The Economic and Community Impacts of Closing Hanford's N Reactor and Nuclear Materials Production Facilities

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(a) Battelle, Human Affairs Research Centers

ABSTRACT

This study discusses the negative economic impact on local cities and counties and the State of Washington of a permanent closure of nuclear materials production at the Hanford Site, located in the southeastern part of the state. The loss of nuclear materials production, the largest and most important of the five Department of Energy (DOE) missions at Hanford, could occur if Hanford's N Reactor is permanently closed and not replaced. The study provides estimates of statewide and local losses in jobs, income, and purchases from the private sector caused by such an event; it forecasts impacts on state and local government finances; and it describes certain local community and social impacts in the Tri-Cities (Richland, Kennewick, and Pasco) and surrounding communities.

EXECUTIVE SUMMARY

This study discusses the negative economic impact on local cities and counties and the State of Washington of a permanent closure of nuclear materials production at the Hanford Site, located in the southeastern part of the state. The loss of nuclear materials production, the largest and most important of the five Department of Energy (DOE) missions at Hanford, could occur if Hanford's N Reactor is permanently closed and not replaced. The study provides estimates of statewide and local losses in jobs, income, and purchases from the private sector caused by such an event; it forecasts impacts on state and local government finances; and it describes certain local community and social impacts in the Tri-Cities (Richland, Kennewick, and Pasco) and surrounding communities.

The study was performed because the Department of Energy, Richland Operations Office (DOE-RL) was concerned that the mutually-dependent Hanford Site operations and their role in the economies of the Tri-Cities and the State of Washington are not well understood by the state and federal policy makers or the general public. DOE-RL accordingly requested that Pacific Northwest Laboratory (PNL) conduct an in-depth, independent analysis of the state and local economic impact of Hanford, with particular emphasis on the effects on the local and state economies of the key nuclear materials production mission. The study was intended as a source of general economic information concerning the Hanford Site and as a source of data for public officials and the general public in developing strategies for coping with potential impacts of halting nuclear materials production at Hanford.

To ensure that the study be as independent and objective as possible the PNL study team sought a wide variety of viewpoints and expertise. For example, in the area of economic impact, the study used the two most widely accepted public sector models of Washington's economy--the Washington Economic Model, operated by the staff of the Washington Department of Revenue, and the Washington Input-Output Model, created and operated by Professor Philip Bourque of the University of Washington. The study team spent many hours interacting with the creators and operators of these models to assure that the statewide economic impact of Hanford was objectively estimated. The Hanford contractors were consulted extensively in determining a credible and logical closure scenario for nuclear materials production. A large number of local government and community leaders were contacted and lent their expertise to the study of local impacts, as did the staffs of key departments of state government. Finally, the report was peer-reviewed by a team of professional economists representing the business community of the State of Washington and the state and national academic communities, to ensure its objectivity, quality, usefulness, and credibility.

CURRENT SITUATION

Since January 1987, the N Reactor has been closed to allow the installation of about \$50 million in safety enhancements, designated the Safety Enhancement Program (SEP). The enhancements were recommended by technical experts who reviewed the reactor's safety after the accident at the Soviet Union's Chernobyl power plant. The announced schedule for restarting the N Reactor was originally July 1987. However, the National Academy of Sciences, which is currently performing a comprehensive study of the plant and the safety enhancements, is not

expected to complete its report until September 1987. It is possible that the reactor will not restart until after that report is issued. It is also possible that opponents of reactor restart will succeed in their efforts to have restart delayed until after an environmental impact statement is written to include issues in addition to the SEP, a process that would take up to two years and lead to some reductions in employment. Finally, it is possible that Congress will intervene. The current situation at Hanford is developing during a national debate over the need for additional nuclear materials and replacements for the existing production facilities at Hanford and at the Savannah River Plant in South Carolina. Meanwhile, the Safety Enhancements Program, restart, and other activities are expected to employ through November virtually the entire regular operating staff at the N reactor.

Because the estimated economic impacts of potential changes in Hanford programs and missions vary according to the scenario discussed, it is worth noting that this study estimates the economic impacts of one credible permanent closure scenario, but does not deal with other, potentially credible, scenarios.

The study is viewed as the initial step in a continuing economic assessment of Hanford programs. It does not deal with potentially favorable economic impacts of replacements for the current nuclear materials production facilities. Conversely, the study does not examine the negative, but harder-to-measure, political and economic effects of phasing out nuclear materials production on remaining Hanford programs. Loss of nuclear materials production could adversely affect support for remaining programs at Hanford, while at the same time forcing these programs to bear a higher proportion of fixed costs of the site, thus rendering them too costly to maintain. The impacts of closing nuclear materials production could easily be higher than shown in the body of the report and summarized below.

CLOSURE SCENARIO

The scenario examined in this study, i.e., permanently closing N Reactor and phasing out nuclear materials production at Hanford, was developed with participation and cooperation of the Hanford contractors and Department of Energy (DOE) program managers. It assumes an orderly and time-phased closure of all defense production facilities at Hanford based on a decision date of July 1, 1987,^(a) and reflects both the future demand for Hanford-produced nuclear material and health and safety and environmental requirements for permanently closing these facilities. Key milestones in this hypothetical process are:

- July 1, 1987 - Decision is made to terminate nuclear materials production at Hanford. No other missions are assumed to be affected.
- 1987 - Closure of N Reactor and cancellation of the Process Facility Modification Project at the Plutonium-Uranium Extraction (PUREX) facility. Layoffs and cleanup begin at the N Reactor.

(a) Short delays in the decision have little or no effect on the magnitude of the impact, but only affect its timing.

- 1990 - N Reactor cleanup is completed to a monitoring and surveillance level. About 60 personnel remain indefinitely to perform maintenance and surveillance activities at the facility.
- 1990 to 1996 - PUREX and the Plutonium Finishing Plant (PFP) complete processing of existing inventories of weapons-grade irradiated fuel and plutonium scrap, followed by fuel-grade materials left over from the 1972 to 1983 period when N Reactor irradiated fuel to greater than weapons grade and produced steam for electric power. Each facility is then cleaned up to a monitoring and surveillance level. Layoffs continue throughout as operations are phased out.
- 1996 - PUREX and PFP cleanup activities are complete. About 230 personnel remain indefinitely to perform maintenance and surveillance activities at these facilities.

This scenario assumes no spillover effects on other programs at Hanford, i.e.: 1) that the loss of nuclear materials production is managed so that there are no higher fixed costs for remaining missions, and 2) that there is no loss of support for these other missions. These assumptions are questionable; however, it is extremely difficult to quantify the probable spillover effects. Consequently, the closure scenario, which does not include spillover effects, is, if anything, less severe than what might really happen.^(a) Table ES.1 shows the cumulative direct losses in Hanford jobs, payroll, and procurements stemming from phasing out nuclear materials production, according to the closure scenario. The 1986 levels of these variables are also shown for reference.

The losses represent slightly over 40% of all Hanford employment and payrolls, and about 22% of all Hanford procurements. The Washington Public Power Supply System's Hanford Generating Plant, which uses byproduct steam of the N Reactor to generate electric power, would also have to close, resulting in the loss of nonfirm generating capacity to the Pacific Northwest power system worth about \$45 to \$47 million per year to the power system over the next 5 to 6 years.

ECONOMIC IMPACTS

The direct losses of jobs, payroll, and procurements shown in Table ES.1 would create significant economic impacts on the Tri-Cities area and the State of Washington. Hanford currently employs more Washingtonians than the entire primary aluminum industry and almost as many as the pulp and paper industry. It supports about 36,000 jobs statewide. The negative impact of the closure scenario perhaps can best be summarized via the total job and income impacts in 1990 and 1996 for the state and for Benton, Franklin, and Yakima counties, as shown in Table ES.2. These total impacts are composed of three parts: losses of jobs and income at Hanford employers (the "direct" effect); losses of jobs and income created in the state and

(a) As a "worst case," the only people who would be left at the Hanford Site would be those necessary for long-term maintenance and surveillance both of closed facilities and remaining nuclear and hazardous wastes--probably less than one quarter the present level of employment.

TABLE ES.1. Current Levels and Cumulative Loss of Direct Hanford Jobs, Payrolls, and Procurements from Loss of Nuclear Materials Production

<u>Current Levels (September 1986)</u>	<u>Direct Jobs</u>	<u>Annual Direct Payrolls (millions of 1986 dollars)</u>	<u>Annual Washington State Direct Procurements (millions of 1986 dollars)</u>
Nuclear Materials Production	6,300	\$213.4	\$ 33.5
All Hanford	14,500	505.4	151.2
<u>Cumulative Losses</u>			
1987	1,200	40.7	6.4
1988	3,200	109.7	17.2
1989	3,200	112.9	17.7
1990	3,500	120.2	18.9
1991	3,500	122.7	19.3
1992	3,700	128.0	20.1
1993	4,300	147.8	23.2
1994	4,500	155.8	24.5
1995	5,200	178.5	28.0
1996	6,000	203.3	31.9
1997	6,000	203.3	31.9

TABLE ES.2. Economic Impact of Loss of Hanford Nuclear Materials Production

<u>Year</u>	<u>Impact</u>	<u>Washington</u>	<u>Benton, Franklin, and Yakima Counties</u>
1990	Jobs Lost(a)		
	Direct	3,500	3,500
	Indirect and induced	3,900	3,300
	Total	7,400	6,800
	Ratio of total/direct	2.13	1.98
	Annual Incomes Lost (million 1986 \$)		
	Direct	\$120.2	\$120.2
	Indirect and induced	131.3	119.3
	Total	251.5	239.5
	Ratio of total/direct	2.09	1.99
1996	Jobs Lost(a)		
	Direct	6,000	6,000
	Indirect and induced	7,800	6,500
	Total	13,800	12,500
	Ratio of total/direct	2.31	2.10
	Annual Incomes Lost (million 1986 \$)		
	Direct	\$203.3	\$203.3
	Indirect and induced	277.2	247.7
	Total	480.5	451.0
	Ratio of total/direct	2.36	2.22

(a) Rounded to nearest 100 workers. Ratios based on unrounded values.

local economies by procurements of Hanford operations of materials and services in Washington State (the "indirect" effect); and losses of jobs and income created in the state and local economies by other Washingtonians spending and respending Hanford payroll and procurement dollars (the "induced" effect). The years 1990 and 1996 are reported because these are the years when the respective closures of the N Reactor and the PUREX/PFP facilities are completed in the closure scenario.

The values shown in Table ES.2 were estimated by reconciling the results of three recognized regional economic forecasting techniques--econometric, input-output, and static economic base techniques. For example, both the State of Washington Economic Forecasting Council's WASHMOD economic model and the University of Washington's 1982 Input-Output Model (modified specifically for this study with the assistance of the model authors) were used to estimate statewide economic impacts. Table ES.2 shows that, in the closure scenario, for every direct job lost at Hanford in 1990 about 1.1 jobs (3,900/3,500) are lost at other Washington employers, for a total of 7,400 jobs lost. This implies a ratio of 2.1 total jobs lost per direct job lost. Some 6,800 of these total jobs are lost in the three-county area. The ratio of total to direct jobs lost increases over time from 2.1 to 2.3 because the effects of earlier losses of Hanford direct income and procurements have a more complete chance to play themselves out. State unemployment insurance benefits may slow the near-term pace of economic impact, but are not expected to alter its eventual level. By the end of 1996, the state's average employment and annual income are 13,800 jobs and \$480.5 million lower as a result of losing nuclear materials production. About 12,500 of these jobs and \$451 million would be lost in the three-county area. The Benton and Franklin County portions of these losses represent 18% of 1986 employment and 21% of 1986 income in the two counties.

FISCAL IMPACTS

State and local governments feel the economic losses, both in lost revenues and effects on expenditures for their various programs. The study team contacted the State of Washington's revenue forecasters and the planning officers of the relevant local jurisdictions to estimate these fiscal impacts in the years 1990 and 1997. The incremental impacts for those years are summarized in Table ES.3. Local impacts are concentrated in the Tri-Cities. Although there is considerable uncertainty concerning exact figures, some of the local jurisdictions believed that they would see up to a 10% drop in the value of their property tax base, comparable in size to the effect felt in the area after the stopping of construction on the Washington Public Power Supply System nuclear plants WNP-4 and WNP-1 at Hanford in 1982. Other data suggest the drop in property values could be greater.

COMMUNITY IMPACTS

The loss of Hanford employees and dollars also means loss of trade to local business, and perhaps, loss of some additional businesses. The loss of nuclear materials production workers, income, and purchases can be expected to result in additional market pressure on a local service economy that already has been put under stress by the post-WPPSS construction downturn. This report discusses the losses that might be sustained by the banking sector and Tri-Cities hospitals, two of the locally-focused sectors likely to be adversely affected.

TABLE ES.3. Effects of Losing Nuclear Materials Production on Annual State and Local Government Revenues and Expenditures in 1990 and 1997 (millions of 1986 dollars)

	<u>State</u>	<u>Local</u>
<u>Revenues</u>		
1990	-\$14.6(a)	-\$4.0
1997	-33.0	-6.7
<u>Expenditures</u>		
1990	3.4(b)	(c)
1997	4.0(b)	(c)

- (a) For comparison, a total of \$17.7 million is lost during the 1988 to 1989 biennium.
- (b) Combined value for schools (decrease), unemployment compensation (increase), jobs training (increase), and public assistance (increase).
- (c) Local governments were not able to say whether they would raise tax rates, reduce expenditures, or both.

Loss of trade will likely mean about a 10% loss in deposits at local financial institutions, restrictions on credit availability and closure or merging of economically marginal institutions or branches. The three Tri-Cities hospitals would be expected to experience at least a 7% to 10% drop in admissions, depending on the year involved. This may not result in closure of any major departments or any of the hospitals, but would exacerbate already-low occupancy rates and would make medical care in the Tri-Cities more expensive. Also, the losses of income and population would be expected to further reduce wealth committed to local real estate markets. Among the effects would be increasing vacancy rates in rental units, additional downward pressure on property values, and increased time required to complete most sales of homes and businesses. Finally, the social impact could be significant if closure of nuclear materials production has serious adverse impacts on the local United Way campaign and staffing. Many social programs in the area depend heavily on United Way, which in turn depends heavily on Hanford support. Many volunteer, recreational, social, and arts institutions in several of the communities near Hanford depend heavily on Hanford contractor employees and managers. Some of these will be adversely affected by significant losses of Hanford-related people.

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1.0 INTRODUCTION

This study calculates the importance of the U.S. Department of Energy's (DOE's) Hanford Site operations, and the site's major mission, nuclear materials production, to the economies of the surrounding communities and the state of Washington. The activities of the federal contractors at Hanford can be categorized into five major missions: 1) nuclear materials production to meet the nation's defense needs; 2) management of defense-related nuclear waste; 3) characterization of the Hanford Site for possible permanent disposal of civilian spent nuclear fuel and high-level waste; 4) nuclear energy research and development; and 5) a broad array of other technological, environmental, and systems research activities. This study focuses on loss of the nuclear materials production mission because of concerns expressed in public policy forums and the news media concerning the safety and desirability of continuing to operate the site's 23-year-old N Reactor, a key facility in that mission. Although the Department of Energy has announced that it intends to operate the N Reactor until the middle 1990's, local and statewide concerns about the potential economic and community impacts of an earlier closure warrant an in-depth analysis. DOE Richland Operations Office accordingly asked Pacific Northwest Laboratory to conduct this study. The study is intended for use both as a source of general economic information concerning the Hanford Site and as a source of data for public officials and the general public to use in developing strategies for coping with potential impacts of closing nuclear materials production at Hanford.

Since January 1987, the N Reactor has been closed to allow the installation of about \$50 million in safety enhancements. The enhancements were recommended by technical experts who reviewed the reactor's safety after the accident at the Soviet Union's Chernobyl power plant. The announced schedule for restarting the N Reactor was originally July 1987. However, the National Academy of Sciences, which is currently performing a comprehensive study of the plant and the safety upgrade, is not expected to deliver its report until September 1987. It is possible that the reactor will not restart until after that report is issued. It is also possible that opponents of reactor restart will succeed in their efforts to have an environmental impact statement written to include issues in addition to the current Safety Enhancements Program, a process that would take up to two years and lead to some reductions in employment.

Meanwhile, the Safety Enhancements Program and restart activities are expected to employ through November virtually the entire regular operating staff at the N reactor. The current situation at Hanford is developing during a national debate over the need for nuclear materials and replacements for the existing production facilities at Hanford and at the Savannah River Plant in South Carolina.

Note that this report discusses the impact of permanently closing down the N Reactor and phasing out nuclear materials production, not other conceivable scenarios such as a temporary delay in resuming operations at the N Reactor. A decision to temporarily delay operations for less than a year might not have a major impact on N Reactor employment; nor would it have any impact on activities or employment at the related Plutonium-Uranium Extraction (PUREX) and Plutonium Finishing Plant (PFP) facilities. On the other hand, an extended period of suspension of operations, particularly of unknown length, could call into question the viability of

resuming such operations. This report does not address how long such a closure might last before it would result in permanent closure of the N Reactor.

Also note that the scenario discussed differs markedly from past and present long-term plans for nuclear materials production at Hanford. Those plans have generally presupposed a replacement for the N Reactor, so that negative economic impacts would not necessarily occur after its closure. If N Reactor is closed early, but later replaced as planned in the mid-1990s, the near-term negative net effect on the Tri-Cities area and Hanford economies could be as high as the direct and secondary economic impacts of the first half of the closure scenario (up to about 1990) discussed in this report.^(a) However, if N Reactor is not replaced, the full economic impacts described here would occur.

The study was organized as follows. DOE Richland Operations Office program managers and contractor management staff were asked to supply current economic data on Hanford operations, including nuclear materials production. These data included employment, payroll, procurement and budgetary data, tax payments, and geographical distribution of employees and procurements. Chapter 2.0 summarizes these data in order to provide a current picture of Hanford's overall role in the economies of the State of Washington, the Tri-Cities (Richland, Kennewick, and Pasco), and surrounding communities. The DOE and contractors were next asked to supply information on two hypothetical N Reactor closure scenarios. The first scenario was one in which only nuclear materials production at Hanford is affected. The second reflected Hanford Site management concerns that the unavoidable, fixed costs of site services at the Hanford reservation might jeopardize remaining research and waste management programs after the loss of N Reactor and associated programs.

As is discussed in Section 3.2, DOE and its contractors were not able to quantify this second scenario despite considerable effort; however, the more moderate closure scenario evaluated in this report is clearly not a worst possible case. The worst case (that is, the case that would result in the largest negative economic impact) may be the phased loss over time of all but a small residual workforce required for indefinite maintenance and surveillance of closed Hanford facilities and remaining nuclear and hazardous wastes.

Chapter 3.0 of the report describes nuclear materials production at Hanford and the direct effects of N Reactor closure on Hanford Site employment, payrolls, tax payments, and procurements. Chapter 4.0 then discusses the statewide and local economic effects of N Reactor closure; Chapter 5.0 discusses the effects on state and local government finances; and Chapter 6.0 discusses various identifiable community and social effects. These local effects include the impact on the economic viability of banks, hospitals, and other community institutions of loss of business volume, the impact of a reduced tax base and reduced population on property values and tax rates; impacts on community organizations from loss of funding, membership, and officers; and other community effects. The report concludes with technical appendices that describe Hanford's nuclear materials production facilities in more detail and discuss the details of the assessment methodology used to evaluate the economic impacts.

(a) Depending on the timing of construction activity, these negative impacts could be partially mitigated by increased construction and operations employment related to the new facilities.

2.0 HANFORD'S ECONOMIC ROLE IN THE STATE OF WASHINGTON

Hanford, a major DOE site, has considerable economic impact on Washington State, despite its relatively isolated location in the southeastern part of the state. The Hanford Site had an aggregate budget of just over \$1 billion during FY 1986 and employed almost 14,500 persons at the end of September 1986 (Table 2.1). These employees earn an annual total of about \$505 million in salaries, a large portion of which is spent locally and in the state's major metropolitan areas. In addition, the Department of Energy and its Hanford Site contractors paid a total of about \$12.5 million in sales, use, and business and occupation taxes to the the State of Washington during FY 1986, a source of revenue the same order of magnitude as the state's collections of estate or timber taxes. Hanford employees paid an estimated \$30 million in taxes and fees during FY 1986 to the state. Both the Hanford Site employers and employees were major sources of local government income, contributing in FY 1986 an estimated \$0.9 million and \$22.1 million, respectively, to the tax collections of local government jurisdictions. Finally, staff expenditures for insured medical care play a significant role in the local health care sector.

TABLE 2.1. Hanford Budget, Employment, Payroll, Procurement, and Taxes, FY 1986 (dollars in millions)

Budget	\$1,010
Employment	14,491(a)
Payroll	\$505(b)
Procurements in Washington State	\$151
State taxes and fees paid	
DOE and Hanford Contractors	\$12.5
Employees (estimate)	<u>\$30.0</u>
Total	\$42.5
Local taxes and fees paid	
DOE and Hanford Contractors	\$ 0.9
Employees (estimate)	<u>\$22.1</u>
Total	\$23.0

(a) September 1986.

(b) September 1986, converted to annual basis.

Figure 2.1 is a bar chart that shows the distribution of Hanford employment by mission and job classification. About 6,300 workers, or 43% of all workers at Hanford, are directly or indirectly employed in nuclear materials production. When the 2,900 defense waste management workers are added, more than 63% are involved in the Hanford Site primary defense mission. The Basalt Waste Isolation Project, which involves the geological and environmental characterization and testing of Hanford as a possible future repository site for the nation's civilian nuclear spent fuel and high-level waste, employs about 1,250 workers, or 9% all workers at the Hanford Site. Nuclear energy research and development, principally the Fast

FIGURE 2.1. Hanford Employment by Mission and Classification of Employee

Flux Test Facility and the Space Reactor Program, employs about 11%, and the remaining 17% (2,500 workers) are employed on a wide variety of miscellaneous technology, research and development, and environmental programs.

Overall, the largest single job classification at Hanford is nuclear production-related blue collar workers (including guards and maintenance staff), who comprise about 27% of the workforce (see Figure 2.2). Scientists and engineers closely follow, with about 25% of the total. Other (nonscientist) executives, administrative, and professional workers comprise 23% of the workforce; office and clerical workers comprise 15%; technicians comprise 5%; and supervisory scientists and engineers comprise a little less than 5%. These percentages vary from program to program (see Figure 2.3). For example, nuclear materials production has almost 58% of all Hanford production related workers, who account for 36% of that mission's employment. About 18% are scientists or engineers. By contrast, the Basalt Waste Isolation Project is currently dominated by scientists and engineers, who account for 50% of total employment in that mission. Thus, employment gains or losses of any particular mission at Hanford may imply that a different mix of people would be hired or laid off than may be required by other missions at the site.

The employment at Hanford plays a major direct role in the state and local economies, particularly in certain industries. This is illustrated in Table 2.2. Hanford employment accounts directly for almost 26% of total nonagricultural employment in Benton and Franklin

FIGURE 2.2. Percentage Distribution of Hanford Workers by Classification of Worker

Counties and 0.8% of all statewide jobs. Hanford employs more Washingtonians than the entire primary aluminum industry, and almost as many as the pulp and paper industry. As can be seen in Table 2.2, it accounts for over two-thirds of Washington employment in chemicals and allied products, or about 2.6% of all Washington manufacturing jobs. The science and research contractors at Hanford account for 1.6% of all state services employment. Hanford's 3,700 scientists and engineers represent a group of professional workers approximately the size of the combined faculty and scientists of the University of Washington and twice the size of the combined faculty and scientists of Washington State University.

Hanford employees' relatively high salaries give them an importance to the state and local economies out of proportion to their numbers. This is illustrated in Table 2.3. Hanford Site operations directly account for an estimated 33% of the dollars earned in Benton and Franklin Counties in 1986^(a) and 1.1% of all dollars earned in Washington State industries.

Table 2.4 shows that Hanford is even more important to the state and local economies once the impacts of Hanford on the service sector are taken into account. On average, each of the 14,500 Hanford jobs supports about 1.2 additional jobs in the local service sector (about 2.2 total jobs) and about 1.5 additional jobs in the state's service sector (about 2.5 total jobs). Similarly, each dollar of Hanford income supports about 2.1 dollars of total local

(a) Based on September-October 1986 employment levels and average wages by sector.

Nuclear Materials Production

Defense Waste

Nuclear Energy R&D

Basalt Waste Isolation Project

Other

- Supervisory Scientists/Engineers
- Scientist/engineers
- Other Professional and Administrative
- Production-Related
- Technicians
- Office, Clerical, and Related

FIGURE 2.3. Percentage Distribution of Hanford Workers by Mission and Classification

TABLE 2.2. Employment by Industry at Hanford Relative to the Local and State Economies, September 1986

Industry	Hanford Employment	Richland-Kennewick-Pasco (Benton & Franklin Counties)		State of Washington	
		Total Employees (September) (a)	Hanford as Percent of Total	Total Employees (b)	Hanford as Percent of Total
Manufacturing					
Food and kindred products	0	2,630	0	34,600	0
Printing and publishing	0	340	0	17,500	0
Chemicals and allied products	7,882(c)	8,120	97.1	11,500	68.5
Primary and fabricated metal products	0	370	0	21,700	0
Other manufacturing	0	630	0	219,700	0
Total manufacturing	7,882(c)	12,090	65.2	305,000	2.6
Contract construction	0	3,410	0	90,600	0
Trans., commun., public utilities	0	2,050	0	97,600	0
Wholesale and retail trade	0	11,650	0	449,400	0
Finance, insurance, real estate	0	1,590	0	106,000	0
Services and mining	6,279(d)	15,320	41.0	402,200	1.6
Business services	6,279(d)	7,050	89.1	NA	NA
Government					
Federal civilian	330(e)	1,020	32.4	69,500	0.5
State and local	0	8,730	0	273,800	0
Total employment	14,491	55,860	25.9%	1,794,100	0.8%

(a) Source: Washington State Labor Area Summaries, 1(11), November 1986.

(b) Source: Washington Labor Market 10(11), November 1986.

(c) Rockwell and UNC.

(d) PNL, Westinghouse, Boeing Computer Services, HEHF, Kaiser, J. A. Jones.

(e) DOE Richland Operations

TABLE 2.3. Earning by Industry at Hanford Relative to the Local and State Economies 1986 (million of dollars)

Industry	Hanford	Richland-Kennewick-Pasco MSA (Benton and Franklin Counties) (a)		State of Washington (a)	Hanford as Percent of Total
		Total MSA	Hanford as Percent of Total		
Manufacturing					
Food and kindred products	\$ 0.0	\$367	72.0	\$ 734	0.0
Printing and publishing	0.0			407	0.0
Chemicals and allied products	264.4			440	60.0
Primary and fabricated metal products	0.0	27	0.0	788	0.0
Other manufacturing	0.0			7,406	0.0
Subtotal	264.4(b)	394	67.1	9,775	2.7
Contract construction	0.0	123	0.0	2,959	0.0
Trans., commun., public utilities	0.0	70	0.0	3,253	0.0
Wholesale and retail trade	0.0	159	0.0	7,567	0.0
Finance, insurance, real estate	0.0	27	0.0	2,562	0.0
Services and mining	229.3(c)	420	54.6	8,992	2.6
Business services	229.3(c)	NA	NA	1,615	14.2
Government					
Federal civilian	11.7(d)	36	32.5	1,997	0.6
State and local	0.0	198	0.0	5,785	0.0
Agriculture	0.0	100	0.0	1,305	0.0
Military	0.0	6	0.0	1,241	0.0
Total payroll	\$505.4	\$1,531	33.0%	\$47,051	1.1%

(a) Preliminary estimate based on U.S. Department of Commerce, Bureau of Economic Analysis estimates of 1984 earnings by industry and ratios of earnings by industry for 1986 versus 1984 from Washington State Department of Revenue (1986). MSA means Metropolitan Statistical Area.

(b) Rockwell and UNC, based on September 30, 1986 employment.

(c) PNL, Westinghouse, Boeing Computer Services, HEHF, Kaiser, J. A. Jones, based on September 30, 1986 employment.

(d) DOE Richland Operations, based on September 30, 1986 employment.

TABLE 2.4. Employment and Income Dependent on Hanford, 1986

	Hanford Related		Total		Hanford as % of Total	
	Jobs (thousand)	Income (million 1986 \$)	Jobs (thousands)	Income (million 1986 \$)	Jobs %	Income %
State of Washington	36.2	\$1,213	2002.2	\$63,849	1.8	1.9
Benton and Franklin Counties	31.9	1,061	52.1	1,910	51.3	55.5

incomes and about 2.4 dollars of total statewide incomes. Thus, Hanford supports about 36,000 jobs in Washington, or 1.8% of all statewide employment, and about \$1.2 billion, or 1.9%, of all statewide income. In Benton and Franklin Counties, Hanford directly and indirectly accounts for over 50% of all jobs and 55% of all income.

