

# ECONOMIC IMPACTS OF GEOTHERMAL DEVELOPMENT IN HARNEY COUNTY, OREGON

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## INTRODUCTION

This study provides local economic impact estimates for a 100 megawatt (MW) geothermal power project in Oregon. The hypothetical project would be in Harney County, shown in Figure 1. Bonneville Power Administration commissioned this study to quantify such impacts as part of regional confirmation work recommended by the Northwest Power Planning Council and its advisors. Harney County was chosen as it has both identified resources and industry interest.

Geothermal energy is defined as the heat of the earth. For purposes of this study, geothermal energy is heat capable of economically generating electricity (using available technology). That translates to steam or hot water over 300°F.

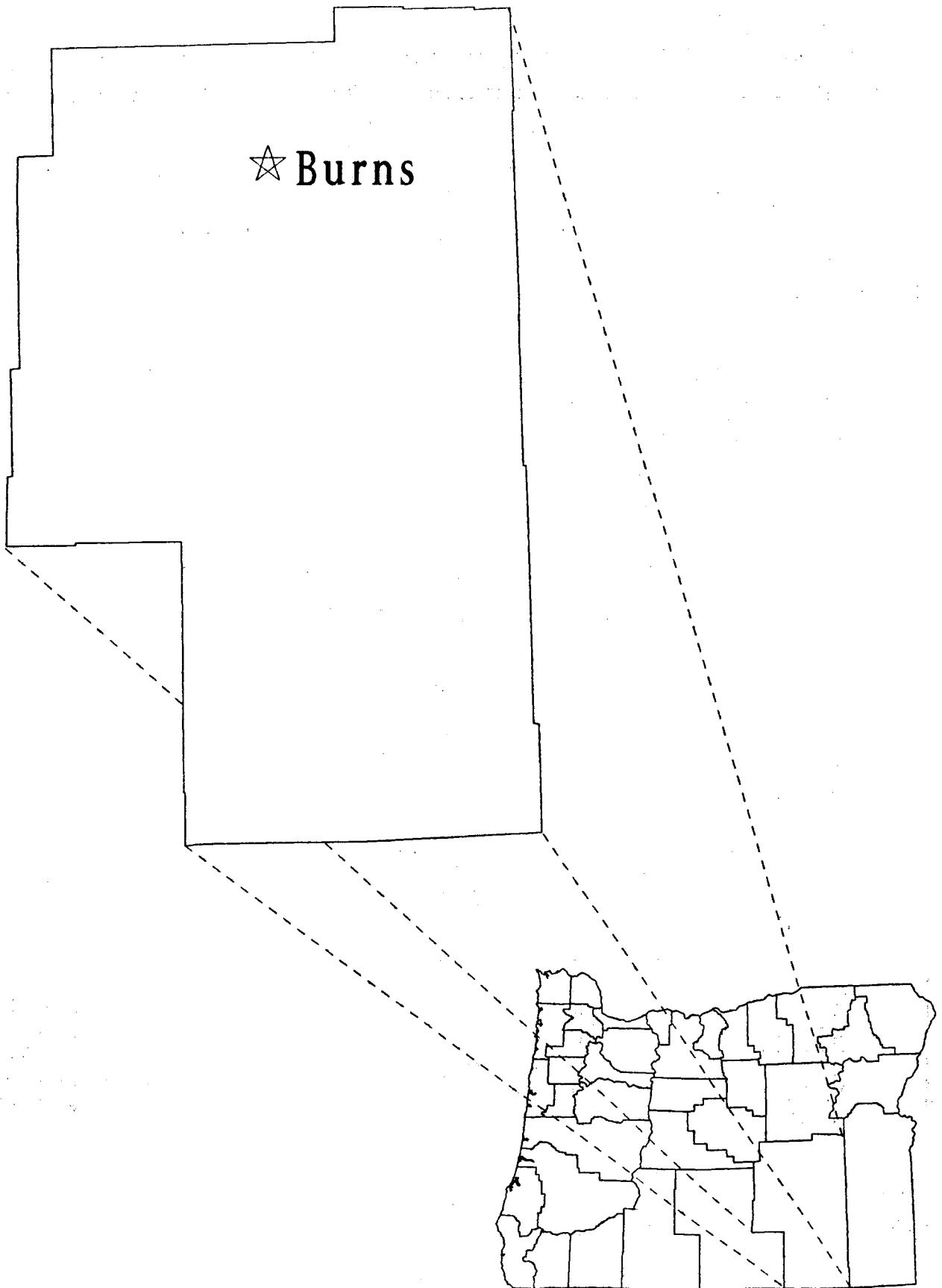
Local economic impacts include direct, indirect, and induced changes in the local economy. Direct economic impacts result from the costs of plant development, construction, and operation. Indirect impacts result from household and local government purchases. Induced impacts result from continued responding as goods and services to support the households and local governments are purchased.

Employment impacts of geothermal development follow a pattern similar to the economic impacts. The workers associated with plant development bring their families to the area. Additional labor is required to provide support services for the new population. Local government services must also increase to support the new community growth and the geothermal plant itself. These changes yield indirect and induced employment impacts associated with the geothermal plant.

Public service impacts include costs such as education, fire protection, roads, waste disposal, and water supply. Experience at other geothermal areas is discussed in the project assumptions. The lesson is that negotiated agreements between developer and impacted public agency are a good tool to mitigate public costs associated with development. Public services are also affected by increased revenues from geothermal development. Property tax revenues increase significantly as plants begin producing electricity. The county also receives royalties from steam production. These revenue increases are assumed to translate into increased public services.

The background section first compares geothermal with conventional power plants. As presented, it is the fuel that primarily distinguishes geothermal from other power sources. Other aspects of development are similar to small scale conventional thermal sources. The process of geothermal development is then explained. Development consists of well drilling, gathering system construction, power plant construction, plant operation and maintenance, and wellfield maintenance.

FIGURE 1  
HARNEY COUNTY, OREGON



Based on the background information, labor, infrastructure and capital requirements of the hypothetical plant in Harney County, Oregon are described. The section first provides estimated labor requirements of each development phase. The construction phase is described in detail with regard to estimated work force, public service requirements, and construction costs. The last part of the development discussion addresses public service impacts of geothermal plant development.

The economic impacts section summarizes operating revenues, local royalty and tax payments, and local payroll of the hypothetical plant development specified for this study. In addition, both indirect and induced economic impacts associated with payments made by the plant owners to local governments and individuals are estimated.

The last section presents conclusions and a brief comparison with other industries in Harney County.

## **BACKGROUND**

### **Geothermal Compared to Conventional Plants**

Power plants convert fuels (or falling water) into electricity. Equipment necessary to create thermal energy or steam varies according to fuel type. Boilers are the most common device. Once steam is created, equipment that transforms thermal energy into electricity is used. Power generation components (turbine, generator, condenser, buildings, switchyard) are similar for all thermal power plants. Table 1 shows example power plant equipment groupings.

Fixed and variable costs differ among plant types. For example, hydroelectric dams have high capital costs and low fuel costs. In contrast, gas combustion turbines are relatively cheap to build and have high fuel costs.

**TABLE 1**  
**GENERATING PLANT EQUIPMENT COMPARISON**

<u>PLANT TYPE</u>	<u>STEAM GENERATION</u>	<u>POWER GENERATION</u>
Coal	Boiler/Fluidized Bed	Turbine-generator
Gas	Boiler/gas turbine	Turbine-generator
Geothermal	Wells	Turbine-generator
Hydro	Diversion, Dam	Turbine-generator
Nuclear	Reactor	Turbine-generator
Wood	Boiler/Fluidized Bed	Turbine-generator

All power projects require a large construction force of contractors and craftsman. This is then followed by a small plant staff that includes engineers, management/clerical, mechanics, and operators.

Geothermal power plants share some construction and operation characteristics common to all power plants. Where geothermal differs is source of fuel, and, to a lesser extent, size. The "fuel" is discussed below. Geothermal plants are typically less than 80 MW due to past federal incentives. Clusters of modular plants e.g., 9 units at Coso and 26 units at ORMESA, are the latest trend. Given the combination of clustered plants and conservative reservoir development, new projects should mirror the hypothetical configuration of this report. Plants in this size range have the added benefits of matching load growth and reduced financial risks. Small power plants - regardless of fuel - offer reduced risks to ratepayer, developer, banker and utility alike.

As the above table shows, geothermal power plants get steam from the ground rather than a boiler. Thermal generating equipment - steam or hot water wells - is unique to geothermal power. An analogy would be the case of a gas power plant located next to the gas wells. Instead of gas (and its requisite combustion), geothermal steam comes out of the ground ready to drive a turbine and generate electricity. Pollution control equipment is only slightly different than from fossil fuel plants. The cost of geothermal plant pollution controls is similar to fossil fuel plants, and is included in cost estimates.

What further distinguishes geothermal power from other sources is the ability to account for steam either as fuel or as part of the plant. Geothermal power can be developed in either joint ventures of steam suppliers and utilities, or entirely by suppliers. That is, a utility can own and operate the power plant, buying steam from a supplier. Like buying fuel, the steam purchases would be expensed each year of operation. Or, a non-utility developer can build, own and operate both wells and plant. Electricity - not steam - would be sold to a utility. In accounting terms, the resource is expensed (as fuel) in the former example and capitalized (as plant) in the latter. For purposes of this report, we will assume an integrated non-utility operation, with both wells and plant under one owner.

For fossil fueled plants, a mineral royalty paid to the resource owner is part of the coal, gas or oil cost. Geothermal resources are treated similarly, with a royalty paid to the land or resource owner. For this study, royalty impacts on the local economy are significant because the resource is on federal land. Half of all federal royalties are returned to the state. Oregon passes the state share through to the county of origin.

## **Development Phases & Workforce**

Exploring for and developing geothermal resources is very similar to oil and gas activities. (In fact, many developers started in the petroleum industry.) Today's geothermal firms coordinate resource exploration, oversee steam or hot water field development, maintain resource production and operate power plants.

