areas. We used estimates of industry-specific multipliers from such a study (Conopask, 1978). The industry-specific multipliers for mining, construction, and manufacturing were weighted by employment in each phase to determine multipliers of .47 for the development phase and .81 for the operations phase. The local government response to extra revenues was assumed to be covered by the multiplier, so it was not activated.

IMMIGRANT CHARACTERISTICS

Once the number of in-migrant workers is determined by the model, the model determines the age-sex distribution of the workers and the level of accompanying spouses and dependents. Tables 7 and 8 show the age-sex distribution of worker in-migrants and the people per worker assumed in each cohort for dependents and spouses. All in-migrants are assumed to be non-Native. We assume that the characteristics of the direct and secondary in-migrants in the operations phase and secondary in-migrants in the development phase are the same. The characteristics of the development phase are assumed to differ primarily because of the short-term nature of the phase. The primary

TABLE 7. KENAI IN-MIGRANT CHARACTERISTICS: DEVELOPMENT PHASE PROJECTION ASSUMPTIONS

	Age-Sex Distribution		Dependents Per Worker		Spouse Per Worker	
Age Cohort	Male	Female	Male	Female	Male	Female
0 - 4	0	0	.140	.140	0	0
5 - 9	0	0	.098	.098	0	0
10 - 14		0	.090	.090		0
15 - 19	.105°	.004	.058	.058	.001°	.019
20 - 24	.127	.005	.007	.007	.004	.093
25 - 29	.172	.007	.002	.002	.004	.101
30 - 34	.218	.009	0	0	.004	.091
35 - 39	.082	.003	0	0	.002	.044
40 - 44	.073	.002	0	0	.001	.031
45 - 49	.062	.003	0	0	.001	.036
50 - 54	.062	.003	0	0	.001	.024
55 - 59	.038	.002	0	0	.001	.018
60 - 64	.020	.001	0	0	0	.011
65 +	.008	0	0	0	0	.004

SOURCE: T. Hertsgaard, S. Murdock, N. Toman, M. Henry, and R. Ludtke, REAP Economic Demographic Model: Technical Description

TABLE 8. KENAI IN-MIGRANT CHARACTERISTICS: SECONDARY AND OPERATIONS PHASE PROJECTION ASSUMPTIONS

Age Cohort	Age-Sex Distribution		Dependents Per Worker		Spouse Per Worker	
	Male	Female	Male	Female	Male	Female
0 - 4	0	0	.333	.333	0	0
5 - 9	0	0	.213	.213	0	0
10 - 14	0	0	.196	.196		0
15 - 19	.077	.012	.102	.102	.010	.062
20 - 24	.094	.014	.006	.006	.011	.075
25 - 29	.201	.030	0	0	.024	.161
30 - 34	.254	.038	0	0	.030	.203
35 - 39	.077	.012	0	0	.010	.062
40 - 44	.069	.010	0	0	.008	.055
45 - 49	.031	.004	0	0	.003	.025
50 - 54	.031	.004	0	0	.003	.025
55 - 59	.018	.003	0	0	.002	.014
60 - 64	.010	.001	0	0	.001	.003
65 +	.009	.001	0	0	.001	.007

SOURCE: T. Hertsgaard, S. Murdock, N. Toman, M. Henry, and R. Ludtke, REAP Economic Demographic Model: Technical Description difference is in the number of dependents and spouses per worker. The shorter nature of the work means that fewer workers will consider this a permanent move. The characteristics are based on surveys taken at large-scale energy projects in the Northern Great Plains (Hertsgaard et al, 1978).

Gravity models developed from studies in the Northern Great Plains were used to determine the proportion of workers residing out of the Kenai Census Division (Wieland, Leistritz, Murdock, 1977). Workers' residence decisions were assumed to be determined by both the attractiveness of other areas and distance to commute. Other areas considered were Seward, Anchorage, and the Matanuska-Susitna Valley. The proportion residing in Kenai was higher in the operations phase than in development; 73.2 percent of the in-migrant workers were assumed to reside in Kenai during development and 82.6 percent during operations.

Projection of Kenai Impact

One test of the model, and the logic of our assumptions, is how well it replicates the historical population growth in the Kenai Census Division. Accuracy in projecting the population of Kenai is not a perfect test of the logic of the model and assumptions. It is impossible to know the portion of the historical growth in Kenai which resulted from the impact of petroleum development and the portion which resulted from other activity. The model could produce accurate projections by overestimating baseline growth and underestimating the impact. This section will compare the results of the projection to actual estimated growth. The sensitivity of the results to important assumptions will also be examined.

The model produces two outputs which can be compared to historical information to test its accuracy. (A sample of the model output is shown in Appendix C.) First, the projections of total population can be compared to actual estimates for 1965, 1970, and 1975, which are the three end years of the projection cycle. Secondly, the age and sex distribution of the population can be compared for 1970, the only period for which it is available.

Table 9 compares the projected population in each cycle-end year with the actual estimated population. The projections are close to actual estimates. The error increases with each cycle. In 1970, the projection is 4 percent less than the estimated population; by 1975 the projected population is 6 percent greater than the estimate. Projected in-migrant population accounts for 4.4 percent of the population in 1965; 22.3 percent in 1970; and 13.1 percent in 1975.

TABLE 9. KENAI POPULATION GROWTH

Year	Baseline Population	Construction Phase Migrants	Operations Phase Migrants	Total Projected Population	Estimated Population
1965	8,078	368	0	8,446	8,446
1970	10,699	2,581	482	13,763	14,250
1975	14,464	0	2,100	16,564	15,621

SOURCE: Table 45, The Alaska Economy Year End Performance Report: 1977, Alaska Department of Commerce and Economic Development.

TABLE 10. KENAI 1970 AGE-SEX DISTRIBUTION

Age Cohort	Projected Male	Projected Female	Census Male	Census Female
o - 4	5.5	5.4	5.4	4.9
5 - 9	4.7	4.5	6.8	6.2
10- 14	6.9	6.2	6.9	6.2
15- 19	5.9	5.1	4.6	4.4
20 - 24	4.1	3.4	3.8	3.1
25 - 29	4.3	3.2	4.3	4.3
30 - 34	5.0	3.9	3.9	3.9
35 - 39	3.7	3.6	4.2	3.4
40 - 44	4.1	3.0	4.1	2.9
45 - 49	3.2	2.4	3.2	2.3
50 - 54	2.4	1.7	2.5	1.9
55 - 59	2.0	1.3	1.8	1.2
60 - 64	1.1	.8	1.1	.7
65 +	1.6	9	1.4	8
Total	54.5	45.5	53.8	46.2

SOURCE: U.S. Department of Commerce, Bureau of the Census, General Population Characteristics, Alaska

The projection of the age-sex distribution of the population can also be compared with the census estimate in 1970. Table 10 compares the projected age-sex distribution with the census distribution. Overall, the age-sex distribution produced by the model is similar to the Kenai distribution in 1970. The overall male-female distribution differs by only .7 percentage points. The largest error in the age distribution occurs in the 5-9 age group; the projection was lower than the census by 2.1 percentage points for males and 1.7 percentage points for females. These results show that the model produced a relatively accurate projection of the historical period. The accuracy of the historical projection is not enough to judge the usefulness of the model. The model could be producing equally good results by overestimating the growth of baseline population and under-estimating the growth of impact population.

One way to assess the logic of the model would be to examine the relation between project employment and in-migrants. Table 11 indicates that for the current projection a large proportion of both project and secondary jobs are taken by baseline population. In 1970, almost 600 of operations and construction phase jobs are taken by baseline population; approximately 30 percent of total project jobs. There is no way of knowing if this is realistic. The models' assumptions about baseline migration and the labor market response rates determine this result; changing these will provide alternate results. The ratio of total in-migration to worker varies from 2.1 to 2.8 for the development phase and 3.0 to 3.3 for the operations phase.

TABLE 11. PROJECT EMPLOYMENT **IN-MIGRANT POPULATION**

	Project Employment	In-Migrant Primary Workers	In-Migrant Secondary Workers	Total In-Migration	Project Employment	In-Migrant Primary Workers	In-Migrant Secondary Workers	Total In-Migration
1965	297	48	82	368	0	0	0	0
1970	1,354	934	291	2,581	237	36	107	482
1975	0	0	0	0	761	270	363	2,185

Sensitivity Tests

The results described above are dependent on the assumptions made about the parameters. This section will describe how important these assumptions are. Since in-migration is determined by the interaction of labor supply and labor demand, assumptions determining these will be examined. Five cases were run, three of which altered the labor supply and two of which altered the demand. Examining these results will provide an idea of the importance to our results of each assumption. Table 12 compares the results for each of five cases for the end of the second projection cycle (1970). Sensitivity tests also allow us to further test the logic of the model by examining the effect of parameter changes on the results.

The local labor supplied to the project is determined in the model by two factors, the potential labor supply and the labor market response rates. Given the project demand, the local labor supplied to the project determines the level of in-migration needed to equate labor supply and demand. Changes in assumptions describing these will affect in-migration. The effect of changing the labor market response rates of each status group are shown in column b of Table 12. A projection was made assuming that only the unemployed responded to the increased project employment; the unemployed were assumed to respond to these opportunities at a rate equal to the proportion of unemployed last holding jobs in the appropriate industries, construction for development and mining for operations. The change in labor market response was only made in the primary phase. The overall effect on total population is minimal; total population differs from the base case by only 114. The major change is in the composition of

TABLE 12. SENSITIVITY TESTS, 1970

	(a) Base Case	(b) Labor Market Response	(c) Baseline Population Growth	(d) Dependent Response	(e) Secondary Multiplier	(f) Enclave Population
Development						
Primary In-migrant Workers	934	1,347	1,077	934	934	934
Secondary In-migrant Workers	291	21	246	363	379	114
Total In-migration	2,581	2,328	2,663	2,834	2,891	1,689
Operations						
Primary In-migrant Workers	37	215	40	37	37	37
Secondary In-migrant Workers	107	0	131	115	356	77
Total In-migration	482	622	578	509	1,356	355
Baseline Population	10,699	10,699	6,960	10,699	10,699	10,699
Total Population	13,763	13,649	10,201	14,042	14,946	12,745

migrants. The change in labor market response increases the primary migrants and reduces the secondary migrants relative to the base case. Since less local labor is supplied to the project, more in-migrants are needed for the primary development and operations phases. The effect on secondary in-migration results from an increase in the potential labor supply. Increases in supply for the secondary phase come from two sources. First, since only unemployed are used in the primary phase, the potential supply of local labor is bigger. Secondly, the greater number of primary and secondary in-migrants results in more in-migrant dependents and spouses which increase the potential supply. Secondary demand is also reduced since there is no replacement of locally employed. One effect of this is to reduce the population impact of the development phase, since development workers have lower people-per-worker multipliers than secondary workers.