Table 2.5 and Figure 2.4 show the estimated distribution of the direct employment and payrolls of Hanford Site employees by residence based on November 1, 1987 postal records. About 92% live in the Richland-Kennewick-Pasco metropolitan statistical area (consisting of Benton and Franklin Counties), 80% live in one of the Tri-Cities (Richland, Kennewick, or

TABLE 2.5. Hanford Site Employees and Estimated Annual Payroll and Percentage Distribution by Residence, November 1, 1986

Richland-Kennewick-Pasco MSA, Benton and Franklin Counties	Employees ^(a)	Estimated Payroll (thousands)	Percent of Total
Richland	6,661	\$229,662	45.4
Kennewick	4,067	140,105	27.7
Pasco ^(b)	1,102	37,819	7.5
Subtotal	11,830	407,586	80.6
West Richland	852	29,418	5.8
Benton City	605	20,782	4.1
Prosser	199	6,924	1.4
Other - Franklin or Benton Counties	24	824	0.2
Total	13,510	465,534	92.1
Yakima County			
Grandview	147	4,997	1.0
Sunnyside	189	6,467	1.3
Yakima	391	13,022	2.6
Other - Yakima County	194	6,409	1.3
Total	921	30,895	6.1
Other Locations	247	9,108	1.8
Grand total	14,652 ^(c)	\$505,447	100.0%

(a) Includes J. A. Jones employment of 774 allocated proportionately.

(b) Including West Pasco, Riverview areas.

(c) Total differs by 161 persons from the September 30, 1986 employment figure used elsewhere in this section.

Sources: Calculated from data supplied by DOE and Hanford contractors.

FIGURE 2.4. Hanford Reservation and Surrounding Communities, Showing Distribution of Hanford Employees

Pasco) and over 45% live in Richland, the nearest city to the site. About 6% live in the Yakima Valley and 1.8% in other Washington locations (mainly Grant and Adams Counties) and other states (mainly Oregon).

Table 2.6 describes the 1986 Hanford procurements from Washington industries and the overall geographic distribution of Hanford procurements. Nearly \$151 million, or 47% of all procurements, are made initially through Washington firms. At least 13% of Hanford orders are filled by Tri-Cities firms. In many cases, these procurements only result in retail and wholesale markups; however, a significant portion of all Hanford orders, \$6.0 million, are placed directly to Washington manufacturers. The contractors spent nearly \$22 million on electricity and other utilities in 1986, ordered nearly \$19 million in business services, and

TABLE 2.6. Hanford Procurements by Location and Hanford Procurements Within Washington by Industry, Fiscal Year 1986

	Millions of Dollars	Percent of Total
Hanford by location		
Total procurements	\$321	100.0
State of Washington	151	47.0
Tri-Cities	42	13.1
Seattle-Bellevue	28	8.7
Olympia	8	2.5
Spokane	8	2.5
Yakima	5	1.6
Other (a)	61	19.0
Out of State	170	53.0

	Thousands of Dollars	Percent of Total
Washington by industry		
Total	\$151,152	100.0
Construction	18,342	12.1
Manufacturing (by SIC code)	6,025	4.0
20 Food and kindred products	0	0
21 Tobacco	0	0
22 Textiles	5	(b)
23 Apparel	6	(b)
24 Lumber and wood products	67	(b)
25 Furniture and fixtures	0	(b)
26 Pulp and paper	231	0.2
27 Printing and publishing	434	0.3
28 Chemicals	689	0.5
29 Petroleum	1,163	0.8
30 Rubber and misc. plastics	218	0.1
31 Leather and leather products	0	0.0
32 Stone, clay, glass, and concrete products	303	0.2
33 Ferrous and nonferrous metals	66	(b)
34 Fabricated metal products	726	0.5
35 Machinery, excluding electric	1,220	0.8
36 Electrical machinery	540	0.4
37 Transportation equipment	2	(b)
38 Measuring, analyzing instruments	407	0.3
39 Misc. manufacturing	14	(b)
Trans., commun., public utilities	21,766	14.4
Wholesale and retail trade	70,545	46.7
Services	18,658	12.3
Government (mostly grants)	15,751	10.4

(a) Includes \$12.7 million in BPA and utility electricity sales to Hanford and \$18.3 million in construction subcontracts not shown by location.

(b) Less than 0.05%.

Sources: Calculated from data supplied by DOE and Hanford contractors.

spent \$73 million with Washington retailers and wholesalers. Finally, DOE and its contractors provided about \$16 million (mainly in grants) to local governments and others for a variety of public purposes. This also added to Washington's economic activity.

Table 2.7 shows some of the estimated 1986 payments of taxes and fees by Hanford contractors and employees to units of state and local government in Washington State. Table 2.7 shows that Hanford contractors paid a total of \$12.5 million in FY 1986 in state taxes on their operations and purchases. In addition, based on the statewide ratios of sales and use taxes and other taxes to personal income, we estimate that Hanford employees paid about \$23.7 million in state sales and use taxes and \$6.3 million in other taxes and fees, respectively. In addition, they paid an estimated \$2.3 million to local governments in Benton,

TABLE 2.7. Estimated Payments of Selected Taxes and Fees to State and Local Government by Hanford Employers and Employees, Fiscal Year 1986

<u>Taxes and Fees</u>	<u>Thousands of Dollars Paid, FY 1986</u>
<u>State of Washington</u>	
Hanford employers	
Business and occupation taxes	\$5,912
Use taxes	<u>6,580</u>
Subtotal	\$12,492
Hanford employees	
Sales and use taxes (state share)	23,700
Other taxes and fees	<u>6,300</u>
Subtotal	30,000
Total to state	\$41,992
<u>Local Government Units</u>	
Hanford employers	
PL 81-874 funds to schools(a)	883
Hanford employees	
Sales and use taxes (local share)	2,300
Property taxes (all local jurisdictions)	18,600
Other taxes and fees	<u>1,200</u>
Subtotal	\$22,100
Total to local government units	\$22,983
Grand total	\$65,475

(a) Not paid by DOE or contractors. These funds are transferred to local school districts directly for students whose parents live or work on a government project. The funds shown are only for those students related to Hanford, and exclude employees at post offices, dams, military, etc.

Sources: DOE Richland Operations Office; State of Washington Department of Revenue (1986); Local Government Officials.

Franklin, and Yakima Counties in sales and use taxes, \$18.6 million in property taxes, and \$1.2 million in other taxes and fees to county, city, and special district governments in the three-county area.

3.0 CLOSING N REACTOR AND NUCLEAR MATERIALS PRODUCTION AT HANFORD

A brief description of nuclear materials production at Hanford is presented in Section 3.1 to provide a general understanding of the relevant facilities. Readers familiar with these facilities may wish to skip directly to Section 3.2, which presents the scenario for closing of N Reactor and related facilities and describes the direct economic effects on Hanford. Section 3.3 discusses the local areas where the direct effects of employment and payroll reduction will first be felt.

3.1 INTRODUCTION TO NUCLEAR MATERIALS PRODUCTION AT HANFORD

This section provides a short description of the history and major facilities involved in nuclear materials at Hanford. The descriptions were extracted from recent environmental impact statements for certain operations at these facilities and are intended to provide a layman's description of the history and the functions of various facilities involved in nuclear materials production. Appendix A discusses the individual facilities in more detail.

3.1.1 Mission History

In January 1943, the Hanford Site in southeastern Washington State was chosen by the Manhattan Engineer District of the Corps of Engineers for the construction of facilities to produce plutonium for the world's first nuclear weapons. In March of that year work was begun on three reactors, three chemical processing plants for recovering plutonium in the fuel, 64 underground waste storage tanks, fuel fabrication facilities and 4,300 homes in the community of Richland.

By late summer 1943, some 51,000 construction workers were living in a temporary construction camp near the townsite of Hanford, making it the fourth largest city in the State of Washington.

In September 1944, 18 months after the start of construction on the Site and 13 months after the start of construction on the first reactor--"B" Reactor went into operation, followed within a few months by "D" and "F" Reactors. In March 1945, just two years from inception, construction was completed at a total cost of about \$350 million.

In July 1945, Hanford plutonium was used in the world's first nuclear detonation at Alamogordo, New Mexico. In August, a bomb containing uranium manufactured at Oak Ridge, Tennessee, was dropped on Hiroshima, then one containing Hanford-produced plutonium was used at Nagasaki, and the war was over.

In 1946 E.I. duPont de Nemours & Company, which had built and operated the facility during World War II, asked to be released from its contract. The government then brought the General Electric Company to Hanford to take over as operating contractor.

The Atomic Energy Commission was established in 1947 to replace the Manhattan Engineer District and to give civilian control to the nation's nuclear complex. It soon was decided that more plutonium was needed and during the next eight years Hanford underwent a major

expansion program. About 28,000 workers--this time living on a campsite at North Richland--built five additional plutonium production reactors, two chemical processing plants for fuel reprocessing, and 81 additional underground waste storage tanks. Two thousand homes were added to the City of Richland.

Between 1959 and 1963, the N Reactor was built at a cost of \$198 million. Unlike the earlier eight production reactors, whose sole mission was the production of plutonium, N reactor also produced steam which could be used to generate electricity, making it the nation's only dual-purpose reactor.

In the period from 1963 to 1966, the Washington Public Power Supply System (WPPSS) built an 860 megawatt generating facility adjacent to N Reactor to utilize N Reactor steam. Since 1966, the WPPSS Hanford Generating Plant has produced more than 50 billion kilowatt hours of electricity.

The first defense nuclear materials were produced at Hanford in December 1944, when plutonium from the Hanford production reactors was first recovered and isolated by processing irradiated uranium in chemical processing plants (PUREX and REDOX). Recovery of plutonium for use in fabrication of nuclear weapons and other national defense activities continued through 1972. At that time, the backlog of spent fuel from closed Hanford production reactors had been processed and the PUREX Plant was placed in standby condition. The PUREX Plant was reactivated in November 1983 to process a backlog of spent fuel from N Reactor operation since 1972, to process fuel from current N Reactor operation, and, with the addition of the Process Facility Modifications (PFM) project, to process fuel from other DOE sources such as fuel from the Fast Flux Test Facility (FFTF), a sodium-cooled reactor that is part of the nuclear energy research and development mission at Hanford.

3.1.2 Nuclear Materials Production Facilities

The nuclear materials production facilities at Hanford comprise an integrated production process. The process begins with uranium fuel and other components that must be formed into fuel rods, and finishes with shipments of uranium oxide, plutonium metal, and plutonium oxide to offsite locations for further processing into nuclear weapons and other items for the nation's defense. In addition, the N Reactor produces byproduct steam that is used to generate electricity for the Pacific Northwest power system. Each facility has a particular role to play in the overall production process, shown in Figure 3.1.

The process begins with uranium fuel billets slightly enriched with the U-235 isotope of uranium, which are delivered to the Hanford Site's fuel fabrication facility in the 300 Area. This facility converts the fuel billets into zirconium-clad fuel rods for use in the N Reactor and provides a series of quality assurance tests on the fuel rods. At the N Reactor the U-235 in the fuel rods undergoes controlled nuclear fission, which generates considerable process heat and converts the main isotope of uranium in the fuel rods, U-238, into the plutonium isotope Pu-239. The process heat is used to produce steam, which is sent to the Washington Public Power Supply System's (WPPSS) Hanford Generating Plant next door to generate electricity. (This WPPSS plant should not be confused with the WNP-2 commercial nuclear reactor, located several miles to the south of N Reactor.) The irradiated fuel rods are sent to the PUREX facility for further processing.

FIGURE 3.1. Hanford Nuclear Materials Production and Related Operations

At the PUREX facility the irradiated fuel is chemically separated from its zirconium cladding, dissolved, and separated into process streams. The first main process stream consists of liquid uranyl-nitrate hexahydrate (UNH), which is converted by Hanford's UO₃ facility into solid uranium oxide for the nation's defense program. The uranium oxide is shipped offsite for further processing at Fernald, Ohio. The second main process stream consists of plutonium oxide, which is also shipped offsite for blending at DOE's Savannah River, South Carolina plant and subsequent use in the defense program at the Rocky Flats, Colorado plutonium processing plant. The third process stream consists of a plutonium nitrate solution, which is sent to Hanford's Plutonium Finishing Plant (PFP). The PFP chemically converts plutonium nitrate solution into plutonium metal needed for weapons fabrication and also recovers and purifies the plutonium. The plutonium metal is shipped offsite for final weapons fabrication.

The Hanford facilities are mutually dependent. The N Reactor is needed to produce the irradiated fuel processed by the PUREX and PFP chemical processing facilities. Without the N Reactor, the chemical processing facilities would have no long-term reason to exist, since the nation's other major nuclear materials production site, the Savannah River Plant in South Carolina, has its own chemical processing facilities. Conversely, without PUREX and PFP, the N Reactor fuel would not have a processing outlet. Due to transportation and cost considerations, and the fact that no other DOE site is currently capable of processing N Reactor fuel, any remaining irradiated fuel inventory likely would be processed before any final closure of

the Hanford nuclear materials processing facilities. Once this inventory is processed, however, the PUREX and PFP facilities would close.

If N Reactor closes, then the Hanford Generating Plant (HGP), which uses N Reactor byproduct steam, would also have to close. Although WPPSS is currently examining the feasibility of running a natural gas pipeline out to the Hanford Generating Plant and installing gas-fired equipment to replace the N Reactor as a source of steam for the turbines located in the plant, it is not assured that such a replacement facility is feasible. In any case, one can estimate the loss to the Pacific Northwest power system if HGP closes prematurely.

The current institutional arrangements regarding the HGP specify that the Washington Public Power Supply System (WPPSS) purchases steam from the N Reactor and in turn sells the power to the Bonneville Power Administration (BPA), Puget Sound Power and Light (PSP&L), and Pacific Power and Light (PP&L). Depending on when during the year the N Reactor is operating, and to what market the power is sold, the power may have a different value, but it is always priced at the applicable, previously negotiated price during the billing period. On an annual average basis, the marginal value of this nonfirm power to the Pacific Northwest power system is about 13 to 14 mills per kilowatt-hour.^(a) Marginal nonsteam operating costs of the plant are about 1.5 mills per kilowatt-hour, so the net economic value of the N Reactor steam (which would be lost if N Reactor closes prematurely) is about 12 mills per kilowatt-hour generated, or about \$45 to \$47 million per year. The HGP is currently assumed in the Northwest Power Council's latest Pacific Northwest Power Plan to operate only through June, 1993; therefore, five to six years of power production would be lost with the premature closure of the N Reactor.

3.2 DIRECT IMPACTS OF NUCLEAR MATERIALS PRODUCTION CLOSURE

The N Reactor and its associated facilities comprise slightly more than 40% of the economic base of the Hanford Site, including employment, payroll, and procurements. For purposes of this analysis, it is assumed that a decision is made July 1, 1987 to close N Reactor permanently without replacement.^(b) Associated facilities are then closed sequentially and cleaned up over a nine-year period ending in 1996 as their related functions are completed. Each facility is assumed to be partially cleaned up and placed into a "maintenance and surveillance" mode, in which the facility is maintained, guarded, and monitored for releases of radioactivity into the environment. The current DOE schedule for major decommissioning activities reaches to at least 1997. Because of funding limitations and because there are likely to be higher national priority candidates for decommissioning during this period than a retired N Reactor, PUREX, PFP and associated facilities, it is assumed that major decontamination and decommissioning (possibly involving facility removal or entombment), would not occur until after 1997. The sequence of major events in the closure scenario follows:

(a) Data on the value and cost of HGP electricity came from a Bonneville Power Administration in-house study, the Hanford Generating Project (HGP) Study, April 4, 1987.

(b) This was the assumed decision date at the time the estimates in this report were prepared. If the decision to close the reactor permanently is made at a slightly later date, the impacts would be much the same in magnitude, but would be delayed. If, for example, the decision date were November 1, 1987, the delay would be approximately one calendar quarter.

- 1987 - Closure of N Reactor and Process Facility Modification Project at PUREX. Layoffs and cleanup begin at N Reactor.
- 1990 - N Reactor cleanup completed to maintenance and surveillance level. A residual workforce monitors, maintains, and guards the N facility, which has had all fuel elements and fluids removed. A crew of 60 remains indefinitely.
- 1990 through 1996 - PUREX and PFP complete processing existing inventories of weapons grade irradiated N Reactor fuel, followed by fuel grade materials left over from the 1972-1983 period. The process piping in each facility is then cleaned out and the recovered materials processed. All inventory is prepared for shipment offsite; all tanks and process piping are flushed; liquids are disposed of; all services, utilities, instrumentation etc. not required for maintenance and surveillance are shut off; and monitoring instrumentation is installed. Each facility is cleaned up to a level compatible with routine maintenance, surveillance and monitoring. A crew of approximately 230 remains indefinitely to perform these functions.

Table 3.1 shows the estimated cumulative impacts of the permanent closure scenario on Hanford direct employment, payrolls, and procurements. About 3,200 jobs are lost in the first two years; then layoffs proceed more slowly as operations are sequentially phased out. The

TABLE 3.1. Estimated Cumulative Losses in Direct Hanford Employment, Payroll and Procurements from Loss of Nuclear Materials Production

Year	Estimated Cumulative Losses in Direct Employment	Estimated Cumulative Losses in Direct Payroll (thousands)	Estimated Cumulative Losses in Direct Washington Procurements (thousands) ^(a)
1987	1,172	\$40,745	\$6,400
1988	3,157	109,715	17,232
1989	3,249	112,927	17,737
1990	3,460	120,243	18,858
1991	3,535	122,715	19,274
1992	3,696	128,024	20,108
1993	4,297	147,829	23,219
1994	4,540	155,836	24,476
1995	5,228	178,506	28,037
1996	5,981	203,320	31,934

(a) Assumed to be proportional to payroll losses. Base level of procurements estimated to be \$33.512 million in 1986.

Sources: Calculated from data supplied by the Department of Energy, Richland Operations Office and Hanford contractors.

exact timing of the 1990 through 1996 actions is somewhat uncertain;^(a) consequently, in the impact analysis this study focuses on the end of 1990 and the end of 1996, by which times the N Reactor and PUREX/PFP phases (respectively) of the closure scenario are expected to be completed. It is not necessarily true that losses in procurements would show the same time phasing as losses in direct payroll; however, there is no reliable basis on which to project any different time phasing.

If permanent closure of nuclear materials production at Hanford actually were to occur, there is no assurance that direct Hanford job, payroll, and procurement losses would be limited to those shown in Table 3.1. The first reason for additional impacts is that loss of the mission, which is the major purpose of the Hanford Site, could undermine support for remaining programs and reduce the pool of Hanford research talent and facilities below the level necessary to maintain some of the remaining programs. This occurs because, with some exceptions, personnel and facilities at Hanford may be used for more than one program or mission. To cite one hypothetical example, loss of a major source of activity for a materials research group might make an entire group of materials scientists nonviable because of the loss of key people or because of loss of key related programs. The second reason for additional impacts is that some Hanford research facility and site costs are relatively fixed. Therefore, when over 40% of the Hanford budget is lost and the nuclear materials production programs are closed, these fixed costs must be paid by remaining programs, which then could become too costly to maintain.

How serious might these additional losses be? The answer is that nobody yet knows, despite the fact that DOE and its contractors spent considerable effort for this study in an attempt to estimate the additional program effects of the closure scenario. It is possible to describe a worst case, however. Some staff would be required indefinitely at Hanford to perform maintenance and surveillance of closed facilities and of remaining nuclear and hazardous wastes even if the entire Hanford Site were to close. Absent a major site cleanup initiative, the level of indefinite staffing of the closed site would probably be less than a quarter of current levels. This is clearly a worst case, because it is not certain that all (or even any) remaining Hanford programs would be lost if nuclear materials production were lost.

Conversely, if the N Reactor either were to close temporarily or were to be replaced with another facility in a timely fashion, the impacts described in Table 3.1 might be largely mitigated. One possibility is that the N Reactor is closed permanently, but is replaced in the mid-to-late-1990's by another defense production reactor. If that were to occur, construction activity would occur to replace N Reactor, while PUREX and PFP would have to be replaced or adapted to accept the new reactor's output. This might largely offset the negative impact on the local and state economy of the loss of N Reactor. From the perspective of economic impact, this is clearly a "best" case, but the timing of replacement facilities, if any, is highly uncertain.

(a) Besides the environmental considerations and demand for nuclear materials, another factor that could affect the rate of closure would be the premature potential loss of key personnel who understand the plants. The scenario might have to be accelerated to avoid loss of "corporate memory" when these key people leave.

Table 3.2 shows the cumulative job losses from nuclear materials production by employee category, giving an indication of the effect on local unemployment. Supervisory scientists and engineers are employees who spend most of their time in employee supervision and for whom a scientific or engineering background (excluding the social sciences) is normally required. These supervisors ordinarily would seek new jobs in the national labor market and can be expected to depart relatively quickly from the area if they cannot find a job at another Hanford employer, an unlikely prospect unless other site activities grow in size. Some of these supervisors might remain in Washington State if they could find employment.

TABLE 3.2. Cumulative Losses in Hanford Employment by Employment Category from Loss of Nuclear Materials Production, 1987-1996

Year	Supervisory Scientists/ Engineers	Scientists/ Engineers	Other Professionals and Administrative	Production Related	Technicians	Office, Clerical, and Related
1987	44	208	296	420	40	161
1988	120	562	800	1,133	108	435
1989	123	578	823	1,166	111	447
1990	131	615	877	1,241	119	476
1991	134	629	896	1,268	121	487
1992	140	657	937	1,326	127	509
1993	163	764	1,089	1,542	147	592
1994	172	808	1,150	1,629	156	625
1995	198	930	1,325	1,876	179	720
1996	226	1,064	1,516	2,146	205	824

Source: Calculated from data supplied by Department of Energy, Richland Operations Office.

The scientists and engineers all have at least a four-year college degree with a major in the physical or life sciences or in a branch of engineering. They can be expected to seek work both nationally and regionally, as well as locally. If they are not hired by another Hanford contractor, they are also likely to leave the area.

The other professional and administrative employees are supervisors, managers, and administrators whose work does not necessarily require a scientific background. Because of their more general skills, these individuals may be more likely than their scientific and engineering counterparts to find an appropriate job with another Hanford contractor or with another local employer. As a group, they may also be more likely to find an appropriate job in Washington State, and are less likely to leave the area as quickly as the scientists and engineers.

The production-related workers perform manual labor associated with facility and process operations. This includes working foremen and all nonsupervisory personnel engaged in fabrication, processing, assembling, inspecting, receiving, storage, handling, packing, warehousing, maintenance, repair, janitorial, and guard services as well as auxiliary production. Separate construction work forces are excluded. There are really two subgroups of these

workers. The highly specialized persons actually engaged in working with radioactive materials and in radioactive areas are likely to be oriented toward the nuclear industry and defense materials production fields and would likely seek work at another facility where their specialized background would be beneficial. Their natural job search would be at remaining Hanford contractors and in the national nuclear and chemicals job market. The more general group of manual workers, including guards and janitorial staff, would likely seek work first in the local area and then within the state.

The technicians include manual workers such as draftsmen, engineering aides, scientific aides, and scientific assistants whose work requires a general scientific background and manual skills obtained through two years of post-high school education or in on-the-job training. These individuals are likely to look first for jobs that require their skills. They might also retrain for another field. Their natural job markets are the remaining Hanford employers and equivalent installations in other states.

The office, clerical, and related employees include secretaries, clerks, cashiers, messengers, and computer operators, and other office occupations. Most of these individuals are not necessarily tied to the Hanford facilities although they may seek work first with other Hanford contractors. Their job search can be expected to be local, or at most regional in scope.

To the extent that any of these classes of workers is unsuccessful in finding local employment quickly, both job retraining and migration become options. Supervisory scientists and engineers, most of the scientists and engineers, a substantial portion of the production workers and of the general professional and administrative workers can be expected to leave the local area, seeking other work in their respective fields. Most would likely leave the state. The remainder of production workers, many of the technicians and virtually all of the office and clerical workers can be expected to remain in the local area and the State of Washington, at least initially, unless they are spouses of workers who leave. These workers would find themselves in direct competition with many of those who lose their jobs in the local retail and service sector. Company records show that about 1,160 workers, between 19% and 20% of all nuclear materials production workers at Hanford, are over age 50. Many of these might take early retirement, somewhat easing the strain placed on the local job market.

3.3 LOCATION OF DIRECT IMPACTS

Table 3.3 summarizes the expected geographic distribution of loss of Hanford jobs and payroll. Almost 90% of the workers involved in nuclear materials production at Hanford live in Benton and Franklin Counties. These counties would feel most of the impact. However, about 9% of these workers live in Yakima County (mainly in Sunnyside, Grandview, and Yakima), so the loss of their jobs would probably be felt in Yakima County as well. The remaining 1.1% of Hanford job losses are expected to be dispersed over a wider geographical area.

TABLE 3.3. Estimated Geographic Distribution of Direct Employment and Payroll Losses from Loss of Nuclear Materials Production, 1987-1996

Year	Benton and Franklin Counties		Yakima County	
	Cumulative Loss of Direct Hanford Jobs	Cumulative Loss of Direct Hanford Payroll (thousands)	Cumulative Loss of Direct Hanford Jobs	Cumulative Loss of Direct Hanford Payroll (thousands)
1987	1,054	\$36,630	105	\$3,667
1988	2,838	98,634	284	9,874
1989	2,921	101,521	292	10,163
1990	3,110	108,098	311	10,822
1991	3,178	110,321	318	11,044
1992	3,323	115,094	333	11,522
1993	3,863	132,899	387	13,305
1994	4,081	140,097	409	14,025
1995	4,700	160,477	471	16,066
1996	5,377	182,785	538	18,299

Source: Calculated from data supplied by the Department of Energy, Richland Operations Office.

4.0 ECONOMIC IMPACTS OF NUCLEAR MATERIALS PRODUCTION CLOSURE

The direct effects already discussed of closing N Reactor and nuclear materials production at Hanford would have substantial economic impacts on the Tri-Cities and Washington State. Employment losses occur across a wide range of industries as a result of reductions of both Hanford payrolls and Hanford purchases of equipment, supplies, and services from businesses within the state.

Section 4.1 provides a brief overview of the strategy and methods used to measure these economic impacts. Following the overview the results are presented and the models used are described. Section 4.2 presents the results of the approaches in terms of employment "multipliers." Section 4.3 shows projections of employment and income losses that would result from phasing out nuclear materials production at Hanford and Section 4.4 places these results in historical perspective. Section 4.5 describes the statewide models used in the study, and Section 4.6 describes the local models. For details, the interested reader is referred to Appendix B.

4.1 OVERVIEW OF STRATEGY AND METHODS

Analysts concerned with measuring the regional impacts of major economic entities such as Hanford's nuclear materials production activities have used a variety of tools and methodologies. In this study, we used alternative approaches to provide alternative quantitative estimates, at both the state and local levels. This strategy provides reasonable bounds on the magnitude of the impacts, given the inherent uncertainty in making economic projections. Also, insights gained from one approach can be used to improve the overall application of other approaches. One disadvantage of this eclectic approach is that to make a single estimate of the most probable impact, judgment must be applied. Where such judgment was exercised in this study is carefully pointed out.

A simplified schematic diagram showing the models and multiple-approach process used in the study is shown in Figure 4.1. In examining the tools available to estimate the economic impact of closing nuclear materials production, the study team found two accepted, public domain statewide models of Washington's economy: the Washington Department of Revenue's WASHMOO model and the Washington Input-Output Model by University of Washington professor Philip Bourque. The analysis at the statewide level therefore focused on using the two available models, extending them, applying them to the loss of the nuclear materials mission and reconciling their results.

Previous work had been done on the economic impact of some Hanford programs on the economy of Benton and Franklin Counties by Cluett, et al. (1984) using a simple economic base model. The DOE Richland Operations Office also had produced a preliminary estimate of the eventual local and state impact of permanently closing nuclear materials production. However, it proved possible to make more extensive use of locally available data and to improve upon the techniques used in both previous projects. Therefore, at the local level, two new independent models of the Benton and Franklin County economies were developed and extended to the affected portions of Yakima County, and their economic impact estimates were then reconciled with the economic impact estimates of the statewide models.