Generating power from geothermal resources is typically done in several major stages. Environmental permitting occurs before each stage. Activities overlap: Some well drilling, steam line construction and plant building will occur concurrently. Some workers will move between these stages in the course of work. Typical stages are as follows:

- Exploring for the resource;
- Developing the wellfield & gathering system;
- Constructing the power plant and related facilities;
- Operating and maintaining resource supplies; and
- Operating and maintaining plant facilities.

Much data is available for geothermal development at The Geysers in northern California. It is the largest developed geothermal field in the world, with about 1850 MW of capacity currently. The first plant there was completed in 1960; the most recent in 1989. Many lessons are to be had from experience at The Geysers. This is combined with recent data from other newer developments in California, Nevada and Utah.

### **Exploration**

Developing geothermal energy begins with the leasing of large tracts of land. Passive exploration includes geologic field surveys, mapping and analysis. Passive exploration occurs both before and after leasing, to reduce prospect area size. Exploratory drilling then follows, to determine the location, amount and quality of underground steam or hot water.

Generally, geothermal development companies maintain a small office in or near the county where development occurs to manage local operations. Staff size in local offices depends upon the amount of leased land, the extent and stage of development activities, and the level of subcontracted work.

Geothermal developers have both office staff and field staff. Office staff may include clerical workers, administrative managers, professionals - such as geologists, earth scientists and environmental specialists - and land agents. Permit compliance work is jointly performed by both corporate staff and contractors. One developer at The Geysers responsible for about 370 MW of steam supplies and 55 MW of power plants has a regional office with eight full time employees (Dellinger, 1990). Office personnel include

environmental compliance staff. Some staff perform both office and field duties. Many workers manage a varying number of subcontractor activities e.g., preparing well pads and access roads, and drilling.

Information provided in Matthews, 1983 and subsequent plant permit documents indicates that local office employees of developers tend to be relatively long-term residents of the local area. Given the length of time between resource leasing and producing electricity, this makes sense. Many job skills required for a developers' office are available in the local labor pool. Those employees whose job skills require familiarity with geothermal resources or specialized technical knowledge may move into the local area for initial development activities and then remain.

Exploration is occurring now in Harney County, with insignificant local impacts. Geothermal company staff manage exploration from offices outside the county.

### Well Drilling

Older geothermal plants in The Geysers require approximately 2,000,000 pounds of steam per hour to produce 110 MW of power (Matthews, 1983). This equates to about 1,820,000 pounds per hour for a 100 MW plant. Newer Geyser plants require about 10 to 20 percent less steam per MW of capacity (Bloomquist, 1987; Nolte, 1987). Therefore, a new 100 MW plant needs about 1,545,000 pounds per hour.

Approximately 20 to 30 wells provide steam for a 110 MW power plant (Matthews, 1983). Prorating that range results in an estimate of 18 to 27 wells per 100 MW plant. The range of resource flow and number of wells is due to variations in reservoir characteristics and steam quality. In simple terms, the hotter the steam or hot water, the less flow (and fewer wells) necessary to generate a fixed amount of power. Similarly, with greater flow of steam or hot water per well, fewer wells are needed to generate a fixed amount of power. Each well is unique and different steam characteristics for wells in the same leasehold are common. Without knowing specific resource parameters, we will assume the same well count of 18 to 27 total for this project.

Development of each well varies with depth and lithology, but at The Geysers it takes approximately 60 days with drilling crews working around the clock. Given high elevation locations in the Oregon Cascades, this drilling period may be extended seasonally. A typical drill rig is operated by four crews of 5 or 6 persons during each 24-hour period (USGS, cited in Matthews, 1983). Overseeing the rig crew is a drilling superintendent employed by the geothermal developer. Thus, there is generally a total work force of about 25 persons associated with each drilling rig.

Workers needed during the steam field development stage include drillers, derrickmen, roughnecks, roustabouts, floorhands, tool pushers, motor operators, welders, and rig superintendents (Cornelison, cited in Matthews, 1983). Most of the steam drilling work force at The Geysers do not belong to a craft union (Matthews, 1983).

Information provided by geothermal developers indicated that The Geysers drilling rig work force tends to be relatively long-term residents of the local area (Matthews, 1983). That drill rig workers moved into the area and stayed is logical, given the mature (30+ years) development of that field. Although there may be changes within the personnel assigned to a drilling rig as workers move in and out, a minimum number of workers must be maintained for the rig to function. Once a particular rig and crew are active in an area, developers prefer to keep it busy there. The crews become familiar with the geologic idiosyncrasies of the area, and drilling equipment is prepared to address those characteristics.

For this study it is estimated that well drilling will employ an estimated 50 persons each year until 1998.

#### Steam/Water Gathering System

Once the majority of wells are complete and plant construction is underway, work begins on the steam/hot water gathering system. The gathering system is a pipeline network that collects the resource and delivers it to the plant. Typical gathering systems have two components: a short two phase resource (steam and hot water) line from the wells, and a longer steam line from separators to the plant. Steam line workers are different from drilling crews and plant constructors. The work force involved in pipeline construction may include plumbers, welders, pipefitters, foremen, and the laborers involved in preparing foundations and footings.

The number of workers constructing steam gathering systems varies with the pipeline design, routing and interconnection plan. The construction period may be a few weeks or a few months. The work force varied between as few as 4 or as many as 50 for a 110 MW plant at The Geysers. Peak steam field and gathering system workers for the 27 MW West Ford Flat plant completed in 1988 were estimated at 35 (Nolte, 1987). The amount of steam gathering system workers is not proportional to plant size. This phase can be either a short term, high worker number effort, or a longer term, low number effort. Weather, construction schedule and contract requirements all affect gathering system employee number.

The gathering system work force is less likely to be long-term local residents, since the duration of the work is short and months may elapse between jobs (Matthews, 1983). Pipeline gathering system workers will be needed shortly before completion of the first plant through startup of the last plant. This is

estimated to be 20 workers for six months each year, for an average of 10 workers per year for 1995 through 1998.

### Power Plant Construction

Once the first production wells are in, plant design begins. Power plant design is based on resource chemistry and enthalpy (heat content). Commercially available power plants range in size from 620 to 135,000 kilowatts. Geothermal plants in the range of 10,000 to 30,000 kilowatts, or 10 to 30 megawatts (MW) are common today. Also prevalent in the power industry is a trend towards more factory fabrication of components and less onsite erection. New geothermal power plants specify modular components where feasible. Engineering and design can be reduced, the construction schedule shortened and revenues generated earlier as a result of modular components (Phair 1989). Equipment obtained as modular units for the Bear Canyon plant included air compressors & accessories, electrical equipment modules, emergency diesel generator, fire water pumps & accessories, gas removal equipment, Stretford™ process and turbine generators (Phair 1989). Skid-mounted modular turbine generator units are available from several firms: Barber-Nichols Inc., ORMAT Energy Systems Inc. and Geothermal Power Co.

Geothermal plant sizes refer to net power at the utility (busbar) grid. Plants are typically designed and operated as baseload facilities; availability and capacity factors average over 90 percent for recent plants. For a background discussion see *PURPA Influence on Contemporary Geothermal Plants*, (Sifford, Bloomquist & Geyer, 1987), and *Innovative Design of New Geothermal Generating Plants*, (Bloomquist, Geyer & Sifford, 1989). Optimal economic development calls for baseload operation whenever possible. Typical "average megawatt" capacity for geothermal plants approaches net output. The latter term is commonly used, and will be throughout this report.

The average construction time for 55 MW to 110 MW geothermal plants in The Geysers was about 28 to 30 months (Matthews, 1983). Newer plants there have shortened this period considerably. The Bear Canyon plant was built in about 20 months instead of a projected 24 months (Phair 1989). The West Ford Flat plant came online only eight months after groundbreaking (Urbank, 1989). Other new plants in California, Nevada & Utah had construction periods of less than two years due to significant shop fabrication of standard or similar units. The shortest construction period for a significant (7 MW) plant in an area similar to Harney County was 13 months, (Bloomquist, Geyer & Sifford, 1989).

Construction of the power plant and related facilities is usually managed by one general contractor and several subcontractors. Construction of these facilities involves a succession of diverse tasks. Work tasks include construction of access roads; site clearance and preparation; placement of foundations and pads, construction of the power plant buildings; placement of the generating unit(s) and associated piping and

electrical work; construction of related facilities, e.g., hydrogen sulfide abatement systems; air or water cooling systems; the switchyard and transmission system; and final site and facility finish work.

Workers needed for these tasks include pipefitters, welders, electricians, iron workers, carpenters, painters, equipment operators, concrete workers and finishers, teamsters and laborers, other manual labor skills, and supervisory and quality control inspection personnel. Many of the work tasks throughout the construction period are of relatively short duration, ranging between a few weeks and a few months. Some of the craft skills required are very specialized, and the number of workers in the state who are qualified to perform the skilled tasks is relatively small. However, a worker with a wide range of abilities and a high degree of skill in each of those various areas could maintain relatively continuous employment on a progression of geothermal power plants.

The peak work force during power plant construction is active on site after the foundations and pads are set, when work begins on generating unit(s) installation and mechanical and electrical connections. Once the major equipment is placed, construction continues simultaneously on the rest of the power plant structure and related facilities.

The majority of the construction work force is composed of electricians and pipefitters who are dispatched through union hiring halls. The number of electrical workers active during the peak period usually ranges between 5 and 35 but has been as many as 55 on a single project. The number of pipefitters active during the peak period may range between 6 and 50. It has been as high as 110. Generally, this peak period extends out over one year, with the largest number of workers needed for six to eight months (Matthews, 1983). At new projects in California, Nevada and Utah, the choice of using union labor rests with the developer and construction firm.

Based on information plant developers provided the California Energy Commission, the maximum number of construction workers of a 110 MW geothermal power plant ranged between 75 and 205 (Matthews, 1983; CEC, 1985). The wide variation may be due to both seasonal limits on earth movement work and phase of construction. Peak plant construction workers for the 27 MW West Ford Flat plant completed in 1988 were estimated at 40 (Nolte, 1987). We therefore have an old range of numbers, and a recent point between them. The old range is .68 to 1.87 workers per MW. The West Ford Flat figure was 1.48. No straight line correlation is made for construction workers and plant capacity. Power sales schedule, seasonal slowdowns, financing and degree of shop fabrication all affect construction workforce levels.