Changes in potential supply to the project result from changes in the baseline population. Column c illustrates the effect of reducing baseline growth. The experiment described in column c reduced baseline net migration to zero by setting migration rates equal to one. This reduced projected baseline population by 3,740; this reduction reduces potential supply and increases the needed in-migrant workers. Total in-migration is increased by 178.

The final type of potential labor includes the dependents and spouses of in-migrant primary workers; these groups supply labor to the secondary sector in each phase. Column c of Table 12 shows the effect of reducing the rate of this response. The labor market response of spouses and dependents is halved in this experiment. By reducing the potential local supply for the secondary employment, the needed in--migration is increased. Secondary worker in-migration is increased by approximately 20 percent, and total in-migration is increased by 9.1 percent.

The other factor affecting in-migration is project labor demand. Increasing project demand will have obvious effects of increasing primary in-migration. Two experiments were performed which affected only secondary employment; the multipliers were increased and a portion of project employment was treated as enclave. The multipliers were increased to the upper bounds estimated by Conopask; they were increased to .57 for the development phase and to 1.89 for the operations phase. These increases had the expected result of increasing secondary in-migration of workers and total in-migration as shown in column e. Secondary in-migration in the development phase is increased by 30.2 percent and by 232.7 percent in operations.

Assuming that a proportion of project employment is enclave reduces secondary demand since it is assumed that the enclave interaction is less than nonenclave. It is assumed that 30 percent of the project employment is enclave and the multipliers are .23 for the development stage and .30 for operations. Total in-migration is reduced by 33.3 percent. The reduction results from the reduced demand for secondary sector employment and the reduced family in-migration which results since enclave workers are not assumed to bring their families. (See column f in Table 12.)

The importance of parameter assumptions to the projection results have been illustrated by these sensitivity tests. The sensitivity test also provided a final test of the logic of the model. The model responded in a reasonable manner to specific parameter changes. The importance of the parameter assumptions to the results means that in future applications of the model, more effort must be put into determining those assumptions.

V. SUMMARY AND CONCLUSIONS

The model described in this report produces population projections which can be used to assess the potential population impact on a community of the development of a major project. This specific model was developed to deal with the particular case of OCS activity which uses small Alaskan communities as its service base, although it is akin to similar models which have been developed to assess major project development in other areas. The model produces projections of the population in a community at the end of each cycle in the projection period. By projecting the growth of both the baseline population and the population growth resulting from OCS activity, the model allows us to isolate the population impact of this activity. The model projects population by age, race, and sex cohorts so that the differential impacts of each of these characteristics can be considered.

The operation of the Alaskan model is similar to other models of this type. Three key factors define its operation. First, baseline population growth is independent of the project development. The baseline (non-OCS) population grows with natural increase and migration. Secondly, direct migration related to the project is determined by the interaction of labor supply and labor demand. The local labor supplied to the project is determined by both the willingness of the local population to take jobs on the project and their ability to do the jobs required. These are described in the model by market response rates for employed, unemployed, and those not in the labor force. Project demand is broken into three groups: those imported because of unavailable skills or previous work with the contractors, those located in enclaves, and those in two skill groups. The net labor demand after local labor is considered is met by in-migration of workers. This process is treated separately for each phase of' the project, development and operations. The final key determinant in the model is the multiplier relation between project demand and the local support sector which determines secondary worker in-migration. For each phase of the project, a multiplier is applied to those resident nonenclave workers and a separate multiplier to resident enclave employees to determine the number of support sector workers needed. In a manner similar to the primary sector, the gap between local labor supply and support sector demand is met through in-migration. In-migrants in both phases are assumed to bring families; the amounts and age-sex distributions are determined by cohort-specific multipliers. The major difference between phases is that the development phase is assumed to be distinct with each cycle. The operations phase employment, because of the long-term nature of the phase, is assumed to remain between cycles and be subject to birth, death, and out-migration.

The application of the model to the Kenai oil boom experience in the 1960s showed the usefulness of the model. The model projection was a good approximation of Kenai historical growth. In the three historical cycles, the model missed the estimated population by 7 percent at the most. When comparing the projected age-sex distribution in 1970 with the census estimates, the model was also shown to produce good results. The major problem is determining how much of the population was impact-associated growth and how much was baseline growth. The projected population could have resulted from overestimating the importance of baseline growth.

The model's application and the sensitivity tests conducted showed the logic of the model to be correct, even if the assumptions about the parameters could be improved. By changing some of the assumptions and examining the change in the results, both the logic of the model and the importance of the specific assumptions were tested. In five such tests, the change in the model results moved in logical ways. The other thing the sensitivy tests showed was the importance of the parameter assumptions to the results.

In application to OCS projects, the most important parameters are the assumed labor response rates and the secondary demand multipliers. In OCS application, the set of project demand parameters will be developed by the OCS office and provided. Work on skill levels and import employment connected with OCS activity has been addressed previously (see discussion of SEAR estimates, ISER, 1979). Better local data will be available to develop fertility, survival, and migration rates. With good information on project demand and baseline population, the most important determinants of migration become the labor market response rates of the local population and the support sector response of the local economy. There is little existing information on either of these factors in rural Alaska.

Overall, the model is useful in assessing local OCS project impacts on population. The general type of model has been used a number of times as the literature review has shown. There are three features of this model which make it useful in Alaska: its simplicity, its generalitity, and its special Alaska and OCS features.

The model is straightforward and easily applied. The simple structure of the model makes the essential determinants of in-migration easily observable. The major determinants are the labor market interaction and the multiplier. This simplicity makes it easier to understand the operation and test sensitivity of the results.

The generality of the model is a second strong point of the model. Although the model is specifically designed to treat OCS impact in small Alaskan communities, changes in its assumptions can make it applicable in many conditions. The model can be used in any type of area or for any type of region. The age, sex, and race cohorts can also be expanded and contracted. The length of the projection cycle can also vary with each run from one year to the entire projection period. Most importantly, there is no specific determination of the parameters in the model. The user is free to make what he feels are the most reasonable assumptions about these parameters and to test any number of assumptions. The freedom to choose labor market response rates is particularly important, since the results are highly sensitive to these assumptions.

There are three specific features of this model which increase its applicability in Alaska: consideration of an enclave component, allowing for labor response from all components of the population, and allowing out-migration. If future resource development follows the path of Prudhoe

Bay development, enclaves will be used in resource development in Alaska; most models related to energy development do not include an enclave sector. The enclave is important because it has only limited interaction with the local economy, so the multiplier effect of enclave employment on the local economy will be extremely small. It is most likely that enclave workers will not bring their families, so the total in-migration will also differ. Most models of this type have an assumed labor market response only from unemployed. This model allows a response from all sectors: employed, unemployed, and not in labor force. This more accurately describes the situation in rural Alaska. Those individuals not in the labor force may be discouraged workers not in the labor force simply because there are no available jobs. Finally, the level of operations phase of employment may peak and fall and not be constant as most models assume. The present model allows for out-migration of the project operations employment if operations employment falls. The level of out-migration is found by comparing the survived project employment with the new demand. If project demand net of local supply is less than the survived project employment, there will be out-migration.

There are five areas in which the model could be improved. The five areas which need improvement are not all of the same level of importance. They are an improved treatment of the baseline, an improved treatment of the multiplier, inclusion of unemployed migrants, combination of secondary responses, and allowing for Native migrants.

The baseline population is assumed to expand at fixed rates. The components of population growth are assumed to remain the same as in the previous census. This is probably not true, especially in rural Alaska. The solution to this problem would require the modeling of the baseline economy and projecting base case growth.

The multiplier is one of the most important determinants of in-migration in the model. Because of its importance, it should have a fuller treatment. Two considerations are relevant, scale and lags. The small size of many rural communities means that the introduction of the project may result in important structural changes. This means the project may change the relation between the support and basic sectors. This also means the multiplier may be influenced by the size of the project--the larger the project, the larger the multiplier. The multiplier may also change with the size of the baseline economy. These effects could be taken into account by making the multiplier a function of community size. Research on this relationship, unfortunately, is not advanced enough to implement at this time. The second change would be to allow some lag in the multiplier. Response of the support sector to changes in basic employment may not be immediate, especially when basic employment peaks and falls such as in the development phase. This becomes more important when the cycle is short.

The other major problem which needs to be solved for the model's application to Alaska concerns the composition of in-migration. One probable source of in-migrants in rural Alaska could be residents who do not leave or who have left and return. Because of this, it would be necessary to allow for Native in-migration in the project and secondary in-migration.

There are two other problems which are simpler to handle. First, seine allowance for unemployed in-migrants is needed. Ignoring this would not be a problem in rural Alaska since much of this type migration may end up in major cities where there are hiring centers. Secondly, separating the secondary response for each phase may be an unnecessary complication to the models. The support sector increases result from increases in both the development and operations sectors. Although the response to each of these may differ, they are not independent. Combining the secondary response would also eliminate the current need to assume that residents prefer employment in the support sector-construction phase to project operations employment.

There are two types of extensions related to the model, addition of specific impact categories and increased research on parameters. Many small area population impact models are elements in larger impact models which describe the probable impact on housing, schools, land use, and public costs and revenues. The model from which this current model evolved (Cluett, Mertaugh, Micklin, 1977) was such a model . The simplest extension of this type would develop multipliers which convert population projections to the appropriate impact category. The multiplier may be for only a certain portion of the population; for instance, the increased demand for schools depends only on the increase in school-age population.

The second extension would improve the use of the existing model. Two important sets of parameters require increased research, the labor market response rates and the multipliers. The labor supply response of rural Alaskans prov des marry interesting research questions. The at achment to tradition" occupations such as fishing or subsistence will determine the response. The skill demands of project employers and the "interrelation of these with Alaska rural labor will also determine the response rates. Increased research on these rates will improve the projections of the model.

The second parameter which needs further research, particularly in the Alaskan context, is the multiplier. Recent work on rural multipliers in the continental United States will be helpful, but a special consideration of rural Alaska is needed. One important special consideration is the existence of enclaves and their special relations to the local economies.