FIGURE 4.1. Models and Process for Estimating Economic Impacts

The analysis primarily focused on the long-term employment multipliers generated by the various models. These multipliers are ratios, defined as follows:

$$\frac{\text{Eventual reduction in total jobs (at either the state or local level)}}{\text{Direct number of jobs lost in nuclear materials production}}$$

In reconciling the various model results, several basic conditions must be satisfied and were considered. First, the longer the time period over which the impact has had time to be felt, the greater is its expected value. Thus the long-term employment multipliers must be higher than short-term employment multipliers. Second, statewide employment multipliers must be higher than local employment multipliers. Losses in Washington employment will occur outside the Tri-Cities as a result of reduced procurements of Hanford contractors from suppliers in the rest of the state and as a result of reduced consumer spending by Tri-Cities workers for goods and services produced in the rest of the state. Third, long-term multipliers from econometric models must be larger than those from input-output models, other things equal. A major reason is that econometric multipliers from models such as WASHMOD incorporate the

effects of business investment and government spending induced by changes in the level of economic activity while input-output models ordinarily do not incorporate these effects.

Because the local and statewide multipliers were initially inconsistent, and because the statewide models were accepted and supported by better data, the study team reconciled the local and statewide models by conducting a third supplementary analysis of the local economy as it relates to the state economy using input-output techniques. The initial local multipliers were then adjusted downward slightly to be consistent with the findings of the third analysis and the statewide model results. The multipliers were then used to estimate statewide and local impacts.

4.2 RESULTS: EMPLOYMENT MULTIPLIERS

For each of the models used, a long-term employment multiplier was developed. The multipliers used in this study incorporate two effects: 1) jobs lost due to the reduction in Hanford payroll and 2) jobs lost due to reduced procurement of materials, supplies, and purchased services. The statewide multipliers are based on the total projected losses of Hanford employment and procurement from firms within the state. Local multipliers refer only to Benton, Franklin, and Yakima counties. They relate to the reduction in total employment in these three counties from layoffs of Hanford employees residing in these counties and losses of local procurement.

Table 4.1 shows the model estimates of the various long-term employment multipliers resulting from the analyses conducted at both the state and local levels. Some of the local multipliers relate to all of the Department of Energy's activities at Hanford, encompassing approximately 14,500 workers. These multipliers can be used to infer the economic importance of Hanford in supporting total employment within Benton, Franklin, and Yakima counties. By and large, the multipliers are reasonably close to and consistent with one another, in spite of the diverse methodologies that were used. With the exception of one variant of the input-output analysis, all the multipliers fell into a narrow range bounded by 2.1 to 2.5.

Appendix B provides a detailed comparative analysis of the multiplier results shown in Table 4.1. Two key points emerge from this comparative analysis, which was conducted to

TABLE 4.1. Summary of Long-Term Employment Multipliers from Models

<u>Statewide</u>	<u>Nuclear Materials Production</u>	<u>Total Hanford (Measure of Economic Importance)</u>
WASHMOD	2.48	N.A
Input-Output	1.8-2.1	N.A
<u>Local</u>		
Static Base	2.28	2.38
Econometric	--	2.40 - 2.45

Source: Appendix B.

select the most probable estimates of the multipliers. At the state level the long-term total employment multiplier estimated from WASHMOD incorporated impacts not captured by the input-output analysis.

The WASHMOD estimate is also preferred on consistency grounds. As mentioned earlier, employment multipliers for the state as a whole are expected to be higher than those for a local area. The estimate of 2.5 derived from WASHMOD is higher than either of the independently calculated multipliers for the Tri-Cities, while the input-output multiplier of 2.1 is not. Therefore, the multiplier derived from WASHMOD was considered to be the better estimate of the long-term state multiplier. As is discussed further in Appendix B, at the local level there is some reason to believe that both economic base methods may be biased very slightly upwards, resulting from incomplete accounting of the basic sector. Therefore, a supplementary local input-output analysis was performed in order to reconcile the state and local multipliers. On the basis of this analysis, a most probable value of the local long-term employment multiplier was estimated to be 2.2. In the short term, however, both the state and local multipliers are less than these long-term values.

4.3 PROJECTED EMPLOYMENT AND INCOME LOSSES

Using the employment multipliers derived from the comparative analysis, we estimated impacts on local and state economies of permanently closing nuclear materials production at Hanford.

Table 4.2 shows the job impacts, based on the long-term values of 2.2 and 2.5 for long-term multipliers at the local and state levels, respectively. The actual number of job losses in any given year reflects a lagged response of secondary sector employment to layoffs at Hanford. Thus, as the table shows, the implied multiplier at any point through 1996 is less than these long-term values.

The eventual job losses statewide are estimated to be over 14,000 upon termination of all nuclear material production activities. That is, eventual state employment would be about 14,000 less than it otherwise would have been, had these facilities continued to operate. The local impacts in this table have been extended to include Yakima as well as Benton and Franklin counties. In addition to nearly 6000 Hanford workers, we expect that over 7,000 other workers would become unemployed in this three-county area. Considering only the Tri-Cities, some 11,000 total jobs would be expected to be lost, representing nearly 20% of total 1986 Tri-Cities employment.

Not all of these job losses would occur at once owing to the time phasing of the Hanford layoffs. By the end of 1990, much of the impact of the closure of the N Reactor alone will have been realized. At this point, some 7,400 jobs statewide would be lost. Approximately 6,800 of these losses would have occurred in the Tri-Cities and in Yakima County. In Benton and Franklin counties, which absorb about 90% of the local losses, the jobs lost represent about 10% of 1986 employment.

Table 4.3 shows the commensurate estimated reductions in direct payrolls and personal income at the local and state levels. The direct payroll figures in column three correspond to the combined job losses shown in the previous table. Personal income at the state level is

TABLE 4.2. Employment Impacts from the Loss of Nuclear Materials Production^(a)

Calendar Year and Quarter	Direct Job Loss (cumulative)	Total Local Job Loss (Benton, Franklin, Yakima Co.)		Total State Job Loss ^(c)	
		Number	Implied Multiplier ^(b)	Number	Implied Multiplier
1987: 4	1,200	1,300	1.14	1,800	1.53
1988: 1	1,800	2,300	1.27	2,900	1.63
2	2,400	3,400	1.41	4,000	1.66
3	3,000	4,600	1.54	5,100	1.72
4	3,200	5,100	1.61	5,600	1.78
1989: 1	3,200	5,300	1.68	5,900	1.86
2	3,200	5,500	1.75	6,000	1.90
3	3,200	5,900	1.82	6,300	1.94
4	3,200	6,000	1.85	6,400	1.97
1990	3,500	6,800	1.98	7,400	2.13
1996	6,000	12,500	2.10	13,800	2.31
Eventual Job Loss	6,000	13,200	2.2	14,900	2.5

- (a) Job impacts rounded to nearest 100 jobs, based on phased closure. A small (~1%) number of these employees live in Grant County and elsewhere in Washington.
- (b) Total local job loss : direct job loss, based on exact numbers rather than rounded values shown in the table. Details of derivation are discussed in Appendix B.
- (c) Total nonagricultural wage and salary job loss x 1.035, the ratio of total nonagricultural wage and salary jobs. A 2.4 long-term multiplier applies for nonagricultural jobs. Figures for 1987-1989 are nonagricultural job loss from WASHMOD, times 1.035. See Appendix B for details of the derivation.

derived from the WASHMOD econometric model; in addition to wage and salary income, it includes "fringe" benefits, proprietors' income, government pensions, unemployment insurance payments, dividends, interest, and rental income.

Corresponding to the job losses, most of the reduction in personal income occurs in Benton, Franklin, and Yakima Counties.^(a) Based on the residential locations of affected workers, over 90% of the personal income loss will occur in Benton and Franklin counties. In 1986 total personal income in the bi-county area was roughly \$1.9 billion. The phasing out of activity at the N Reactor itself, largely completed by the end of 1990, would reduce total

(a) Local personal income impact estimates were derived as a percentage of state estimates. The percentage was computed on the basis of the estimated ratio between the total reduction in local wage and salary income and the reduction of state wages and salaries in each time period. See Appendix B, Section B.6, for details.

TABLE 4.3. Cumulative Reduction in Payroll and Personal Income from Loss of Nuclear Materials Production (in millions of 1986 dollars)

<u>Year</u>	<u>Quarter(a)</u>	<u>Direct Hanford Payroll</u>	<u>Local Personal Income (Benton, Franklin, and Yakima Counties)</u>	<u>State Personal Income</u>
1987	4	\$ 41	\$ 45	\$ 52
1988	1	63	76	87
	2	85	112	123
	3	104	149	158
	4	110	165	175
1989	1	110	172	183
	2	110	182	191
	3	113	194	202
	4	113	202	209
1990		120	240	252
1996		203	451	481

(a) Quarterly figures expressed as annual rates.

real (inflation adjusted) personal income in Benton and Franklin counties by about 11% relative to its 1986 levels. By 1996, the percentage decline in total real personal income would be nearly 21% of its 1986 level.

4.4 EMPLOYMENT MULTIPLIERS IN HISTORICAL CONTEXT

Section 4.3 indicates that over 11,000 jobs may be lost in the Tri-Cities alone as a result of the closure of the N Reactor. As described in Section 4.2, this result is based upon a careful integration of employment multipliers resulting from several economic models discussed in the rest of this chapter and in Appendix B. However, as a test of the estimates, one may observe whether the projected impacts appear to be reasonable in light of historical experience in the Tri-Cities. In more direct terms, what would the multipliers used in this analysis have implied for previous economic downturns in the Tri-Cities?

The Tri-Cities economy has previously experienced boom and bust cycles since its selection as a site for the Manhattan project in World War II. Two of the downturns have occurred over the past two decades--the first in the early 1970's with the closing of several DOE reactors and the second involving the termination of WPPSS construction in 1982.

As described in Section 4.5.2, the study team compiled annual data for 1967 through 1986 for total employment in the Tri-Cities and for three principal components of the basic sector: DOE and contractors, WPPSS, and agriculture. These data are plotted in Figure 4.2. The secondary sector is defined as total employment less primary employment. These broader groupings are shown in Figure 4.3. The figures are based on data from Appendix 8, Table B.9.

Looking first at the experience of the early 1970's, Figure 4.2 shows a sharp reduction in DOE-related employment from 1969 to 1971. Annual employment dropped by two thousand, from 8,500 to 6,500. Other things being equal, we might have expected a total decline in Tri-Cities employment of a little over 4,000 (using 2.2 as the multiplier as shown in

FIGURE 4.2. Employment in the Three Components of the Basic Sector of the Tri-Cities Economy, 1967-1986

FIGURE 4.3. Primary, Secondary, and Total Employment in the Tri-Cities Economy, 1967-1986

Table 4.2). Instead of declining, total employment increased by two thousand. Of course, Hanford employment made up only a portion, albeit a very large one, of the total economic base of the Tri-Cities. Figure 4.2 shows that while DOE-related employment fell during this period, agricultural employment increased by over a thousand. Agricultural employment increased sharply during the decade 1967-1976, as more land came under irrigation and a major food processing sector was developing.

Although agriculture grew, it did not fully offset the decline at Hanford. Figure 4.3 shows that secondary employment actually increased in the face of this decline of primary

employment. Three possible explanations may be advanced for this behavior contrary to the result the multipliers would have suggested. First, the secondary sector in the figures may include some portions at the economic base that do not fall neatly into one of three major basic sector categories. One example is the Columbia Center shopping mall, which opened in late 1969. At the time, Columbia Center was the only enclosed mall in eastern Washington, which helped promote the Tri-Cities as a regional shopping center.

Second, lags and expectations may also explain a portion of this discrepancy. The secondary sector may have been still catching up with overall demand simulated by the rapid growth in agriculture. Also, expectations of future Hanford projects, exemplified by the Fast Flux Test Facility, may have stimulated activity in the retail and service sectors over what it would have been otherwise. Finally, diversification of the local economy began in about 1965, when the new Hanford contractors replacing General Electric made significant investments and brought in new firms such as Iowa Beef Packers and Sandvik Special Metals.

The second major downturn occurred as a result of the decision by WPPSS in 1982 to halt construction on two nuclear power plants located at Hanford (WNP-1 and WNP-4). As shown in Figure 4.2, this resulted in a drop from nearly 12,000 workers in 1981 to less than 2,000 in 1984. Adding in DOE-related and agricultural employment, total basic sector employment dropped some 7,000 over the same period. A long-term employment multiplier of 2.2, would have predicted a total job loss of about 15,500. Actual employment dropped by more than 16,000 over the same period. In this situation, the multiplier approach predicts quite closely the actual employment decline, even understating it to a small degree.

Consideration of these episodes should reinforce a point made in the previous section. The projected employment losses should be interpreted against the level of employment that would have occurred had N Reactor continued to operate. As the 1969-1971 experience shows, the projections need not imply that actual employment will decline by 11,000 in the Tri-Cities. In 1969-1971, growth in other sectors in basic economy and, perhaps, expectations of future growth offset the repercussions of the DOE cutbacks.

However, the WPPSS episode shows that a severe reduction in the basic sector can in fact yield total employment losses in the range suggested by the multiplier model. Which one of these episodes may be more applicable to future downturn is open to speculation. In our judgment however, the present business climate is considerably different from the early 1970's, and the WPPSS experience is probably more relevant. With no near-term prospect of restarting construction on WNP-1, and a flat agricultural economy there is little in the basic economy to offset the large reduction in the Hanford workforce. Without expectations of large new programs at Hanford, other sectors of the economy would likely respond as during the 1981-1984 period. As a result, the projection of an 11,000 drop in area employment may well be realized.

4.5 DESCRIPTION OF STATEWIDE MODELS

To measure statewide impacts of nuclear materials production closure, two "off-the-shelf" public sector economic models were used. The first, the Washington Economic Model

(WASHMOD),^(a) was a quarterly econometric model of the state used principally by the Washington State Department of Revenue to assist in making revenue projections. The second was an input-output model of the state economy developed by Professor Philip Bourque at the University of Washington (Bourque 1987), and used widely for impact assessment in the state.^(b)

These models differ markedly in their underlying specifications and data, but both contain unique aspects that are relevant to impact analysis. As an econometric model, WASHMOD is based on relationships between economic variables, which are estimated from time series of historical observations. Although the model is dynamic (i.e., current levels of variables depend, in part, on past levels), the overall structure takes a very short-term view of the economy (in the range of two or three years into the future). Because of this, it was necessary to use the short-term behavior of the model to estimate long-term employment multipliers. WASHMOD encompasses a variety of economic variables: employment, wage rates, unemployment benefits, dividends and interest income, and investment.

The input-output model on the other hand, is a comparative static model. Essentially this means that no particular time frame can be attached to the model's response to any change in one of its determining variables. Operationally, the model takes on a long-term orientation--its predictions are assumed to be valid after all variable interactions from one time period to the next have been fully worked out. The input-output model embodies detailed information concerning linkages among industries within the state whereas WASHMOD contains very little such information. This aspect of the input-output model allows analysis of impacts that emanate from very narrowly defined sectors of the economy. However, the input-output model does not incorporate effects of public sector spending and business investment induced by Washington economic activity, effects that are included in WASHMOD.

4.5.1 Application of WASHMOD

Statewide impacts of nuclear materials production closure were calculated as the differences in the WASHMOD model's solution values between two forecasts: a "base" case and an "impact" case. The base case used in this study was one developed by the Washington State Economic and Revenue Forecast Council for the 1988-1989 Department of Revenue state budget projections (released in March 1987) and for several other departments of state government. The impact case results from adjustments that were made to the model equations for particular industries. The principal adjustments were to subtract laid-off employees from the employment equations for industrial chemicals, and services sectors to account for job losses at Hanford and to adjust the average wage rates paid in these sectors for the loss of Hanford wages. The adjustments follow the phased layoff scenario shown in Table 3.3, but with quarterly, rather than annual values used. The reduced number of workers in these sectors directly lowers overall personal income within the state, and in turn, leads to further reductions in overall

(a) See Economic and Revenue Forecast Council (1986a) for a model description.

(b) A third economic model exists for the state of Washington, WPSM II (Washington Projection and Simulation Model). This model combines an input-output structure based on Professor Bourque's work with a set of econometric equations to project various final demands and income components. The proprietary nature of this model was the principal reason it was not used in the study.

employment. The relationships between WASHMOD variables in the forecasts for the period 1987-1989 were extrapolated to the period 1990-1996 to estimate longer-term impacts. The details of the analysis are discussed in Appendix B.

4.5.2 Application of Input-Output Techniques

The statewide input-output analysis of nuclear materials production closure was based upon Professor Philip Bourque's recently published (Bourque 1987) input-output table for the State of Washington for 1982. Such a table provides a detailed description of purchase and sales patterns of various industries within the state along with an estimate of the distribution of goods and services sold to households within the state. This information was used to measure the statewide impact of reductions in payrolls and purchases of materials and supplies that would occur in Washington if the N Reactor and related facilities were to close permanently. A detailed discussion of the input-output table and how it was applied in the impact analysis is given in Appendix B.

Within the input-output framework, plutonium from nuclear materials production is treated as an export of the state. To measure the economic impact on the state of the loss of this export, a detailed accounting of the inputs used in its production (i.e., materials and services purchased from Washington firms, labor, and capital maintenance and repair expenditures) was required. Using detailed procurement information provided by Hanford contractors and other data maintained by the Department of Energy, a schedule of inputs was developed for nuclear materials production for Fiscal Year 1986. (Much of this information, particularly employment and payroll data, was the same as used in developing the adjustments to the WASHMOD econometric model.) After converting this bill of inputs to the industrial classifications used in the Washington input-output table, statewide employment impacts were calculated using the input-output techniques suggested by Bourque.

4.6 DESCRIPTION OF LOCAL MODELS

The analysis of secondary economic impacts at the local level also involved several alternative approaches. In both approaches, a primary, or basic, sector of the economy was distinguished from a secondary, or support, sector. In the first approach, the relationship of these two sectors was examined at a single recent point in time. In the second approach, the history of the area was investigated and a simple statistical relationship was developed to describe how these sectors have responded to one another in the past. To reconcile these results with statewide impacts, a supplementary input-output analysis was also conducted, but the resulting local input-output multipliers were not used directly.

As was true for the models at the state level, the premise of both local approaches is that the level of local economic activity is changed primarily by activities that sell products or services outside the local area (the export base or basic sector). This behavior is incorporated in what is termed an economic export-base model. These models estimate economic impact through the use of a base multiplier. The base multiplier assumes that total local economic activity, as measured by employment, income, or other indicators, expands or contracts in a fixed ratio to the level of activity in the basic sector. As an example, a base

multiplier of 2.0 for employment would indicate that for each new job in the basic sector, one additional job would always be generated in the support sector, for a total of two jobs in the economy.

4.6.1 Static Base Approach

The static base approach applied in this study relies on a classification of the Tri-Cities economy into basic and secondary sectors for 1986. Employment and payroll information were developed for each component of the basic and secondary sectors. Three major sectors were identified as the principal driving forces in the Tri-Cities economy since the early 1970's: 1) DOE and its contractors operating the Hanford Site; 2) the Washington Public Power Supply System (WPPSS) in its construction and operation of nuclear power plants, and 3) the agricultural community, including a substantial food processing component. In addition to their direct employment and payrolls, these major sectors also support a sizeable number of jobs in the local economy through their procurement of equipment, supplies, and business services.

In addition to these three major employment sectors, three other sectors were also identified as contributors to the economic base of the Tri-Cities economy. The first of these can be loosely termed "other major employers." The second of the other sectors is tourism. The final component in the economic base relates to the local purchasing power of retirees. Government transfer payments in the form of pension benefits constitute a significant proportion of total spendable income in the local economy and comprise a significant portion of the local economic base.

The secondary sector consists of all other workers in Benton and Franklin counties after the basic sector workers are subtracted. The actual number is computed as the difference between total employment of Tri-Cities residents and the sum of the resident basic sector employment as described above (estimated to be about 29,500 in 1986). In 1986, this difference resulted in an estimate of some 32,600 workers in the secondary sector.

The estimation of total impacts using the static base approach depends upon the assumption that each dollar of basic sector spending generates the same level of activity in the secondary sector, and that changes in spending levels in the basic sector generate proportional changes in secondary sector activity. This assumption implies that the share of a dollar of income spent in the local economy is assumed to be constant regardless of income level or the source of income. This assumption is undoubtedly not strictly true, but in the absence of detailed survey-based information, it is often assumed to be a good first approximation.

Using this assumption, the Tri-Cities data yield an estimate of about 36 jobs in the secondary sector per million dollars of basic sector payroll or income. Losses in the components of the basic sector related to nuclear materials production (losses in direct Hanford employment and payrolls and the employment generated by procurement) were then translated into estimates of job losses elsewhere in the local economy. Details of the analysis are covered in Appendix B.

4.6.2 Dynamic Base Approach

The dynamic base approach follows the theory of an economic base model, but it is dynamic in that it recognizes that secondary sector activity will not respond instantaneously to changes in the basic sector. To apply the approach, additional evidence as to the multiplier impacts of basic sector employment was collected by an examination of the historical record of economic activity in the Tri-Cities.

The historical examination of the Tri-Cities economy used linear regression techniques to statistically estimate mathematical relationships between historical observations of the level of economic activity in the basic and secondary sectors. Relationships were estimated between key employment variables using annual data for the period 1967-1986. The estimated parameters of the resulting mathematical equations can be interpreted as multipliers, similar to those calculated for the static base approach. Details of the approach are covered in Appendix B and are summarized below.

The relationship estimated relies on the following assumptions:

1. In the long term, changes in secondary sector employment are proportional to changes in basic sector employment.
2. Secondary employment responds with a lag to changes in basic sector employment.

To perform the estimation used in the dynamic base approach, historical data were required for the basic and secondary sectors. Annual data for 1967 through 1986 were compiled for total employment in the Tri-Cities and for the principal components of the basic sector: DOE and contractors, WPPSS, and agriculture. In this analysis the available historical data did not permit nuclear materials production to be separated from the remainder of Hanford. Therefore, all Hanford jobs were assumed to have similar effects on the secondary sector.

Incorporating the assumption that secondary sector employment responds with a lag, a set of mathematical equations was estimated that related secondary employment levels to various alternative definitions of basic sector employment. The estimated parameters of these equations provide a basis for predicting impacts on secondary sector employment from potential changes in basic sector employment stemming from nuclear materials production closure.

The magnitude of the estimated reductions in employment and personal income discussed in this chapter have important implications for state and local government finances and for the social fabric of the affected communities. These implications are discussed in the following two chapters.

5.0 IMPACT OF NUCLEAR MATERIALS PRODUCTION CLOSURE ON STATE AND LOCAL GOVERNMENT FINANCE

The economic effects of closing the N Reactor and phasing out nuclear materials production at Hanford would not end with the reduction in jobs and income described in Chapter 4. These economic effects are further mirrored in a loss of revenues to state and local governments and changes in the level of their expenditures. In Washington, state and local government revenues come from four principal sources: 1) sales, gross receipts, use, and other sales-related special excise taxes, 2) property taxes, 3) intergovernmental transfers, and 4) a large number of special licenses and user fees. This section describes how the base for each of these sources of government income is likely to be affected. In addition, it is possible that expenditures for certain programs associated with economic downturns will increase. While the expenditure effects are less certain than the revenue impacts, this section discusses these effects also.

5.1 IMPACTS ON THE STATE OF WASHINGTON

The most immediate effect on State of Washington finances is likely to be through reductions in the tax bases for Washington's retail sales, use, and excise taxes.^(a) In Washington, the retail sales tax base consists of all final sales of tangible personal property, charges for labor services rendered in connection with tangible personal property, and other activities defined by law as retail sales. This includes sales to business and to state and local government but excludes sales for resale, sales of certain ingredient or component parts consumed in production, and other selected items such as food. The business and occupations tax is a broad-based, gross receipts tax imposed on nearly all business transactions in the state. The use tax supplements the retail sales tax, by imposing an equivalent amount of tax on the use of tangible property on which the retail sales tax has not been paid. Major components of the use tax base are business expenditures for equipment purchased out of state, certain items used in the production process and the private sales of automobiles. Special excise taxes are levied on several public utility services, motor vehicles use, real estate conveyances, cigarettes, liquor, timber sales etc. The ultimate base for much of the business activity included under these taxes is the level of personal and business income in the State of Washington. A useful rule of thumb in forecasting tax receipts is that a one percent change in Washington personal income generates approximately a one percent change in these taxes.^(b)

A second major component of Washington State taxes is the state levy on real and personal property. Real and personal property can be expected to decline in value in Benton and Franklin Counties under the closure scenario. The estimated decline in assessed valuation can

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- (a) Most of the description of the tax bases at the state level is drawn from Economic and Revenue Forecast Council (1986b, 1986c).
 - (b) Personal communication with Byron Angel, State of Washington Office of the Forecast Council, April 22, 1987. A recently released study by the Washington State Department of Revenue (1987) indicates that the average "elasticity" of the retail sales tax, which collects half the state sales-related tax revenue, may be less than 1.0 during economic downturns. If so, our estimates of revenue impact may be too high by about 5% to 10%.

be multiplied by the current (maximum allowed) state tax rate of \$3.60 per \$1,000 of assessed value to obtain an estimate of the impact on state collections of property taxes.

Intergovernmental transfers from the federal government and collections of user fees may decline slightly at the state level because of interstate outmigration associated with the closure of the N Reactor and associated facilities. No estimate of this decline is made in this report. The major nontax revenue sources are tuition at the State's colleges and universities (about 2.8% of General Fund revenues) the State Lottery Commission (about 1.5% of General Fund revenues), and Liquor Control Board profits and fees (about 0.5% of General Fund revenues). We assume that the impact on these sources of revenue is proportional to changes in state personal income.

Table 5.1 shows the estimated impact from loss of nuclear materials production on State General Fund revenues by source and time period. Because the local jurisdictions contacted during the course of this study were only asked to give estimates of changes in their assessed valuation for the years 1990 and 1997, the years after the first and second phases of the closure scenario are expected to be completed, respectively, the estimates for the declines in state property tax collections reported in Table 5.1 for 1987-1990 are linear interpolations.

TABLE 5.1. Reductions of State General Fund Revenues, by Calendar Year and Revenue Source from Loss of Nuclear Materials Production, 1987-1997 (millions of dollars)

Calendar Year	Sales-Related Taxes	State Property Taxes (for schools)	Other Sources	Total
1987	\$0.9	\$(a)	\$0.1	\$1.0
1988	9.0	0.2	0.6	9.8
1989	13.3	0.4	0.9	14.6
1990	13.0	0.7	0.9	14.6
1997	24.8	6.5	1.7	33.0

(a) Less than 0.05.

Sources: Calculated from 1986 data in State of Washington, Economic and Revenue Forecast Council (1986c).

The study team identified four major categories of state expenditures that could be directly affected by the nuclear materials production closure and the associated economic changes in the state: public schools, unemployment compensation, job training, and public assistance. First, state funding for local schools in the Hanford area would be reduced because of enrollment losses. It is more difficult to specify whether there would be offsetting increases in funding for schools elsewhere in the state because it is uncertain whether people leaving the Hanford area would migrate to another part of Washington or would leave the state altogether. However, based on records of outmigrants from Benton and Franklin counties between 1975 and 1980, recorded in the 1980 Census of Population and compiled by the State of Washington Office of Financial Management, it is assumed that approximately 58% of the school-age outmigrants from these counties can be expected to show up somewhere else in Washington

State (and would require the same level of state expenditures) so that state school expenditures reductions would apply only to the 42% of the lost Hanford area students that can be expected to leave the state.^(a) The figures in Table 5.2 for school funding reflect this assumption. Annual costs for schools statewide (in 1986 dollars) are projected to decrease by less than \$50 thousand in 1987. By 1990 the total cost declines by \$2.4 million; in 1997, by \$4.5 million.

TABLE 5.2. Effects from Loss of Nuclear Materials Production on Selected State of Washington Expenditures, 1987-1997 (millions of 1986 dollars)

Year	Program or Function				Net Total
	Public Schools	Unemployment Compensation	Job Training and Related Programs	Public Assistance	
1987	\$(a)	\$6.0	\$0.3	\$(a)	\$6.3
1988	(0.8)	8.9	0.6	0.6	9.3
1989	(1.6)	2.5	0.1	1.4	2.4
1990	(2.4)	3.9	0.2	1.7	3.4
1997	(4.5)	5.3	0.3	2.9	4.0

(a) Less than \$50 thousand. Public school impacts are decreases in expenditures at the state level.

Sources: Calculated from data supplied by the local school districts and Washington State Departments of Employment Security and Social and Health Services.