Based on a range of 13 to 36 months, a 24 month construction period for the each plant is assumed. Workers would begin earth movement activities for the first plant in late 1993, but for ease of modelling,

all construction is shown to begin in 1994. Plant building will be staged, but will include overlapping work whenever possible. It is expected that construction will be more efficient after the first plant is built.

### Wellfield Maintenance

Once a geothermal power plant comes on line, it operates at full capacity all the time, barring technical or mechanical problems. Periodically throughout the lifetime of the power plant, the steam wells supplying the plant need to be redrilled to clear out obstructions or to regain full flow of the steam. New wells must be drilled if an existing supply well does not maintain sufficient output.

The work force needed to maintain an adequate resource supply for each well field and power plant is similar to the field development phase. A California Division of Oil and Gas representative in Santa Rosa believed that the average number of drilling rigs active in the Geysers in the early 1980s will continue to be active for the lifetime of the geothermal resources in the Geysers. Steamfield work has shifted from developing new steam supplies to maintaining existing supplies. This makes sense as the last plant built there was in 1989. California Division of Oil and Gas staff estimated in Matthews that 9 to 12 rigs maintain steam flow at The Geysers. That requires a continuing work force of 225 to 300. An estimated 8 field staff maintain over 370 MW of Calpine Corp. wellfield at The Geysers (Dellinger, 1990). As discussed earlier, the steam field work force is expected to be drawn from long-term residents of the local area.

### Power Plant Operation and Maintenance

In the final months of construction, personnel from the plant developer/operator begin testing equipment and systems. These workers may include power plant operators, plant engineers, electricians, instrument repairmen, and maintenance workers. Once the power plant comes on line, the permanent operation and maintenance work force maintains routine operations. Periodically, this work force may be supplemented by additional outside workers for facility overhaul and maintenance activities.

The number of workers that operate and maintain power plants and related facilities, (excluding the wellfield), varies by power plant owner/operator. The Pacific Gas & Electric Company (PG&E) operation and maintenance work force in 1981 for 17 Geysers plants (and 1135 MW of net capacity) was about 130 (Matthews, 1983). At that time, PG&E managed the plants from one administration center, the West Geysers Power Plant. In 1984 PG&E created a separate satellite administration center, Geysers East, to manage growth in that part of the field. Geysers East had full duplicate staff of Geysers West. However, PG&E recently reduced management at the Geysers East center and now operates the various units from Geysers West. Periodic checking of daily operations and necessary maintenance are performed by roving crews based at each administrative center. Each crew is responsible for two or more units. Current staff

numbers about 210 persons, responsible for 1302 MW of capacity (Stukey, 1991). This results in an average of .16 plant O&M employees per MW. This number is low due to the enormous size of development there. PG&E Geysers data provides the low end of plant O&M staff levels.

In the last decade developers other than PG&E began operating new plants in The Geysers. These developer/owners have initial operation and maintenance work forces of 10 to 20 workers per power plant. Fewer workers are required to operate and maintain subsequent power plants since the basic work force is already involved in their initial operation. This staff economy of scale holds true at the recently built Bear Canyon and West Ford Flat plants operated by Calpine Corp. Approximately 12 plant staff operate and maintain these plants (49 MW total), for an average of .24 employees per MW (Dellinger, 1990). Factoring in an additional 8 field staff results in an average of .41 total employees per MW. (This conservatively excludes additional, sizable steam reserves managed by the same field staff.)

The recently completed Coso development currently employs about 90 persons in plant operations and 170 people total (McClain, 1991). This results in an averages of .38 plant employees per MW and .73 total employees per MW. Table 2 provides ranges of employees by development phase. From these estimates Harney County assumptions were chosen.

**TABLE 2**  
**RANGE OF EMPLOYEE ESTIMATES**

<u>PHASE</u>	<u>NUMBER PER MW</u>	<u>NUMBER PER 25 MW</u>
Drilling	25 per rig	25 per rig
Wellfield Construction	.04 - 1.30	4 - 33
<u>Plant Construction</u>	<u>.68 - 1.87</u>	<u>17 - 47</u>
Total Construction	.72 - 3.17	21 - 79
Wellfield Maintenance	25 per rig	25 per rig
<u>Plant Operation</u>	<u>.16 - .38</u>	<u>4 - 10</u>
Total Operation	.41 - .73	10 - 18

Sources: Cited above

One reason for a range of worker estimates is economy of scale that affects plant personnel. Such ranges are not linear as plant sizes increase. A minimum number of employees is needed for any plant. Research shows that a geothermal plant 10 MW in size requires almost as many operating staff as a plant two to five times that size (Bloomquist, Geyer & Sifford, 1989). There is no record of the total number of geothermal industry workers. Neither is there sufficient accounting of actual numbers of workers employed in each

stage of development. Contractual employees further compound estimates. However, there are at least some ranges of employees estimates, both with and without construction and field maintenance personnel.

## **HARNEY COUNTY PROJECT ASSUMPTIONS**

Development assumptions are presented below. Information in this section is directly related to development phases. Cost and operation estimates are provided in detail. Research revealed unique factors regarding public service impacts in Oregon counties. These are discussed below.

Construction and operation assumptions for the hypothetical 100 MW (net) project are as follows. Drilling for the first plant is assumed to begin in early 1993. Well drilling is assumed to average about 18 months per plant. (In reality, it will likely be longer than average for the first wells, and shorter than average for the last ones.) Given the uncertainty of Northwest resources, this report conservatively uses high well numbers. Approximately 25 wells - the midpoint of our 20 to 30 range - are needed to provide steam for a 100 MW project. This total includes observation and injection wells. That same number of wells will be drilled again over the 30 year life of the power plant as replacement resources are needed.

The project will have four 25 MW double flash or binary plants. Both technologies are capable of generating electricity from expected resources in Harney County's geothermal area (Pueblo Valley). Double flash refers to the number of separator stages needed to get usable steam. Hence, a double flash plant uses two separators to provide steam to the turbine. Binary refers to the use of a second working fluid, heated by geothermal steam or water, that drives the turbine.

The snow season in Pueblo Valley should not impede construction as at The Geysers. Although average elevation is about 4,000 feet above sea level, precipitation is only about 10 inches each year. It is therefore not necessary to expect seasonal delays in earth movement activities. A 24 month construction period per plant, conservative compared to most recent plants, is assumed for this analysis. The development scenario is presented over a six year period leading up to full operation at the end of 1998. The plants will operate 90 percent of the year.

Most high temperature geothermal resources in the Pacific Northwest are on federal land. Such is the case at Pueblo Valley, excepting a small private inholding. Therefore, a 10 percent operating royalty will be collected by the federal government. Half of the royalties are given back to the state. All such (mineral) royalties are passed back to the counties in Oregon, per Oregon Revised Statutes 294.055. Royalties derive from steam - not power - production. Therefore, data from existing steam supplier agreements are useful to determine plant assumptions. Steam cost values are estimated from two-party contractual data. Power plant steam use is taken from one of the most efficient plants at The Geysers. Royalty estimates are

thus conservative. Less efficient plants may be built for slightly lower capital costs, but will experience higher operation, maintenance and royalty costs. Prudent developers will optimize steam efficiency with capital costs.

### **Labor Requirements**

Table 3 shows estimated workforce and wage projections. The well drilling, pipeline gathering and plant construction crews will vary each year, depending on development stage. Well drilling will employ an estimated 50 persons each year until 1999. Plant construction staff will go from 10 in 1993 to 80 each year until 1998, when the last plant nears completion with only 40 workers. The same workforce would build each plant. Construction staff levels will remain constant (plus or minus a few supervisory personnel) after the first year.

Table 4 shows development projections from construction through the first years of operation. The first plant would begin commercial operation in January 1996. Over the power plant lifetime (typically 30 years), an additional 25 wells could be drilled to maintain the necessary supply of steam or hot water. One hundred percent reinjection of the resource would reduce this number to zero. Replacement well drilling will require workers only for a few months per year. This equates to about six full time employees maximum. At that time, drilling workers may be gradually drawn from the local labor pool. Wellfield maintenance employees start at 2 in 1995 and rise to 6 once replacement well drilling begins. The number of plant and wellfield operation staff will ramp up from 12 with the first plant to 20 at full operation. Operating personnel will be evenly divided between plant and wellfield for the first year. Purchase shares are discussed in a later section, with the breakout of local labor (and equipment) highlighted there.

For the complete 100 MW development assumed for this study, 20 operation and maintenance workers are forecast. This is low compared to the ranges in Table 2. One reason is the expectation that a single main control room will serve all plants. Direct employment estimates used in this analysis are intentionally conservative.

Construction worker wages vary between wellfield and plant. Given the specialized nature of well drilling, those staff wage levels are projected at \$40,000 per year. The average salary in Oregon for industrial building construction is about \$30,000 per year (Lux et al., 1989). Plant construction workers are not distinguished as union or non-union, but salaries are projected to closely match local union scale. For this study, above average plant construction salary rates of \$34,000 per year were chosen. Note that all wages forecast are average for many levels of workers and do not include benefits. Plant O&M wages were estimated to be \$40,000 per year.