APPENDIX A

MODEL FLOW CHARTS

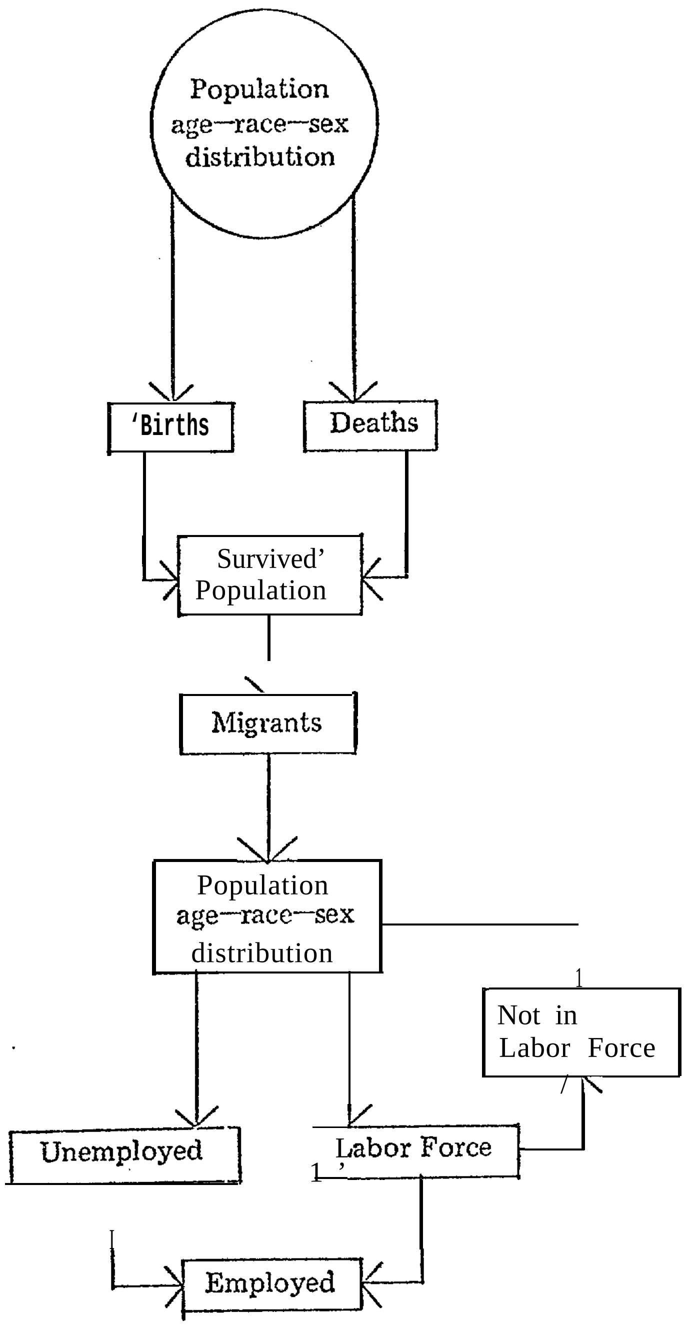
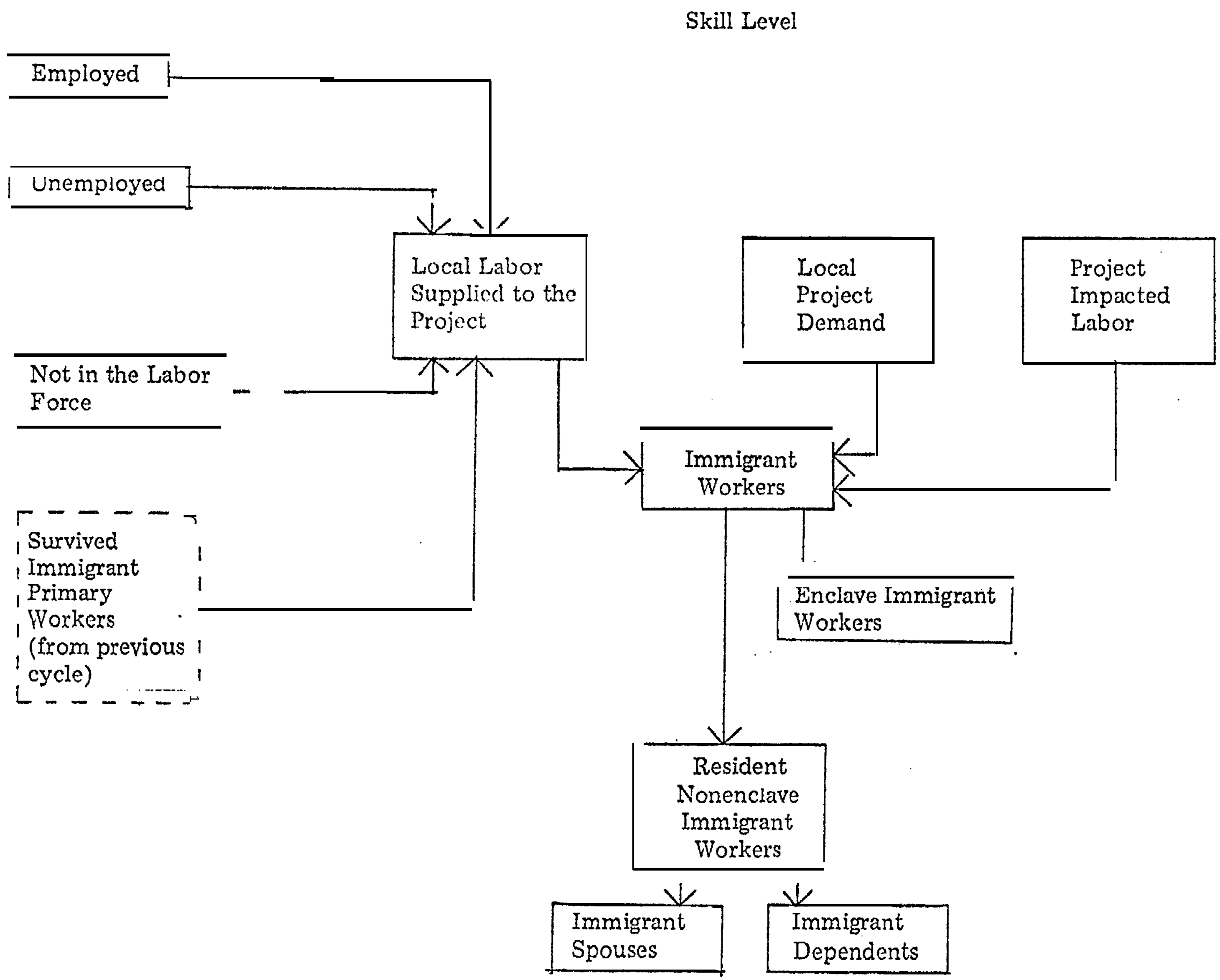