State spending on unemployment compensation related to closing nuclear materials production would depend upon the number of people rendered unemployed, the duration of their unemployment, and the level of benefits. Unemployment benefits to residents in the State of Washington are a maximum of \$197.00 per week at the salary levels under consideration for up to 30 weeks of unemployment. The average duration of unemployment in Washington State is currently 17.5 weeks. This accounts for those former workers who outmigrate and take jobs elsewhere and for those who drop out of the labor force. The Table 5.2 expenditure figures for unemployment compensation were arrived at by multiplying job losses in the Washington economy times average duration of unemployment, times weekly benefits.^(b) The large-scale early layoffs create high unemployment compensation costs in 1987 and 1988.

(a) This may be a slight underestimate for two reasons. First, if other areas in the state remain depressed relative to the period 1975-1980 it would be more likely that a higher percentage of parents of these school-age children would leave the state than would be indicated by the 1975-1980 figures. Second, a higher percentage of the nuclear materials production workers may be oriented to national markets than were the outmigrants between 1975 and 1980 and therefore may be more likely to leave the state. If so, the state would save proportionately more on school funding and the impact on state expenditures would be higher (i.e., more negative).

(b) Some benefits would be earned by lower-paid support sector workers, so \$197.00 a week, the benefit which corresponds to a salary level of \$19,700 per year, may be a slight overestimate. Also, current duration of unemployment is one week longer than the 1986 annual average. If the Table 5.2 figures were adjusted for these two factors using average 1986 benefits and unemployment duration, the 1990 figure would be \$2.7 million; the 1997 figure, \$3.7 million. On the other hand, average duration of unemployment may increase if the local job market becomes glutted with Hanford layoffs.

Job training (or retraining) expenditures would be expected to depend both upon the expenditures per trainee and the number of potential trainees in the program. There are two classifications of potential trainees involved: 1) the lower-salaried and lower-skilled former Hanford workers still resident in Washington State who are not able to secure employment, and 2) the more general class of laid-off support sector workers. It is assumed for purposes of this analysis that supervisory scientists and engineers, scientists and engineers, and other professional and administrative workers would not undergo retraining but would either seek and find work in the state or else would leave the state. Of the remaining three categories--production related workers, technicians, and office workers--about 27% are assumed to migrate out of state. This figure is an arithmetic average of two numbers from the 1980 Census pertaining to interstate outmigrants from Benton and Franklin Counties. The lower value, 13.6%, is the percentage of all working-age persons (employed or not) in the two counties in 1975 who had subsequently migrated out of state by 1980. Clearly, this is an underestimate for unemployed persons since the unemployed are more likely than the employed population to leave to find work. The higher value, 41%, is the percentage of all 1975 two-county outmigrants who left the state by 1980. This percentage is too high, since it assumes that all laid off workers would leave the state. The average of the two figures appears reasonable, given little or no other information concerning Hanford workers' propensity to migrate.

The same 27% figure is also applied to workers laid off in the support sector, since they are expected to have many similar skills and the same regional orientation as the Hanford production-related workers, technicians, and office workers. The cost of the job retraining program per worker retrained is assumed to be \$1,500 and the participation rate in the program is assumed to be 20%, based on contacts with staff of the Department of Employment Security, Displaced Workers Program, who run the state's retraining programs.^(a) This number is multiplied times the statewide employment impact of newly lost Hanford jobs, adjusted for outmigration and program participation. The annual cost rises from \$0.3 million (1986 dollars) in 1987 to \$0.6 million in 1988, falls to \$0.1 million in 1990, and rises to \$0.3 million in 1997.

Finally, Table 5.2 shows the impact on state government expenditures for public assistance, mainly the Aid to Families with Dependent Children categories R (regular program) and E (employable program). The caseload and cost figures for 1987 through 1989 were obtained from the Washington State Department of Social and Health Services' (DSHS) caseload forecasting model.^(b) Figures for the period 1990 through 1997 were obtained by comparing caseload figures from 1987 through 1989 with corresponding values for statewide employment losses and then multiplying by the current average cost per case. Annual costs rise from less than \$0.1 million in 1987 to \$1.7 million in 1990 and \$2.9 million in 1997.

(a) Personal contact with T. Fenton, Washington State Department of Employment Security, Olympia, Washington, May 12, 1987.

(b) Data supplied by DSHS Budget Office, Olympia Washington, May 7, 1987. The Budget Office reports that the ultimate caseload effect of a given layoff event occurs about 18 to 24 months after the change in employment levels. Personal contact with Dick Ritchie, DSHS, Olympia, Washington, April 27, 1987.

5.2 IMPACTS ON HANFORD AREA LOCAL GOVERNMENTS

With closure of N Reactor and phasing out of nuclear materials production, school districts and county and municipal governments all face a similar problem--the reduction in employment and population will likely reduce the ability of the jurisdiction to collect taxes sufficient to maintain desired services. This section discusses how these reductions would affect local governments and school districts and presents estimates of several of these impacts.

The reduced employment and associated population reduction could impact local cities and counties in a number of ways. First, the local government units lose some intergovernmental revenues, based directly on population, from the state and federal governments. Second, the reduced local consumer and business spending implies reduced revenue from the local portion of the Washington State retail sales and use taxes. Third, many city revenue sources such as fines, fees and licenses are related to the level of population. As population declines, the amounts collected from these sources would also decline.

Expenditures on many city or county services may also be expected to fall. However, for some city services such as municipal utilities, operational costs may not fall in proportion to the decline in revenues. In these cases, the relatively fixed costs of providing the city or county services are spread among fewer households. The result can be a larger tax or utility bill for the remaining residents. Also, Washington cities and counties are restricted, by state law, on both the maximum annual increase in property taxes and the maximum level of property tax that can be applied. These restrictions inhibit the ability of cities and counties to raise property taxes. For example, cities are presently limited to a maximum 6% annual increase in property taxes and a maximum assessment for city taxes of \$3.60 per \$1000 of assessed valuation.^(a) Thus, cities and counties might be unable to raise property taxes sufficiently to compensate for a fall in assessed valuation.

School districts face a similar problem. The reduced school enrollment that results from the outmigration means that several state and Federal sources of funding for local schools are reduced. This implies reductions in staff or cutbacks in other operations may be necessary in order to reduce expenditures. Finally, the reduced market values of property that would be expected to accompany the unemployment and outmigration would be expected to lower assessed property values. The taxes levied by school districts are based on assessed property values and the local tax rate. While school districts would be allowed to increase the tax rate to offset the reduced assessed valuation, there might be lags where revenues would be less than anticipated due to foreclosures.

Discussions were held with local officials to estimate the impacts of the loss of nuclear materials production. The officials were presented with preliminary estimates of the lost employment for their respective jurisdictions, the corresponding payroll loss, and the reduced population. They were requested to provide their estimates of the effect of the closure on revenues and expenditures for their respective jurisdictions. Although the PNL study team provided some guidance and a set of consistent employment and population impact estimates as

(a) The maximum limit is on property taxes paid to cities and does not apply to property taxes paid to schools or other jurisdictions.

input, the officials were allowed considerable latitude to use their knowledge and experience with their individual financial situation to develop their estimates, so individual estimates reported in this section may be based on different assumptions in different jurisdictions.^(a) The PNL study team reviewed, but did not adjust the local revenue estimates. Although the final study estimates of local population impacts were greater than the preliminary values and final employment losses were lower than those used by the local governments, the final study estimates of lost employment, payroll, and population were very similar to the preliminary estimates.

Table 5.3 shows estimates, produced by the study team, of employment and population losses and estimates, obtained from the local officials, of revenue losses for nine cities and three counties near the Hanford Site. Section B.7 in Appendix B describes how the community-level estimates of employment and population losses were obtained. Although other cities and counties may experience job losses or other impacts from closing nuclear materials production, the cities and counties listed in Table 5.3 include over 97 and 99%, respectively, of the expected total job losses if the N Reactor and associated facilities were closed. As might be expected, the most severely affected were some of the cities closest to the Hanford Area: Richland, Kennewick, Pasco and Benton City. In terms of reduced population as a percent of total 1986 city population, Benton City would be the most severely impacted, losing over 20% of its population by 1997. Total revenue losses ranged from over 2 million dollars for the city of Richland to no significant impact for Grandview. Eight of the nine cities felt the closure would negatively impact them. Nearly all municipalities mentioned that the remaining population would be required to pay higher taxes to pay for some of the relatively fixed city costs, such as local utilities. County financial impacts are also shown in Table 5.3. Benton and Franklin Counties would have reduced revenues as a result of the 1997 population declines of 11.2 and 8.4%, respectively, from 1986 levels.

The public port districts created by the local counties reported that they could also be affected. In particular, the Port of Pasco, which operates the Tri-Cities Airport, could have difficulty obtaining sufficient airport revenues to repay the revenue bonds used for financing a recent expansion of the airport. The Port obtains revenues from the operation of parking lots, terminal rentals to airlines and rental car companies and airline landing fees. A reduced Tri-Cities population and reduced Hanford-related business-travel would almost certainly reduce the number of airline passengers and possibly the number of airlines and airplanes using the Tri-Cities airport. A reduction of airport revenues could force the Port of Pasco to use its local tax revenues to subsidize the repayment of the airport bonds, which is undesirable from the Port's perspective because these funds are a prime source for the capital improvements necessary to attract new businesses to the Tri-Cities.

(a) For example, some of the jurisdictions mentioned that they might expect a loss in their property tax base of about the same size as occurred after shutdown of WPPSS construction of WNP-4 and WNP-1 at Hanford in 1982--about 10%. They acknowledged that the type of worker involved is different with nuclear materials production and that the impact might be worse, but they had no better analogies with which to work. The 10% figure is thus uncertain, and other studies suggest it may be higher. For example, based on analyses after the fact by Nesse et al. (1985) for Pacific Northwest aluminum plant closures, and Hodge (1984) for depressed northern Idaho mining communities, losses of up to 15% in property values would not be surprising.

TABLE 5.3. City and County Employment, Population, and Local Government Revenue Impacts from Loss of Nuclear Materials Production

City	Total Losses Employment		Population Losses		Percent Population Losses (a)		Revenue Losses (thousands) (b)	
	1990	1997	1990	1997	1990	1997	1990	1997
Richland	2,223	4,013	2,890	5,218	9.6%	17.3%	\$1,290	\$2,229
Kennewick	2,220	4,073	2,869	5,296	7.8	14.5	864	1,481
Pasco	1,209	2,293	1,572	2,981	6.2	11.7	612	1,057
West Richland	200	353	261	459	7.0	12.3	90	246
Benton City	188	335	245	435	13.4	23.9	18	33(c)
Prosser	116	213	151	277	3.8	6.9	75	136
Grandview	109	201	142	261	2.2	4.1	0	0
Sunnyside	164	301	213	392	2.2	4.1	65	92
Yakima	225	414	293	538	0.6	1.0	56	90
<u>County</u>								
Benton	4,935	8,988	6,416	11,685	6.2	11.2	651	932
Franklin	1,209	2,293	1,572	2,981	4.5	8.4	280	396
Yakima	615	1,129	800	1,468	0.4	0.8	(d)	(d)
Total(e)	6,759	12,410	8,788	16,134	2.7	5.0	\$4,001	\$6,692

(a) Population loss as a percent of 1986 population (Washington State Office of Financial Management, 1986). Pasco population for 1986 was adjusted to include about 7,000 persons in the West Pasco/Riverview area.

(b) Source: Local officials from each jurisdiction.

(c) These estimates are based on population changes from 1986, reported population, and Benton City's 1986 budget. City officials felt this was a minimum estimate of the impacts.

(d) Yakima County unable to provide estimates of revenue loss.

(e) Totals represent 99% of local employment and population losses and their effects on revenue. About one percent of nuclear materials production workers reside outside of Benton, Franklin, and Yakima Counties.

Table 5.4 shows the estimates of financial and program impacts from loss of nuclear materials production obtained from representatives of the local school districts based on enrollment estimates provided by the study team (for details, see Appendix B, Section B.7). Major sources of funding that would be affected include state and Federal funds that are allocated according to school enrollment. Of particular importance to many of the school districts are Federal funds from Public Law 81-874 (PL 81-874), which provides revenues to school districts based on the students with parents working on certain Federal lands. Examples of Federal lands that qualify for PL 81-874 include military bases, Corps of Engineers projects, and much of the Hanford Site. Richland and Kennewick school districts could be particularly hard hit by the loss of these funds as each qualifies as a district with over 20% of its students qualifying for PL 81-874 funds, and this 20% figure places these districts in a special category (a "Super B" district) that enables them to receive a substantially higher amount per student. Many of the school districts in Table 5.4 mentioned the difficulties that they would experience making up these lost funds through revenues obtained from local levies and property

TABLE 5.4. Impacts from Loss of Nuclear Materials Production on Local School Districts

School District	Enrollment Losses		Staff Reductions		Total Funding Losses (Thousands of 1986 \$)(a)	
	1990	1997	1990	1997	1990	1997
Richland	999	1,799	94	128	\$2,058	\$4,159
Kennewick	909	1,679	48	92	2,083	3,499
Pasco	498	945	31	54	1,435	2,827
Kiona-Benton	77	138	7	10	193	333
Prosser	48	88	2	4	725	808
Grandview	45	83	3	6	110	191
Sunnyside	68	124	3	6	169	277
Yakima	93	170	3	5	320	558

(a) Total changes in local, state and Federal funding.

Sources: Local school district officials for staff and funding.

Enrollment calculated as discussed in Appendix B.

taxes. The legal limit concerning annual property tax rate increases, presently 6%, might constrain their ability to increase revenue sufficiently. However, the more severely affected districts felt it would be very difficult to pass levies with any increase in taxes if large numbers of people are unemployed in the district.

The two postsecondary schools in the Tri-Cities are Columbia Basin College, the local community college located in Pasco, and the Tri-Cities University Center (TUC), a consortium of Washington and Oregon universities offering graduate and undergraduate programs in Richland. These two schools also provided information on the potential impacts of the closure scenario on them. Of these two institutions it is likely that the TUC would experience the more significant negative impacts. According to representatives of the TUC, approximately 40% of TUC students and many of the part-time instructors are employed by Hanford contractors. In addition, some of the TUC's budget is paid by DOE through a "service assessment" overhead charge on certain Hanford employment. Closure of the N Reactor and related facilities would likely affect TUC operating revenue through a loss of both tuition and the subsidy provided by the DOE overhead charge. Columbia Basin College is presently at its state-mandated enrollment limit and any enrollment decline due to the reduced population could be offset by the retraining necessitated by the loss of Hanford jobs.

6.0 OTHER LOCAL IMPACTS OF NUCLEAR MATERIALS PRODUCTION CLOSURE

The economic and fiscal impacts discussed in the previous sections of the report imply losses in community population, wealth, and services--including many of the quality-of-life aspects of the communities near Hanford that make living pleasant, comfortable, and attractive to residents. An extensive social science literature exists on the social, personal, and community impacts of major losses of employment in local communities. This includes public sector energy and defense facilities (e.g., Grady et al. 1986; Daicoff 1973) as well as private sector industrial plants (e.g., DiNoto and Merk 1983; Buss and Redburn 1983; Francaviglia 1983; Langerman et al. 1982; Sewell and Wybrow 1982). As identified in this literature, besides the obvious economic stress on the individuals left unemployed and their families, there may be additional social impacts if these individuals remain unemployed for extended periods (Bubolz 1974; Ferman and Gordus 1979; Mick 1975; Kasl and Cobb 1979; Kinicki 1985). Impacts may extend to whole communities (e.g., see Nesse et al. 1985; Aronson and McKersie 1980). Uncertainty and costs of leaving may, at the same time, reduce the outmigration that may be necessary to relieve unemployment, thus compounding the problem (Sewell and Wybrow 1982; Hodge 1984). With this literature as a background the study team conducted a series of informal interviews with business and community leaders to identify the potential "other" impacts on the Tri-Cities area. This chapter discusses some of the potential adverse impacts on the local communities from closure of N Reactor and its associated facilities, and the loss of people, wages, and procurements that comprise a large part of the local economic base. Section 6.1 discusses impacts on the local financial sector, hospitals, and the business community; Section 6.2 discusses social impacts.

6.1 BANKS, HOSPITALS, AND BUSINESSES

Reductions in personal income and population due to closure of the N Reactor would result in reduced demand for financial services (banks, savings and loans, and credit unions), hospital care, and other community services. The methods by which these losses were calculated are described in detail in Appendix B. For some of the cities, the impacts are estimated to be substantial. This section discusses these induced impacts, focusing on the potential for some services to be discontinued, resulting in inconvenience and additional costs to the study area's population.

6.1.1 Banking Services

Closing N Reactor and phasing out nuclear materials production at Hanford would result locally in decreased levels of savings and checking deposits, as well as reduced personal and business loan demand. Profit margins for some local banks would be reduced, and some branches could be closed. Competition by banks to capture the smaller local deposit market could, in the short run, result in slight increases in deposit interest rates. However, the study area's shrinking income base could make loans more risky for banks; their response would likely be to tighten loan qualification criteria, and perhaps to add risk premiums to loan interest rates. The changes in interest rates on loans and deposits would be small, since interest rates are increasingly controlled by national and world, rather than local, economic

factors. However, reduced availability of credit could be more significant. These effects are described below, based on discussions with local branch managers.

Although a moderate number of intercommunity transactions occurs, commercial banks, savings and loan associations, and credit unions (referred to herein collectively as financial institutions) in the study area reportedly draw their deposits, and make loans, primarily from people and businesses located in the city in which their branches are located. Therefore, branches in cities with the highest proportional population and income losses can also be expected to experience the greatest proportional losses in their deposit and loan bases. These losses are shown in Table 6.1, which indicates that the cities with the largest proportional losses in income would be Benton City, Richland, Pasco, Kennewick and West Richland, while Yakima County communities are expected to experience relatively small effects.

TABLE 6.1. Proportional Losses of Population and Income (millions of 1986 dollars) by Area from Loss of Nuclear Materials Production

Area	1986 Population (a)	Estimated 1986 Income (b)	1990				1997			
			Population		Income		Population		Income	
			Loss (c)	% of 1986	Loss (c)	% of 1986	Loss (c)	% of 1986	Loss (c)	% of 1986
Benton County	104,000	\$1,500	6,416	6.2%	172.8	11.5%	11,685	11.2%	\$320.8	21.4%
Richland	30,240	436	2,890	9.6%	77.7	17.8%	5,217	17.3%	142.1	32.6%
Kennewick	36,600	528	2,869	7.8%	77.4	14.7%	5,296	14.4%	147.1	27.9%
W. Richland	3,720	54	261	7.0%	7.0	12.9%	459	12.3%	12.2	22.6%
Benton City	1,820	26	245	13.4%	6.6	25.2%	435	23.9%	11.7	45.0%
Prosser	4,010	58	151	3.8%	4.1	7.0%	277	6.9%	7.7	13.2%
Franklin County	35,300	410	1,572	4.5%	42.6	10.4%	2,981	8.4%	84.7	20.7%
Pasco	25,420 ^(d)	295	1,572	6.2%	42.6	14.4%	2,981	11.7%	84.7	28.7%
Yakima County	183,600	2,100	800	0.4%	21.6	1.0%	1,468	0.8%	40.6	1.9%
Yakima	49,590	567	293	0.6%	7.9	1.4%	538	1.1%	14.9	2.6%
Sunnyside	9,650	110	213	2.2%	5.7	5.2%	392	4.1%	10.8	9.8%
Grandview	6,320	72	142	2.2%	3.8	5.3%	261	4.1%	7.2	10.0%

(a) Source: Washington Office of Financial Management (OFM), 1986.

(b) Estimated by applying ratio of community to county population to total county personal income from the U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economics Information System.

(c) For methodology, see Appendix B, Section B.5 through B.7.

(d) Population and income adjusted to account for West Pasco/Riverview area. The City of Pasco had 18,420 residents in 1986.

The most immediate effect on the study area's financial institutions is expected to be a reduction in loan demand by households and businesses, possibly even before layoffs begin. Although large commercial loans are often obtained from institutions outside the study area, smaller business loans and consumer loans (such as for mortgages) are important sources of income for local branches. Reduced loan demand could likely be accompanied by tightened loan qualification requirements, and possibly increased loan interest rates, as the financial institutions add risk premiums to interest rates on local loans to make up for the likely increase in nonperforming loans.^(a) Thus, not only would credit become less widely available, it could become somewhat more expensive.

(a) Some local banks have apparently increased their rates recently to reflect risk premiums to address the possibility of N Reactor closure.

Another effect that could occur almost immediately is withdrawal of savings and checking account funds by people who move away from the study area. Deposits at local financial institutions in Benton and Franklin Counties in 1985 totaled \$802.8 million and \$222.4 million, respectively (Decision Research Sciences, Inc., 1987). Assuming that the loss in local deposits would be proportional to the losses in population shown in Table 6.1, then the loss in deposits in Benton and Franklin Counties could total about 5% or \$50 million, by 1990, and 9% or \$100 million, by 1996.^(a) In addition, many persons who lose their jobs but do not leave the area can be expected to draw down their savings accounts over time.

The shrinking deposit market could result in increased competition between financial institutions for deposits in the short run, potentially manifested by higher deposit rates and other inducements. The Tri-Cities area has about 40 main branches (and many satellite branches) of financial institutions, and apparently, a very competitive financial services sector, due in part to federal and state deregulation in recent years. Thus, while personnel expenses could decrease if banks cut staff, their interest expenses, which represent far higher costs, could be increased if competition for deposits increases.

Simultaneously, reduced loan demand could produce downward pressure on revenues. With profit margins being squeezed, and deposit and loan bases eroded, high-cost branches of financial institutions could be closed, and mergers may occur.

Based on an analysis of deposit data for each branch in the study area and discussions with financial institution officials, the feasibility threshold for a branch appears to be about \$6-10 million in deposits.^(b) A number of branches, particularly in those cities that would lose the greatest proportional population and payrolls, are sufficiently close to this threshold that layoffs at the N Reactor could cause their closure.

Credit unions are an important part of the local financial sector and may have to provide lower deposit rates if the area base erodes. Many Hanford workers belong to nonprofit federal credit unions. Discussions with credit union representatives indicated that they would be unlikely to discontinue services currently offered. (Generally, these are savings, checking, and consumer loans. They do not offer business or real estate loans.) However, they could be forced to reduce interest rates paid on deposits, which are often above the rates charged by for-profit banks. The reasons for the potential decrease in deposit rates for credit unions, and the increase for other financial institutions, is that credit unions, which are nonprofit, report that they do not generally compete for market share on the same basis as other financial institutions; their deposit rates are more affected by the cost of service than by price competition. Given economies of scale, reduced deposit bases could cause reductions in the deposit rate that the credit unions could afford to pay their members.

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- (a) Several factors would tend to raise or lower these proportional losses. Factors tending to reduce the loss in deposits include: 1) payment of interest on deposits, and 2) increased rates of savings by workers concerned about a possible loss of their jobs. Factors tending to increase the estimated loss in deposits include drawdown of savings by persons who lose jobs or suffer reduced incomes but do not leave the area.
- (b) Feasibility threshold is a term that implies whether a branch is contributing enough business to be economically viable. Besides deposits, loan volumes also contribute to the feasibility threshold. No loan volume data, however, are available for the study area.

Impacts on locally-based financial institutions would be likely to be different from impacts on financial institutions with statewide operations. At least four savings and loan associations derive the bulk of their deposits from the Tri-Cities, while larger statewide commercial banks generally draw only about 1 to 5% of their deposit bases from the Tri-Cities area. Many local officials feel that the local financial institutions would be likely to be more willing to accept short-term reductions in profitability before closing branches than would institutions with statewide operations; however, some local institutions also tend to have deposit bases closer to the feasibility threshold value of \$6 to \$10 million and therefore may be under pressure to close in the face of reduced profitability.

Although the local market is sufficiently competitive that the closure of some branch operations would not mean major changes in the local financial markets, inconvenience to consumers would likely result. In addition, over the longer term, the combination of branch closures and mergers could reduce competition somewhat, resulting in less advantageous deposit and loan terms to local consumers. However, the ability of local banks to greatly raise or lower interest rates to compete locally is already quite restricted, because the financial services industry is becoming increasingly controlled by national and world factors; thus, with the possible exception of risk premiums charged on business loans, changes in local interest rates would likely be very small. The primary impact would likely be reduced credit availability.

6.1.2 Hospitals

Losses in population under the closure scenario would result directly in reduced demand for hospital services. Employment losses by persons who remain in the area may also cause some additional reduced demand, but this reduction would be dampened to the extent that those persons are able to retain or replace their health insurance benefits.

In general, the local hospital officials estimate that impact of closure of the N Reactor on the three hospitals in the Tri-Cities would be noticeable--up to about a 10% loss in the number of admissions, but would probably not result in termination of major services offered by any of them. The scale of services offered would be reduced, and costs could increase, but communities would not suffer loss of available services.^(a) The primary source of the effects would be outmigration by working-age persons and their families, rather than by Medicare/Medicaid patients. Thus, some services, such as maternity services, could experience noticeably decreased demand. On the other hand, increases in stress-related illnesses such as heart attack and stroke can be expected to cause increased demand for some services. These effects are described below.

There are three hospitals in the Tri-Cities area: Kadlec Medical Center (136 licensed beds) in Richland, Our Lady of Lourdes Hospital (119 licensed beds) in Pasco, and Kennewick General Hospital (71 licensed beds) in Kennewick. Hospitals are also located in Prosser and Yakima county, but the potential proportional losses in population in those areas, and hence

(a) This conclusion appears to be supported by the data we were able to obtain from the hospitals. However, to the extent that they are not able to pass their fixed costs through to a shrinking patient population, one or more of the hospitals may be put under more severe financial stress than indicated in this section, and some services may in fact be lost.

the effects on hospital services, are expected to be small. All three Tri-Cities hospitals offer general medical services, including a 24-hour emergency room, basic surgical services, intensive care, and neo-natal care.

Kadlec Medical Center in Richland is the Tri-Cities' largest hospital, capturing 47 to 48% of the total Tri-Cities market. Kadlec's average occupancy is about 50% of capacity. Of Kadlec's 6,000 annual admissions, about 70%, or 4,200, are non-Medicare/Medicaid. About 50% or 2,100 of these patients, are from Richland, with the remainder from the rest of the Tri-Cities.

Based on the admissions data above, analysis of the expected changes with Kadlec administration, and the proportional population losses in Table 6.1, we estimate 282 fewer annual admissions could be directly lost by the year 1990, and 489 by the year 1996.^(a) In addition to these direct losses, indirect losses could occur due to reduced demand by persons who remain in the area but do not retain insurance benefits. These reduced admissions are more difficult to quantify, but would likely be relatively small. Thus, we project that about 300 to 400 fewer admissions (7% of the current total) could occur by 1990, and 500 to 700 (10% of the current total) by 1996. Kadlec non-Medicare/Medicaid patients average 3.2 days per admission. Thus, the loss in admissions would reduce Kadlec's occupancy rate from today's 50% to 47% by 1990 and 45% by 1996.

This loss would probably affect maternity and neo-natal intensive care services the most because the working-age population would be most affected. Because fixed costs exist and Kadlec is already at a lower-than-optimal occupancy rate, costs of health care would likely rise somewhat, and some layoffs would likely occur. However, no services would likely be discontinued.

Discussion with representatives of Kennewick General Hospital indicated that similar, but slightly lower, impacts would likely occur. Impacts would be lower since the primary market area for Kennewick General is in Kennewick (70% of admissions), with a relatively low reliance on the Richland market (5%). Based on the population losses shown in Table 6.1, the direct loss in annual admissions would be about 151 in 1990 and 264 by 1996. Including reduced use of services by laid-off workers who remain in the area the loss in admissions would be about 175 to 200 by 1990, and 275 to 300 by 1996. This compares with a total of 3,900 admissions in 1986. At 3.2 patient-days per admission, these losses would reduce Kennewick General's occupancy rate from its current 50% to 48% by 1990 and 46% by 1996. It is unlikely that any services would be discontinued, although some services might be subject to review.

Our Lady of Lourdes Hospital in Pasco reports a low, and declining, occupancy rate (27%), but a significant outpatient component which provides the hospital's primary income base. About 75% of its clients are from Pasco, 20% from Kennewick, and 5% from other areas. Of its 3,000 admissions in 1986, about 1,500 were non-Medicare/Medicaid. Based on this geographic market area distribution and the proportional population losses shown in Table 6.1, we

(a) By the year 1990, about 187 annual admissions could be lost from the Richland market (8.9% times 2,100), and 95 annual admissions could be lost from the non-Richland market (4.5%, or the proportional loss in Benton and Franklin counties' population outside of Richland, times the 2,100 non-Richland admissions). Similar calculations were used to estimate the 1996 loss in admissions.

project a direct loss of 140 annual admissions by 1990 and 200 by 1996. Indirect losses due to reduced demand by those laid-off workers who remain in the area could increase annual admissions losses to 150 to 200 by 1990 and 250 to 300 by 1996. Based on 3.2 days average stay per admission for non-Medicare/Medicaid patients, the loss in annual patient-days would be up to 640 by 1990 and 960 in 1996. These losses would lower Lourdes' occupancy rate to 26% by 1990 and 25% in 1996. Given the presence of fixed costs, the cost of inpatient services would probably increase.