Table 3

**WORKFORCE & WAGE PROJECTIONS**

	1993	1994	1995	1996	1997	1998	1999	2000
<b>WORKFORCE</b>								
Well Drilling	50	50	50	50	50	50	0	0
Pipeline Gathering	0	10	10	10	10	10	0	0
Plant Construction	<u>0</u>	<u>40</u>	<u>40</u>	<u>40</u>	<u>40</u>	<u>40</u>	<u>0</u>	<u>0</u>
Construction Workforce	50	100	100	100	100	100	0	0
Replacement Drilling	0	0	0	0	0	2	2	2
Wellfield Maintenance	0	0	0	6	6	6	6	6
Plant Operation	<u>0</u>	<u>0</u>	<u>0</u>	<u>6</u>	<u>12</u>	<u>12</u>	<u>12</u>	<u>12</u>
O & M Workforce	<u>0</u>	<u>0</u>	<u>0</u>	<u>12</u>	<u>18</u>	<u>20</u>	<u>20</u>	<u>20</u>
TOTAL WORKFORCE	50	100	100	112	118	120	20	20
<b>PAYROLL</b>								
Construction Jobs	50	100	100	100	100	100	0	0
Average Salary	<u>\$34,000</u>	<u>\$34,000</u>	<u>\$34,000</u>	<u>\$34,000</u>	<u>\$34,000</u>	<u>\$34,000</u>	<u>\$34,000</u>	<u>\$34,000</u>
Construction Payroll	\$1,700,000	\$3,400,000	\$3,400,000	\$3,400,000	\$3,400,000	\$3,400,000	\$0	\$0
Operation Jobs	0	0	0	12	18	20	20	20
Average Salary	<u>\$40,000</u>	<u>\$40,000</u>	<u>\$40,000</u>	<u>\$40,000</u>	<u>\$40,000</u>	<u>\$40,000</u>	<u>\$40,000</u>	<u>\$40,000</u>
Operation Payroll	\$0	\$0	\$0	\$480,000	\$720,000	\$800,000	\$800,000	\$800,000
TOTAL PAYROLL	\$1,700,000	\$3,400,000	\$3,400,000	\$3,880,000	\$4,120,000	\$4,200,000	\$800,000	\$800,000

Table 4

# **GEOHERMAL DEVELOPMENT PROJECTIONS**

	1993	1994	1995	1996	1997	1998	1999	2000
Plant Size (MW)	0	0	0	25	50	75	100	100
Plant Value (\$/KW)	<u>2.800</u>	<u>2.800</u>	<u>2.800</u>	<u>2.800</u>	<u>2.800</u>	<u>2.800</u>	<u>2.800</u>	<u>2.800</u>
CApital Value (\$000)	0	0	0	70,000	140,000	210,000	280,000	280,000
Property Tax Rate (\$/000)	<u>21.04</u>	<u>22.50</u>	<u>20.00</u>	<u>17.50</u>	<u>15.00</u>	<u>15.00</u>	<u>15.00</u>	<u>15.00</u>
Property Taxes	\$0	\$0	\$0	\$1,225,000	\$2,100,000	\$3,150,000	\$4,200,000	\$4,200,000
Steam eff. (#/kWh)	14	14	14	14	14	14	14	14
Steam price (\$/000#)	<u>1.45</u>	<u>1.45</u>	<u>1.45</u>	<u>1.45</u>	<u>1.45</u>	<u>1.45</u>	<u>1.45</u>	<u>1.45</u>
Steam value (\$/kWh)	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203
Steam value per yr.	\$0	\$0	\$0	\$4,001,130	\$8,002,260	\$12,003,390	\$16,004,520	\$16,004,520
Royalty Rate (%)	<u>10.00</u>	<u>10.00</u>	<u>10.00</u>	<u>10.00</u>	<u>10.00</u>	<u>10.00</u>	<u>10.00</u>	<u>10.00</u>
Royalty per year	\$0	\$0	\$0	\$400,113	\$800,226	\$1,200,339	\$1,600,452	\$1,600,452
County 50% Share	\$0	\$0	\$0	\$200,057	\$400,113	\$600,170	\$800,226	\$800,226
Power Sales (kWh/yr)	0	0	0	197,100,000	394,200,000	591,300,000	788,400,000	788,400,000
Power Price (\$/kWh)	<u>0.000</u>	<u>0.000</u>	<u>0.000</u>	<u>0.065</u>	<u>0.065</u>	<u>0.065</u>	<u>0.065</u>	<u>0.065</u>
Gross Revenue per yr.	\$0	\$0	\$0	\$12,811,500	\$25,623,000	\$38,434,500	\$51,246,000	\$51,246,000
Profit (@20 %)	\$0	\$0	\$0	\$2,562,300	\$5,124,600	\$7,686,900	\$10,249,200	\$10,249,200
Corp. Tax Rate	<u>6.50%</u>	<u>6.50%</u>	<u>6.50%</u>	<u>6.50%</u>	<u>6.50%</u>	<u>6.50%</u>	<u>6.50%</u>	<u>6.50%</u>
Corp. Income Taxes	\$0	\$0	\$0	\$166,550	\$333,099	\$499,649	\$666,198	\$666,198
Pers. Tax Rate	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
Total Payroll \$/yr.)	<u>\$1,700,000</u>	<u>\$3,400,000</u>	<u>\$3,400,000</u>	<u>\$3,880,000</u>	<u>\$4,120,000</u>	<u>\$4,200,000</u>	<u>\$800,000</u>	<u>\$800,000</u>
Income Taxes (\$/yr.)	\$170,000	\$340,000	\$340,000	\$388,000	\$412,000	\$420,000	\$80,000	\$80,000

## **Capital Requirements**

Project cost assumptions are \$2,800 per net kW, for \$280,000,000 total. The authors again use conservative assumptions for capital costs. Data from prior studies show a range of \$1,550 to \$3,778 per net kilowatt for recently built geothermal plants (Bloomquist, Geyer & Sifford, 1989; OESI, 1991). Our estimate is broken down as \$1,800 for the plant and \$1,000 for the wells, on a per kW basis. While resources in Harney County appear easier to exploit, this report Total costs include engineering, construction, management, materials, and regulatory compliance. Construction costs include everything from preliminary earth movement through transmission line interconnection.

Little information is available on relative shares of labor, materials, and other costs as a portion of total plant capital costs. For the 20 MW Bear Canyon plant, share estimates before completion were about 41% labor, 40% materials and 19% other (Bloomquist, Geyer & Sifford, 1989). We assume relatively high percentages of material to total costs For this study, labor cost share was estimated at twice the total payroll to account for fringe benefits, overhead and other labor-related costs generally billed as markups to labor. The total labor cost share projected in this report is about 16 percent. Materials cost are expected to be higher for this plant because of the availability of newer, more efficient technology, extensive use of modular components and because labor costs have not kept pace with inflation in recent years. For this study, materials cost share is estimated at about 60 percent and other costs at 24 percent. Materials are assumed to be spent in proportion to labor costs over the development time period.

The Harney geothermal site is close to an existing power line. Therefore, a two mile transmission line was chosen as representative for this study. Transmission costs equal about \$220,000 for materials plus \$300,000 for labor totalling \$520,000 (Hubsy, 1990). These costs are included in construction estimates, and are in 1991 dollars.

Capital necessary for this project will come from sources outside of Harney County. Financing geothermal power plants typically involves developer equity and lender debt packaged in a project finance loan or leveraged lease. Energy projects of this size obtain capital in either national or international markets (Bloomquist, Geyer & Sifford, 1989).

## **Public Service Impacts**

This section describes public sector costs and benefits associated with geothermal development. Development of the geothermal resources in Harney County will yield revenues for local government in the form of property taxes and resource royalties. It will also generate costs as the county will need to provide increased education services and infrastructure. Some costs may occur before revenues are

generated. As noted below, recently developed techniques now allow fees to be collected prior to incurring public service costs.

### Costs

Public service impacts are the costs of education, fire protection, roads, waste disposal, and water supply. Any large scale development will require some additional public services. Education and road impacts that adversely affected prior developments in California would be avoided in Harney County.

Education impacts are increased enrollment of project-related students (children of new workers) and potential new classroom space and buses. Schools in Oregon are financed by a combination of base level property tax levies and specific school bonding levies. Given the passage of Ballot Measure 5 in November 1990 and its attendant drop in school property tax rates, it is assumed that bond funding will no longer be available to fund increased services. Increased property taxes from geothermal development should raise school funding revenues. The critical factor is existing school enrollment: will new students exceed current capacity? Given the remote location, any students will likely either go to the boarding school at Crane or to a temporarily built school at Fields. The staged nature and small size of these projects is not expected to result in negative school capacity impacts. However, given the worst case scenario of maximum enrollment capacity, developers and the school district may choose to adopt a mitigation agreement providing for a temporary school at Fields.

Matthews, 1983 compares Geysers area school impact mitigation agreements. The one used by an 80 MW project there could be useful here. For a period of 8 years, the developer pays the school district an agreed upon amount. The developer and district then settle accounts between prepaid fees and property tax payments. The amount is calculated as follows:

The number of students times 55 square feet of classroom per student times the construction cost per foot, plus \$1,000 per student for buses.

Education impacts will be mitigated through increased property tax revenues, royalties returned to the county, negotiated agreement or perhaps some combination of the three sources.. Net cost to the County should approach zero, depending upon how much additional cost is borne by the developer.

Fire protection measures will likely be negotiated agreements with the Forest Service to build and maintain water storage facilities at the plant site. Temperature gradient drilling to date included fire protection measures, i.e., water tanks on site. This cost is included in plant capital costs. Net cost to the County should be zero.

Roads in southern Harney County are the responsibility of both the state Highway Division and the county Roads Department. The state manages Highway 206 from Burns to Roaring Springs Ranch. The county manages Highway 206 from Roaring Springs Ranch to Denio, Nevada. That section of the highway was recently upgraded and paved (White, 1991). The remaining unimproved road from Fields to the Pueblo Valley site is about 5 miles long. This road is constructed to handle loaded cattle truck traffic. This will result in road development costs significantly lower than those experienced at The Geysers, where heavy duty roads did not already exist. About 75 percent of payments in lieu of taxes from federal agencies are dedicated to County road maintenance (White, 1991). County road costs are estimated at less than \$1,000,000 per year. Increased royalties to the county will cover those costs.