Figure A-1. Baseline Population Growth



gu A-2. Determination of Project Immigrants

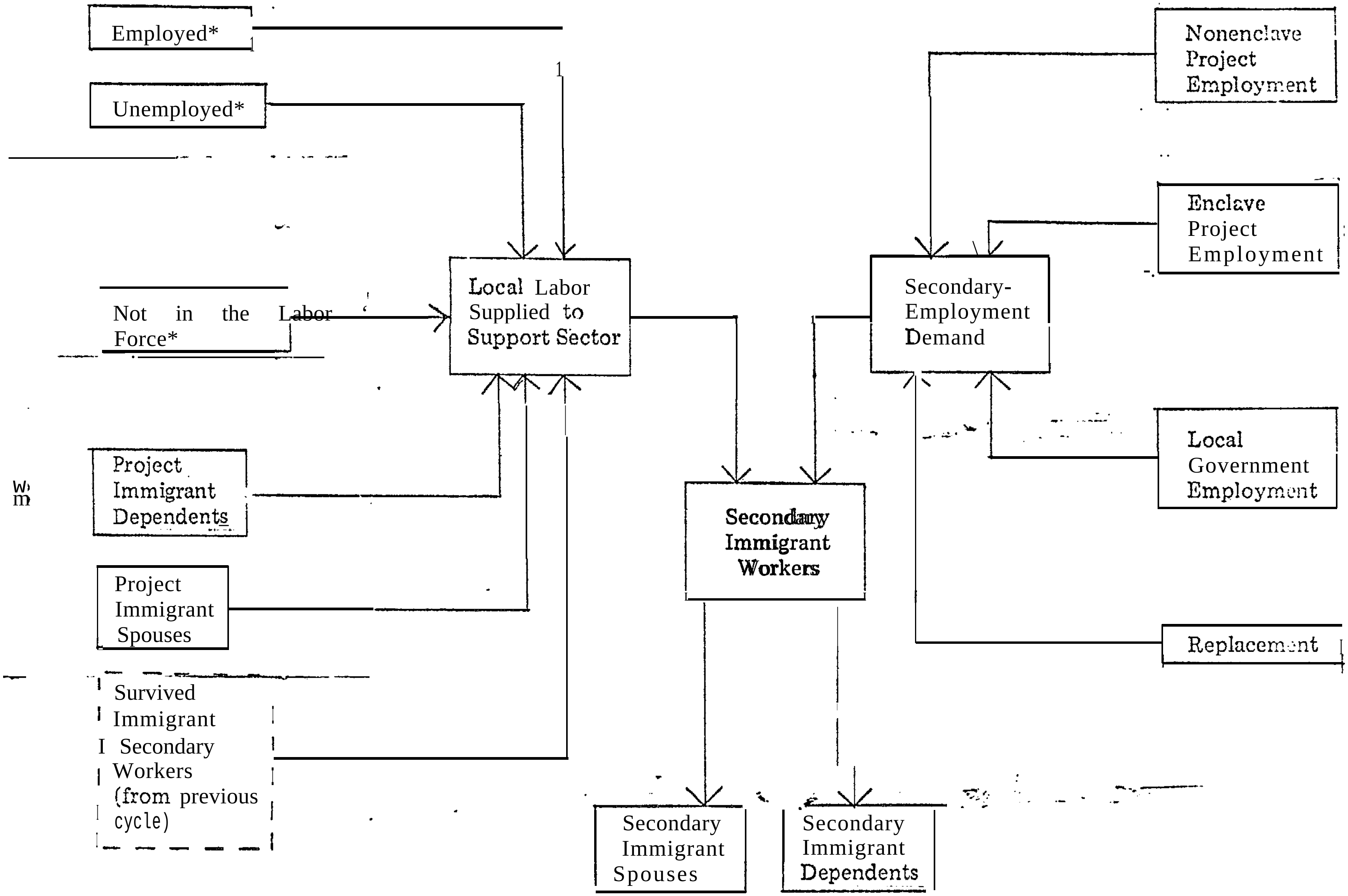


Figure A-3. Determination of Secondary Immigration

APPENDIX B

COMPUTER PROGRAM

```
C
C     POPULATION MODEL -TASK9AA
C
C     THIS PROGRAM FORECASTS FUTURE SMALL AREA POPULATION
C     DEVELOPMENT BASED UPON THE IMPACTS OF THE PETROLEUM
C     DEVELOPMENTS.
C
C     THE MODEL CONSISTS OF THREE PHASES: DEVELOPMENT,
C     BASELINE, AND OPERATION. THESE PHASES ARE LINKED
C     TO THE LOCAL LABOR SUPPLY EQUATION.
C
C     THE FOLLOWING CONVENTION WILL BE OBSERVED IN DEFINING
C     THE COHORTS FOR EACH VARIABLE:
C
C     M(T,A,S,R)   WHERE:
C
C          T=TIME PERIOD       9-3
C          A=AGE COHORT        1-14
C          S=SEX COHORT        1=MALE, 2=FEMALE
C          R=RACE COHORT       1=NATIVE, 2=NONNATIVE
C
      INTEGER A,AA,AL/14/
      REAL    ALPHA/0.0/,ALPHA1/.25/,ALPHA2/. 10/
      REAL    BB,BBB,BBBIRT(2) ,BBIRTH(2)
      REAL    BETA/0.0/,BETA1/.25/,BETA2/.1 0/
      REAL    BIRTHS(2,2),BN,BNN
      REAL    CDPAS(14.2.2)
     8 /.140, .098, .090, .058, .007,.002,8*0.0,
     &  .140,.098,.090,.058,.007,.002,36*0.0/
      REAL CEMLTI/0.0/
      REAL    CIMG(14,2,2)
      REAL    CNBN(2),CNMLTI/.49/
      PEAL    CONDEM(3,2)/119.,542.,0.0,1 78.,812.,0.0/
      REAL    CONSLB(3,2)/.015,.009,.074,.017, .022,.113/
      REAL    CONSUP(2)
      REAL    CSPAS(14,2,2)
     & /3*0.0,.001,.004,.004,.004, .002,4*.001,2*0.0,
     & 3*0.0, .019, .093,.101, .091,.044, .031, .032,.024,.018,
     &  .011,.004,28$0.0/
      REAL    EIMGW,EMPCT/0.0/,EMULTI/0.0/,ENCLV/0.0/
      REAL    ,5R(14,2)
     & /2*0.0,.230, .732,.894,.577, .247, .090,.022,5*0.0,
     & 2*0.0,.272, 1.023,1.408,.986, .545,.312,.095,5*0.0/
      REAL    GRAVD/.826/,GRV/.732/
      INTEGER I
      REAL    IMGW
      REAL    IMGWAS(14,2,2)
     & /3*0.0,.105,.127,.172,.218, .082, .073,.062,.062, .03%,
     &  .020,.008,
     & 3*0.0,.004, .005,.007,.009,.003, .002,.003,003,.002,
     &  .001,0.0,28*0.0/
      INTEGER J
      REAL    LFPR(14,2,2)
     & /3*0.0,.254,.895,.802,.802,.832, .832,4*.766,.256,
     & 3$0.0, .165,.186,.234,.234,.353, .353,4*.369,.152,
     & 3*0.0,.254,.895, .802,.802,.832, .832,4$.766,.256,
     & 3*0.0, .165, .186,.234, .234,.353, .353,4*.369,.152/
```

```
      REAL    MIGR(14,2,2)
     & /1.332,1.540,1.390,1.158,1.1 46,1 .392,! .339,1.414,
     & 1.242, 1.141,1.146,1.083,1.056 ,.992,
     & 1.283, 1.484, 1.353,1.161,1.130 ,1.712,1.322,1.385,
     & 1 .192,1.105,1.168,1.059,1.014, .992,
     &  .808,1 .112, 1.023,.8S2,1 .012, .933,1.037,1.048,1.124,
     & 1.007,1,000,1 .009,1.153,1 .020, .947, 1.053,1.024,.906,
     &  .479, 1.03S, ?.OOS,l .206,1.081, .844,.875,1.020,1.018,1.020/
      REAL    NEO
      REAL    NODPI(14,2,2),NOIN(14,2,2)
      REAL    NOINGW,NOR
      REAL    NOSPI(14,2,2),NSODPI(14,2,2)
      REAL    NSOI
      REAL    NSOIN(14,2,2) ,NSOSPI(14,2,2)
      REAL    NSOINT
      REAL    NWMLTI/.81/
      REAL    O(2)
      REAL    ODPAS(14,2,2)
     & /.333,.213,.196,.102,.006,9*0.0,
     &  .333, .213V.196,.102,.006,37*(),W
      REAL    ODPING(14,2,2)/56*0.0/
      REAL    OENCLV/0.0/
      REAL    OINGW(14,2,2)/56*0.0/
      REAL    OINT
      REM.    OLOCAL(2)
      REM     OINGWS(14,2,2)
     & /3*0.0,.077,.094,.201,.254,.077, .069, .031,.031,.018,.010,
     &  .009,3$0,0,.012,.014,.030,.033, .012, .010,.004,.004,
     &  .003,.001,.001,28*0.0/
      REAL    OMR(14,2,2)
     & /.784,.813,.825,.822,.784, .813, .825, .838, .850,.863,.875,
     & .888,.900,0.0,
     &  .784, .813, .825, .823,.779,.81 3,.825, .838, .850,.863,.875,
     &   .88,.900,29*0.0/
      REAL    OPDEN(3,2)/0.0,88.,282.,0.0,149. ,479./
      REAL    OPLBR(4,2)/.015,.005,.040,0.0, .013,.023,.102,0.0/
      REAL    OPS,OPSPP
      REAL    OPSUPP(2)
      REAL    OSPAS(14,2,2)
     & /3*0.0,.019,.011,.024,.030, .010,.008,.003, .003,.002, .001,
     &  .001,3*0.0,. 062,.075,.141,.203, .042, .055,.025,.025,.014,
     &  .008,.007,28*0.0/
      REAL    OSPING(14,2,2)/56*0.0/
      REAL    POP(14,2,2)/334.,350.,292. ,213. ,209.,201.,266.,267. ,
     &      221 .,189.,128.,104.,85.,117.,31 4.,330.,253.,134.,109.,
     &      14?. ,206. ,209. ,148. ,128.,85.,63. ,35.,39.,32.,/)2.,58.,4?.,
     &       46.,34.,26.,31.,19.,26., 15.,15. ,11. ,12.,78.,65.,56. ,
     &       36. ,33. ,16. ,23.,35.,19.,1 3.$14.,6.,8.,7./
      REAL    POSUP(4),PSOUP(6),PSUP(5)
      INTEGER R
      REAL    REV(3)/3*0.0/
      REAL    RINGW
      INTEGER RL/2/
      INTEGER S
      REAL    SC
      REAL    SCDPAS(14,2,2)
     & /.333,.213,.196,.102,.006,9*0.0,
```

```
980         & .333,.213,. °o . 02 .00  37*0.0/
990          REAL    SCOND
1000         REAL    SCONL(5)/0.0,.0 8,.084,.365,.125/
1010         REAL    SCONS(5)
1020         REAL    SCSPAS(14,2,2)
1030        & /3*0.0,.019,.011,.024,.030,.010,.008,.003,.003,.002,.001
1040        &  .001,3*0.0,.062,.075,.161,.203,.062,.055,.025,.025,.014
1050        &  .008,.007,28*0.0/
1060         REAL    SIMGW
1070         REAL    SIMGWS(14,2,2)
1080        & / 3*0.0,.077,.094,.201,.254,.077,.069,.031,.031,.018,.0 0,
1090        &  .009,3*0.0 .012,.014,.030 .038,.012,.010,.004,.004,
1100        &  .003,.001,.001,28*0.0/
1110         INTEGER SL/2
1112         REAL             14,2,2)
1114        & /.333,.213,.196,.102,.006,9*0.0,
1116        &  .333,.213,.196,.102,.006,37*0.0/
1120         REAL    SODPIN(14,2,2)/56*0.0/
1122         REAL    SOMGWS(14,2,2)
1124        & /3*0.0,.077,.094,.201,.254,.077,.069,.031,.031,.018,.010,
1126        &  .009,3*0.0,.012,.014,.030,.038,.012,.010,.004,.004,
1128        &  .003,.001,.001,28*0.0/
1130         REAL    SOIMGW(14,2,2)/56*0.0/
1131         REAL    SOIMT
1132         REAL    SOMR(14,2,2)
1134        & /.784,.813,.825,.822 .7≥4 .8 3, 825 .838,.850  863 .875,
1136        &  .888,.900,0.0,
1138        &  .784,.813,.825,.823,.779,.≥ ≥, 825,.83≥ .850,.863,.875,
1140        &  .88,.900 29*0.0/
1145         REAL    S≥PD/0.0/