The loss of admissions would likely be greatest for services typically provided to working-age persons and their families, such as maternity services. The hospital's region-wide alcoholism program could receive greater use. It is doubtful that any services would be discontinued; rather, their scale would likely be reduced to match decreased demand.

6.1.3 Impacts on the Business Community

Closing nuclear materials production would adversely affect local businesses due to a number of factors, including the declining local markets illustrated in Chapter 4, the decrease in property values of as much as 10% leading to higher property tax rates discussed in Chapter 5, reduced availability of credit, and possibly higher interest rates on loans discussed in this chapter. The real estate and construction industries would appear particularly vulnerable because construction and real estate activity are already very low.

Besides a significant loss in residential construction activity in the Tri-Cities over the period since 1980, the relatively slack local housing market is reflected in the sharply increased average vacancy rates for residential housing in the area. Table 6.2 shows that local average vacancy rates have risen up to the date of the last survey in October 1985 from April of 1980. Even though the local housing market was considered "tight" in 1980 the increase is substantial. This has contributed to a fall in housing values from the inflated levels recorded in 1980 to more "normal" levels. For example, the average price of a single family house in the service area of the Tri-Cities Multiple Listing Service (Franklin County, plus Benton County, excluding the Prosser area) has fallen from \$67,300 in 1980 to \$60,000 in 1986.^(a) Time-to-sale probably has also increased, although precise figures are not available. Further employment and population losses can be expected to put additional downward pressure on housing occupancy, housing prices, rental rates, and businesses and individuals dependent on the residential real estate market. Similar effects should be felt on the commercial side of the real estate business as well. Several local shopping areas have significant vacant space. The most outstanding example of this is a small shopping center to the immediate west of Columbia Center, which stands vacant. Both Ernst Hardware and Safeway Stores have each recently closed a Tri-Cities store, though both firms maintain a substantial presence in the area. Several small local retail establishments also have closed since 1982.

The magnitude of the overall impact on the business community cannot easily be predicted in spite of these indicators and depends upon other factors affecting the study area economy. If national economic conditions are strong, and the local economy is performing well

(a) Data supplied by Larry Miller, Tri-City Board of Realtors, August 8, 1986. Peak average sales value was \$73,000 in 1981.

TABLE 6.2. Vacancy Rates in Housing by Type of Unit: Richland, Kennewick, and Pasco 1980 and 1985^(a)

<u>City and Year</u>	<u>All Housing</u>	<u>Detached Single Family Residences</u>	<u>Apartments (Multi-Family Units)</u>	<u>Mobile Homes</u>
<u>Richland</u>				
April 1980	3.7%	1.4%	9.7%	1.5%
October 1985	9.0	4.6	25.7	13.5
<u>Kennewick</u>				
April 1980	2.5	1.2	5.5	2.2
October 1985	8.3	4.6	15.4	11.9
<u>Pasco</u>				
April 1980	1.9	1.1	5.5	1.0
October 1985	8.4	4.4	14.3	8.2
<u>Tri-Cities</u>				
April 1980	2.8	1.2	7.0	1.6
October 1985	8.2	4.4	17.7	10.4

(a) October 1985 is the date of the last vacancy survey completed in the Tri-Cities.

Source: "Tri-Cities, Washington Housing Vacancy Survey, October 1985," Federal Home Loan Bank, Seattle, Washington.

in sectors basically unaffected by Hanford activities (in particular, agriculture), the effects on local business would be relatively less severe. Local businessmen interviewed for this study declined to speculate on the degree of impact. However, if economic conditions are generally poor, it is conceivable that the burden added on local business could become magnified by the closures. In either case, costs from local tax increases and increased loan interest costs would likely be felt by local business.

6.2 SOCIAL IMPACTS OF N REACTOR CLOSURE

The purpose of the social impact analysis conducted in the study was to identify and assess the local social consequences of job, payroll, and population loss resulting from closing N Reactor and related nuclear materials processing production. In particular, the study of social effects attempted to identify and describe significant impacts of closure on the social structure and community organization of the Tri-Cities, specifically: 1) how a decline in population could influence Tri-Cities social service and cultural organizations; 2) how declines in income and the local tax base could influence funding for community public services; and 3) how loss of personal security relative to employment and income could contribute to stress on individuals and anti-social behavior in the community. The study found that there would be significant social impacts.

6.2.1 Procedures

The following procedures were used. A number of sources were reviewed or contacted to compile a likely set of candidates to represent various types of service and cultural

organizations, including mutual referral by the contacts themselves and contributors to the 1987 Progress Editions of the Tri-City Herald. Following discussions of the closure scenario discussed in this report in Sections 3.2 and 4.2, informal interviews were then arranged, and conducted either in person or by telephone, as time permitted. As a result of this approach, the data gathered were primarily qualitative in nature.

6.2.2 Results

Analysis of field interview data suggests that if N Reactor and associated facilities were closed, significant social impacts are likely to occur in the funding, leadership, and need for social services.

Funding

Significant community-wide effects would be felt if the substantial contributions made by Hanford workers to the United Way campaign were reduced. These contributions include both financial support and volunteer efforts in fund-raising. The United Way fund provides extensive support for many community services which would be impacted proportionally if funds declined. The United Way raises \$1.2 million at Hanford (about 70% of all area contributions), and uses approximately 3,000 total volunteers on the campaign, many of whom are Hanford-related. In the Tri-Cities, then, the United Way campaign can be described as "Hanford-driven" and noticeable impacts would occur with an N Reactor closure.

Additionally, local public programs that are dependent on contributions (including United Way funds), user fees, or other grants-in-aid, would also be impacted by an N Reactor closure. These include recreation and sports programs run through the cities' parks and recreation departments or run privately, social and health services that receive agency or state funding, and direct Hanford services (for example, the van pool service for employees).

Some examples will illustrate these points. The City of Richland Parks and Recreation Department has a full-time staff of 6, but over 50 part-time staff work on many of the recreation and sports programs. If program participation declined, recreation programs that are not self supporting would be cut and part-time staff would be reduced.

The Tri-Cities Volunteer Center, which receives approximately 25% of its funding from United Way, expects a proportional decrease in funding if United Way contributions were reduced. Furthermore, the ability of the community to provide services and programs through the Volunteer Center would be greatly impacted by a decrease in the number of Hanford-related local volunteers who might leave the community.

The Tri-Cities Chaplaincy, an interdenominational ministry providing support to over 10,000 persons in 1986, would be likely to lose not only a portion of its United Way funding, but also funding from church donations--which could be expected to decline with personal income.

Benton-Franklin County Transit owns 30 vans, funded separately from the rest of the transit system, which are used for vanpool service primarily for Hanford employees. The cost of the vanpool program is assumed by the riders. However, if a reactor closure occurred, the

vans would be idle, and potentially, sold. The revenues from a 0.3% sales tax which are earmarked for transit as well as general farebox revenues of the system, would also be adversely affected.

Leadership

Hanford employees contribute significant time, energy, and expertise to the social and cultural development of the Tri-Cities area. A closure of the N Reactor and related facilities would likely mean not only a decline in membership in community organizations, but also a negative impact on leadership.

For example, of a United Way allocations committee of approximately 100 members, 80% are Hanford employees. In addition, approximately half of the nearly-70 member United Way Board of Directors are Hanford employees. While there is a mix of all worker categories, management provides the heaviest involvement (about 75%) in the United Way programs.

Some community leaders estimate that for all volunteer agencies in the Tri-Cities area, 50% to 75% of the memberships of Boards of Directors are Hanford-related employees or spouses. At the Chaplaincy, for example, half of the 24 member Board of Directors either are Hanford-related, or are local small businessmen who would be affected directly by a reactor closure.

These estimates are representative for community cultural projects as well. Within the Arts Council of the Mid-Columbia region, approximately half of the 275 membership, and many of the 22 member Arts Council Board, are Hanford connected (employees or spouses).

Need for Social Services

Closure of the N reactor and related production facilities would likely result in an increase in the demand for basic social services. Additional stress would be placed on existing social services that provide minimum-level, immediate aid in emergency situations. These include the local food banks, and the social and health services which provide counseling, financial aid, surplus food, and other services. Adverse impacts would likely occur on an individual level as well, and manifest themselves as increases in personal stress, anti-social behaviors, and health disorders.

Some examples will illustrate these points. The Tri-Cities Food Bank served 48,641 individuals in 1986 on a \$218,000 budget (16% from United Way; other funds from churches and private donors; half of the budget was in goods and produce donations). Their current patrons include migrants and farm workers, welfare recipients, and unskilled, low-income residents. However, under the closure scenario the number of families attempting to "make ends meet" can be expected to increase while an out-of-work breadwinner searches for a new job. This, in fact, was what occurred during the WPPSS downturn in the early 1980's.

The Benton-Franklin Community Action Committee, an organization providing basic emergency services for low-income people, reported serving 153,000 persons in 1986; in 1982, during the WPPSS downturn, they served three times that many. At that time, they were unable to meet the needs of the "new poor"--the spouses and children of laborers, craftsmen, and mid-management employees who stayed in the community receiving welfare services and attempting to sell homes,

while the former employees looked for work in other states. For these workers and families, the problems were magnified and the needs continuous, as the job search stretched out over a period of years.

For the scenario we presented, the local office of the Washington State Department of Social and Health Services expected to see an immediate and significant impact on their food stamp program, since people generally apply for food stamps preliminary to other kinds of assistance. (Their average foodstamp caseload per year is currently approximately 4,000 applicants.) Further, while it now takes 7 to 9 days for an applicant to see a caseworker, it is estimated that under the scenario we presented, that time would be likely to increase to approximately 30 days.

On the individual level, one could expect an increase in stress-related disorders, including alcohol and drug abuse, symptoms of depression, and family-related problems (including child and sexual abuse, desertion, and divorce). A mental health professional at the Mid-Columbia Mental health Center reports that during the WPPSS downturn, stress-related disorders increased, and suicide rates nearly doubled in the Tri-Cities area. To compound the problem, when employees are out of work, they are often unable to pay for the personal or family treatment they need.

Further, empirical studies have found that unemployment is a significant source of stress and of stress-related psychological and physiological distress. For example, job loss has been found to be associated with feelings of loss of control over one's life, lowered sense of self-worth, depression, elevations in urinary catecholamines (an index of physiological stress), and decreases in immune function.^(a) Thus, there may be increased levels of medical problems among the unemployed.

6.3 CONCLUSION

Closure of the N Reactor and related facilities will clearly have a significant impact on the social structure and community services of the Tri-Cities area. Although these impacts are not easy to quantify, the experiences of the years following the WPPSS downturn have given a sense of the magnitude of the impacts that might occur. The social impacts described in this section should be understood as illustrative of the social adjustments that would be required in the case of loss of the nuclear materials production mission.

(a) Baum, A., J. Fleming, and V. Reddy. 1986. "Unemployment Stress, Loss of Control, Reactance, and Learned Helplessness." Social Science in Medicine (in press).

APPENDIX A

HANFORD NUCLEAR MATERIALS PRODUCTION FACILITIES

APPENDIX A

HANFORD NUCLEAR MATERIALS PRODUCTION FACILITIES

This appendix describes the individual nuclear materials production facilities at Hanford in more detail than in the main text of the report. The descriptions were developed from public information materials and environmental impact statements produced for the various facilities by the Hanford contractors. The environmental impact statements for some of these facilities (e.g., PUREX) provide some additional process detail. In general, details concerning the amounts of material processed (and in some cases, capacities) are classified.

A.1 N REACTOR

The history of N Reactor began in 1958, when Congress authorized its construction, at a cost of \$198 million. N Reactor was primarily designed for production of plutonium, but with the capability for later conversion to dual-purpose operation whereby both plutonium and steam for the generation of electrical power would be produced. N Reactor was started up in December of 1963 and produced only plutonium (no electricity) until the spring of 1966.

Meanwhile, in 1962, Congress passed legislation authorizing the dual purpose operation of N Reactor, and the Washington Public Power Supply System, representing 19 public utilities in the Northwest, proceeded to construct an electrical power generating plant adjacent to N Reactor at a cost of \$125 million. The first electrical power was generated from N Reactor steam in April, 1966.

N began generating electric power in 1966 with a capacity of 860 million watts of electricity (MWe). At that time only three commercial nuclear power plants were in operation in this country, with a combined generating capacity of 640 million watts (MWe).

N Reactor is primarily a large cube of stacked graphite bars penetrated horizontally by 1,003 Zirconium process tubes and surrounded by a thick shield of very dense concrete.

The uranium fuel assemblies are placed in the process tubes. High-purity, high-pressure cooling water (primary coolant) is pumped through these tubes to pick up the heat which is released from the uranium during the fission process. The reactor is designed to be operated at a power level to produce up to 4,000 megawatts of heat.

From the reactor, primary coolant is circulated to 10 of the 12 parallel heat exchangers (steam generators) where the process heat is transferred to a secondary system causing the boiling of water and production of steam in the secondary system. A small fraction of this steam is used to drive the reactor's primary coolant pumps and to generate electric power for use within the reactor plant. During plutonium-only operation, the balance of the steam is dissipated in the reactor plant's dump condensers. During dual-purpose operation, this steam is used to drive two large turbine generators producing approximately 860 million watts of electrical energy in the Washington Public Power Supply System's adjacent plant. This power is fed to the Bonneville Power Administration electrical grid covering the Northwest.

The basic fuel for N Reactor is slightly enriched uranium--uranium with a slightly higher U-235 content than naturally occurs. The uranium in metallic form is contained in fuel assemblies made of two separate tubular zirconium alloy-clad fuel pieces, one nesting within the other, with an overall diameter of about 2.5 in., a length of about two feet and weight of approximately 50 pounds. It takes about 17,000 of these assemblies to fuel the reactor.

The high quality fuel needed for N Reactor requires extreme care in its fabrication. Highly sophisticated technology and equipment are used to ensure that each fuel piece will withstand the rigorous conditions of the reactor environment. Key to the fuel element fabrication process is a 3,000 ton capacity hydraulic press which co-extrudes zirconium-encased uranium billets into the tubular pieces. The extrusion process metallurgically bonds the zirconium and uranium together to ensure efficient heat transfer and high fuel integrity. The zirconium alloy-clad fuel for the N Reactor is made at a facility in the Hanford site's 300 area.

Operation of N Reactor, as well as commercial light water reactors, is based on the nuclear fission process. In a uranium-fueled reactor, the fissionable material is the isotope uranium 235, which is the only naturally occurring substance that is fissionable by "slow" (low energy) neutrons. It is an isotope of the element uranium, and makes up 0.7% of natural uranium. Essentially all of the rest of the natural element is the isotope uranium 238.

In nuclear fission, a U-235 atom in the uranium fuel is split into two lighter atoms, called fission products, by a neutron that has been slowed down or moderated by the reactor moderator (graphite in N Reactor and water in most conventional nuclear power reactors). The splitting of the atom also results in the emission of two or three neutrons and the release of a large amount of energy in the form of radioactivity and heat. Some of these neutrons escape from the graphite to be contained in the shielding. Other neutrons are slowed and strike U-235 atoms, causing these atoms to split, releasing more neutrons that strike additional U-235 atoms thus perpetuating the "chain reaction"; or they may be absorbed by atoms of the heavier U-238 isotope, transforming them into atoms of U-239. The U-239 isotope, through the process of radioactive decay, ultimately changes to plutonium, the end product in a production reactor such as N Reactor. Plutonium is separated from the spent N Reactor fuel at Hanford's PUREX plant.

A.2 PUREX - UO₃ PLANTS AND PROCESS FACILITY MODIFICATIONS PROJECT

The PUREX plant consists of a large processing building and associated support facilities located in the 200 East Area of the Hanford Site. The processing building is about 300 m (1,000 ft) long, 35 m (120 ft) wide, and 30 m (100 ft) high. In the processing building are cells containing vessels, tanks, pipes, columns, and other equipment necessary for fuel processing. The UO₃ plant includes facilities for receiving and concentrating the uranyl nitrate hexahydrate (UNH) produced by the PUREX plant, six electrically-heated continuous calciner processing units that convert UNH to UO₃, acid recovery equipment, and facilities for packaging and shipping of UO₃. The UO₃ facility is much less complex in comparison with the PUREX facilities. Further, it processes materials of very low radioactivity, not exceeding that of natural uranium, that do not require shielding or remote operations. The UO₃ production facilities are located about 8 km (5 miles) west of the PUREX plant in the 200 West Area.

The PUREX/ UO_3 process operation is similar to many chemical processing plants; the major difference is that many materials in the PUREX process are radioactive and require special handling procedures. The processing operations include decladding and dissolution of fuel elements, solvent extraction and recovery of uranium and plutonium, and concentration and calcination of extracted liquids into solid form for further processing.

There are three sections to the PUREX Plant:

1. Head end (feed preparation). Spent irradiated fuel rods from N Reactor are shipped 8 miles by rail in special water-filled, lead-shielded casks to the PUREX Plant. There, the zirconium alloy (zircaloy) cladding that encloses the fuel is chemically removed, and the uranium metal fuel is dissolved with nitric acid.
2. Solvent Extraction. The dissolved fuel is processed to recover plutonium and uranium. The uranyl nitrate solution is transferred to the UO_3 conversion plant in the 200 West Area.
3. Plutonium Oxide Conversion (N Cell). The plutonium nitrate solution is converted into plutonium oxide powder in N Cell. The oxide is then transferred to the Plutonium Finishing Plant in the 200 West Area for storage and eventual shipment to the Rocky Flats, Colorado, plutonium-processing plant.

The UO_3 (Uranium Oxide) Plant converts liquid uranyl-nitrate hexahydrate (UNH) into a solid uranium oxide (powder) which is shipped to the government's Feed Material Production Center (FMPC) in Fernald, Ohio, for further processing. The UO_3 Plant is a link in the Department of Energy's nuclear program involving the PUREX Plant and N Reactor.

The process flowsheets for the UO_3 Plant reflect a capacity of 36.4 metric tons of uranium per day. This capacity has been exceeded during several of the plant's production runs when 40 to 42 metric tons were produced in a single day. Twelve successful production campaigns have been completed, between plant restart in July 1984 and July 1986.

The UNH is shipped from the PUREX Plant to the UO_3 Plant via 3,000 gallon UNH tank trailers. Upon reaching UO_3 , a material inventory is performed to ensure proper control of special nuclear materials. Afterward, the material is stored until there is sufficient quantity on hand to warrant a production campaign. The UO_3 Plant's process capability greatly exceeds PUREX Plant's capacity.

The 60% UNH solution is pumped through thermo-siphon steam-heated concentrators where the material is concentrated to approximately 100% UNH. The concentrated UNH is routed to a storage tank where a controlled quantity of sulfuric acid is added.

The concentrated UNH is then pumped through a heated feed loop to the six electrically heated calciners. The UNH is introduced into each calciner through four feed points. Once inside the calciners, the UNH instantly decomposes to UO_3 powder, nitrogen oxide, oxygen, and water vapor.

The UO_3 powder is pneumatically conveyed through a powder handling system and loaded into shipping and storage containers called T-hoppers, where it is again inventoried. Afterward, the material is shipped to the FMPC in Fernald, Ohio, for further reprocessing.

Off-gas from the process containing nitrogen oxide, oxygen, and water vapor are routed through a wet scrubber, gas cooler, acid absorber tower, and condenser to recover the nitrogen oxide as nitric acid.

More than 90% of the nitrogen oxide is recovered as nitric acid. The recovered nitric acid is shipped back to the PUREX Plant via rail tank car for reuse in the PUREX process.

Any waste solutions containing uranium are collected and concentrated in a waste concentrator tank. This waste solution is filtered and shipped to the PUREX Plant for rework and is eventually returned to the UO_3 Plant as feed material.

Work began recently to modify the PUREX Plant to permit the recovery of plutonium from the irradiated Fast Flux Test Facility (FFTF) fuel, for use in DOE programs, by preparing the fuel in the Process Facility Modifications (PFM) project for subsequent processing in the PUREX Plant. A corollary purpose of the PFM is to provide an improved method of preparing irradiated fuel from DOE's N Reactor (N fuel) for processing in the PUREX Plant. The PFM will not be a stand-alone facility that produces a final end product; its function will be to segment the fuel elements or pins into short pieces from which the contained fuel will then be dissolved. The dissolved fuel solution will be transferred to the PUREX Plant for separation and purification of the contained plutonium, uranium, and desired byproducts.

The irradiated fuels to be prepared in the PFM for processing in the PUREX Plant would come from the FFTF and from the N Reactor. The FFTF fuel is clad in stainless steel that presently cannot be dissolved or mechanically removed in the PUREX Plant. The PFM would provide the capability for mechanically segmenting the FFTF fuel, which permits selective dissolution of the fuel from the cladding segments. Zircaloy-clad N fuel is currently processed in the PUREX Plant via chemical decladding and subsequent dissolution of the fuel. The PFM would also prepare N fuel by mechanically segmenting the fuel elements and selectively dissolving only the fuel, not the cladding, prior to transferring the dissolved fuel solution to the PUREX Plant for subsequent processing.

A.3 PLUTONIUM FINISHING PLANT (PFP)

The Plutonium Finishing Plant (PFP), sometimes known as Z Plant, gives the Hanford Site the capability to convert plutonium nitrate solutions to plutonium metal. This is a critical process that previously had to be done offsite. Additionally, the PFP recovers and purifies plutonium by a solvent extraction process to produce the plutonium nitrate solution.

The PFP is located in 200 West Area, Building 234-5 (known as Z Plant) at the Hanford Site (27 miles north of Richland). The facility contains 212,477 sq ft and consists of eight major operations.

- Remote Mechanical C (RMC) line, which converts plutonium nitrate solutions to the plutonium metal form needed for weapons fabrication.

- Plutonium Reclamation Facility (PRF), which recovers and purifies plutonium by solvent extraction to produce plutonium nitrate solution.
- Analytical and developmental laboratories, used to perform analytical work and studies.
- Storage vaults, used to store several plutonium forms packaged in metal containers.
- Plutonium Storage and Support Facility, which stores plutonium that is packaged in metal containers. Also used for shipping, receiving, repackaging, and nondestructive assay of plutonium.
- Slag and Crucible Dissolver (S&C), which processes scrap metal from the RMC line.
- Underground sump pit, which contains five tanks in five separate cells that are used for intermediate storage and neutralization of Z Plant liquid waste.
- Miscellaneous Treatment, which prepares feed for PRF and includes scrap preparation, stabilization, dissolution, and solid handling.

The PFP was built in 1949 and the PRF was added in 1964. The facility was closed in 1979 and restarted in 1984. The RMC weapon fabrication line started in 1959, and was closed in 1965. The RMC plutonium metal line closed in 1973 and was restarted July 1, 1985.

A.4 FUEL FABRICATION

The fuel fabrication facility is located in the 300 Area (about 3 miles north of Richland). It produces the zirconium alloy-clad fuel used in the N Reactor. Twenty-inch uranium billets arriving from offsite go through a seven-step process to become N Reactor fuel. These steps are: billet preparation, extrusion, brazing, heat treatment, nondestructive tests, autoclaving, and final assembly. The fuel manufacturing plant can produce more than 1,800 quality uranium fuel assemblies per week. N Reactor's fuel differs from fuel from commercial power reactors in both form and content. N Reactor fuel is designed to produce plutonium, while fuel for a commercial reactor is designed for electrical generation. Commercial reactor fuel is a more highly enriched (greater amounts of U-235) ceramic uranium oxide.

- Extrusion. The heart of the manufacturing process is the Loewy extrusion hydropress. A uranium billet, heated to 1,100°F is extruded through a conical-shaped die to form a 30-ft long tube sheathed in Zircaloy. In spite of its massive appearance, the press can produce diametrical tolerances of within three-thousandths of an inch.

After cooling and inspection, the 30-ft tubes are cut into fuel length sizes ranging around 26-in.

The fuels plant can also perform high-precision machine work and create special components used at N Reactor. The 3,000-ton extrusion press has been used to fabricate the reactor's control rods and fuel storage canisters.

- Brazing. The fuel length sections are machined on a precision lathe to assure uniform lengths. The ends of the sections are chemically milled to remove a layer of uranium in preparation for end caps.

Zircaloy end caps are placed on each end of the fuel piece and exposed to 1,900°F heat, which bonds the end cap to the fuel. Time, temperature, and pressure are closely monitored during this step.

After rigid inspections, a serial number is stamped on each piece to provide a permanent record.

- Heat Treatment. In order to assure the dimensional stability of the fuel when it is irradiated in the reactor, each piece receives a heat treatment. This process produces a random, stable grain structure in the uranium.

The elements are placed in a 1,355°F salt bath for up to 10 min and are then quenched in a 572°F salt bath. A water rinse removes the residual salt scale. Following another inspection, the fuel elements are grit blasted and machined in preparation for final end welding.

- Nondestructive Testing. The fuel is ultrasonically tested to check the bonding between the cap, the cladding, and the core. After the final weld is made on the end cap, a combined ultrasonic-eddy current test is used to verify that the cladding is bonded to the uranium and that the thickness of the cladding meets specifications.
- Autoclaves. The final test--a potentially destructive one--is performed by putting the fuel elements in an autoclave. The autoclave simulates the heat and pressure the fuel will encounter in the reactor. Any cladding flaws that would permit water to come into contact with the uranium will be discovered here.
- Final Assembly. Before final assembly, each element will pass several more examinations. Typically, specifications limit allowable deformation to only three-thousandths of an inch, and a variation of only two-hundredths of an inch in the annular space between the inner and outer pieces.

After inspections, the inner and outer element pieces are matched for length, joined one-inside-the-other, and locked in position to form a completed fuel assembly. Steel shoes are attached to the outer element to provide a smooth sliding surface when the fuel is charged into the reactor. The shoes also position the fuel within the process tube to preserve a pathway for cooling water to pass over the fuel.

APPENDIX B

ECONOMIC IMPACTS: DETAILED METHODOLOGY

APPENDIX B

ECONOMIC IMPACTS: DETAILED METHODOLOGY

This appendix is a more detailed presentation of the methodology for determining the economic impact of closing N Reactor and phasing out nuclear materials production at Hanford. This information is summarized in Chapter 4 of the main report. The closure scenario would have substantial economic effects upon the Tri-Cities and the State of Washington. Employment losses would occur across a wide range of industries as a result of reductions of both Hanford payrolls and Hanford purchases of equipment and supplies from businesses within Washington. This section presents quantitative estimates for state and local employment losses and the potential outmigration of population from the Tri-Cities area.

Section B.1 discusses statewide impacts of nuclear materials production closure and Section B.2 discusses the impacts within the Tri-Cities. Section B.3 assesses and reconciles the various estimates of long-term employment multipliers at both state and local levels and seeks to provide a most probable case. Section B.4 describes the time-phasing of multiplier response while Section B.5 presents estimates of the likely outmigration from the Tri-Cities area. Section B.6 discusses the procedures utilized to estimate impacts on personal income. Finally, Section B.7 describes the methods used to estimate the impacts on individual cities, counties, and school districts.

B.1 STATEWIDE IMPACTS ON JOBS AND PAYROLLS

To measure statewide impacts of nuclear materials production closure, two "off-the-shelf" economic models were used. The first, the Washington Economic Model (WASHMOD), is a quarterly econometric model of the Washington State economy and is used principally by the Department of Revenue to assist in making revenue projections (Economic and Revenue Forecast Council 1986a). The second is an input-output model of the state economy developed by Professor Philip Bourque at the University of Washington (Bourque 1987).

B.1.1 Washington Economic Model

WASHMOD is used to forecast employment and earnings in major Washington industries, housing, construction, and personal income. The model is linked to forecasts of national economic activity and generates quarterly forecasts for up to three years in the future.

The model considers employment and payroll in 23 private industries--16 in manufacturing and 9 encompassing mining, construction, utilities, trade, and services. The behavioral specification of the model follows the framework of an economic base model. Most of the state's manufacturing industries are treated as part of the state's economic base. Because they sell their products outside of the Washington economy, the equations yielding employment levels in these sectors use variables that characterize national or international demand. Other sectors such as trade, services, transportation, and state and local government, are linked to overall personal income or population of the state.