Preliminary indications are that the developer with prospects in Harney County prefers a binary power generation process. If this technology is used, no solid wastes would result as the power cycle is closed, i.e., all resources are returned to the reservoir. (Should a flash steam process be used, some solid wastes would result. Solid wastes from flash plants may be cooling tower sludge and sulfur cake from air pollution control and treatment systems (Felperin, 1989). It is expected that these solid wastes would be classified as hazardous wastes unless trace elements are washed out. In that case, the sulfur cake is classified as designated waste (Nolte, 1987). Waste disposal will consist of truck trips from the plant to a landfill near Arlington, Oregon. Arlington is the state's only commercial facility licensed to accept chemical hazardous waste.) It is premature to estimate numbers of such truck trips based on other plants because of the likelihood of binary cycle technology being used. Regardless, solid waste disposal costs will be borne by the developer.

Water supplies are primarily dust suppression and fire protection up until plant operation. At that time, a single large purchase of water from a market source (e.g., a holder of a valid water right) will occur to fill the cooling system. Once plant operation begins, cooling water makeup will come from resource condensate. Net cost to the County will be zero.

### Revenues

State and local government revenue projections based on the above assumptions are included in the annual summary shown in Table 4. Capital costs, steam efficiency, and tax rates all affect the accuracy of these projections. Higher capital costs and lower steam efficiency would result in additional property taxes and royalties accruing to Harney County. Lower property tax rates will yield less revenues to the county. Building permit fees are not included in this work because they are "fees for service" (Prante, 1989). Taxes and royalties are the primary revenue sources, and are the biggest direct economic impacts to Harney County. This report uses the book value construction cost to base property taxes on. The

property tax rate in Tables 4 and 5 reflects limitations imposed by the passage of Ballot Measure 5 in 1990. Current Harney County property tax rates are only slightly above newly mandated levels. Table 5 summarizes revenues to state and local governments at full operation.

**TABLE 5**  
**STATE & LOCAL PROJECTED REVENUES**  
**100 MW PLANT (1999)**

<u>SOURCE</u>	<u>STATE</u>	<u>COUNTY</u>
Federal Royalty (50% county return)	\$0	\$800,226
Property Tax	\$0	\$4,200,000
Corporate Income Tax (6.5% of Pretax Profit)	\$666,198	\$0
Personal Income Tax (10% of wages)	<u>\$80,000</u>	<u>\$0</u>
<b>TOTALS</b>	<b>\$746,198</b>	<b>\$5,000,226</b>

## **ECONOMIC IMPACTS**

### **Methodology**

Estimation of local economic impacts associated with plant development is a three-phase task. First, the costs of building the plant and the returns to local governments associated with plant operation must be estimated for each year of plant development and for a typical year in which the plant is fully operational. These are based on the plant development assumptions and information described in the preceding section.

The second step in estimating local economic impacts is to identify or estimate the share of goods and services associated with plant development, construction and operation that are purchased locally, and the share of revenues that is returned to the local government. For this study local expenditures are those made within Harney County.

The last phase of assessing economic impacts is to estimate the indirect and induced impacts of the local expenditures and local government revenues identified in phases 1 and 2. An input/output model describes interactions between industries and estimates the impacts of changes in demand for goods and services provides this information. The model used for this study is the IMPLAN model developed by the U.S. Forest Service. Estimates of local expenditure shares and development of multipliers from the IMPLAN model are discussed below.

### Local Purchase Shares

The identification of local and non-local expenditure shares for wages paid and equipment purchased during plant development represents an estimate drawn from interviews with industry representatives, consultation with Washington State Energy Office researchers, and the author's knowledge of the industry. Data on payroll for geothermal plants is proprietary and there is little literature on the topic. The authors did find one vendor list that was useful in identifying sources of equipment. For Harney County we estimate 20 percent of the drilling crew, 40 percent of the pipeline gathering crew and 25 percent of construction labor will be local to the county. Non-local workforce includes workers commuting in from other counties and temporary workers that live elsewhere. Some workers may commute from Humboldt County Nevada (about 25 miles south), or send their wages back to whatever locale they originally came from. Few wage impacts will be concentrated in Harney County, as trade areas include Bend, Ontario, Boise, Idaho and even Winnemucca, Nevada for those workers. Table 6 shows local share estimates of labor and equipment used in this study: Because Harney County has very few industries producing materials and equipment needed for geothermal development, those respective local share estimates are assumed to be zero. In fact, some gravel or concrete supplies would likely come from local sources. This analysis estimate, at three percent, produces no appreciable indirect and induced impacts.

**TABLE 6**

#### **LOCAL SHARE ESTIMATES**

	<u>LOCAL</u>	<u>NON-LOCAL</u>
MATERIALS AND EQUIPMENT		
Drilling	0%	100%
Well field	0%	100%
Plant	3%	97%
LABOR		
Drilling Crew	20%	80%
Pipeline	40%	60%
Construction	25%	75%
Operation	100%	0%
Maintenance	100%	0%

### Use of the IMPLAN Model

Input/output models estimate the direct, indirect and induced impacts of changes in final demand for a product or service. In the case of geothermal development, the direct impacts are the local employment and supply purchases associated with plant construction and maintenance. Indirect impacts are the employment and supply purchases associated with production of the supplies for plant development. For example, *direct* purchase of locally produced sheet metal for the plant *indirectly* generates additional

purchases of supplies used to produce the sheet metal, such as raw metal and energy. The additional employment associated with production of the supplies for the geothermal plant also *induces* increased household spending as the employees spend their wages. Further information related to the IMPLAN model and data used in this study is included in Appendix A.

Total impacts are the sum of the initial and subsequent rounds of direct, indirect and induced impacts. In larger economies, total impacts are greater because in each successive round of respending, more money is respent locally. In smaller economies, fewer supplies and consumer goods are available locally. Total local impacts are reduced because purchases occur outside of the region.

The IMPLAN model lacks a specific sector that relates closely to geothermal development. The impact analysis conducted for this study is therefore based on patterns of household and local government spending, and purchases of construction materials generated by development. Most local impacts result from wages paid to plant construction workers and maintenance and operation staff, and from royalties and taxes paid to the Harney county government. Local government spending falls into two general categories, education and other local government services (including road and infrastructure development and other public services).

For this study, the IMPLAN model was used to develop response coefficients or estimates of the impacts of wages paid to local employees and the impacts of education and non-education related local government expenditures. The advantage to using response coefficients is that they represent the response - in both dollars and jobs - associated with an increase in spending valued in dollars. It therefore becomes unnecessary to convert values from current dollars to the 1982 base used by IMPLAN for analysis, and then convert back to current dollars for presentation. It also allows readers to differentiate between the impact estimate and the initial analysis of payroll and government spending associated with the project.

The IMPLAN model also provides information that can be used to generate a spending pattern for local purchases of construction materials. The "New Utility Structures" interindustry purchases identified by the model were used to help select sectors impacted by construction purchases. However, only 10 other local industries expected to be main recipients of geothermal development were included in the spending patterns used for this analysis. A portion of the construction expenditures were also allocated to the New Utility Structure sector. The response coefficient reflects both the author's judgement of spending patterns and the model's version. Sectors represented and their respective portion of local expenditures allocated to them are listed in Appendix D.

Programs developed by Jonathan Lesser at the Washington State Energy Office were used to expedite extraction of the household and local government spending patterns. Appendices B, C and D include tabular presentations of spending patterns generated from the model. For this study, the mid-range spending level was used as the input in developing household expenditure response coefficients. The response coefficient or multiplier associated with spending in each category is generated and then applied to estimates of local payroll and government spending to calculate the impacts of geothermal development. Each expenditure pattern illustrates the average impact of project related spending in the Harney County economy. It describes the portion of each dollar of spending that goes to each industry in the local economy.

Before presenting the results of the IMPLAN analysis, it is important to review some of the assumptions associated with use of this model.

### Assumptions

Using IMPLAN or any input/output model for impact analysis requires several assumptions:

1. The interindustry trade patterns provided in the model are a reasonable estimate of trade patterns in the county.
2. The total industry output (final demand components) and regional purchase coefficients used in the model reflect the county.
3. Relative prices of goods and services relevant to this analysis have not changed significantly since 1982. If, for example, the price of concrete has gone up more than the price of other goods since 1982, the model will yield somewhat inaccurate estimates of trade patterns that involve concrete.
4. The relative quantities of each input used in producing goods and services are consumed in fixed proportion to the quantity produced.
5. Activity in each project year is independent of activity in any other year. This assumption is required because IMPLAN is not a dynamic model -- it does not incorporate estimates of change during one year into estimates of change in subsequent years.
6. New employment generated by changes is assumed to be met via population increases. But the percentage unemployment in the county is assumed to stay the same.

The IMPLAN model yields estimated changes in output, income, employment and population. These results depend on assumptions about profit margins, population per employee, wages in each industry, and ratio of part-time and full time jobs in each industry. For this analysis, model assumptions were accepted and data provided with the model was used without modification, with a few exceptions which are discussed below.

## Impact Estimates

### Response Coefficients

This section summarizes results of the impact analysis. Response coefficients (also called income multipliers) calculated for each component of the analysis are summarized below. Additional detail on response by major sector categories is included in Appendix D.

**TABLE 7**

**HARNEY COUNTY RESPONSE COEFFICIENTS**  
(Dollars or Jobs per Thousand Dollars of Increased Local Spending)

	<u>INCOME</u>	<u>EMPLOYMENT</u>
Household spending	\$251	0.012
Local Government Education Spending	\$886	0.023
Other Local Government Spending	\$628	0.017

Total impacts are calculated as the initial local response plus additional impacts estimated with the response coefficient. Thus the multipliers for household, government education, and other government spending are 1.251, 1.886, and 1.628, respectively. Calculations for household spending are explained below. The response coefficient is higher for education spending than for other services, implying that a greater share of purchases related to education are made locally. The direct impact of education related spending is about \$759; indirect and induced impacts bring the total to about \$886. For other local government services, the direct local impact is smaller, about \$537, so the total response coefficient is a lower \$628.

In developing the employment multipliers, the results of the IMPLAN model were adjusted to account for the author's disagreement with the model's assumptions. For education spending impacts, the model assumes fixed proportions of employment and other inputs. In reality, the school district is unlikely to hire as many new teachers as the model would indicate because the increase in population associated with geothermal development is fairly small. The county would probably hire a few teachers, and use the remainder of the new revenues for other improvements in the education system. The employment estimates were therefore adjusted downward for the government industry sector, which includes teachers' wages.