1150         REAL    SOPLBR(6)/0.0,.o ≡ .084,. 25, 365,1.0/
1160         REAL    SOPS
1162         REAL    SOSPAS(14,2,2)
1164        & /3*0.0,.019 .011, 024,.030,.010,.008,.003 .003,.002,.001,
1166        &  .001,3*0.0  062 .075,.161,.203,.062,.055 .025,.025,.014,
1168        &   .008,.007,28*0.0/
1170         REAL    SOSPIM  4,2,2)/56*0.0/
1180         REAL    SPOP  4 2 2)
1190         REAL    SR(14,2,2)
1200        & /.984,.997,.992,.987,.985, 9≡5, 984 .979, 965,.95 ,.936,
1210        &  .894,.794,.723,
1220        &  .985,.998,.997,.996,.995,.996,.996,.992,.989,.979,.967,
1230        &  .955,.878,.806,
1240        &  .972,.995,.988,.963,.959,.977,.982 .966,.946,.946,.937,
1250        &  .869,.758,.699,
1260        &  .980,.997,.996,.989,.986,.982,.9= ,.959,.905,.90 ,.945,
1270        &  .900,.833,.810/
1280         REAL    SRD(14,2,2),SRDP M(14,2,2
1290         REAL    SRO( 4 z 2 ,SRS(14,2,2)
1300         REAL    SRSO(14,2,2),SRSS(14,2,2)
1310         REAL    SXR(2)/.503,.497/
1320         INTEGER
1330         REAL     C
1340         INTEGER TL/3/
1350         REAL    TIMG(14,2,2)
1360         REAL    TPOP
1370         REAL    TOPIMG  4,2,2),TPOP(14,2 2)
```

```
      REAL    TPOP1
      REAL    TSOPIM(14,2,2)
      REAL    TSRO/0.0/,TSRSO/0.0/
      REAL    TTIMG,TTPOP
      REAL    UR(14,2,2)
     & /3*0.0,.244,.203,.147,.125,. 154, .155, .142, .174,.?66,.193,
     &  .167,3*0.0, .130,.127,.086, .092, .092, .052,.066,.079,
     &  .065, .094, .064,3*0.0,.244, .203, .147,.125,.154, .155,.142,
     & .174,.224,. 193, .167,3*0.0, .130,.127,.086, .092,.092,
     &  .052,.066, .079,.065,.094, .064/
      REAL    X(2),XH(2),XQ
      REAL    Y(2),YH(2),YQ
      REAL    Z(2),ZH(2),ZQ
      T=0
  110 T=T+1
      BN=0.0
      BNN=0.0
C     BASELINE PHASE
C
C     EQUATION B.1
C
      DO 120 A=1,AL
      BNN=BNN+POP(A,2,1 )*FR(A,1)
  120 BN=BN+POP(A,2,2)*FR(A,2)
C
C
      BIRTHS( 1,1)=BNN*SXR(1 )
      BIRTHS( 1,2)=BN*SXR(1 )
      BIRTHS(2,1 )=BNN*SXR(2)
      BIRTHS(2,2)=BN*SXR(2)
C
C     EQUATION 3.3 MOVE P(IP DOWN ON AGE COUNT
C
      DO 130 A=1,AL
      DO 130 S=1,SL
      DO 130 R=1,RL
  130 SPOP(A,S,R)=POP(A,S,R)*SR(A,S,R)
      DO 150 R=1,RL
      DO 150 S=1,SL
      SPOP(AL,S,R)=SPOP(AL,S,R)+SPOP(AL-1 ,S,R)
      DO 140 A=1,AL-1
      AA=AL-A
  140 SPOP(AA,S,R)=SPOP(AA-1,S,R)
C
C     EQUATION B.2 BRING BIRTHS IN BEGINNING  AGE
C
  150 SPOP(1,S,R)=BIRTHS(S,R)
      WRITE (6,151)
  151 FORMAT( "1",19("*")," POPULATION MODEL - TASK 9AA",19("*"))
      WRITE (6,152) T
  152 FORMAT("0BASELINE PHASE     - TIME PERIOD",I2)
      PRINT,"GENERATION",T, " POP"
      WRITE (4,}56)
  156 FORMAT( "0",8X,"POPULATION BY AGE, RACE, & SEX")
      WRITE (6,157)
  157 FORMAT ("0", 8X,' "+-----+",2(15( '-") ,"+"),/,
     &             19X,":",5X,":",3X,"NON-NATIVE",2X,":",
```

```
     &              5X "NATIVE",4X,":",/,
     &             19X ": AGE +",4("-------+" ,/,
     &             19X,":",5X,2(": MALE  : FEMALE"),":")
      PRINT,"AGE,  NN MALE,  NN FEMAL=,  N MALE,  N FEMALE"
      WRITE (6,158)
    5 FORMAT (19X,"+-----+",4("-------+"))
      TPOP1=0.0
C
C     EQUATION B.4
C
      DO 165 A=1,AL
      DO 160 S=1,SL
      DO 160 R=1,RL
      POP(A,S,R)=SPOP(A,S,R)*MIGR A,S,R
C
C     EQUATION B.5  OTAL POP
C
      POP =TPOP +POP(A,S,R)
  160 CONTINUE
      PRINT,A,POP(A,1,1),POP(A,2,1),POP(A, ,2 ,POP A,2,2)
      WRITE (6,162) A,POP(A,1,1),POP(A,2,1 ,POP(A,1,2),POP(A,2,2)
  162 FORMAT (19X,":",I4," :",4(F6.0," :")
  165 CONTINUE
      PRINT,"POP(1)=",TPOP
      WRITE  6, 58)
      W  TE  6 167) TPOP1
   67 FORMAT ("0",8X,"TOTAL POPULATION",24X,F7.0)
C
C     EQUATION B.6 THRU   0 FORM CONSTRUCTION SUPPLY
C
      PSUP(1)=0.
      PSUP(2)=0.
      PSUP(3)=0.
      DO 170 A=1,AL
      DO 170 S=1,SL
      DO 170 R=1,RL
C
C     EQUATION D.1
C
      PSUP(3)=PSUP(3)+POP(A,S,R)*LFPR(A,S,R)*UR(A,S,R)
      PSUP(1)=PSUP(1)+POP(A,S,R)*LFPR(A,S,R)-POP(A,S,R)*
     &  LFPR(A,S,R)*UR(A,S,R)
      PSUP(2)=PSUP(2)+POP(A,S,R)-POP(A,S,R)*LFPR(A,S,R)
  170 CONTINUE
C     DEVELOPMENT PHASE
C
C     EQUAT  N D.2
C
      DO 180 J= ,2
      CONSUP J)=0.0
      DO 180 I= ,3
  180 CONSUP(J =CONSUP(J)+CONSLB I,J *PSUP(I
      PRINT,"CONSUPPLY(  ,CONS P LY 2)=",CO SUP
      CNBN  )= 1.-BETA1)*CONDEM(T,1)-CONSUP(1)
      CNBN 2 =  .-BETA        M T,2 -CONSUP(2
      IF (CNBN(1).LT.0.  CNBN   =0.0
      IF (CNBN(2 .LT.0..  CNBN(2)=0.0
```

```
C
C     EQUATION D.3
      INGW=CNBN( 1)+CNBN(2)+BETA1*CONDEM(T ,1)+BETA2*CONDEM(T,2)
      PRINT, "INGW=",INGW
C
C     EQUATION D.4, D.5
C
      EINGW=ENCLV*(CONDEM(T, 1)+CONDEM(T,2))
      RINGW=(INGW-EINGW)*GRV
C
C     EQUATION D.9 COMPUTE X, Y, Z
C
      DO 185 J=1,2
      Y(J)=0.0
      Z(J)=0.0
      IF (CONDEM(T,J).LT.CONSLB(1,J)*PSUP( 1)) GO TO 183
      X(J)=CONSLB(1,J)*PSUP(1)
      IF (CONDEM(T,J)-CONSLB(1,J)*PSUP( 1) .LT.CONSLB(3,J)*PSUP(3))
     & GO TO 182
      Y(J)=CONSLB(3,J)*PSUP(3)
      IF (CONDEM(T,J)-CONSLB( 1,J)*PSUP( 1)-CONSLB(3,J)*PSUP(3)
     & .LT.CONSLB(2,J)*PSUP(2)) GO TO 181
      Z(J)=CONSLB(2,J)*PSUP(2)
      GO TO 184
  181 Z(J)=CONDEM(T,J)-CONSLB(1,J)*PSUP( 1)-CONSLB(3,J)*PSUP(3)
      GO TO 184
  182 Y(J)=CONDEM(T,1 )-CONSLB(1 ,J)*PSUP( 1)
      Z(J)=0.0
      GO TO 184
  183 X(J)=CONDEM(T,J)
      Y(J)=0.0
      Z(J)=0.0
  184 CONTINUE
  135 CONTINUE
C
C     EQUATION D.9
C
      PSUP(1)=PSUP(1 )-X(1)-X(2)
      PSUP(3)=PSUP(3)-Y(1)-Y(2)
      PSUP(2)=PSUP(2)-Z(1 )-Z(2)
      PSUP(4)=0.
      PSUP(5)=0.
      DO 190 A=1,AL
      DO 190 S=1,SL
      DO 190 R=1,RL
      PSUP(4)=PSUP(4)+RINGW*CSPAS(A,S,R)
  190 PSUP(5)=PSUP(5)+RINGW*CDPAS(A,S,R)
      PRINT,"PSUPPLY(I)=",PSUP(1),PSUP( 2),PSUP(3),PSUP(4),PSUP(5)
      SC=0.
C
C     EQUATION D.10
C
      DO 200 I=1,5
      SCONS(I)=SCONL(I)*PSUP(I)
  200 SC=SC+SCONL(I)*PSUP(I)
      PRINT,"SCONSPPLY(1 )=",SC
C
```

```
C      EQUATION D.12
C
       SCOND=CNMLTI*(CONDEM(T, 1)+CONDEM(T,2)-EINGW-( IMGW-RIMGW))+
     & CEMLTI*EIMGW+
     & EMPCT*REV(T)+X( 1)+X(2)
C
C      EQUATION D.13
C
       SIMGW=SCOND-SC