The number of building permits for residential housing is determined within the model. This variable depends upon the stock of existing housing in Washington, total employment in the state, mortgage interest rates, and the price of new homes.

Because Washington personal income is a key variable within the model, its determination is considered carefully in the model specification. Employment and wage rates determine total wage and salary payments. Wage rates in turn depend primarily on national wages, but also respond to the overall level of employment within the state. Components of nonlabor income include farm and business proprietor's income, transfer payments (including unemployment insurance benefits that respond to the level of employment); and interest, dividend, and rental income. Payrolls of wage and salary workers are considered with the sum of these non-labor items to make up total personal income within the state.

The process of preparing a state forecast with WASHMOD begins with an evaluation of Data Resources Inc.'s (DRI) forecast of the national economy. This evaluation is made by the Office of the Forecast Council. The DRI national forecast is sometimes modified if it differs considerably with the views of the Forecast Council. The output from the final national forecast such as income, interest rates, prices, and industrial production, are used to drive the equations of the state economic model. The Forecast Council also uses other state data to define the final state forecast. This information includes the latest revenue collection data, the Purchasing Managers of Washington index, and the Washington index of leading economic indicators.

B.1.1.1 Adjustments to WASHMOD

To use WASHMOD in a statewide impact analysis, one must first translate the direct effects of nuclear materials production closure into changes in certain variables within the model. In performing this task, three sets of adjustment factors were computed. First, the reduction in direct Hanford employment was converted into changes in employment for two WASHMOD industries, Industrial Chemicals and Services. Workers involved directly in the N Reactor, PFP, PUREX and other related Hanford facilities are classified as part of the industrial chemicals sector. As shown previously in Figure 2.3, there are a large number of scientists, engineers, and other support staff involved in the nuclear materials production at Hanford. These workers fall into the business services portion of WASHMOD's large and diverse service industry classification. For each type of worker, an estimate of quarterly job losses was made beginning with the fourth quarter of 1987. These estimates were then inserted into the model as adjustment factors to the equations that predict employment in these sectors.

The adjustment procedure is illustrated for the case of the Services Sector. The adjusted WASHMOD equation for Services employment is:

$$\begin{aligned} \text{ESV@WA} = & -557.58 + 2.486 * \text{YP82@WA} + 6.0871 * \text{EEA} \\ & + 404.61 * \text{RuADJ@WA} + \text{ESVADJ} \end{aligned}$$

where ESV@WA = Employment in Services, Washington

YP82@WA = Real personal income, Washington

EEA = Wage and salary employment, U.S.

RuADJ@WA = Proportion of people age 18 to 64 who are not working (with time trend removed), Washington

ESVADJ^(a) = Adjustment to equation, number of employees in Washington.

Beginning in the fourth quarter of 1987, ESVADJ takes on the values for job losses of Hanford workers classified in business services. These values increase over time as the number of layoffs increase. As the equation above shows, ESVADJ is an additive adjustment. Thus, at any level of ESV@WA implied by the other explanatory variables, it is reduced by ESVADJ.

Salaries of Hanford workers in both of the key affected sectors are higher than statewide averages for the corresponding industries. To accurately reflect the impact due to reductions in Hanford payroll within the state economy, separate adjustments were made to the model's wage rate equations for industrial chemicals and services. Thus, in step two an adjustment factor is computed for each quarter that reduces average wages within the affected industries.

The third step in this process was to account for employment impacts of Hanford procurements within the state. The N Reactor and related activities were estimated to have purchased some \$33.5 million of goods and services within the state in 1986. The pattern of purchases was used to generate employment losses in ten other industries within the model, primarily concentrated in wholesale and retail trade. These estimates were based on information contained in the University of Washington 1982 input-output study of Washington State, updated with Fiscal Year 1986 procurement information supplied by Hanford contractors. The total number of direct losses in employment throughout the state from this source was estimated to be slightly over 300. The end result of this procedure was to generate additional adjustment factors on a quarterly basis for each of the impacted industries.

B.1.1.2 Scenarios Run

Two scenarios were run to assess nuclear materials production closure within the model. The first, termed "time-phased closure," used the quarterly adjustment factors to the employment and wage rate equations exactly as described above. The preferred method would have been to simply run WASHMOD with and without nuclear materials production closure. However, since WASHMOD is designed to assist in making revenue projections for the state only over the next biennium, it was not set up to provide forecasts beyond the fourth quarter of 1989. In particular, it was not calibrated for changes in the national economy after the fourth quarter of 1989; nor had post-1989 values been specified for the numerous national variables necessary to run the model.^(b) Because layoffs associated with the N Reactor proper were projected to occur into 1989, the complete response to these reductions was not shown by the model as of 1989, fourth quarter.

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- (a) The variable ESVADJ is shown here for explanatory purposes; in reality there is no variable by this name in WASHMOD. However, the WASHMOD computer program inserts these equation adjustment, in a numerically equivalent manner.
- (b) WASHMOD is normally run out only two or three years into the future, corresponding to the state budget cycle. Providing a complete set of forecast "driver" variables (e.g., national variables representing demands for Washington state goods) to permit a more extended projection, was a task outside the scope of this study.

To overcome this limitation, an attempt was made to estimate the model's probable long-term response to nuclear materials production closure. A second scenario, "rapid closure," was run for which the total job and wage rate adjustment was applied in 1987, fourth quarter. In other words, all of the approximately 6,300 workers associated with nuclear materials production are assumed to be laid off in a single quarter. Although this is not a realistic scenario and was not used directly for forecasting impacts, it does allow the researcher to observe the full impact of any given single-quarter cut in nuclear materials production employment upon the rest of the Washington economy over two years. Observing the time pattern of responses over this period (i.e., the degree to which the impacts are dampening toward the end of this period) permits an estimate of the likely ultimate model response for the more gradual time-phased scenario.

B.1.1.3 Model Results

Table B.1 summarizes the model's results for both scenarios for three selected quarters: the initial quarter and quarters one and two years into the future. For the time-phased closure scenario, the true time frame shown corresponds roughly to the cessation of activities at the N Reactor itself, as described in Chapter 3. By the end of this period, total job losses within the state are estimated at over 6,000, with 2,900 non-Hanford workers affected in various industries due to the loss of Hanford payrolls and procurement.

TABLE B.1. Statewide Reductions in Employment Estimated Via the WASHMOD Economic Model, 1987-1989

Quarter	Time-Phased Closure			Rapid Closure		
	Estimated Cumulative Loss in NMP (a) Employment	Total Statewide Nonagricultural Wage and Salary Employment Loss	Implied Multiplier	Estimated Cumulative Loss in NMP (a) Employment	Total Statewide Nonagricultural Wage and Salary Employment Loss	Implied Multiplier
1987:4	1,172	1,727	1.474	6,274	9,589	1.528
1988:4	3,157	5,439	1.72	6,274	11,942	1.903
1989:4	3,249	6,172	1.900	6,274	12,901	2.056

(a) Nuclear materials production.

Source: Calculated from WASHMOD output.

A common concept in impact analysis involving economic models is a multiplier. Multipliers are derived as the ratio of two variables. The denominator expresses the initial effect of an autonomous change (in this case, the reduction in direct N Reactor employment); the numerator expresses total effects of that change in some particular subsequent time period for a particular variable. Applying this concept to the time-phased closure scenario, the 1989 multiplier is calculated as 1.900 for nonagricultural wage and salary employment, a key variable forecast by WASHMOD. It is somewhat larger (about 3.5% larger) for total employment, which includes proprietors in the support sector.

The multipliers in this table and generally throughout this report are termed implicit multipliers. This designation is intended to remind the reader that the multipliers related to job losses are only implied from the various model outputs--they are not independent variables within these models.

The rapid closure scenario is able to paint a more comprehensive picture of the long-term response to closure of all nuclear materials production activities at Hanford. After two years, 13,000 workers would be affected statewide, implying a two-year multiplier of about 2.056.

The righthand column suggests that the impact of the initial employment reduction is still increasing, although slowly, at the end of this period. To estimate the eventual response of total employment, one must look at behavior of the multiplier itself over time. By analyzing the rate of quarter-to-quarter changes in the multiplier over the 1987-1989 period, an extrapolation of the multiplier was made for an additional two years. The value of the total nonagricultural employment multiplier at the end of this extended period is estimated to be approximately 2.4.^(a) Using this multiplier we can estimate the long-term impact of nuclear materials production closure on nonagricultural wage and salary employment statewide to be 2.4 times 5,981, or 14,400 jobs. Impact on total employment would be 3.5% larger, or 14,900 implying a multiplier of about 2.5. Given the pace of the phased closure scenario, about 96% of the impact would occur by the end of 1996.

B.1.2 Input-Output Model

The second approach to analyzing the secondary state-wide impacts of nuclear materials production closure involves the use of input-output analysis. This technique uses data on structural interdependencies among industries in Washington State. The input-output method analyzes the pattern of material and labor inputs purchased by each industry within the state and the distribution of sales for each industry's output, both within and outside the state.

The input-output analysis in this study is based on a model developed by Professor Philip Bourque at the University of Washington, modified for this study with the assistance of Professor Bourque and Dr. L. Charles Miller of Seattle. Bourque's work in applying input-output methods to the Washington economy extends back to the late 1960's. His most recent study, The Washington State Input-Output Study for 1982 (Bourque 1987) was funded primarily by a grant from the Washington State Legislature, with additional support from the Washington State Departments of Employment Security, Natural Resources, and Transportation. It was published in March 1987.

B.1.2.1 Transactions Table

The purchases and sales information gathered for an input-output model is entered into an interindustry transactions table. The rows of such a table describe the distribution of each industrial sector's output throughout the economy. Columns provide a picture of each sector's inputs. Bourque's model is based on a transactions table for Washington State constructed for 1982. Information for the table is derived from a variety of sources, including industrial censuses, regulatory agency reports, and surveys of business establishments.

The Bourque transactions table for 1982 is divided into 51 industrial sectors. To illustrate some of the concepts of the input-output method, this table has been reduced to three broad sectors as shown in Table B.2. The titles of the sectors are suggestive only. Agriculture includes crops, live stock, forestry, and fisheries. Trade and services includes

(a) See Section B.4.

TABLE B.2. Illustration of the State of Washington Input-Output Accounting Structure
(millions of 1982 dollars)

Inputs	Outputs					Total Output
	Agriculture	Manufacturing	Trade and Services	Household Expenditure	Government and Exports	
Agriculture	\$ 500	\$1,300	\$ 0	\$ 200	\$ 1,100	\$ 3,100
Manufacturing	300	5,800	2,800	3,500	25,500	37,900
Trade and Services	300	3,300	7,700	17,900	18,300	47,500
Wages	1,000	8,600	21,000			
Other Costs/Profits	800	4,300	9,700			
Imports	200	14,600	6,300	12,700	2,400	
Total Input	3,100	37,900	47,500	34,300		

Source: Derived from Bourque (1987), Appendix Table 1.

all sectors outside agriculture and manufacturing. Wholesale and retail trade and services are the dominant components, but the figures also include utilities, transportation, and construction activity. The figures in Table B.2 are based on the actual 51-sector table, but have been rounded to the nearest \$100 million. Nevertheless, they provide a perspective on the relative importance of these three broad sectors in the Washington economy.

Using agriculture as an example, some explanation of some of the entries in Table B.2 may be useful. Row one gives the sales of agricultural products for 1982. We first find \$500 million in sales within the agricultural sector. This intra-industry flow stems largely from the degree of aggregation within the table. Field crops and livestock are separate sectors in the 51-sector table. A large proportion of the \$500 million are sales of crops for livestock feed. In column two of the first row, we find over a billion dollars of agricultural products that were sold to food processing within the state. The \$200 million estimate under household consumption represents sales of unprocessed agricultural and fishery products to consumers in the state. Finally, a large proportion of agricultural commodities (wheat, apples, etc.) are exported, either to foreign buyers or to other states. The last column gives an estimate of total gross sales (i.e., including sales of agricultural commodities from one type of farm to another) of all agricultural sectors in Washington.

A look down column one gives a picture of the inputs used by the total agricultural sector. The agricultural sector purchased about \$300 million of materials from Washington manufacturers, primarily in the form of petroleum products and agricultural chemicals. Another \$300 million was purchased from the remaining sectors in the economy. The biggest single component of this group is wholesale and retail trade. In the input-output accounting system the "sales" of the trade sector are only the gross margins on goods sold.

The next two items represent payments to labor and capital inputs. In the Washington table, wages include earnings by both wage and salary workers and by proprietors. Other costs/profits include depreciation allowances, interest payments, indirect business taxes, and corporate profits. The final input item is imported goods, e.g., supplies and services not produced by Washington industries. The sum of total input costs is \$3100 million, equal to total gross sales in the agricultural sector.

The conceptual basis for inputs and outputs for manufacturing and trade and services is similar to that of agriculture. In addition to the producing sectors, the household column is of particular interest. Over a third of goods and services purchased by Washington households (excluding payments for housing) are produced outside the state.

B.1.2.2 The Input-Output Model and Multipliers

The transactions table provides a detailed description of the sectoral linkages within the economy at a given point in time. However, the usefulness of input-output analysis derives from its ability to predict the likely outcome of changes stemming from one sector of the economy to other sectors.^(a)

The formal derivation of an input-output model based on an interindustry transactions table is beyond the scope of this report. Conceptually, the output of each industry is determined by demands for its output by other industries, consumers, government and exports. Inputs required to satisfy these demands are assumed to vary proportionately with the level of output. The resultant output of each sector becomes a function of the size and distribution of autonomous demands--government, investment, and exports. In the Bourque model of the Washington economy, households are treated as "inside" the system of linkages, that is, income earned by workers is used, in turn, to buy goods and services produced by Washington firms. This demand further stimulates industrial output over and above the response to the initial change in exports or any other category of autonomous spending.

Using the matrix equations of the input-output model, one can derive various types of impact multipliers. As discussed in Section B.1, multipliers are nothing more than the ratio of two numbers. The denominator expresses the initial effect of an autonomous change (from, for example, exports or government demand); the numerator expresses the total effects of that change. In the Bourque model of the Washington economy, various multipliers were developed for each of the 51 sectors of the input-output table. These multipliers relate to several economic indicators--output, earnings, and jobs.

Because this study is particularly concerned with the employment impacts of the nuclear materials production closure, we will focus on those multipliers related to jobs. Table B.3 lists two types of job multipliers based on the Washington State input-output table. The first column gives the estimated number of jobs associated with a million dollars of final demand (i.e., government, investment or exports). The numbers reflect both overall labor intensity of the industries required to deliver a fixed level of output (measured as a million 1982 dollars) of the industry in question, as well as the degree to which material inputs are required from supporting industries located in the state.

Trade and services, as represented by sectors 49 through 51, all generate 50 or more jobs per million 1982 dollars of final demand. With only a few exceptions, most manufacturing sectors are less labor intensive, as might be expected, and generate fewer than 40 jobs per million dollars of final demand.

(a) See Bourque (1987), pp. 15-18 for an abbreviated discussion. A more comprehensive reference pertaining to the use of input-output methods in the context of regional economic analysis is a recent book by Miller and Blair (1985).

TABLE B.3. Standard Earnings and Jobs Multipliers for Sectors of the Washington Economy (direct, indirect, and induced effects)

Number	Title	Total Impact per Million Dollars of Direct Final Demand Upon Jobs	Total Impact Per Direct Impact Upon Jobs
1	Field Crops	30.6	2.19
2	Vegetables	50.7	1.51
3	Livestock	59.3	1.83
4	Other Agriculture	87.0	1.30
5	Fisheries	133.7	1.19
6	Meat Products	28.3	7.65
7	Dairy Products	48.1	20.05
8	Canning	40.0	4.25
9	Grain Mills	19.0	4.42
10	Beverages	25.9	5.29
11	Other Foods	30.5	2.85
12	Textiles	36.4	1.52
13	Apparel	48.2	1.40
14	Mining	36.2	2.00
15	Forestry	22.2	2.45
16	Logging	32.6	3.98
17	Sawmills	42.2	3.06
18	Plywood	38.5	3.19
19	Other Wood	39.6	2.23
20	Furniture	38.9	1.94
21	Pulp Mills	25.2	4.07
22	Paper Mills	28.6	5.03
23	Paperboard	31.8	4.82
24	Printing	39.1	2.04
25	Industrial Chemicals	24.8	2.73
26	Other Chemicals	24.3	2.51
27	Petroleum	2.6	6.58
28	Glass	30.4	2.51
29	Cement	33.1	2.53
30	Ferrous Metals	25.9	2.47
31	Nonferrous Metals	20.0	2.15
32	Aluminum	16.1	4.03
33	Structural Metal	23.5	2.28
34	Light Metals	22.3	2.82
35	Farm Machinery	24.8	2.34
36	Machine Tools	35.5	1.89
37	Industrial Equipment	29.6	2.04
38	Electrical Machinery	25.9	2.20
39	Aerospace	17.0	2.00
40	Motor Vehicles	12.6	3.49
41	Ship Building	27.0	1.96
42	Other Manufacturing	28.7	1.83
43	Transportation	29.5	2.02
44	Electric Utilities	17.1	5.03
45	Gas Utilities	6.3	4.82
46	Other Utilities	33.7	1.83
47	Communications	28.9	2.26
48	Construction	36.4	2.11
49	Trade	49.8	1.65
50	F.I.R.E.	64.4	1.61
51	Services	67.6	1.51
Average		34.7	3.16
Median		30.4	2.28

Source: Bourque (1987), p. 28.

The second column of Table B.3 relates the total number of jobs created or lost to the direct number of jobs in any given sector. As an example, if Sector 39, Aerospace, were representative of the Boeing Company, the multipliers suggest that any increase in Boeing orders that required an additional Boeing job would also stimulate one additional job within the state. (The total multiplier of 2.0 includes the initial Boeing job.) The use of these multipliers is considered in detail below as they apply to the impact of the nuclear materials production closure.

B.1.2.3 Input-Output Assessment of Nuclear Materials Production Closure

The analytical approach to measuring the impact of nuclear materials production closure is to treat the plutonium product as an export of the state. If nuclear materials production were a separate industry sector within the input-output model, the resultant employment multipliers, similar to those in Table B.3, could be used directly. However, in considering nuclear materials production as an industry in itself, one observes that the level of its production is not dependent upon economic activity within the state. From an analytic standpoint, this fact means that no separate row in the input-output table would be required. And, rather than including nuclear materials production as a separate productive activity inside the table, a numerically equivalent approach is to consider it as a autonomous component of demand, similar to exports or government expenditures. The materials and labor service inputs required by nuclear materials production can then be considered equivalent to separate export demands placed on the Washington economy.

This approach requires a detailed accounting of the materials and supplies used in nuclear materials production. The DOE supplied detailed listings of procurements by contractor for Fiscal Year 1986. These listings provided names of vendors located in Washington State and the amount purchased. Each purchase was assigned an industry within the 51-sector classification of the Washington State input-output table. The bulk of purchases were assigned to the wholesale and retail trade sector. These are items which are manufactured outside the state, but are sold by a wholesaler or retailer within Washington. In the input-output accounting system, the "sales" by the wholesale and retail sector are only the gross margins on the cost of such goods because it is only the margins that generate jobs and income in the state. The DOE procurement information provides only the total cost of procurements, including the trade (and transportation) margins. Using information on average trade and transportation margins developed in the U.S. input-output study for 1977 and in the 1982 Washington study, estimates were developed of the Washington trade and transportation margins for nuclear materials production procurements.

The final processing step required adjustment of the purchase data to 1982 dollars. Percentage factors, based on national price changes by various product groupings, were used to make this conversion.

In addition to the material inputs, a separate accounting was made for the payroll, fringe benefits, contract fees (profit income), depreciation and business taxes associated with nuclear materials production. As with the material inputs, these components were deflated (multiplied times 0.85) to 1982 dollars.

B.1.2.4 Results of Input-Output Analysis

The basic results of the input-output simulations are most easily interpreted by comparison with the economic importance of the Industrial Chemicals industry. As discussed in the previous section, inputs for 1982 activities related to nuclear materials production were included as part of the Industrial Chemicals Industry in the 1982 Washington input-output study.

Table B.4 lists the input structure of Industrial Chemicals as published in the 1982 input-output table. Based on procurement records and other information supplied by

TABLE B.4. Comparison of Industrial Chemical and Nuclear Materials Production Purchases (millions of 1982 Dollars)

Input-Output Sector Number	Title	Industrial Chemicals (1982) (a)	Nuclear Materials(b) Production (1986)
11	Other Foods	1	.013
13	Apparel	1	
14	Mining	1	
21	Pulp Mills	2	.094
22	Paper Mills	1	.016
23	Paperboard	4	.027
24	Printing	1	.103
25	Industrial Chemicals	32	.213
26	Other Chemicals	4	.020
27	Petroleum	6	.267
28	Glass	1	.046
33	Structural Metal		
37	Industrial Equipment	1	.082
38	Electrical Machinery	1	.075
39	Aerospace	5	1.348
42	Other Manufacturing	1	.110
43	Transportation	10	5.050
44	Electric Companies	18	2.600
45	Gas Companies	25	
46	Other Utilities	4	.418
47	Communications	2	.696
48	Construction	6	3.071
49	Trade	30	3.372
50	F.I.R.E.	2	.198
51	Services	20	.692
Total Washington Purchases		182	18.730
Labor Earnings		263	217.7
Other Value Added		280	32.9
Item: Total Value Added (Labor Earnings plus Other)		543	250.6
Imports		132	53.651
Total Input		857	325.104

(a) Bourque 1987, Appendix Table 1.

(b) Personal communication with L. Charles Miller, Consulting Economist, Seattle, Washington, April 30, 1987.

DOE^(a), the key material and labor inputs used in nuclear materials production are also shown in Table B.4. The reader should note that these vectors of inputs are for different years. In 1982, the PUREX and PFP facilities were not in full operation and, thus, not fully included in the pattern of purchases by the overall Industrial Chemicals sector.

As mentioned in Appendix A, Section A.2, the PUREX/UO₃ process operation is similar to many chemical processing plants. Since the PUREX facilities are a major component of nuclear materials production, it might be reasonable to expect that its economic impact within the

(a) The procurements data were collected and classified by the PNL study team and jointly analyzed by PNL and two of the authors of the 1982 input-output study, Dr. L. Charles Miller and Professor Philip Bourque. The final sectoral estimates were produced by Dr. Miller.

state would be similar to that of the Industrial Chemicals industry as a whole. Use of the detailed information on material and labor inputs as shown in Table B.4 reveal why this presumption is not true.

Table B.5 presents a decomposition of employment multipliers for the Industrial Chemicals sector as published in the 1982 Bourque study, and for the nuclear materials production mission. To analyze the multiplier for Industrial Chemicals, we assumed that export demand was reduced by \$100 million. This represents a little over a 10% reduction of the 1982 output of chemicals of an estimated \$852 million. Based on data for the 1982 I/O table, there were 9.1 jobs per million dollars of output in Industrial Chemicals. The immediate decrease in output leads to a reduction of 910 jobs (9.1×100); these can be classified as a direct effect of this change.

TABLE B.5. Comparison of Multipliers Between Industrial Chemicals and Nuclear Materials Production Operations Input-Output Employment

	Loss of 100 Million 1982 Dollars in Exports, Industrial Chemicals Jobs	Loss of Hanford Nuclear Materials Production Jobs
Direct effects	910	6,274
Indirect and induced effects ^(a)		
From intermediate purchases	666	623
From payrolls and other added value	<u>927</u>	<u>4,528</u>
Total Indirect and Induced	1,593	5,151
Implicit multiplier	$(1,593 + 910)/910$ $= 2.75^{(b)}$	$(6,300 + 5,151)/$ $6,300 = 1.82$

(a) Indirect and induced effects based on average of earnings and value added models as discussed in Bourque (1987), pp. 26-27.

(b) Published multiplier was 2.73 in Bourque (1987), p. 28.

The power of the input-output method is that it can trace the source of additional jobs that would be lost as a result of the reduction in export demand. The Industrial Chemicals sector reduces both the level of its purchases from other industries and the size of its payroll. Solving the input-output model in two separate runs, the effects of each of these categories can be estimated. Table B.5 shows that 666 jobs would be lost as a result of reduced purchases, 927 jobs would be lost as a result of reduced payroll. The total number of jobs lost is 2,503, implying an employment multiplier of 2.75.

The right column of Table B.5 analyzes the multiplier for the nuclear materials production. Using the same decomposition as for the Industrial Chemicals sector, one can see

how the much smaller multiplier of 1.82 is obtained.^(a) As might have been expected from looking at the mix of inputs in Table B.4, the number of jobs generated by purchases is relatively small. The 18.7 million (1982\$) of sales from Washington firms ultimately generates about 600 jobs within the state. This figure is an order of magnitude smaller than suggested by the 1982 data relating to the entire chemicals sector.

The induced number of jobs is also relatively smaller; the number of jobs lost here is about 4,500, only about 70% of the direct jobs lost. This result stems largely from assumptions made in the input-output model concerning household consumption expenditures. Two alternative formulations are used 1) household expenditure is a function of total value added (labor earnings, profits, depreciation, indirect business taxes summed over all industries), and 2) household expenditures is a function of labor earnings only. Neither of these assumptions is exactly correct, but data from which to improve this situation would be costly to obtain. The Bourque approach is to average the results from the use of both assumptions. (The multipliers shown in Table B.5 are in fact an average of separate multipliers from the "value-added model" and the "earnings" model).

For most industries the multipliers resulting from the two variants of the input-output model are fairly similar, and one need not be concerned. Unfortunately, this is not the case for a relatively capital-intensive sector such as industrial chemicals. As published in the 1982 input-output study (Bourque 1987, pp. 24-25), the "value added" multiplier exceeds the "earnings" multiplier by nearly 1.0, 3.21 versus 2.24 (whose average is 2.73 as discussed above and shown in Table B.3). As shown in Table B.4, this difference is based on an 1982 estimate of value added of \$543 million and labor earnings of \$263 million.

In developing the value-added components for nuclear materials production, labor earnings, indirect taxes, and contractor profits (fee) are easy to identify. Because these are federal government facilities, depreciation and interest payments are either not available or not comparably treated as would be the case for a privately-owned plant. An estimate of depreciation was available, resulting from internal accounting procedures maintained for the Department of Energy by the contractors involved. Interest payments are not defined on a specific item of government capital. As shown in Table B.4, under "Other Value Added," the sum of these quantifiable nonlabor components of value added amounted to about 33 million 1982 dollars. Using this figure, along with labor earnings of 217 million 1982 dollars in the input-output model, yielded an estimate of 4,528 induced jobs. In relation to the number of direct jobs, this figure is relatively lower than the industrial chemicals as a whole, primarily due to the quantitatively small estimates for nonlabor value added.

(a) For consistency, the input-output calculations for nuclear materials production are based on the published input-output table for 1982--the same table used to study the impact of a hypothetical decline in industrial chemicals exports. In developing the bill of goods for nuclear materials production, revised columns for the 1982 table were estimated for industrial chemicals and services; these omit the purchases by Hanford operations for running the N Reactor. Conceptually, this revised table would be more appropriate in computing impacts within a state economy that did not include nuclear materials production. Use of this revised table produced an overall multiplier for nuclear materials production that was negligibly higher, roughly 0.3%.

Since an element of arbitrariness is involved in the treatment of household expenditures in the Bourque model, and owing to the limitations in the accounting for government capital, the induced effect of 4,528 jobs should be treated with some skepticism. On the face of it, we should expect that the induced impact would be as high for nuclear materials production workers as for the average worker in Industrial Chemicals. If we apply this assumption, we can use the induced/direct ratio of 1.0186 in the overall Industrial Chemicals sector (927 induced/910 direct) to calculate an induced job loss of 6,391 due to a complete loss of all 6,274 nuclear materials production workers ($1.0186 \times 6,274$). Using this estimate along with the some 600 workers affected by the reduction of materials purchases, a revised multiplier would be about 2.1.

In conclusion, we can say that the input-output approach provides an estimate of the statewide multiplier in the range of 1.8 to 2.1. Even at the upper end of the range the multiplier is lower than that for Industrial Chemicals as a whole, a result driven by the relatively smaller level of intermediate inputs purchased within the state. Nevertheless, an estimate of 2.1 still exceeds the multipliers for the state's two largest manufacturing sectors, Aerospace and Shipbuilding, as shown in Table B.3.