For employment impacts associated with household and other government services expenditures, the estimated employment impacts were checked against employment impacts calculated by dividing income impacts by \$20,000 annual salary. The results appear reasonably consistent, so IMPLAN's employment impacts were accepted for these categories.

### Impacts

Table 8 shows the calculation of local economic impacts associated with geothermal development. Local employment and equipment shares are shown. For every additional thousand dollars in household expenditures resulting from geothermal development payroll (take-home pay), about \$251 additional income accrues to businesses and individuals in the Harney County economy. Similarly, local government revenues spent on education generate about \$886 in additional local income for every \$1000 in spending. Other government services produce \$628 in direct, indirect and induced impacts for every \$1,000.

The response coefficients or multipliers are applied to the wage and local government values to compute estimated impacts. To compute total payroll impacts for each year, the estimated payroll associated with construction is first multiplied by the 75 percent local share. Then it is adjusted downward again to reflect take-home pay at 75 percent of local payroll. The household expenditure impacts are calculated as the multiplier times the household expenditures. The total payroll impacts are the sum of household expenditure impacts and local payroll.

To compute the impacts of local government spending, the local government revenues are shared out between (67 percent) education related spending and (33 percent) spending for other government services. These share were prorated from data provided by the Harney County Assessor's Office. The multiplier for each type of government spending is one plus the response coefficient because the impacts include the initial payments to local government plus the response to local government spending.

As shown in Table 8, there are payroll impacts but no local government spending impacts during the first three years of geothermal development. As the first plant comes on line in 1996, royalties and taxes are paid to the county government. Local government revenues and impacts increase until 1999 and then stabilize. Payroll impacts decline to full plant operation levels in 1999.

Employment impacts are calculated in Table 9. For each category, the expenditure change is multiplied by the jobs multiplier to yield estimated direct, indirect, and induced employment changes. The total employment impacts include the employment directly associated with geothermal development, plus the employment impacts for each category except construction materials.

Table 8

## LOCAL ANNUAL INCOME IMPACTS

	1993	1994	1995	1996	1997	1998	1999	2000
TOTAL PAYROLL	<u>\$1,700,000</u>	<u>\$3,400,000</u>	<u>\$3,400,000</u>	<u>\$3,880,000</u>	<u>\$4,120,000</u>	<u>\$4,200,000</u>	<u>\$800,000</u>	<u>\$800,000</u>
LOCAL PAYROLL (75%)	\$1,275,000	\$2,550,000	\$2,550,000	\$2,910,000	\$3,090,000	\$3,150,000	\$600,000	\$600,000
HOUSEHOLD EXP. (75%)	\$956,250	\$1,912,500	\$1,912,500	\$2,182,500	\$2,317,500	\$2,362,500	\$450,000	\$450,000
HOUSEHOLD INCOME MULTIPLIER	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
HOUSEHOLD EXP. IMPACTS	<u>\$240,019</u>	<u>\$480,038</u>	<u>\$480,038</u>	<u>\$547,808</u>	<u>\$581,693</u>	<u>\$592,988</u>	<u>\$112,950</u>	<u>\$112,950</u>
TOTAL PAYROLL IMPACTS	\$1,515,019	\$3,030,038	\$3,030,038	\$3,457,808	\$3,671,693	\$3,742,988	\$712,950	\$712,950
PROPERTY TAXES	\$0	\$0	\$0	\$1,225,000	\$2,100,000	\$3,150,000	\$4,200,000	\$4,200,000
FEDERAL ROYALTY SHARE (50%)	\$0	\$0	\$0	\$200,057	\$400,113	\$600,170	\$800,226	\$800,226
TOTAL TAX & ROYALTIES	\$0	\$0	\$0	\$1,425,057	\$2,500,113	\$3,750,170	\$5,000,226	\$5,000,226
EDUCATION SHARE T&R (67%)	\$0	\$0	\$0	\$954,788	\$1,675,076	\$2,512,614	\$3,350,151	\$3,350,151
EDUCATION MULTIPLIER	<u>1.89</u>	<u>1.89</u>	<u>1.89</u>	<u>1.89</u>	<u>1.89</u>	<u>1.89</u>	<u>1.89</u>	<u>1.89</u>
EDUCATION IMPACTS	\$0	\$0	\$0	\$1,800,730	\$3,159,193	\$4,738,789	\$6,318,386	\$6,318,386
OTHER SERVICES SHARE T&R (33%)	\$0	\$0	\$0	\$470,269	\$825,037	\$1,237,556	\$1,650,075	\$1,650,075
OTHER SERVICES MULTIPLIER	<u>1.63</u>	<u>1.63</u>	<u>1.63</u>	<u>1.63</u>	<u>1.63</u>	<u>1.63</u>	<u>1.63</u>	<u>1.63</u>
OTHER SERVICES IMPACTS	\$0	\$0	\$0	\$765,597	\$1,343,161	\$2,014,741	\$2,686,321	\$2,686,321
TOTAL LOCAL IMPACTS	\$1,515,019	\$3,030,038	\$3,030,038	\$7,449,191	\$10,674,159	\$14,246,687	\$14,717,883	\$14,717,883

**TABLE 9**

**LOCAL ANNUAL EMPLOYMENT IMPACTS**

	1993	1994	1995	1996	1997	1998	1999	2000
GEOHERMAL EMPLOYMENT	50	100	100	112	118	120	20	20
HOUSEHOLD EXPENDITURES	\$956,250	\$1,912,500	\$1,912,500	\$2,182,500	\$2,317,500	\$2,362,500	\$450,000	\$450,000
JOBS MULTIPLIER (JOBS/\$1,000,000)	<u>12</u>	<u>12</u>	<u>12</u>	<u>12</u>	<u>12</u>	<u>12</u>	<u>12</u>	<u>12</u>
HOUSEHOLD EXP. JOB IMPACTS	11	22	22	25	27	27	5	5
EDUCATION SHARE T&R	\$0	\$0	\$0	\$954,788	\$1,675,076	\$2,512,614	\$3,350,151	\$3,350,151
JOBS MULTIPLIER (JOBS/\$1,000,000)	<u>23</u>	<u>23</u>	<u>23</u>	<u>23</u>	<u>23</u>	<u>23</u>	<u>23</u>	<u>23</u>
EDUCATION JOB IMPACTS	0	0	0	22	39	58	77	77
OTHER SERVICES SHARE T&R	\$0	\$0	\$0	\$470,269	\$825,037	\$1,237,556	\$1,650,075	\$1,650,075
JOBS MULTIPLIER (JOBS/\$1,000,000)	<u>17</u>	<u>17</u>	<u>17</u>	<u>17</u>	<u>17</u>	<u>17</u>	<u>17</u>	<u>17</u>
OTHER SERVICES JOB IMPACTS	0	0	0	8	14	21	28	28
<b>TOTAL EMPLOYMENT IMPACTS</b>	<b>61</b>	<b>122</b>	<b>122</b>	<b>167</b>	<b>197</b>	<b>226</b>	<b>130</b>	<b>130</b>

## CONCLUSIONS

It is useful to first clarify limitations of the study. This study presents economic impact estimates of geothermal development in Harney County. It is not a cost/benefit analysis. No comprehensive comparison of quantifiable project costs and benefits is provided. The public service discussion addressed some environmental impacts, but a comprehensive analysis is beyond the scope of this study. No attempt was made to assess the value of geothermal development compared to other types of electric resources, whether efficiency or new generation.

The primary effects of geothermal development - or any large construction project - on the local economy are income associated with wage payments, and income from local purchases of construction material. The next big direct impact is revenue for the County government from property taxes and royalties. State level revenue impacts occur through income taxes. The multipliers for household and local government expenditures estimated for this analysis are equally applicable to any source of payroll or county government revenues.

It is instructive to compare estimated geothermal economic impacts with existing industry in Harney County. Harney County's total 1990 assessed tax base was \$3,164,505,791 (Assessors Office, 1991). Table 10 compares projected geothermal property values with the top five current (private) property owners in Harney County.

**TABLE 10**

### **HARNEY COUNTY PROPERTY COMPARISON**

<u>OWNER</u>	<u>1990 ASSESSED VALUE</u>
PACIFICORP	\$31,603,800
TETON LAMINATES	\$16,045,220
SNOW MTN. PINE	\$ 9,296,610
Geothermal Plant - 25 MW	\$70,000,000
Geothermal Plant - 100 MW	\$280,000,000

Source: Harney County Assessor's Office

Simple multiplication is used between 25 MW plant costs and those for a 100 MW plant. A 25 MW geothermal development would represent a little over 2 percent of the total current base and the full 100 MW about nine percent. To put it in perspective, the combined value of Pacific Northwest Bell and Pacificorp property is roughly equal to one 25 MW plant in value. A 100 MW project would be four times

the combined value of Pacific Northwest Bell and Pacificorp property in Harney county. Any investment of this size - regardless of what the project produces - would become the largest development in Harney County.

Table 11 compares projected geothermal revenues with recent payments to Harney County. Harney County's major industries are timber, agriculture and tourism. Principal products are lumber, moulding, particleboard, plywood, cattle and potatoes. The largest county landowner is the federal government. As shown, only returned receipts from sales of federal timber represent a comparable revenue source for Harney County. That portion of timber sale receipts paid to the County is about \$4.1 million. (Additional income from National Forest lands is about \$285,000. It includes land use, recreation, power, minerals, user fee and grazing fee payments.)

On an employment basis, the long-term impacts of geothermal power development are small compared to existing industries. The trend toward modular design and shop fabrication results in a smaller construction workforce compared to both early geothermal projects and other (recent) thermal plants. Geothermal development would lead to only marginal increases in total employment once the construction phase concludes. It should be noted that plant operation and maintenance jobs would pay relatively well. This results in greater economic impacts per job.