       IF (SIMGW.LT.0.0) SIMGW=0.0
       PRINT,"SCONDEM=",SCOND
       PRINT, "SIMGW=",SIMGW
       TC=0.0
       WRITE (6,201) T
   201 FORMAT ("0DEVELOPMENT PHASE - TIME PERIOD",I2)
       WRITE (6,202) IMGW,SC,SCOND,SIMGW,RIMGW
   202 FORMAT ("0",8X,"DIRECT PRIMARY MIGRATION",16X,F7.0,/,
     &             9X,"SECONDARY EMPLOYMENT SUPPLY",13X,F7.0,/,
     &             9X,"SECONDARY EMPLOYMENT DEMAND",13X,F7.0,/,
     &             9X,"DIRECT SECONDARY MIGRATION",14X,F7.0,/,
     &             9X,"RESIDENT PRIMARY MIGRATION",14X,F7.0,/,
     &             9X,"MIGRATION BY AGE, RACE, 8 SEX")
       PRINT,"RIMGW=",RIMGW
       PRINT,"EIMGW=",EIMGW
       PRINT,"CIMG"
       PRINT,"AGE, NN MALE, NN FEMALE, N MALE, N FEMALE"
       WRITE (6,157)
       WRITE (6,1S8)
C
C      EQUATION D.17
C
       DO 220 A=1,AL
       DO 210 S=1,SL
       DO 210 R=1,RL
       CIMG(A,S,R)=(RIMGW+EIMGW)*IMGWAS(A ,S,R)+
     &             RIMGW*CSPAS(A,S,R)+RIMGW*CDPAS(A,S,R)+
     &             SIMGW*SCSPAS(A,S,R)+SIMGW*SCDPAS(A,S,R)+
     &             SIMGW*SIMGWS(A,S,R)
C
C      EQUATION D.18 TOTAL CIMG
C
       TC=TC+CIMG(A,S,R)
   210 CONTINUE
       WRITE (6,162) A,CIMG(A,1,1 ),CIMG(A,2,1 ),CIMG(A ,1,2),CIMG(A,2,2)
   220 PRINT,A,CIMG(A,1 ,1),CIMG(A,2, 1),CIMG(A, 1,2),CIMG(A,2,2)
       WRITE (6,158)
       PRINT,"TOTAL CIMG =",TC
C
C      EQUATION 0.2 COMPUTE MODIFICATION TO SUPPLY
C
       YQ=0.0
       ZQ=0.0
       IF (SCOND.LT.SCONS(1)) GO TO 223
       XQ=SCONS(1)
       IF (SCOND-SCONS(1 ).LT.SCONS(3) ) GO TO 222
       YQ=SCONS(3)
       IF (SCOND-SCONS(1 )-SCONS(3) .LT.SCONS(2) ) GO T(J 221
```

```
      ZQ=SCONS(2)
      GO TO 224
  221 ZQ=SCOND-SCONS( 1)-SCONS(3)
      GO TO 224
  222 YQ=SCOND-SCONS(1)
      ZQ=0.0
      GO TO 224
  223 XQ=SCOND
      YQ=0.0
      ZQ=0.0
  224 CONTINUE
      WRITE (6,226) TC
  226 FORMAT ("0",8X,"TOTAL MIGRATION",25X,F7.0)
C     OPERATIONS PHASE
      WRITE (6,151)
      WRITE (6,227) T
  227 FORMAT ("0OPERATIONS PHASE - TIME PERIOD",I2)
      TSRO=0.0
      DO 240 A=1,AL
      DO 240 S=1,SL
      DO 240 R=1,RL
      SRO(A,S,R)=OINGW(A,S,R)*SR(A,S,R)*OMR(A,S,R)
      TSRO=TSRO+SRO(A,S,R)
  240 SRS(A,S,R)=OSPING(A,S,R)*SR(A,S,R)*OMR(A,S,R)
      DO 242 R=1,RL
      DO 242 S=1,SL
      SRO(AL,S,R)=SRO(AL,S,R)+SRO(AL-1 ,S,R)
      SRS(AL,S,R)=SRS(AL,S,R)+SRS(AL-1 ,S,R)
      DO 241 A=1,AL-1
      AA=AL-A
      SRO(AA,S,R)=SRO(AA-1 ,S,R)
  241 SRS(AA,S,R)=SRS(AA-1,S,R)
      SRO(1,S,R)=0.0
  242 SRS(1,S,R)=0.0
      POSUP(1)=PSUP(1 )-XQ
      POSUP(2)=PSUP(2)-ZQ
      POSUP(3)=PSUP(3)-YQ
      POSUP(4)=TSRO
      PRINT,"ALPHA,BETA",ALPHA,BETA
      OPLBR(4,1 )=ALPHA
      PRINT,"POSUPPLY",POSUP
      OPLBR(4,2)=BETA
C
C     EQUATION 0.3, 0.4
C
      DO 230 J=1,2
      OPSUPP(J)=0.0
      DO 230 I=1,4
  230 OPSUPP(J)=OPSUPP(J)+OPLBR( I,J)*POSUP(I)
      PRINT,"OPSUPPLY(T,J)",OPSUPP
      OLOCAL(1)=(1 .-ALPHA1 )*OPDEM(T,1 )-OPSUPP(1 )
      OLOCAL(2)=(1 .-ALPHA2)*OPDEM(T,2)-OPSUPP(2)
      PRINT,"OLOCAL",OLOCAL
      DO 231 I=1,2
      IF (( (T.EQ. 1).OR. ((T.GT.1).AND.(OPDEM(T-1 ,1)+OPDEM(T-1,2))
     &  .LE.0.0) .AND.(OLOCAL(I).LT.0.0) )) OLOCAL(I)=0.0
  231 CONTINUE
```

```
C
C      EQUATION O.5
C
       NOIMGW=ALPHA *OPDEM(T,1)+ALPHA2*OPDEM(T,2)+OLOCAL(   +
      &  OLOCAL(2)
       IF (OLOCAL    +O OCAL(2).LT.-TSRO) NOIMGW=
      & ALPHA *.P. M   1)+ALPHA2*OPDEM(T 2)-TSRO
       PRINT "N.IMGW=",NOIMGW
C
C      EQUATION O.6
C
       NEO=OENCLV*(OPDEM(T, )+OPDEM( ,2 .
       PRINT,"NEOIMGW",NEO
C
C      EQUATION O.7
C
       NOR=NOIMGW*(1.-OENCLV *GRAVO
       PRINT,"NORIMGW",NOR
       OIMT=0.0
       DO 243 A=1,AL
       DO 243 S=1,SL
       DO 243 R=1,RL
C
C      EQUATION O.8
C
       NOSPI(A,S,R =NOR*OSPAS(A S,R)
       IF (NOIMGW.LT.0.0.AND.A.G .1) NOSPI(A,S,R =NOR*OSPAS(A-1,S,R)
C
C      EQUATION O.9
C
       NODPI(A,S,R)=NOR*ODPAS(A,S,R)
       IF (NOIMGW.LT.0.0.AND.A.GT.1) NODPI(A,S,R)=NOR*ODPAS(A-1,S,R
C
C      EQUATION O. 0
C
       NOIM(A,S,R)=NOIMGW*OIMGWS A,S,R)
       IF (NOIMGW.LT.0.0.AND.A.GT.1) NOIM(A,S,R)=NOIMGW*
      & OIMGWS(A- ,S,W
C
C      EQUATION O. 2
C
       O MGW(A,S,R     (A,S,R)+NOIM(A,S,R)
   243 OIMT=OIMT+OIMGW A S,R)
       BB=0..
       DO 25. A=1,AL
       W. 250 R=1,RL
   250 BB=BB+(ODPIMG(A,2 R)+OSPIMG(A,2,R))*FR(A,R)
C
C      EQUATION O.22 COMPUTE MODIFICATION TO SUPPLY
C
       DO 255 J=1,2
       YH(J)=0.0
       ZH(J)=0.0
       IF (OPDEM(T,J).LT.OPLBR(1,J)*POSUP( )) GO TO 253
       XH(J)=OPLBR(1,J)*POSUP(1)
       IF (OPDEM(T.J)-OPLBR(1,J)*POSUP(1).LT.OPLBR(3,J)*POSUP(3)
      & GO  O 252
```

```
      YH(J)=OPLBR(3,J)*POSUP(3)
      IF (OPDEM(T,J)-OPLBR( 1,J)*POSUP( 1)-OPLBR(3,J)*POSUP(3)
     & .LT.CONSLB(2,J)*POSUP(2)) GO TO 251
      ZH(J)=OPLBR(2,J)*POSUP(2)
      GO TO 254
  251 ZH(J)=OPDEM(T,J)-OPLBR(1 ,J)*POSUP( 1)-OPLBR(3,J)*POSUP(3)
      GO TO 254
  252 YH(J)=OPDEM(T,J)-OPLBR(1,J)*POSUP( 1)
      ZH(J)=0.0
      GO TO 254
  253 XH(J)=OPDEM(T,J)
      YH(J)=0.0
      ZH(J)=0.0
  254 CONTINUE
  255 CONTINUE
C
C     EQUATION 0.22 MODIFY SUPPLY
C
      PSOUP(1)=POSUP(1 )-XH(1)-XH(2)
      PSOUP(2)=POSUP(2)-ZH(1)-ZH(2)
      PSOUP(3)=POSUP(3)-YH(1 )-YH(2)
      PSOUP(4)=0.0
      PSOUP(5)=0.0
      PSOUP(6)=0.0
C     EQUATION 0-13
      BBIRTH(1 )=BB*SXR(1 )
      BBIRTH(2)=BB*SXR(2)
      PRINT,"OSPIMG"
      PRINT,"AGE, NN MALE, NN FEMALE, N MALE, N FEMALE"
C
C     EQUATION 0.14
C
      DO 256 A=1,AL
      DO 256 S=1,SL
      DO 256 R=1,RL
      OSPIMG(A,S,R)=SRS(A,S,R)+NOSPI (A,S,R)
  256 SRDPIM(A,S,R)=ODPIMG(A,S,R)
      DO 2560 A=1,AL
 2560 PRINT,A,OSPIMG(A,1,1 ),OSPIMG(A,2, 1),OSPIMG(A,1 ,2),OSPIMG(A,2,2)
C
C     EQUATION 0.15 MOVE ODPIMG DOWN ONE AGE COHORT
C
      DO 258 R=1,RL
      DO 258 S=1,SL
      SRDPIM(AL,S,R)=SRDPIM(AL,S,R)+SRDPIM(AL-1 ,S,R)
      DO 257 A=1,AL-1
      AA=AL-A
  257 SRDPIM(AA,S,R)=SRDPIM(AA-1,S,R)
  258 SRDPIM(1,S,R)=BBIRTH(S)
      DO 2581 A=1,AL
      DO 2581 S=1,SL
      DO 2581 R=1,RL
 2581 SRDPIM(A,S,R)=SRDPIM(A,S,R)*SR(A,S,R)*OMR(A,S,R )
      PRINT,"SRDPIM"