B.2 IMPACTS IN THE TRI-CITIES AREA

The analysis of secondary economic impacts at the local level involved, several alternative approaches. In both approaches, a primary, or basic, sector of the economy is distinguished from a secondary, or support, sector. In the first approach, we examine the relationship of these two sectors at a single recent point in time. In the second approach we look at the history of the area and seek to describe how these sectors have responded to one another in the past.

As was true for the WASHMOD model at the state level, the premise of both approaches is that local economic conditions are changed primarily by activities that export products or services outside the local area. This behavior is incorporated in what is termed an economic export-base model. These models base their usefulness for impact analysis on the stability of a base multiplier. The base multiplier assumes that total activity, as measured by employment, income or other indicators, bears a constant ratio to activity in the basic sector. As an example, a base multiplier of 2.0 for employment would indicate that for each new job in the base sector, one additional job would always be generated in the support sector (a total of two jobs in the economy).

B.2.1 Static Base Approach

The Static Base approach relies on a breakdown of the Tri-Cities economy into basic and secondary sectors for a recent year.^(a) In this study, 1986 was chosen as reference point even though a complete set of employment and income figures is not yet available from government sources. For some variables, it was necessary to extrapolate or otherwise estimate 1986

(a) All data used in developing multipliers at the local level were actually for Benton and Franklin counties; the multipliers obtained were assumed to also apply to Yakima county. See Table 4.2. Throughout this section the terms Tri-Cities and Benton/Franklin counties are used interchangeably.

values from a variety of sources. The last year in which complete information is available is 1984, a year in which the Tri-Cities economy was still adjusting from the shutdown of the Washington Public Power Supply System (WPPSS) reactor construction.

B.2.1.1 Description of Basic Sectors

A general criticism of economic base models has been that it is often difficult to distinguish between the basic and secondary sectors. As the local geographic area covered by the analysis becomes larger, more and more sectors sell to both the local home and export markets, thus blurring the distinction between the basic and secondary sectors. The size and nature of the Tri-Cities economy, however, suggest that this problem is likely to be small in this instance.

Three major sectors have been the principal driving forces in the Tri-Cities since the early 1970's: 1) DOE and its contractors operating the Hanford Site; 2) the WPPSS in its construction and operation of nuclear power plants, and 3) the agricultural community including a substantial food processing component. With the exception of a minor amount of agricultural commodities sold to local area consumers, the goods and services produced by these sectors are exported outside of the Tri-Cities. In addition to the direct employment and payrolls, these major sectors also support a sizeable number of jobs in the local economy through their procurement of equipment, supplies, and business services.

In addition to these three major employment sectors, three other components can be readily identified as contributors to the economic base of the Tri-Cities economy. The first of these can be loosely termed "other major employers." For this study, four such employers were identified: 1) Advanced Nuclear Fuels in north Richland, 2) Sandvik Special Metals in Kennewick, 3) Boise-Cascade's Wallula corrugated paper mill, and 4) Burlington Northern railroad's regional terminal operations in Pasco. The second of the other components is tourism. The Tri-Cities area has increased its convention business substantially in recent years, in addition to business generated by pleasure travel. The final component in the economic base relates to the local purchasing power generated not from current employees but from retired former employees. Government transfer payments in the form of pension benefits constitute a significant proportion of total spendable income in the local economy.

B.2.1.2 Measuring the Basic and Secondary Sector

Table B.6 presents 1986 estimates of employment and income for the various components of the economic base mentioned above. Some of the figures in Table B.6 differ from those in Table 2.2 because they have been adjusted to reflect the residence of the workers involved. Below we discuss each of basic sectors and the derivation of these estimates in detail.

DOE and Contractors (Hanford). Hanford continues to dominate the local employment picture, with over one-fifth of the total jobs in Benton and Franklin Counties in 1986 (13,300 out of 62,100). As discussed in Chapter 2, the figure at 13,300 represents only Hanford workers living in either Benton or Franklin counties.

In fiscal year 1986 (October 1985 through September 1986), DOE and its contractors purchased approximately \$50 million of goods and services in the Tri-Cities. For this study, it is assumed that a comparable amount of spending occurred over calendar year 1986. The

TABLE B.6. Basic and Secondary Sectors in Benton and Franklin Counties, 1986

Basic	Employment	Average Annual Earnings	Earnings/Income (millions)
DOE and contractors	13,200 ^(a)	\$34,900	\$ 461
Local procurement (direct employment)	800 ^(b)	23,000 ^(b)	19
WPPSS and contractors	1,700	35,000	60
Agriculture	10,000	14,300	143
Proprietors	2,500	18,000	43 ^(c)
Employees	3,900	10,000	39
Agri-business	1,200 ^(d)	15,000	18
Food processing	2,400	18,000	43
Other major employers	1,930 ^(e)	33,700	65
Tourism	1,900 ^(f)	8,000	15
Retirees	N/A	NA	135 ^(g)
Total	29,530		898
Secondary	32,570	\$15,400	501
Total area employment/income	62,100		\$1,399

- (a) Eight percent of total employment used as a residence adjustment (see text). Annual averages rather than the September, 1986 values used in Chapter 2.
- (b) Estimated from procurement data and the 1982 input/output study of Washington.
- (c) Proprietors' income for 1984, last year for which data is available from Regional Economic Information Service, U.S. Department of Commerce.
- (d) Based on estimate made by local area labor economist, D. Schau, in April 1983.
- (e) Boise Cascade's employment adjusted to include only workers living in Tri-Cities area.
- (f) Derived from an estimate by Washington State Department of Tourism, as published in Tri-City Herald, April 17, 1987.
- (g) Government pension benefits--federal civilian and military, state and local. Source: Regional Economic Information System, Bureau of Economic Analysis, 1984. See Table B.7.

Leading categories of these purchases include office equipment, furniture, computers, small tools, and electrical supplies. Using the same methodology described in Section B.1.2, total DOE procurement is estimated to have supported approximately 800 jobs in Benton and Franklin Counties, the vast majority of these jobs falling into the wholesale and retail sector. The jobs directly supported by nuclear materials production procurements comprise about 22% of the 800 procurement-supported jobs or about 180 jobs. In total, these jobs provided an additional \$19 million in payroll to the economy, over and above that generated directly by DOE and contractor workers.

Washington Public Power Supply System. Although activity related to nuclear power construction ceased with the completion of the WNP-2 reactor in 1983, WPPSS continues to be a

TABLE B.7. Government Retirement Payments in Benton and Franklin Counties, 1984
(millions of dollars)

	<u>Benton County</u>	<u>Franklin County</u>	<u>Total</u>
Social security (including survivors and disability)	\$62.0	\$21.3	\$ 83.3
Railroad retirement		5.2	5.2
Federal civilian retirement	6.8	2.2	9.0
Veterans pension and military retirement	10.2	2.9	13.1
State and local employee retirement	<u>13.9</u>	<u>3.6</u>	<u>17.5</u>
Total	\$92.9	\$35.2	\$128.1

Source: Regional Economic Information System, Bureau of Economic Analysis, April 1986.

major employer in the Tri-Cities area. Headquarters personnel based in Richland oversee the operation of two generating facilities and perform a variety of functions related to two moth-balled nuclear plants. In the last quarter of 1986, WPPSS headquarters employment averaged slightly over 1,500 workers. Approximately 200 additional people worked for two major WPPSS contractors during 1986. Average earnings per worker at WPPSS was about \$35,000. Assuming a roughly equivalent wage for the 200 contractor workers, WPPSS activities generated roughly a \$60 million payroll in the Tri-Cities during the year.

Agriculture. Agricultural activities in Benton and Franklin counties are responsible for nearly 10,000 jobs, or nearly one-sixth of total employment. According to the U.S. Department of Commerce's Regional Economic Information System, there were about 2,500 people classified as farm proprietors in 1984. Farm proprietor's income from this same source was estimated to be \$43 million in the same year. More recent data are not available, but since farm prices have remained relatively stable over the past several years, this figure should be a reasonable estimate for 1986 income.

About 4,000 wage and salary jobs were related to crop and livestock production in the two-county area. This figure represents only employees covered by unemployment insurance. The presence of seasonal farm workers would make the total number of farm workers higher. Apart from the difficulty of obtaining reliable information on the number of seasonal workers, there is the question of how much of these earnings is actually spent in the local area. For this analysis, we assumed that the impact of seasonal workers on the local economy is sufficiently small to be safely ignored.

The area's farms and ranches generate a sizeable number of jobs in supporting activities, such as agricultural services (e.g., application of pesticides and fertilizers, irrigation system development, etc.), and sales of farm supplies and equipment. These activities have been often termed "agri-business." In April 1983, Dean Schau, the area economist for the Washington State Employment Security Department, estimated approximately 1,350 jobs in 1981 were involved with agri-business in the Tri-Cities area. Based on a somewhat depressed farm sector in 1986, as compared to 1981, this figure was reduced to 1,200. Assuming average

worker earnings of \$15,000, this component of agriculture generated roughly an \$18 million payroll in the Tri-Cities area in 1986.

Although formally classified as a manufacturing activity, food processing is a natural extension of the farm sector discussed above. More than 20 food processors in Benton and Franklin counties produce such things as potato products, canned fruits and vegetables, wine, and animal feed. Full-time employment in this sector averaged over 2,400 in 1986, with an estimated payroll of \$43 million.

As a whole, the agricultural sector accounts for about two-thirds as many jobs as DOE and its contractors. Since average earnings are only about half those of Hanford workers, the payroll is about one-third of that generated by the Hanford operations.

Other Major Employers. Other major employers--Advanced Nuclear Fuels, Sandvik Special Metals, Boise-Cascade, and Burlington Northern--generate about \$65 million in payroll to Tri-Cities residents. Although Boise Cascade's Wallula mill lies outside either Benton or Franklin county, the vast majority of its workforce resides in the study area.

Tourism. In recent years, tourism activity has increased significantly in the Tri-Cities. In 1986, over 300 conventions or tournaments were held in the Tri-Cities, in which an estimated \$19 million was spent by visitors. A 1987 study by the Washington State Department of Tourism estimated that overall tourism expenditures in the Tri-Cities were roughly \$80 million in 1986. An adjustment to these figures was made to deduct the business travel associated with visitors on DOE business. Adjusted tourism generated an estimated \$15 million payroll and roughly 1,900 jobs in the local economy.

Retirees. Although the Tri-Cities has a relatively young population (61% under the age of 35 as compared to a national average of 56%), over 12,000 people over the age of 65 reside in Benton and Franklin counties. This segment of the population supports the local economy on the basis of income received from government transfer payments and pensions, private pension benefits, and from prior individual savings.

Although information on private pensions and savings is not available, data are available regarding the magnitude of government transfer payments. The Department of Commerce's Regional Economic Information System has estimated transfer payments by various programs at the county level. A summary of estimated major government pension benefits received by Benton and Franklin county residents in 1984 is shown in Table B.7. Extrapolating 1984 figures by the change in the Consumer Price Index between 1984 and 1986, total transfer payment income was about \$135 billion in 1986. About two-thirds of the Social Security payments go to retired workers; the remainder are for disability and other payments. The historical importance of government activity in the Tri-Cities area is reflected in the relative magnitude of the government employee pension benefits as compared to total payments. Federal, state, and local retirement benefits comprise 21% of the total benefits shown. On a national basis, this percentage is smaller, approximately 18% (in 1984).

The Washington State Office of Financial Management estimated that there were 12,670 people 65 years or older living in Benton and Franklin counties in 1986. This estimate implies per capita transfer payments of \$10,700. Of course, some of these payments are received by younger retirees. Adding in the population aged 60 to 64, this average is reduced

to about \$8,400, which may be a reasonable lower bound. From another perspective these figures may be compared to national averages. Using the population base of 65 and over, the \$10,700 may be compared to a national average of \$9,200 for the same categories of transfer payments. The higher average in the Tri-Cities reflects the historically higher average wages in the area. Data for 1980 show that monthly social security benefits in Benton County were about 9% higher than the national average. In addition, the greater share of retirees receiving government employee pensions, as mentioned above, is also likely contributing to the higher per capita figure.

The discussion above may help to reveal that, just as for the nation as a whole, purchasing power of senior citizens is an important component of the economy. Taken as a whole, the estimated income of this component of the basic sector is roughly equivalent to the entire agricultural sector as seen in Table B.6.

Secondary Sector. The secondary sector consists of all other workers in Benton and Franklin counties. The actual number is computed as the difference between total employment of Tri-Cities residents and the sum of the basic sector employment as described above. In 1986, this difference resulted in an estimate of 32,570 workers in the secondary sector. This group is dominated by wholesale and retail trade with about 10,000 wage and salary workers. Various services (excluding business services, mainly DOE contractor employment) employed about 6,000 people and local government employs around 8,000 workers. The remaining workers are in transportation, communication, utilities, finance, real estate or construction.

B.2.1.3 Derivation of Local Impacts

The estimation of total impacts using the static base approach depends upon the assumption that each dollar of basic sector spending generates the same level of activity in the secondary sector, and that changes in spending levels in the basic sector generate proportional changes in secondary sector activity. This assumption implies that the share of a dollar of income spent in the local economy is assumed to be constant regardless of income level or the source of income. This assumption is undoubtedly not strictly true, but in the absence of detailed survey-based information, was assumed to be a good first approximation.

Using this assumption, the figures in Table B.6 yield an estimate of about 36 jobs in the secondary sector per million dollars of basic sector payroll or income (32,570 secondary jobs, divided by \$898 million of primary income). Using the components of the basic sector related to nuclear materials production and Hanford as a whole, the losses in direct Hanford employment and the employment generated by procurement were translated into estimates of dependent job losses elsewhere in the local economy. A summary of the number of local jobs dependent on Hanford is shown in Table B.8.

Row one shows the estimated number of job losses in the secondary sector associated with the nuclear materials production and also with Hanford activities as a whole. Loss of the payroll of nuclear materials production workers would result in an estimated additional 6,600 jobs lost in the Tri-Cities. Purchases of materials and supplies to support N Reactor and associated nuclear materials production operations supported approximately 180 jobs. In turn, the payroll associated with these workers, generated an additional 150 jobs in the secondary sector. The total number of jobs from procurements is thus 330, as shown in row 2 of

TABLE B.8. Summary of Tri-Cities Secondary Sector Jobs Dependent on Hanford

	Nuclear Materials Production			Total Hanford		
	Basic Sector	Secondary Sector	Implied Job Multiplier	Basic Sector	Secondary Sector	Implied Job Multiplier
Impact due to:						
Employment	5,380	6,630	2.23	13,200	16,570	2.25
Procurement	0	330	1.83	0	1,490	1.86
Total (a)	5,380	6,960	2.29	13,200	18,060	2.37

(a) Total multiplier uses only Hanford jobs in base. This is because procurement-related jobs are generally considered to be an "indirect" consequence of Hanford activity, and thus part of the secondary sector.

Source: Calculated. See text.

Table B.8. The job multiplication factor for procurements is 1.83 (330/180), shown in column 3. Several types of multipliers are implied by these impacts. For each direct N Reactor job lost from the local economy, an additional 1.2 jobs are lost in the secondary sector. If the impacts of local procurement for loss of all of nuclear materials production are added, an additional 330 jobs are lost. Continuing to use nuclear materials production employment as a base for the multiplier calculation, the total employment multiplier would be 2.29 (5,380 + 6,630 + 330, divided by 5,380).

In the right half of Table B.8 we can use the same approach to assess the economic importance of Hanford as a whole to the Tri-Cities economy. The estimated job multipliers are slightly higher for two reasons. First, earnings per average Hanford worker are higher than those of just the N Reactor employees. Second, the level of procurement in the local area is relatively greater than that for Nuclear Materials Production operations. Without considering the income multiplier impacts, total procurement (including construction) is estimated to directly support approximately 800 jobs.

Before turning to the dynamic base approach, a note may be warranted on the effect of unemployment insurance benefits. Because these benefits are only temporary, they have been ignored in the analysis above. Over the short run, however, these payments would reduce the number of jobs that are lost in the secondary sector. To get an idea of this impact we chose 1988, the year these payments would be at their highest level. As shown in Table 5.2, this total is approximately 8.9 million dollars.

As described above, the breakout of payrolls by sector suggests about 36 jobs per million dollars of primary sector payroll or income. Thus, at 1988 levels of unemployment benefits, some 324 workers in the secondary sector could be supported. By the end of 1988 the nuclear materials production workforce is expected to be reduced by 2,838 (see Table 3.3). Using the 2.29 multiplier shown in Table B.8, this results in a drop in total employment of 6,499. If we add back the workers supported by unemployment insurance, we obtain a revised figure of 6,175 (6,499 - 324). Recalculating the multiplier, we now have 2.18 (6,175/2,838). In the long-run, these benefits would end, and the appropriate multiplier would be closer to 2.3 as described for Table B.8. A significant uncertainty surrounding this analysis is where the laid-off workers will actually be located when they draw unemployment benefits. To the extent that they leave the local area and the state, the cushioning effects of unemployment insurance on the local and state economies will be reduced.

B.2.2 Dynamic Base Approach

The previous section used a detailed analysis of local economic statistics for the most recent year (1986) as a means of estimating the impacts of nuclear materials production closure. This approach assumes that firms in the secondary sector will respond in a rigidly proportional manner to changes in basic sector payroll and income. Moreover, each dollar of income to all groups in the basic sector is assumed to have equal impact on the local economy. Although we cannot independently confirm the appropriateness of either of these assumptions, some additional evidence as to the multiplier impacts of basic sector employment was provided by an examination of the historical record of economic activity in the Tri-Cities. This approach still follows that of an economic base model, but it is dynamic in that it considers that secondary sector activity will not respond instantaneously to changes in the basic sector.

B.2.2.1 Conceptual Foundation

The historical examination of the Tri-Cities economy follows an econometric methodology. Statistical relationships are developed by linear regression techniques between key employment variables using data over the period 1968-1986. The parameters of these relationships can be interpreted as multipliers, similar to those calculated for the static base approach.

The relationship to be estimated relies on the following assumptions:

1. In the long term, changes in secondary sector employment are proportional to changes in basic sector employment.
2. In any year, actual secondary employment adjusts by some fraction of the difference between its eventual long-term value and its level in the previous year.

Letting B represent basic employment, and S^* represent long-term secondary sector employment, these two assumptions can be expressed mathematically as:

$$S^* = a + b B \quad (B.1)$$

$$S_t - S_{t-1} = \lambda(S^* - S_{t-1}) \quad (B.2)$$

Equation B.1 indicates that in the long term, a change in basic sector employment, ΔB , will stimulate demand for $(b * \Delta B)$ employees in the secondary sector. The constant, a , in Equation B.1 is included to account for the fact that some level of secondary sector employment may be relatively insensitive to changes in the basic sector (at least over the period of observation).

Equation B.2 assumes that in each period t , the secondary sector employment S_t changes by the factor λ to its long term or equilibrium value S^* . By substituting Equation B.1 into Equation B.2, and rearranging terms, the resulting equation can be estimated statistically:

$$S_t = \alpha_0 + \alpha_1 B + \alpha_2 S_{t-1} \quad (B.3)$$

where $\alpha_0 = \lambda a$
 $\alpha_1 = \lambda b$
 $\alpha_2 = 1 - \lambda.$

Simple transformations of the estimated coefficients (α_0 , α_1 , and α_2) can be used to infer the parameters of the original model. The long term parameter λ , termed the speed of adjustment, is given by one minus the estimated coefficient on the lagged value of secondary employment, S_{t-1} . The parameters a and b are then computed as $a = \alpha_0 / (1 - \alpha_2)$ and $b = \alpha_1 / (1 - \alpha_2)$.

In summary, two measures are important from the standpoint of impact analysis. First, the parameter b provides an estimate of the number of jobs gained (or lost) in the secondary sector per job gained (or lost) in the basic sector, after all adjustments have taken place. Second, the speed of adjustment parameter, λ , provides critical insight as to how fast the secondary sector may adjust to any impact occurring in the basic sector. Values of λ near 1.0 suggest that much of the response may occur in the same year as the initial impact. Values of λ of 0.5 or smaller imply a minimum of two or three years before the process of adjustment is substantially completed.

B.2.2.2 Data

To implement the econometric methodology for the dynamic base approach, historical data were required for the Tri-Cities basic and secondary sectors. Annual data for 1967 through 1986 were compiled for total employment in the Tri-Cities and for the principal components of the basic sector: DOE and contractors, WPPSS, and agriculture.

Consistent historical series of employment were not available for the other smaller employers that might be considered as a part of the basic sector; this omission, however, is not likely to substantially change the empirical results. A correction for the likely bias would be required to obtain the final employment multipliers derived from this approach.

Total employment is defined on a place of residence basis. This measure also corresponds to the monthly unemployment and labor force estimates for Benton and Franklin counties as provided by the Washington State Department of Employment Security. Total employment on this basis may differ from the total number of jobs in the area for two reasons. First, many jobs in the Tri-Cities over the past several decades have been held by commuters from neighboring counties, particularly Yakima County. Second, some workers have more than one job.

Table B.9 shows historical data for the principal components of the basic sector and the derivation of secondary sector employment through 1986. Average annual employment for the DOE and its contractors and for WPPSS and the contractors through 1981 were taken from an earlier study by Battelle-HARC (Cluett et al. 1984). Comparable estimates for data after 1981 were provided by Dean Schau, the area labor economist for the Washington State Department of Employment Security.

Data on agricultural employment was taken from two sources. Farm proprietors and farm worker estimates were taken from the Regional Economic Information System (REIS) (U.S. Department of Commerce - Bureau of Economic Analysis) for the period 1969-1984. These figures

TABLE B.9. Employment on Basic and Secondary Sectors, in Benton and Franklin Counties: 1967 to 1986

Year	Total Employment ^(a)	Basic Employment				Basic Total	Secondary
		DOE ^(b)	WPPSS ^(c)	Agriculture ^(d)	Residence Adjustment		
1967	33,910	9,000	0	4,610	450	13,160	20,750
1968	34,410	8,850	0	5,080	442	13,488	20,922
1969	34,530	8,500	0	5,835	425	13,910	20,620
1970	36,570	7,900	0	6,695	395	14,200	22,370
1971	36,500	6,500	0	6,931	325	13,106	23,394
1972	36,960	7,000	0	6,867	350	13,517	23,443
1973	38,960	7,570	530	7,732	378	15,454	23,506
1974	42,300	8,700	1,115	8,407	435	17,787	24,513
1975	45,550	9,800	1,946	8,941	490	20,197	25,353
1976	51,800	10,680	2,945	10,167	534	23,258	28,542
1977	55,500	12,300	3,412	8,823	803	23,732	31,768
1978	64,340	11,750	7,097	9,036	1,394	26,827	37,513
1979	70,480	12,000	8,926	9,716	1,091	29,551	40,949
1980	72,100	12,100	7,935	9,668	946	28,757	43,343
1981	75,600	11,880	11,728	8,855	1,966	30,497	45,403
1982	70,000	11,357	8,841	9,559	1,708	28,049	41,951
1983	63,200	11,740	5,498	9,064	1,315	27,840	35,360
1984	59,400	12,891	2,015	9,055	673	23,288	36,112
1985	61,100	13,570	1,800	9,120	678	23,812	37,288
1986	62,100	14,200	1,700	9,100	710	24,316	37,784

- (a) As measured by place of residence, consistent with labor force and unemployment statistics as prepared by Washington State Department of Employment Security.
- (b) U.S. Department of Energy, as reported by Cluett, et al, 1984. The 1985 estimate was provided by Schau. For 1986 Schau provided an estimate of 14,000 for June; DOE reports 14,500 as of September 30. Annual average was taken to be about 14,200.
- (c) From McGinnis and Schau, (1983), for data through 1981. Subsequent unpublished estimates provided by Schau for 1982-1986.
- (d) Farm employment from Regional Economic Information System through 1984. No data was available for 1985-86; based on 1984 figure of 6,755, farm employment is estimated at 6,700 for 1985 and 1986. In addition to farm employment, food processing employment is added to farm employment. Source for food processing is Washington State Department of Employment Security.

were extrapolated back to 1967 on the basis of information provided in the earlier Battelle-HARC study. Consistent estimates for the latest two years were derived from year-to-year changes in the number of agricultural workers covered by unemployment insurance.

A rough estimate of the number of Hanford (DOE and WPPSS) workers commuting from other counties was made in order to convert these place-of-work estimates to a place-of-residence basis. An adjustment factor for the years 1977 through 1983 was used to reduce WPPSS payroll numbers, based on estimates provided by REIS relating to the payroll earned in Benton and Franklin counties by workers not living in the two counties. In 1981, the peak of WPPSS construction activity, this factor was estimated to be 0.12, implying that about 12% of WPPSS contractor employees did not live in either Benton or Franklin County.

Based on the number of Hanford workers related to DOE living outside the study area in 1986 (see Section 3.3), a (conservative) constant 5% residence adjustment was applied to this category of workers. The total residence adjustment is shown in the column titled "Residence Adjustment" of Table B.9.

Secondary sector employment is defined as a residual. It is computed as the difference between total employment and basic sector employment.

B.2.2.3 Results

Several variants of Equation B.3 were estimated using the data described in the previous section. The first uses a single basic variable, BASEW. The employment levels for the three key sectors--DOE and contractors, WPPSS and contractors, and agriculture--have been adjusted to roughly match their relative earnings per worker. BASEW is defined as

$$\text{BASEW} = \text{EDOE} + \text{ESS} + 0.5 \text{EAGG} \quad (\text{B.4})$$

where EDOE = DOE and contractor employment

ESS = WPPSS and contractor employment

EAGG = total agricultural employment, including food processing.

Using BASEW as the basic employment variable, the results of estimating (A.3) over the 1968-1986 period were

$$S = 3,537 + 0.727 \text{ BASEW} + 0.500 S_{t-1} \quad \bar{R}^2 = 0.942 \quad (\text{B.5})$$

(2.0) (3.5) (3.7)

The t-ratios in parentheses indicate each estimated coefficient is statistically significant at the 5% level. The long-term secondary/base multiplier is computed, (described in Section B.2.2.2) as $0.727/(1 - 0.500) = 1.45$. For consistency with the total jobs multipliers discussed earlier on the report, add 1.0 (direct jobs) to this figure to obtain 2.45. The estimated speed of adjustment is 0.5, implying that secondary employment would make only half of its eventual adjustment in the same year in which basic employment changed.

The presence of a statistically significant constant term suggests that secondary employment in the Tri-Cities adjusted only at the margin to changes in basic employment over the past decade and a half. Although there may be a variety of reasons for this result, a probable explanation is that there are some fairly stable elements of the basic sector that are not captured in BASEW. Recalling the methodology employed in the static base approach, one hypothesis is that this result is reflecting local service demands stemming from retirees.

Combining agriculture with the Hanford and WPPSS workers in the manner shown in Equation B.4 implies that the relative contribution of agriculture is only through the consumer spending of its workers in the local economy. The importance of "agri-business" is ignored in this approach. In addition, as the brief discussion of the historical data in the previous section indicated, the late 1960's and early 1970's represented a period in which the relative employment levels of DOE and agriculture were moving in opposite directions. These considerations suggest an alternative equation in which the independent effects of Hanford and the agricultural sector are allowed to manifest themselves. In Equation B.6, DOE and WPPSS workers are consolidated into a single variable, EHAN, together with total agricultural employment (EAGG). The results of this estimation are:

$$S = 2,835 + 0.691 \text{ EHAN} + 0.484 \text{ EAGG} + 0.506 S_{t-1} \quad \bar{R}^2 = 0.938 \quad (\text{B.6})$$

(0.8) (2.6) (0.9) (3.6)

A key finding of Equation B.6 is that the long-term multiplier for Hanford (including WPPSS) jobs is changed little from the previous equation, declining from 2.45 to 2.40, which equals $1 + [0.691/(1-0.506)]$. The speed of adjustment estimate is nearly identical. The coefficient on EAGG is relatively higher compared with the coefficient on EHAN than might be surmised simply from relative wage levels ($0.484/0.691 = 0.70$, versus Table B.6 relative wage rates of about 0.4).

This might be expected from greater integration of agriculture in the local economy. Unfortunately, the result is only suggestive, as the t-ratio on EAGG is less than unity.

B.3 COMPARATIVE ANALYSIS OF MULTIPLIERS

Up to this point the discussion has presented the results of the various approaches to measuring the impact of nuclear materials production closure in a fairly matter-of-fact style. The purpose of this section is to provide some perspective as the various results are considered in relation to each other. A principal product of this task is a set of point estimates that reflect the "most probable" impacts at the state and local levels.

Table B.10 shows the estimates of the various employment multipliers resulting from the previous analyses at both the state and local levels. By and large the multipliers are reasonably close to one another, in spite of the diverse methodologies that were used. For example, with the exception of one variant of the input-output analysis, all the state multipliers fell into a narrow range bounded by 2.1 to 2.5.