One reason impacts are not greater is the lack of a geothermal industry infrastructure in Harney County. If major geothermal resource development were to occur over time, more of the materials and labor for development would come from local sources. Findings presented here are also sensitive to plant capital costs, steam efficiency, tax rates and the health of the economy in Harney County. Other similar developments in the region may also affect these projections.

TABLE 11

HARNEY COUNTY REVENUE COMPARISON

<u>TAXPAYER</u>	<u>1990 PAYMENT</u>
MALHEUR & OCHOCO NATIONAL FOREST (Payments in lieu of taxes)	\$4,318,670
PACIFICORP	\$777,717
BLM (Payments in lieu of taxes)	\$328,000
Geothermal Plant - 25 MW	
Property Taxes	\$1,225,000
Royalties	<u>\$200,057</u>
Total	\$1,425,057
Geothermal Plant - 100 MW	0
Property Taxes	\$4,200,000
Royalties	<u>\$800,226</u>
Total	\$5,000,226

Sources: Harney County Assessor's Office  
National Forest staff

## References

- Bloomquist, R.G., J. Geyer & A. Sifford, 1989, *Innovative Design of New Geothermal Generating Plants*, DOE/BP-13609-5, prepared for the Bonneville Power Administration under agreement no. DE-AI79-878P66141, Portland, OR.
- Bloomquist, R.G., J. Geyer & A. Sifford, 1987, *PURPA Influence on Contemporary Geothermal Power Plants, Case Studies 1986*, DOE/BP-13609-4, prepared for the Bonneville Power Administration under agreement no. DE-AI79-878P66141, Portland, OR.
- Bloomquist R.G., et. al., 1985, *Evaluation & Ranking of Geothermal Resources for Electrical Ranking or Offset in Idaho, Montana, Oregon & Washington*, DOE/BP-13609-1, prepared for the Bonneville Power Administration under agreement no. DE-AI79-83PBI3609, Portland, OR.
- California Energy Commission, 1985, *Preliminary Staff Assessment for Central California Power Agency No. 1 Coldwater Creek Geothermal Power Plant*, 84-AFC-2, Sacramento, CA
- California Energy Company Inc., 1988, *Third Quarter 1988 Report*, San Francisco, CA
- Dellinger, M., Personal Communication, Lake County Planning Department, December 11, 1990
- Felperin, Daniel J., 1989, *Geothermal Sulfur, Marketing Strategies*, Geothermal Resources Council Transactions, Vol. 13, Davis, CA
- Hubsky, M., 1991, Personal communication with J. Lesser, WSEO, Olympia, WA
- Matthews, Kathryn M., 1983, *Public Service Impacts of Geothermal Development*, Final Staff Report, P700-83-004, California Energy Commission, Sacramento, CA
- Lux, K. et. al., 1989, *Oregon Covered Employment and Payrolls by Industry and County 1988*, Employment Division, Oregon Department of Human Resources, Salem, OR
- Means Facility Cost Data*, 1990, R. S. Means Co., Kingston, MA
- Means Building Cost Data*, 1990, R. S. Means Co., Kingston, MA.
- OESI Power Corporation, 1991, *Common Stock Prospectus*, Kidder, Peabody & Co., New York, NY
- Phair, K. A., 1989, *Modular Design and Construction At The Bear Canyon 20 MW Power Plant*, Geothermal Resources Council Transactions, Vol. 13, Davis CA
- Prante, Lois J., 1989, *Letter to John Geyer*, Deschutes County Commissioners, February 8, 1989, Bend, OR
- Nolte and Associates, 1987, *Executive Summary Draft Supplemental Environmental Impact Report West Ford Flat Power Plant Project*, Freeport-McMoran Resource Partners/Geysers Geothermal Co., Santa Rosa, CA

Schoonmaker, James L., 1989 *The Coso Geothermal Power Projects*, Geothermal Resources Council Transactions, Vol. 13, Davis CA

Stukey, K., Personal Communication, West Geysers Power Plant, Healdsburg, CA., Pacific Gas & Electric Company, January 23, 1991

Urbank, K. F., 1989, *Design and Construction Of The West Ford Flat Power Plant At The Geysers*, Geothermal Resources Council Transactions, Vol. 13, Davis CA

White, D., 1991 Personal Communication, Harney County Court, Burns OR, February 20, 1991



## APPENDIX A

### IMPLAN MODEL SUMMARY

IMPLAN is a secondary-data input/output model that translates national level information about the goods and services purchased and products sold by each industry in the economy into state- or county-level input output models using local economic information. The model is based on industry production functions estimated in 1977 by the U.S. Bureau of Economic Analysis. The 1977 model has been price-updated to 1982. In other words, trade between industries and purchases of labor and other services reflects patterns that occurred in 1977, translated into 1982 dollars. In using the model the assumption is made that interindustry trade is reasonably comparable to 1977 trade patterns. The IMPLAN software allows for adjustments to most of the data and industry structures where more current information is available. However, large scale revisions of the basic model were beyond the scope of this study. For this analysis, IMPLAN's national data and Oregon and Harney County data previously reviewed by Alan Fox, an IMPLAN consultant, formed the basis for the Harney model. The data was provided as part of an IMPLAN training workshop.

## APPENDIX B

### HARNEY COUNTY PERSONAL CONSUMPTION EXPENDITURE PATTERNS FRACTION OF TOTAL CONSUMER SPENDING WITHIN REGION

INDUSTRY		PCE-LOW	PCE-MED	PCE-HI
DAIRY FARM PRODUCTS	1	.00076	.00061	.00044
POULTRY AND EGGS	2	.00003	.00002	.00002
RANCH FED CATTLE	3	.00000	.00000	.00000
RANGE FED CATTLE	4	.00001	.00001	.00001
CATTLE FEEDLOTS	5	.00005	.00005	.00004
SHEEP, LAMBS AND GOATS	6	.00000	.00000	.00000
HOGS, PIGS AND SWINE	7	.00000	.00000	.00000
OTHER MEAT ANIMAL PRODUCTS	8	.00000	.00000	.00000
MISCELLANEOUS LIVESTOCK	9	.00036	.00034	.00026
FOOD GRAINS	11	.00000	.00000	.00000
FEED GRAINS	12	.00000	.00000	.00000
HAY AND PASTURE	13	.00006	.00009	.00010
GRASS SEEDS	14	.00000	.00000	.00000
VEGETABLES	18	.00242	.00199	.00147
SUGAR CROPS	19	.00000	.00000	.00000
MISCELLANEOUS CROPS	20	.00000	.00000	.00000
FOREST PRODUCTS	22	.00001	.00001	.00001
GREENHOUSE AND NURSERY PRODUCTS	23	.00083	.00098	.00133
AGRICULTURAL, FORESTRY, FISHERY	26	.00013	.00013	.00013
LANDSCAPE AND HORTICULTURAL SERV	27	.00003	.00002	.00002
CRUSHED AND BROKEN LIMESTONE	45	.00000	.00000	.00000
CONSTRUCTION SAND AND GRAVEL	48	.00000	.00000	.00000
BENTONITE	50	.00000	.00000	.00000
MISC. NONMETALLIC MINERALS, N.E.	58	.00000	.00000	.00000
NEW RESIDENTIAL STRUCTURES	66	.00000	.00000	.00000
NEW INDUSTRIAL AND COMMERCIAL BU	67	.00000	.00000	.00000
NEW UTILITY STRUCTURES	68	.00000	.00000	.00000
NEW HIGHWAYS AND STREETS	69	.00000	.00000	.00000
NEW FARM STRUCTURES	70	.00000	.00000	.00000
NEW MINERAL EXTRACTION FACILITIE	71	.00000	.00000	.00000
NEW GOVERNMENT FACILITIES	72	.00000	.00000	.00000
MAINTENANCE AND REPAIR, RESIDENT	73	.00000	.00000	.00000
MAINTENANCE AND REPAIR OTHER FAC	74	.00000	.00000	.00000
MAINTENANCE AND REPAIR OIL AND G	75	.00000	.00000	.00000
SMALL ARMS	79	.00000	.00000	.00000
SMALL ARMS AMMUNITION	80	.00000	.00000	.00000
MEAT PACKING PLANTS	82	.00285	.00271	.00202
FLUID MILK	90	.00696	.00567	.00408
BREAD, CAKE, AND RELATED PRODUCT	106	.00056	.00047	.00036
BOTTLED AND CANNED SOFT DRINKS	116	.00106	.00092	.00064
ANIMAL AND MARINE FATS AND OILS	121	.00008	.00007	.00006
MANUFACTURED ICE	124	.00005	.00005	.00005
KNIT OUTERWEAR MILLS	147	.00001	.00001	.00002
APPAREL MADE FROM PURCHASED MATE	151	.00007	.00008	.00009
CURTAINS AND DRAPERIES	152	.00014	.00015	.00020
CANVAS PRODUCTS	155	.00002	.00002	.00002
PLEATING AND STITCHING	156	.00010	.00010	.00014