      PRINT,"AGE,NN MALE, NN FEMALE, N MALE, N FEMALE"
      DO 259 A=1,AL
  259 PRINT,A,SRDPIM(A,1 ,1),SRDPIM(A,2, 1),SRDPIM(A,1,2),SRDPIM(A,2,2)
```

```
      TOP1=0.0
C
C     EQUATION 0.15
C
      DO 260 /)=j,ly-
      IIO 260 S=1,SL
      DO 260 R=1,RL
      ODPIMG(A,S,R)=SRDPIM(A,S,R)
     & +NODPI(A,S,R)
      PSOUP(4)=PSOUP(4)+ODPIMG(A,S, R)
      PSOUP(5)=PSOUP(5)+SRS(A,S,R) +NOSPI(A,S,R)
      TOPIMG(A,S,R)=DIMGW(A,S,R)*( (1 .-OENCLV)*GRAVO+OENCLV)+
     & OSPIMG(A,S,R)+ODPIMG(A,S,R)
C
C     EQUATION 0.20 TOTAL TOPIMG
C
  260 TOP1=TOP1+TOPIMG(A,S,R)
      PRINT,"ODPIMG"
      PRINT,"AGE, NN MALE, NN FEMALE, N MALE, N FEMALE"
      DO 261 A=1,AL
  261 PRINT,A,ODPIMG(A,1,1 ),ODPIMG(A,2, 1),ODPIMG(A,1,2),ODPIMG(A,2,2)
      PRINT, "TOPIMG"
      PRINT, "AGE, NN MALE, NN FEMALE, N MALE, N FEMALE"
      DO 265 A=1,AL
  265 PRINT,A,TOPIMG(A,1,1),TOPIMG(A,2, 1),TOPIMG(A,1,2),TOPIMG(A,2,2)
      PRINT,"TOPIMG(1 )",TOP1
C
C     EQUATION 0.29, 0.31
C
      DO 280 A=1,AL
      DO 230 S=1,SL
      DO 280 R=1,RL
      SRSO(A,S,R)=SOIMGW(A,S,R)*SR(A,S,R)*DMR(A,S,R)
  280 SRSS(A,S,R)=SOSPIM(A,S,R)*SR( A,S,R)*DMR(A,S,R)
      DO 282 R=1,RL
      DO 282 S=1,SL
      SRSO(AL,S,R)=SRSO(AL,S,R)+SRSO(AL-1 ,S,R)
      SRSS(AL,S,R)=SRSS(AL,S,R)+SRSS (AL-1,S,R)
      DO 281 A=1,AL
      AA=AL-A
      SRSO(AA,S,R)=SRSO(AA-1 ,S,R)
  281 SRSS(AA,S,R)=SRSS(AA-1,S,R)
      SRSO(1,S,R)=0.0
  282 SRSS(1,S,R)=0.0
      TSRSO=0.0
      DO 283 A=1,AL
      DO 283 S=1,SL
      DO 283 R=1,RL
  283 TSRSO=TSRSO+SRSO(A,S,R)
      PSOUP(6)=TSRSO
      SOPS=0.0
C
C     EQUATION 0.23
C
      DO 270 I=1,6
  270 SOPS=SOPS+SOPLBR(I)*PSOUP(I)
      PRINT, "SOSPPLY(1 )",SOPS
```

```
      OPS=0.0
      DO 275 J=1,2
      IF (OPDEM(1,J).LT.O(J)) O(J)=OPDEM(1,J)
  275 OPS=OPS+O(J)
C
C     EQUATION 0.24
C
      SOPD=NUMLTI*( (OPDEM(T,1)+OPDEM(T,2)-NEO-(1.-OENCLV)*(1.-GRAVO)*
     & OIMT)) +EMULTI*NEO+XH(1)+XH(2)
      PRINT,"SOPDEM(1)",SOPD
C
C     EQUATION 0.25
C
      NSOI=SOPD-SOPS
      IF (NSOI.LT.0.0.AND.T.EQ.1) NSOI=0.0
      IF ((T.GT. 1.AND.OPDEM(T-1,1)+OPDEM( T-1,2) .LE.0.0).AND.
     & NSOI.LT.0.0) NSOI=0.0
      NSOIMT=0.0
      SOIMT=0.0
      DO 286 A=1,AL
      DO 286 S=1,SL
      DO 286 R=1,RL
C
C     EQUATION 0.26
C
      NSOSPI(A,S,R)=NSOI*SOSPAS(A,S,R)
      IF (NSOI.LT.0.0.AND.A.GT.1) NSOSPI(A,S,R)=NSOI*SOSPAS(A-1,S,R)
C
C     EQUATION 0.27
C
      NSODPI(A,S,R)=NSOI*SODPAS(A,S,R)
      IF (NSOI.LT.0.0.AND.A.GT.1) NSODPI(A,S,R)=NSOI*
     S SODPAS(A-1,S,R)
C
C     EQUATION 0.28
C
      NSOIM(A,S,R)=NSOI*SOMGWS(A,S,R)
      IF (NSOI.LT.0.0.AND.A.GT.1) NSOIM(A,S,R)=NSOI*SOMGWS(A-1,S,R)
      NSOIMT=NSOIMT+NSOIM(A,S,R)
      TSRSO=TSRSO+SRSO(A,S,R)
C
&     EQUATION 0.30
C
      SOIMGW(A,S,R)=SRSO(A,S,R)+NSOIM(A,S,R)
      SOIMT=SOIMT+SOIMGW(A,S,R)
  286 CONTINUE
      PRINT,"SOIMGW"
      PRINT,"AGE, NN MALE, NN FEMALE, N MALE, N FEMALE"
      DO 285 A=1,AL
  285 PRINT,A,SOIMGW(A,1,1),SOIMGW(A,2,1),SOIMGW(A,1,2),SOIMGW(A,2,2)
      WRITE (6,287) NOIMGW,NOR,NSOIMT,OIMT,SOIMT,SOPS,SOPD
  287 FORMAT ("0",8X,"CHANGE IN PRIMARY MIGRATION",13X,F7.0,/,
     &            9X,"CHANGE IN RESIDENT PRIMARY MIGRATION",4X,F7.0,/,
     &            9X,"CHANGE IN SECONDARY PRIMARY MIGRATION",3X,F7.0,/,
     &            9X,"TOTAL PRIMARY MIGRATION",17X,F7.0,/,
     &            9X,"TOTAL SECONDARY MIGRATION",15X,F7.0,/,
     &            9X,"SECONDARY EMPLOYMENT SUPPLY",13X,F7.0,/,
```

```
     &              9X,"SECONDARY EMPLOYMENT          3X,F7.0,/,
     &              9X,"TOTAL MIGRATION ≥Y AGE, ≥AC≡  & SEX")
      ≥≥≥=0.○
      DO 29○ A=1,AL
      DO 290 R=1,RL
C
C     EQUATION 0.33
C
  290 BBB=BBB+(SOSPIM(A,2,R)+SODPIM(A.2,R))*FR(A,R)
      BBBIRT(1)=BBB*SXR(1)
      BBBIRT(2)=BBB*SXR(2
      ≥O 291 A=1,AL
      DO 29  S= ,SL
      DO 291 R= ,RL
  29  SRD(A,S,R)=SODPIM(A,S,R)
      DO 293 R=1,RL
      DO 293 S=1,SL
      SRD(AL,S,R)=SRD AL,S,R)+SRD(AL- ,S,R)
      DO 292 A=1,AL-1
      AA=AL-A
  292 SRD(AA,S,R)=SRD(AA-1,S,≥
  293 SRD(1,S,R)=BBBIRT(S)
      DO 294 A= ,AL
      ≥≥ 294 S= ,SL
      ≥O 294 R= ,≥L
  2 4 SRD(A,S,R)=SRD(A,S,R)*SR(A,S,R)*SDMR(A,S,R)
      TTIMG=0.○
      TPOP=0.0
      DO 300 A=1,AL
      DO 300 S=1,SL
      DO 300 R= ,RL
      SOSPIM(A,S,R)=SRSS(A,S,R +NSOSPI A,S,R)
C
C     EQUATION 0.36
      SODPIM(A,S,R)=SRD(A,S,R)+NSODPI(A,S,R)
C
C     EQUATION 0.37
      TSOPIM(A,S,R)=SOIMGW(A,S,R)+SOSPIM(A,S,R)+SODPIM(A,S,R)
C
C     EQUATION 0.38
C
      TIMG(A,S,R)=TOPIMG(A,S,R)+TSOPIM(A,S,R)
C
C     EQUATION ..3
      TPOP(A,S,R)=TIMG(A,S,R)+POP(A,S,R)+CIMG(A,S,R
      TTIMG=TTIMG+TIMG(A,S,R)
C     EQUATION 0-37
      TTPOP=TTPOP+TPOP(A,S,R)
  300 CONTINUE
      WRITE (6,157)
      WRITE (6,158)
      PRINT,"TIMG"
      PRINT,"AGE, NN MALE, NN FEMALE, N MALE, N FEMALE"
      DO 305 A=1,AL
      WRITE (6,162) A,TIMG(A,1, ),.IMG A 2,1),TIMG(A, ,2 .IMG(A,2,2)
  305 PRINT,A,TIMG(A,1,1),TIMG(A,2,1),TIMG(A, ,2),TIMG(A,2,2)
      WRITE (6,158)
```

```
      WRITE (6,306) TTIMG
  306 FORMAT ("0",8X,"TOTAL MIGRATION",25X,F7.0)
      WRITE (6,307) T
  307 FORMAT ("0TOTAL",13X,"- TIME PERIOD",I2)
      WRITE (6,308)
  308 FORMAT ("0",8X,"TOTAL POPULATION BY AGE, RACE, SEX")
      WRITE (6,157)
      WRITE (6,158)
      PRINT,"TSOPIMG"
      PRINT,"AGE, NN MALE, NN FEMALE, N MALE, N FEMALE"
      DO 310 A=1,AL
  310 PRINT,A,TSOPIM(A,1,1),TSOPIM(A,2,1 ),TSOPIM(A,1,2),TSOPIM(A,2,2)
      PRINT, "TPOP"
      PRINT, "AGE, NN MALE, NN FEMALE, N MALE, N FEMALE"
      DO 320 A=1,AL
      WRITE (6,162) A,TPOP(A,1,1 ),TPOP(A,2,1 ),TPOP(A, 1,2),TPOP(A,2,2)
  320 PRINT,A,TPOP(A,1,1 ),TPOP(A,2, 1),TPOP(A,1,2),TPOP(A,2,2)
      WRITE (6,158)
      WRITE (6,321) TTPOP
  321 FORMAT ("0",8X,"TOTAL POPULATION",24X,F7.0)
      PRINT,"TIMG(1 )",TTIMG
      PRINT,"TPOP(1 )",TTPOP
      ALPHA=0.0
      BETA=0.0
      IF (NOIMGW.EQ.0.0) GO TO 330
      BETA=(ALPHA1*OPDEM(T,1 )+OLOCAL(1))/NOIMGW
      ALPHA=1.-BETA
  330 CONTINUE
      IF (T.GE.TL) GO TO 340
      GO TO 110
  340 CONTINUE
      STOP
      END
```