Statewide Multipliers

The most glaring difference between the multipliers reported in Table B.10 involves the difference between the statewide multipliers produced by the input-output model and those produced by the econometric-based Washington Economic Model. There are several reasons to prefer the higher estimates generated by WASHMOD. The first reason is that WASHMOD contains a much more fully developed structure for modeling (personal) income within the state. As mentioned in the model overview in Section B.1.1.1, WASHMOD contains separate equations for a

TABLE B.10. Summary of Preliminary Multiplier Results

<u>Statewide</u>	<u>Nuclear Materials Production</u>	<u>Total Hanford (Measure of Economic Importance)</u>
WASHMOD	2.48	N.A
Input-Output	1.8-2.1	N.A
<u>Local</u>		
Static Base	2.29	2.38
Econometric	--	2.40 - 2.45

number of nonlabor components of personal income. By contrast, the input-output model's treatment of nonlabor income, and its influence on personal consumption expenditures, is constrained so as to be fairly simple.

A second reason, perhaps more important, involves what is termed the degree of closure in the input-output model. In the present model, both state and local government and investment demand do not change with respect to changes occurring within the business and household sectors. This has the effect of reducing multipliers below the values they might be otherwise. By contrast, in WASHMOD, the housing construction component of investment and state and local government employment depend upon the overall level of activity as measured by total employment and personal income.

Conway (1979) provides some evidence as to the magnitude of the underestimate. By using a combined input-output/econometric model of Washington State, he estimated multipliers that ranged from 15% to 50% higher than those resulting from an input-output approach similar to that used in this study. The exact difference within this range varied by sector. For five manufacturing sectors reported by Conway, the average difference was about 25%. Adjusting the estimated 2.1 multiplier by this amount would yield a revised multiplier of around 2.6, very close to WASHMOD's result of 2.5.

Local Multipliers

The only meaningful comparison of the alternative approaches used at the local level pertains to the multipliers that represent the economic importance of the entire Hanford Site. As shown in Table B.10, the numbers are remarkably similar. That these numbers are so close may be partially due to the reasonably stable economy in the Tri-Cities since 1984. In these circumstances, the static approach, using only a single year of data, is more apt to reflect long-term relationships between the basic and secondary sectors. The parameters describing this long-term relationship are a product of the general specification used for the econometric analysis.

The detailed treatment of the basic sector in the static model suggests, however, that the econometric estimates may be biased upwards. This bias stems from omitted portions of the basic sector for which time series data are not available. On the basis of the estimated payrolls from other major employers in 1986, and the fact that most of these employers have had a substantial presence in the Tri-Cities economy throughout most of the data period (1970's and 1980's), the upward bias in the estimated long term multiplier for the secondary sector may be on the order of 10%. This adjustment implies that the total multipliers would fall about 0.15 (i.e., $0.90 * (2.45 - 1.0) + 1.0 = 2.3$).

Even after this adjustment, an issue that still remains for both approaches is whether the basic sector is underestimated, implying that multipliers are still overestimated. Several additional items could be considered for inclusion in the base. The first involves federal government employees not related to DOE. The second concerns the role of the Tri-Cities as a regional shopping center for people living outside Benton and Franklin counties. In considering these and other items, it appears that a point of diminishing returns has been reached in terms of either the quantitative impact or the cost required to acquire necessary

data. Nevertheless, this discussion suggests that the estimates of the local multipliers shown in Table B.10 be considered upper bounds and may require further slight downward adjustment.

Relation of State and Local Multipliers

The relevant comparison between the statewide and local multipliers involves the long-term estimate derived from WASHMOD and that resulting from the static base approach. Using a differential of 0.19 (2.48-2.29) Table B.10 implies that about 1000 more jobs ($0.19 * 5377$; see Table 3.3) would be ultimately lost in the state as a whole, as compared to those in the Tri-Cities, as a result of layoffs of Tri-Cities residents working at Nuclear Material Production facilities. The difference in direct employment would account for about one third of these jobs [(320 direct jobs from procurement statewide, less 180 direct jobs in the Tri-Cities from procurement) $* 2.4 \approx 336$]. The remaining job losses are due to the reduction in incomes from the approximately 13,000 workers who would lose their jobs in the Tri-Cities.

Although the statewide impact is higher than that at the local level based on these disparate methodologies, it is difficult to assess the reasonableness of the 1000 job difference. For this reason, we turned to an alternative procedure to cross-check the estimate. An alternative estimate is best derived from the use of a similar methodology at both the state and local levels, and computing the difference. Fortunately, one component of the study provided a means of putting at least a rough lower bound on this difference. Using an approach suggested by three economists at the University of Kentucky (Pagaoulatos, Mettas, and Debertin 1986), county-level employment multipliers (i.e., combined Benton and Franklin) were estimated from the Washington State input-output table. As mentioned earlier, the state multipliers from the input-output approach are lower than those from WASHMOD for several reasons. The input-output approach here was used only to infer the ratio between the secondary effects at the local level as compared to those statewide.

The adjustment of the state table to the county level involved two steps. In the first step, industries in the state input-output table that are not located in Benton and Franklin Counties were deleted. These include sectors such as forestry, fisheries, aerospace, and so forth. The second step involved adjusting the input coefficients to reflect the relative quantities of goods and services that are purchased within the study area. A set of adjustment factors was developed for key sectors; these factors represent the percentage of in-state goods and services that would be purchased within Benton and Franklin Counties.

The local purchase adjustment factors were based on a concept termed location quotients. Such quotients provide a crude measure of the concentration of an industry in a small region as compared to a larger region. If, for example, local concentration of employment per capita is relatively smaller than for the corresponding statewide value for a particular sector, it is assumed that local demand must be satisfied by imports. Employment and population data at the county and state levels were used to compute location quotients for three sectors: printing and publishing; communications; and finance, insurance, and real estate. For retail trade, a location quotient was developed by comparing the ratio of retail sales to personal income at both the state and bi-county levels. Services were assumed to be similar to trade. The resulting adjustments were as follows:

Printing and Publishing	0.70
Communications	0.90
Finance, Insurance, and	
Real Estate	0.80
Wholesale and Retail Trade	0.97
Services	0.97

Employing these adjustment factors to reduce purchases per dollar of payroll in the local input-output table, the employment change was computed for a fixed \$100 million of payroll. This change was compared to the same experiment performed with the original 51-sector state model. The ratio of the changes was approximately 0.85, suggesting that 15% of the (induced) impacts of lower total payroll in the Tri-Cities would be felt in the rest of the state.

The estimate of 15% for rest-of-state impact should be viewed as suggestive only. The short-cut method, discussed by Pagaoulatos et al. (1986), cannot yield results with the measure of confidence that would be achieved with a detailed input-output study at the county level. In addition to measuring the sectoral linkages within the local economy, two additional types of information would be required in such a study: 1) the level of trade margins associated with wholesalers in the state serving the Tri-Cities (predominantly Spokane and Seattle), and 2) direct information on the share of goods and services purchased by Tri-Cities residents in other counties of Washington. Such an effort was obviously beyond the scope of this study.

As it stands, the 15% figure is probably a lower limit. Using the local quotient approach for the share of retail goods (and share of wholesale trade) purchased locally resulted in an estimate of 0.97, a figure that appears to be too high in our judgment. Using an estimate of 0.90 for wholesale and retail resulted in a ratio of 0.79, as compared to 0.85. Without data to support an alternative estimate, we chose to maintain the original result of 0.85 (and, thus, the 15% rest-of-state impact).

With these caveats in mind, the 15% estimate does provide a useful additional piece of evidence to help place the previous state and local multiplier results in perspective. In order to achieve consistency in the overall results at the two levels of analysis, the estimated local multiplier was adjusted downward slightly. Putting the brunt of the adjustment at the local level reflects the greater uncertainty in having fully reflected all components of the local basic sector (in the economic base approach), as compared to the accuracy of WASHMOD for impact analysis. After making adjustments to reflect the impact of nuclear materials production related procurement in the Tri-Cities, the final local multiplier is taken to be 2.2. The 2.2 multiplier was used in developing the estimates for local employment losses shown in Chapter 4.0, for Yakima County as well as for Benton and Franklin counties.

B.4 TIME-PHASING OF MULTIPLIER RESPONSE

Because the job losses associated with closure of the nuclear materials production mission occur over an extended period of time, it was necessary to estimate how much of the eventual employment impact would be felt during each year or quarter through 1996. The approaches

used for the state and local impacts differed slightly because of the different structure of the models and the different nature of available data at the state and local levels; however, the approaches are consistent and produce compatible short-term impact estimates.

As was explained in Section B.1, WASHMOD is a short-term forecasting model. The results of the rapid closure scenario were first examined to determine the time path of the implied total employment multiplier and to adjust both long and short-term multipliers. We concentrated our attention initially on the impact of direct employment losses on total statewide nonagricultural wage and salary employment. This definition of total employment excludes self-employed persons and some categories of farm labor and is therefore more limited than desired for this study. However, this is the definition generally used by the state's forecasters in their assessments of economic change. The rapid closure scenario implied a total employment multiplier for nonagricultural wage and salary employment of about 2.1 at the end of calendar year 1989. The average quarterly rate of change of that multiplier during 1989 was about 2% per quarter, with no obvious trend toward smaller rates. This average rate of change was extrapolated for two more years, by which time all significant impacts associated with the original rapid closure scenario were assumed to have worked themselves out. This resulted in a total nonagricultural wage and salary employment multiplier of about 2.4 in the long term. Next, because we wished to include proprietors in the multiplier response to obtain a more comprehensive picture of statewide economic definition, the 2.4 multiplier was multiplied by the average ratio of WASHMOD's total employment impacts to non-agricultural wage and salary employment impacts. This increased the multiplier at each time period by about 3.5%, or to about 2.5 in the long term. Finally, based on the average of annual difference between the total employment impact of the phased closure scenario and the rapid closure scenario in WASHMOD, the annual multipliers based on rapid closure were all deflated by 8%. By 1996, therefore, the final annual multiplier was actually about 2.31.

The local impact model presented a different problem for multiplier time phasing, since the long-term multiplier had already been estimated for a comprehensive definition of employment. The problem was to estimate a short-term response. In this case we adopted the time phasing of the annual multiplier response implicit in Equation B.6, which had about half the response estimated to occur in the first year and half the remaining impact estimated to occur over a more extended period, according to a slowly increasing geometric sequence. The coefficient on DOE and contractor employment in Equation B.6 was adjusted downward by 15% (0.691×0.85) so that the secondary sector, long-term multiplier for a rapid closure approximately equaled its assumed value of about 1.2, and the total multiplier equaled 2.2, i.e.,

$$b = (0.691 \times 0.85) = 0.587 \quad (B.7)$$

and

$$1 + b/(1 - .506) \approx 2.2 \quad (B.8)$$

Next, the multiplier in each year was assumed to divide its response equally across the four quarters to derive quarterly values. Finally, each multiplier response was divided by 1.08 to

reflect the difference between phased and rapid closure multipliers in WASHMOD. This produced an adjusted 1996 multiplier of about 2.1 in 1996, for example.

B.5 MIGRATION

The reduction in jobs in the Tri-Cities stemming from loss of nuclear materials production would be expected to lead to migration of workers and their families out of the area. The number who would leave and the time frame over which this might occur are difficult to estimate with a high degree of confidence. Nevertheless, some estimate of the potential outmigration is important from the standpoint of projecting the fiscal impacts on local governments and school districts.

Previous research using migration data from the Census Bureau has attempted to develop migration propensities (i.e. probabilities) based on various characteristics of workers. As might be expected, this research shows that migration is related to both occupational and age characteristics of workers. Professional and managerial workers, and those with no children or very young children, are the most likely to migrate to pursue more attractive employment opportunities.

An approach by which the results of some of this research could be used to project migration out of the Tri-Cities was rejected for several reasons. First, detailed data on age and family characteristics was not readily available. Second, the application of national average estimates was judged a tenuous approach to characterizing a local situation.

As an alternative approach, this study examined the outmigration of Tri-Cities residents subsequent to the construction rampdown of the WPPSS. Based on this experience, a migration/employment multiplier was developed. The year 1981 was chosen as the base year for computing this multiplier; 1981 was the peak of WPPSS construction activity. This multiplier was then applied to the year-to-year changes in employment resulting from a phase out of the Nuclear Material Production mission to estimate reductions in local area population.

Tables B.11 and B.12 present the basic data upon which this multiplier was based. Population change, births, deaths, and migration were taken from reports published by the Washington State Office of Financial Management. Migration is compiled as a residual, i.e., an estimate of population is developed for each year based on a variety of indicators including housing occupancy, school enrollment, and employment. Between any pair of years, births and deaths are known by county of residence from state vital statistics data.

The balancing item is assumed to be migration. On the basis of the numbers given in Table B.11, migration out of Benton and Franklin Counties appears to have been unabated between 1985 and 1986, with total outmigration on the order of 4000 people (18,991 - 14,911). Two caveats are in order, however. First, because these estimates are developed as residuals, there is considerable uncertainty associated with any estimate of a single year's migration based on taking differences in the published figures. Second, recent data suggest that the apparent outmigration is occurring for other reasons than simply a response to labor market conditions. As Table B.11 shows, 1986 represented the second year in a row in which

TABLE B.11. Employment and Population in Benton and Franklin Counties, 1980-1986

<u>Year</u>	<u>Employment(a)</u>	<u>Population(b)</u>
1980	72,100	144,469
1981	75,900	147,200
1982	70,000	147,900
1983	63,200	144,700
1984	59,400	144,000
1985	61,100	140,900
1986	62,100	139,300

(a) From Washington State Employment Security Department, annual averages.

(b) Washington State Office of Financial Management (1986).

TABLE B.12. Changes in Employment and Population in Benton and Franklin Counties, 1981-1985, 1981-1986

<u>Years</u>	<u>Employment Change</u>	<u>Population Change</u>	<u>Births</u>	<u>Deaths</u>	<u>Migration</u>	<u>ΔMigration/ ΔEmployment Multiplier</u>
1981-1985(a)	-14,800	-6,300	+11,775	-3,164	-14,911	1.01
1981-1986(b)	-13,800	-7,900	+14,917	-3,826	-18,991	1.37

(a) Forecasts of the State and County Population by Year for Selected Age Groups, Washington State Office of Financial Management (OFM), September 1986. OFM published changes for 1980-1985. Data to subtract 1980-1981 change were taken from 1982 Population Trends in Washington State, OFM, 1982.

(b) Based on data from 1986 Trends for Washington State, Washington State Office of Financial Management, August 1986. Adjustment for 1980-1981 change same as described in (a) above.

annual average employment increased in the Tri-Cities. Preliminary results from the Office of Financial Management suggest that migration out of the two-county area is continuing into 1987, in spite of a slightly improving labor market.

In the face of these mixed signals regarding recent migration and employment trends, the approach has been to choose a value intermediate between the multipliers based on the two periods 1981 through 1985 and 1981 through 1986 (multipliers given by the values in the last column of Table B.12). More weight was given to the 1981 through 1986 period as more truly reflecting the economic response to the WPPSS rampdown. For projecting migration in response to job losses from nuclear materials production closure, a multiplier of 1.3 was used in this study.

The 1.3 population multiplier can be supported by detailed analysis of the propensity of the Tri-Cities workforce to outmigrate. The 1980 Census reveals that, of the 60,303 people between the ages of 20 and 64 present in Benton and Franklin Counties in 1975, a total of 17,720 or 29.3% had migrated out of the two counties by 1980. Unfortunately, because some of

the outmigrants were undoubtedly employed before they migrated, it is not possible to attribute the observed outmigration to reductions in employment or to employment status. On the one hand, it is expected that the outmigration rate would be higher among the unemployed than among other local residents of working age. In addition, the Tri-Cities economy was very construction-oriented in the late 1970s. Growth in the local construction sector between 1975 and 1980 probably reduced observed outmigration below what it otherwise might have been under more depressed circumstances. Thus, it is likely that a much higher percentage of unemployed workers would leave the local area if nuclear materials production were to be lost than is indicated by the 19.3% value for 1975 to 1980. On the other hand, it is not likely that every unemployed worker would leave the area.

A detailed assessment of outmigration is shown in Table B.13. For purposes of this detailed assessment, we assumed that all professional (exempt) Hanford workers who lose their jobs leave the local Hanford area, since they are oriented to national markets. As a reasonable lower bound, 50% of nonexempt Hanford workers (see Chapter 2.0 for a definition of nonexempt) and secondary sector workers are assumed to outmigrate; 100% are assumed to outmigrate in the upper bound case. To estimate the impact on total population, we calculated the ratio between total Benton-Franklin outmigrants and outmigrants aged 20 to 64 for the period 1975 to 1980. This ratio is about 1.63. The average of the upper and lower bound cases shows total outmigration to be about 1.3 times the fall in employment.

B.6 PERSONAL INCOME

The estimated change in state personal income through the end of 1989 from a phased closure of the nuclear materials production was taken directly from the WASHMOD econometric model. Estimates after 1989 were developed in much the same manner as employment. A long-

TABLE B.13. Worksheet for Detailed Analysis of Population Multiplier

	Cumulative Employment Impact		(A) Outmigration: 50% of Nonexempt and Secondary Leave Area ^(a)		(B) Outmigration: 100% of Nonexempt and Secondary Leave Area	
	1990	1996	1990	1996	1990	1996
Hanford Exempt ^(b)	1,623	2,806	1,623	2,806	1,623	2,806
Hanford Nonexempt	1,836	3,175	918	1,588	1,836	3,175
Secondary	3,375	6,568	1,688	3,284	3,375	6,568
Working Age	6,834	12,549	4,229	7,678	6,834	12,549
Total Outmigration	NA	NA	6,893	12,515	11,139	20,455
Average of (A) and (B) for 1990: 9,016						
Average of (A) and (B) for 1996: 16,485						
1990 Migration Factor: $9,016/6,834 = 1.32$						
1996 Migration Factor: $16,485/12,549 = 1.31$						

(a) Assumed lower bound value of 50%, to be larger than 29.3% figure for 1975 to 1980 working age population.

(b) Hanford exempt workers.

term income multiplier was developed by taking the 1987 to 1989 ratios of the changes in personal income to the changes in direct payroll of the N Reactor work force. This ratio was extrapolated beyond 1989 by observing its quarterly rate of change during 1989 (about 3.1%) and projecting that rate for two more years. As was done for employment, the income multiplier was then adjusted downward (by 11.4% in this case) to take account of the lesser impacts of a phased, rather than an immediate layoff of N Reactor workers.

The impact on personal income at the local level was developed by applying an allocation fraction to the state estimates. The allocation fraction was based on the following formula:

$$F = \frac{\text{direct payroll} + ES_L * 16,000}{\text{direct payroll} + ES_S * 16,000} \quad (B.9)$$

where direct payroll = reduction in payroll of N Reactor workers

ES_S = reduction in secondary employment at state level from indirect and induced effects

ES_L = reduction secondary employment at local level, from indirect and induced effects.

The numerator in Equation B.9 is an estimate of the total payroll reduction at the state level--direct, indirect, and induced. An average wage of \$16,000 was assigned to the non-Hanford workers affected; this figure was based on an analysis of Tri-Cities wages for 1986.^(a) The denominator in Equation B.9 is an estimate of the total payroll reduction at the local level.

Local personal income is computed by multiplying state personal income by F for each time period in the forecast. This procedure assumes that the ratio of changes in nonwage personal income--principally dividends, interest, rental income, and transfer payments--relative to changes in wages and salaries, is the same at the state and local levels. Based on 1984 estimates from the Regional Economic Information System (Bureau of Economic Analysis, U.S. Department of Commerce), the proportion of personal income in Benton and Franklin Counties composed of nonwage components was lower than in the state as a whole. However, one would expect that these nonwage components, particularly rental income, would decline relative to wages and salaries by as much in the Tri-Cities as in the state as a whole.

Using this allocation procedure, the impact on personal income is slightly more concentrated in the local area than the impact on the number of jobs. This result stems from the fact that the payrolls associated with the relatively higher paid nuclear materials production workers are lost in the local area, where they make up a larger proportion of total income than they do statewide. At the end of 1989, the ratio of local to state personal income is 0.964; for employment the corresponding ratio is 0.943.

(a) Data in Table B.6 shows the average wage per non-Hanford worker in 1986 to be \$15,400. Considering the higher wage of workers impacted by procurements (including construction workers), this figure was rounded upward to \$16,000 for this procedure.

B.7 GEOGRAPHICAL ALLOCATION OF LOCAL IMPACTS

In order to estimate the impact of closure of nuclear materials production on specific local government jurisdictions, it was necessary to develop a procedure to consistently allocate to specific localities the local impacts estimated by the economic models. The only data available to aid in this allocation were the 1986 population of each community in the local area, the distribution of Hanford workers across these communities in late 1986 (Table 2.5), and data from sales tax receipts for each jurisdiction for the state fiscal years 1986 and earlier. No data other than these exist to show local trade patterns, even though it is these trade patterns that would ultimately determine which cities would feel the impact of closing nuclear materials production.

To estimate local trade patterns, we assumed that the Tri-Cities, including West Richland and Benton City, comprise a single market area. Within this market area, spending patterns of all the residents can best be determined by examination of relative sales tax receipts. The cities of Prosser, Grandview, Sunnyside, and Yakima were each assumed to be separate market areas. While these assumptions may not be strictly true, it is also clear from the available data that local spending is not strictly proportional to population. In particular, both Kennewick and Pasco appear to have larger retail sales than their population alone would suggest, while those in Richland, West Richland, and Benton City are smaller.

In estimating impacts on employment, population, and income, we first allocated direct Hanford employment and payroll impacts to individual cities in proportion to the current residence of affected employees. Local secondary employment and income impacts (indirect and induced impacts, or total impacts minus direct impacts) predicted by the models were allocated first to market area based on nuclear materials production employment and then by relative sales tax receipts within the Tri-Cities market area. Table B.14 shows the percentage distributions of both primary and secondary impacts on jobs and incomes by city. Impacts on population were derived by applying the 1.3 population multiplier from Section B.5 to job losses for each city.

We then estimated the impacts on school enrollments required for fiscal analysis of the local school districts. We calculated the proportions of outmigrants in each age group from Benton and Franklin counties between 1975 and 1980 from 1980 Census data supplied by the State of Washington, Office of Financial Management. The proportion of outmigrants of elementary school age (ages 5 to 12) was 0.168; for secondary school age (ages 13 to 18) the proportion was 0.149. These proportions were multiplied times the total population impact in each city to obtain an estimate of enrollment impact by school district.

TABLE B.14. Geographic Allocation of Job and Income Losses within the Local Tri-Cities Area (Benton, Franklin, and Yakima Counties)

<u>City</u>	<u>Primary (Direct) Losses (%)</u>	<u>Secondary (Indirect and Induced) Losses (%)</u>
Richland	41.6	23.2
Kennewick	29.4	35.3
Pasco	8.0	27.6
West Richland	5.0	0.8
Benton City	4.2	1.3
Prosser	1.7	1.7
Grandview	1.6	1.6
Sunnyside	2.4	2.4
Yakima	3.3	3.3
Other Yakima Counties	1.7	1.7
Other Washington (Local)	<u>1.1</u>	<u>1.1</u>
	100.0	100.0

REFERENCES

- Aronson, R. L., and R. B. McKersie. 1980. Economic Consequences of Plant Shutdowns in New York State. Cornell University, Ithaca, New York.
- Bourque, P. J. 1987. The Washington State Input-Output Study for 1982. Graduate School of Business Administration, University of Washington, Seattle, Washington.
- Bubolz, M. J. 1974. "Family Adjustment Under Community Decline." In Communities Left Behind: Alternatives for Development, ed. L. R. Whiting, pp. 54-66. The Iowa State University Press, Ames, Iowa.
- Buss, T. F., and F. S. Redburn. 1983. Shutdown at Youngstown: Public Policy for Mass Unemployment. State University of New York Press, Albany, New York.
- Cluett, C., et al. 1984. Nuclear Waste Repository in Basalt: Preliminary Socioeconomic Assessment. RHO-BW-CR-142P/BHARC-400/83/023. Rockwell Hanford Operations, Richland, Washington.
- Conway, R. S. 1979. "Simulation Properties of a Regional Interindustry Econometric Model." Papers, Regional Science Association 43 (1979):45-57.
- Daicoff, D. J. 1973. "The Community Impact of Military Installations." In Economic Consequences of Reduced Military Spending, ed. B. Udis, pp. 149-166. Lexington Books, Lexington, Massachusetts.
- Decision Research Sciences. 1987. 1985-86 Branch Directory and Summary of Deposits with Market Indicators, Alaska, Idaho, Oregon, and Washington. Blue Bell, Pennsylvania.
- DiNoto, M., and L. Merk. 1983. The Economic Status of Shoshone Country, Idaho: A Post-Mortem or Period of Transition. University of Idaho, Department of Economics, Moscow, Idaho.
- Ferman, L. A., and J. P. Gordus, eds. 1979. Mental Health and the Economy. W. E. Upjohn Institute for Employment Research, Kalamazoo, Michigan.
- Francaviglia, R. V. 1983. "Bisbee, Arizona: A Mining Town Survives a Decade of Closure." Small Town (Jan-Feb):4-8.
- Grady, S., R. Braid, J. Bradbury, and C. Kerley. 1986. Socioeconomic Impact of Plant Closure: The Case Studies of Large Manufacturing Facilities. Science Applications International Corporation, Oak Ridge, Tennessee.
- Hodge, I. 1984. Employment Adjustments and the Economic Costs of Decline in a Small Rural Community: A Case Study in Kellogg, Idaho. Bulletin No. 629. Idaho Agricultural Experiment Station, Moscow, Idaho.
- Kasl, S. V., and S. Cobb. 1979. "Some Mental Health Consequences of Plant Closings and Job Loss." In Mental Health and the Economy, eds. L. A. Ferman and J. P. Gordus, pp. 255-300. W. E. Upjohn Institute for Employment Research, Kalamazoo, Michigan.
- Kinicki, A. J. 1985. "Personal Consequences of Plant Closings: A Model and Preliminary Test." Human Relations 38(3):197-212.
- Langerman, P. D., R. L. Ryerly, and K. A. Root. 1982. Plant Closings and Layoffs: Problems Facing Urban and Rural Communities. Drake University, Des Moines, Iowa.
- McGinnis, K., and D. Schau. 1983. "The Downside of Nuclear Power Plant Construction." Paper presented at the Northwest Regional Economics Conference, May 5-7, 1983, Bellingham, Washington.
- Mick, S. S. 1975. "Social and Personal Costs of Plant Shutdowns." Industrial Relations 14(2):203-208.

- Miller, R. E., and P. D. Blair. 1985. Input-Output Analysis: Foundations and Extensions. Prentice-Hall, Englewood Cliffs, New Jersey.
- Nesse, R. J., et al. 1985. An Environmental and Socioeconomic Analysis of Northwestern Aluminum Smelters. Pacific Northwest Laboratory, Richland, Washington.
- Pagoulatos, A., K. Mattas, and L. D. Debertin. 1986. "A Comparison of Some Alternatives to Input-Output Multipliers." Land Economics 62(4):371-377.
- Sewell, J., and P. Wybrow. 1982. "Invergordon Smelter Project Preliminary Research Report." ISP 1, Institute for the Study of Sparsely Populated Areas, Aberdeen, Scotland.
- State of Washington. Office of Financial Management (OFM). 1986. 1986 Population Trends for Washington State, P86-09, Population Estimating and Forecasting Unit, Olympia, Washington.
- State of Washington, Department of Revenue. 1987. Tax Base Growth and Stability: A Comparative Examination of Washington's Major Tax Sources 1976-1985. Olympia, Washington.
- State of Washington, Department of Revenue. 1986. 1986 Tax Statistics. Olympia, Washington.
- State of Washington, Department of Revenue. 1985. 1984 Property Tax Collections and Levies Due in 1985. Olympia, Washington.
- State of Washington, Economic and Revenue Forecast Council. 1986a. The Washington Economic Model. (July). Olympia, Washington.
- State of Washington, Economic and Revenue Forecast Council. 1986b. Description of the Office of the Forecast Council's Revenue Forecasting Model. Olympia, Washington.
- State of Washington, Economic and Revenue Forecast Council. 1986c. Economic and Revenue Forecast for Washington State (November 1986.)
- State of Washington, Department of Revenue. 1984a. Quarterly Business Review, 1st Quarter, 1984. Olympia, Washington.
- State of Washington, Department of Revenue. 1984b. Quarterly Business Review, 2nd Quarter, 1984. Olympia, Washington.
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