APPENDIX C

SAMPLE OUTPUT

************** POPULATION MODEL - TASK 9AA*****************

LINE PHASE - TIME PERIOD 1

POPULATION BY AGE, RACE, & SEX

AGE	NON-NATIVE MALE	NON-NATIVE FEMALE	NATIVE MALE	NATIVE FEMALE
1	283.	271.	57.	66.
2	506.	462.	89.	80.
3	485.	446.	63.	66.
4	335.	25'3.	49.	51.
5	241.	153.	48.	24.
6	285.	186.	41.	34.
7	265.	307.	34.	16.
8	370.	284.	27.	27.
9	325.	247.	34.	36.
10	243.	162.	18.	15.
11	206.	146.	25.	10.
12	130.	87.	14.	13.
13	98.	61.	15.	5.
14	151.	62.	17.	13.

TOTAL POPULATION 8078.

ELOPMENT PHASE - TIME PERIOD 1

DIRECT PRIMARY MIGRATION 48.
SECONDARY EMPLOYMENT SUPPLY 131.
SECONDARY EMPLOYMENT DEMAND 213.
DIRECT SECONDARY MIGRATION 82.
RESIDENT PRIMARY MIGRATION 35.
MIGRATION BY AGE, RACE, & SEX

AGE	NON-NATIVE MALE	NON-NATIVE FEMALE	NATIVE MALE	NATIVE FEMALE
1	32.	32.	0.	0.
2	21.	21.	0.	0.
3	19.	19.	0.	0.
4	22.	17.	0.	0.
5	14.	11.	0.	0.
6	25.	20.	0.	0.
7	31.	23,	0.	0.
8	IQ.	8.	0.	0.
9	9.	6.	0.	0.
10	5.	4.	0.	0.
11	5.	3.	0.	0.
12	3.	2.	0.	0.
13	2.	1.	0.	0.
14	1.	1.	0.	0.

TOTAL MIGRATION 3.68 .

**************** POPULATION MODEL - TASK 9AA******************

ERATIONS PHASE - TIME PERIOD 1

CHANGE IN PRIMARY MIGRATION	0.
CHANGE IN RESIDENT PRIMARY MIGRATION	0.
CHANGE IN SECONDARY PRIMARY MIGRATION	0.
TOTAL PRIMARY MIGRATION	0.
TOTAL SECONDARY MIGRATION	0.
SECONDARY EMPLOYMENT SUPPLY	118.
SECONDARY EMPLOYMENT DEMAND	0.

TOTAL MIGRATION BY AGE, RACE, & SEX

AGE	NON-NATIVE MALE	NON-NATIVE FEMALE	NATIVE MALE	NATIVE FEMALE
1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
6	0.	0.	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.
11	0.	0.	0.	0.
12	0.	0.	0.	0.
13	0.	0.	0.	0.
14	0.	0.	0.	0.

TOTAL MIGRATION 0.

TAL - TIME PERIOD 1

TOTAL POPULATION BY AGE, RACE, SEX

AGE	NON-NATIVE MALE	NON-NATIVE FEMALE	NATIVE MALE	NATIVE FEMALE
1	317.	304.	57.	66.
2	527.	483.	89.	80.
3	504.	465.	63.	66.
4	357.	310.	49.	51.
5	255.	165.	48.	24.
6	309.	205.	41.	34.
7	296.	330.	34.	16.
8	380.	292.	27.	27.
9	334.	254.	34.	36.
10	248.	165.	18.	15.
11	211.	150.	25.	10.
12	133.	89.	14.	13.
13	100.	62.	15.	5.
14	152.	62.	17.	13.

TOTAL POPULATION [illegible]

ATIONS PHASE - TIME PERIOD 2

CHANGE IN PRIMARY MIGRATION	37.
CHANGE IN RESIDENT PRIMARY MIGRATION	30.
CHANGE IN SECONDARY PRIMARY MIGRATION	107.
TOTAL PRIMARY MIGRATION	37.
TOTAL SECONDARY MIGRATION	107.
SECONDARY EMPLOYMENT SUPPLY	164.
SECONDARY EMPLOYMENT DEMAND	271.

TOTAL MIGRATION BY AGE, RACE, & SEX

AGE	NON-NATIVE		NATIVE	
	MALE	FEMALE	MALE	FEMALE
1	46.	46.	0.	0.
2	29.	29.	0.	0.
3	27.	27.	0.	0.
4	27.	24.	0.	0.
5	15.	13.	0.	0.
6	31.	26.	0.	0.
7	39.	33.	0.	0.
8	12.	10.	0.	0.
9	11.	9.	0.	0.
10	5.	4.	0.	0.
11	5.	4.	0.	0.
12	3.	2.	0.	0.
13	2.	1.	0.	0.
14	1.	1.	0.	0.

TOTAL MIGRATION 482.

AL - TIME PERIOD 2

TOTAL POPULATION BY AGE, RACE, SEX

AGE	NON-NATIVE		NATIVE	
	MALE	FEMALE	MALE	FEMALE
1	686.	669.	64.	75.
2	590.	555.	61.	68.
3	847.	769.	90.	82.
4	754.	647.	53.	60.
5	521.	442.	48.	34.
6	546.	418.	43.	25.
7	649.	509.	42.	33.
8	464.	487.	35.	18.
9	534.	3%6.	2?.	28.
10	415.	306.	32.	28.
11	323.	216.	17.	11.
12	244.	171.	23.	10.
?3	141.	?4.	14.	12.
14	195.	109.	24.	15.

***************** POPULATION MODEL - TASK YAA********************

ELINE PHASE - TIME PERIOD 2

POPULATION BY AGE, RACE, & SEX

AGE	NON-NATIVE MALE	NON-NATIVE FEMALE	NATIVE MALE	NATIVE FEMALE
1	147.	431.	64.	73.
2	432.	397.	61.	68.
3	701.	524.	90.	82.
4	557.	516.	53.	60.
5	379.	330.	48.	34.
6	328.	261.	43.	25.
7	375.	337.	42.	33.
a	369.	423.	35.	18.
9	450.	336.	2?*	28.
10	357.	270.	32.	28.
11	265.	?85.	17.	11.
12	209.	150.	23.	10.
13	122.	84.	14.	12.
14	186.	102.	24.	15.

TOTAL POPULATION 10699.

VELOPMENT PHASE - TIME PERIOD 2

DIRECT PRIMARY MIGRATION 934*
SECONDARY EMPLOYMENT SUPPLY 349.
SECONDARY EMPLOYMENT DEMAND 640.
DIRECT SECONDARY MIGRATION 2?1 .
RESIDENT PRIMARY MIGRATION 684.
MIGRATION BY AGE, RACE, & SEX

AGE	NON-NATIVE MALE	NON-NATIVE FEMALE	NATIVE MALE	NATIVE FEMALE
1	193.	193.	0.	0.
2	12?.	12?.	0.	0.
3	119.	119.	0.	0.
4	170.	107.	0.	0.
5	?27.	99.	0.	0.
6	187.	131.	0.	0.
7	234.	138.	0.	0.
8	83.	54.	0.	0.
9	73.	41.	0.	0.
10	53.	32.	0.	0.
11	53.	27.	0.	0.
12	32.	19.	0.	0.
13	17.	11.	0.	0.
14	8.	5.	0.	0.

TOTAL MIGRATION 2581.

ATIONS PHASE - TIME PERIOD 3

CHANGE IN PRIMARY MIGRATION	241.
CHANGE IN RESIDENT PRIMARY MIGRATION	199.
CHANGE IN SECONDARY PRIMARY MIGRATION	276.
TOTAL PRIMARY MIGRATION	270.
TOTAL SECONDARY MIGRATION	363.
SECONDARY EMPLOYMENT SUPPLY	421.
SECONDARY EMPLOYMENT DEMAND	697.

TOTAL MIGRATION BY AGE, RACE, & SEX

AGE	NON-NATIVE		NATIVE	
	MALE	FEMALE	MALE	FEMALE
1	179.	179.	0.	0.
2	138.	138.	0.	0.
3	117.	117.	0.	0.
4	116.	106.	0.	0.
5	74.	64.	0.	o*
6	119.	101.	0.	0.
7	160.	136.	0.	0.
8	73.	62.	0.	0.
9	46.	3?.	0.	0.
10	25.	21.	0.	0.
11	20.	17.	0.	0.
12	13.	11.	0.	0.
13	7.	6.	0.	0.
14	7.	6.	0.	0.

TOTAL MIGRATION 2100.

L - TIME PERIOD 3

TOTAL POPULATION BY AGE, RACE, SEX

AGE	NON-NATIVE		NATIVE	
	MALE	FEMALE	MALE	FEMALE
1	912.	885.	74.	87.
2	816.	768.	69.	?7.
3	716.	653.	62.	69.
4	922.	828.	76.	?4.
5	705.	645.	52.	40.
6	635.	662.	43.	35.
7	592.	609.	43.	24.
8	595.	527.	43.	39.
9	495.	540.	38.	19.
10	520.	389.	28.	21.
11	410.	326.	30.	22.
12	282.	201.	16.	11.
13	205.	151.	23.	9.
14	236.	141.	28.	23.

TOTAL POPULATION 14564

**************** POPULATION MODEL - TASK 9AA********** ** **** ***

ELINE PHASE - TIME PERIOD 3

POPULATION BY AGE, RACE, & SEX

AGE	NON-NATIVE MALE	NON-NATIVE FEMALE	NATIVE MALE	NATIVE FEMALE
1	734.	707.	74.	87.
2	678.	630.	69.	77.
3	5?9,	536.	62.	69.
4	806.	?22.	76.	74.
5	630.	581.	52.	40.
6	516.	561.	43.	35.
7	433.	473.	43.	24.
8	522.	465.	43.	39.
9	448.	500.	38.	19.
10	495.	367.	28.	21.
11	390.	309.	30.	22.
12	26?.	189.	16.	11.
13	t??.	145.	23.	9.
14	230.	155.	28.	23.

TOTAL POPULATION 1441$4*

ELOPMENT PHASE - TIME PERIOD 3

DIRECT PRIMARY MIGRATION 0.
SECONDARY EMPLOYMENT SUPPLY 234.
SECONDARY EMPLOYMENT DEMAND 0.
DIRECT SECONDARY MIGRATION 0.
RESIDENT PRIMARY MIGRATION 0.
MIGRATION BY AGE, RACE, & SEX

AGE	NON-NATIVE MALE	NON-NATIVE FEMALE	NATIVE MALE	NATIVE FEMALE
1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
5	0.	0.	0.	0.
5	0.	o*	0.	0.
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.
11	0.	0.	0.	0.
12	0.	0.	0.	0.
13	0.	0.	0.	0.
14	0.	0.	0.	0.

TOTAL MIGRATION 0.

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