LOGGING CAMPS AND LOGGING CONTRA	160	.00000	.00000	.00000
SAWMILLS AND PLANING MILLS, GENE	161	.00034	.00035	.00033
HARDWOOD DIMENSION AND FLOORING	162	.00000	.00000	.00000
SPECIAL PRODUCT SAWMILLS, N.E.C	163	.00000	.00000	.00000
MILLWORK	164	.00005	.00007	.00008
WOOD KITCHEN CABINETS	165	.00000	.00000	.00000
VENEER AND PLYWOOD	166	.00001	.00001	.00001
STRUCTURAL WOOD MEMBERS, N.E.C	167	.00001	.00001	.00001
WOOD PRESERVING	169	.00000	.00000	.00000
PARTICLEBOARD	171	.00001	.00001	.00001
WOOD PRODUCTS, N.E.C	172	.00011	.00013	.00018
WOOD HOUSEHOLD FURNITURE	174	.00162	.00214	.00259
WOOD PARTITIONS AND FIXTURES	183	.00001	.00001	.00001
FURNITURE AND FIXTURES, N.E.C	186	.00001	.00001	.00001
NEWSPAPERS	200	.00104	.00103	.00102
PERIODICALS	201	.00078	.00078	.00077
BOOK PUBLISHING	202	.00024	.00024	.00023
MISCELLANEOUS PUBLISHING	204	.00003	.00002	.00002
COMMERCIAL PRINTING	205	.00005	.00005	.00005
TYPESETTING	212	.00000	.00000	.00000
FERTILIZERS, MIXING ONLY	217	.00001	.00001	.00001
TOILET PREPARATIONS	233	.00039	.00039	.00034
FABRICATED RUBBER PRODUCTS, N.E.	243	.00000	.00000	.00000
MISCELLANEOUS PLASTICS PRODUCTS	244	.00008	.00008	.00008
LEATHER GLOVES AND MITTENS	250	.00011	.00012	.00014
WOMENS HANDBAGS AND PURSES	252	.00026	.00024	.00031
PERSONAL LEATHER GOODS	253	.00021	.00020	.00020
LEATHER GOODS, N.E.C	254	.00001	.00001	.00001
GLASS AND GLASS PRODUCTS, EXC CO	255	.00008	.00010	.00014
BRICK AND STRUCTURAL CLAY TILE	258	.00000	.00000	.00000
CLAY REFRACTORIES	260	.00000	.00000	.00000
POTTERY PRODUCTS, N.E.C	266	.00000	.00000	.00000
CONCRETE BLOCK AND BRICK	267	.00000	.00000	.00000
CONCRETE PRODUCTS, N.E.C	268	.00000	.00000	.00000
READY-MIXED CONCRETE	269	.00000	.00000	.00000
MINERALS, GROUND OR TREATED	276	.00000	.00000	.00000
HEATING EQUIPMENT, EXCEPT ELECTR	307	.00001	.00001	.00001
FABRICATED STRUCTURAL METAL	308	.00000	.00000	.00000
SHEET METAL WORK	311	.00000	.00000	.00000
ARCHITECTURAL METAL WORK	312	.00000	.00000	.00000
METAL STAMPINGS, N.E.C.	318	.00002	.00003	.00004
PLATING AND POLISHING	323	.00000	.00000	.00000
METAL COATING AND ALLIED SERVICE	324	.00000	.00000	.00000
FARM MACHINERY AND EQUIPMENT	332	.00000	.00000	.00001
CONSTRUCTION MACHINERY AND EQUIP	334	.00003	.00004	.00005
CONVEYORS AND CONVEYING EQUIPMEN	338	.00000	.00000	.00000
INDUSTRIAL TRUCKS AND TRACTORS	340	.00000	.00000	.00000
SPECIAL DIES AND TOOLS AND ACCES	343	.00001	.00001	.00001
WOODWORKING MACHINERY	349	.00006	.00006	.00005
PRINTING TRADES MACHINERY	351	.00000	.00000	.00000
SPECIAL INDUSTRY MACHINERY, N.E.	352	.00000	.00000	.00000
MACHINERY, EXCEPT ELECTRICAL, N.	361	.00000	.00000	.00000
ELECTRONIC COMPUTING EQUIPMENT	362	.00003	.00003	.00003
REFRIGERATION AND HEATING EQUIPM	368	.00016	.00016	.00016

INSTRUMENTS TO MEASURE ELECTRICI	371	.00001	.00001	.00001
RADIO AND TV RECEIVING SETS	389	.00012	.00011	.00011
TELEPHONE AND TELEGRAPH APPARATU	391	.00000	.00000	.00000
RADIO AND TV COMMUNICATION EQUIP	392	.00002	.00002	.00002
TRUCK TRAILERS	402	.00000	.00000	.00000
MOTOR VEHICLE PARTS AND ACCESSOR	404	.00000	.00000	.00000
AIRCRAFT AND MISSILE EQUIPMENT,	407	.00000	.00000	.00000
BOAT BUILDING AND REPAIRING	409	.00004	.00006	.00007
MOTORCYCLES, BICYCLES, AND PARTS	411	.00008	.00010	.00013
TRAVEL TRAILERS AND CAMPERS	412	.00019	.00032	.00035
MOBILE HOMES	413	.00000	.00000	.00000
MOTOR HOMES	414	.00076	.00109	.00130
SURGICAL APPLIANCES AND SUPPLIES	420	.00020	.00013	.00010
DENTAL EQUIPMENT AND SUPPLIES	421	.00001	.00001	.00001
SILVERWARE AND PLATED WARE	428	.00001	.00002	.00002
GAMES, TOYS, AND CHILDRENS VEHIC	431	.00054	.00083	.00090
SPORTING AND ATHLETIC GOODS, N.E	433	.00001	.00002	.00002
LEAD PENCILS AND ART GOODS	435	.00002	.00001	.00002
SIGNS AND ADVERTISING DISPLAYS	444	.00000	.00000	.00000
MANUFACTURING INDUSTRIES, N.E.C.	445	.00006	.00006	.00006
RAILROADS AND RELATED SERVICES	446	.00099	.00070	.00095
LOCAL, INTERURBAN PASSENGER TRAN	447	.00151	.00107	.00142
MOTOR FREIGHT TRANSPORT AND WARE	448	.00345	.00243	.00241
AIR TRANSPORTATION	450	.00167	.00118	.00160
TRANSPORTATION SERVICES	452	.00002	.00002	.00002
ARRANGEMENT OF PASSENGER TRANSPO	453	.00008	.00008	.00008
COMMUNICATIONS, EXCEPT RADIO AND	454	.01360	.01066	.00795
RADIO AND TV BROADCASTING	455	.00017	.00016	.00016
GAS PRODUCTION AND DISTRIBUTION	457	.00562	.00434	.00367
WATER SUPPLY AND SEWERAGE SYSTEM	458	.00030	.00028	.00025
SANITARY SERVICES AND STEAM SUPP	459	.00041	.00038	.00033
OTHER WHOLESALE TRADE	461	.00020	.00019	.00019
RECREATIONAL RELATED RETAIL TRAD	462	.00438	.00660	.00798
OTHER RETAIL TRADE	463	.06636	.06409	.06258
BANKING	464	.01386	.01475	.01677
CREDIT AGENCIES	465	.00328	.00349	.00397
SECURITY AND COMMODITY BROKERS	466	.00133	.00142	.00161
INSURANCE CARRIERS	467	.00225	.00332	.00427
INSURANCE AGENTS AND BROKERS	468	.00000	.00000	.00000
OWNER-OCCUPIED DWELLINGS	469	.06505	.09006	.12183
REAL ESTATE	470	.03758	.02029	.00700
HOTELS AND LODGING PLACES	471	.00513	.00471	.00836
LAUNDRY, CLEANING AND SHOE REPAI	472	.00117	.00293	.00166
FUNERAL SERVICE AND CREMATORIES	473	.00115	.00122	.00139
PORTRAIT AND PHOTOGRAPHIC STUDIO	474	.00226	.00386	.00418
ELECTRICAL REPAIR SERVICES	475	.00239	.00167	.00167
WATCH, CLOCK, JEWELRY AND FURNIT	476	.00151	.00105	.00105
BEAUTY AND BARBER SHOPS	477	.00444	.00409	.00407
MISCELLANEOUS REPAIR SHOPS	478	.00000	.00000	.00000
SERVICES TO BUILDINGS	479	.00000	.00000	.00000
PERSONNEL SUPPLY SERVICES	480	.00000	.00000	.00000
COMPUTER AND DATA PROCESSING SER	481	.00000	.00000	.00000
MANAGEMENT AND CONSULTING SERVIC	482	.00000	.00000	.00000
DETECTIVE AND PROTECTIVE SERVICE	483	.00000	.00000	.00000

EQUIPMENT REPAIR AND LEASING	484	.00000	.00000	.00000
PHOTOFINISHING, COMMERCIAL PHOTO	485	.00000	.00000	.00000
OTHER BUSINESS SERVICES	486	.00000	.00000	.00000
ADVERTISING	487	.00000	.00000	.00000
LEGAL SERVICES	488	.00000	.00000	.00000
ENGINEERING, ARCHITECTURAL SERVI	489	.00000	.00000	.00000
ACCOUNTING, AUDITING AND BOOKKEE	490	.00007	.00004	.00001
EATING AND DRINKING PLACES	491	.04340	.05258	.04997
AUTOMOBILE RENTAL AND LEASING	492	.00008	.00008	.00009
AUTOMOBILE REPAIR AND SERVICES	493	.01641	.02011	.01788
MOTION PICTURES	495	.00027	.00032	.00046
DANCE HALLS, STUDIOS AND SCHOOLS	496	.00002	.00002	.00003
BOWLING ALLEYS AND POOL HALLS	498	.00025	.00030	.00043
COMMERCIAL SPORTS EXCEPT RACING	499	.00038	.00045	.00065
MEMBERSHIP SPORTS AND RECREATION	501	.00057	.00068	.00098
AMUSEMENT AND RECREATION SERVICE	502	.00263	.00450	.00488
DOCTORS AND DENTISTS	503	.06973	.05089	.04183
HOSPITALS	504	.05042	.03680	.03025
NURSING AND PROTECTIVE CARE	505	.00695	.00507	.00417
OTHER MEDICAL AND HEALTH SERVICE	506	.00495	.00361	.00297
ELEMENTARY AND SECONDARY SCHOOLS	507	.00002	.00002	.00002
COLLEGES, UNIVERSITIES, SCHOOLS	508	.00132	.00141	.00160
OTHER EDUCATIONAL SERVICES	509	.00008	.00009	.00010
BUSINESS ASSOCIATIONS	510	.00023	.00025	.00028
LABOR AND CIVIC ORGANIZATIONS	511	.00267	.00284	.00323
RELIGIOUS ORGANIZATIONS	512	.00518	.00294	.00530
OTHER NONPROFIT ORGANIZATIONS	513	.00090	.00051	.00092
RESIDENTIAL CARE	514	.00092	.00115	.00174
SOCIAL SERVICES, N.E.C.	515	.00775	.00618	.00987
U.S. POSTAL SERVICE	516	.00188	.00182	.00177
OTHER FEDERAL GOVERNMENT ENTERPR	518	.00105	.00117	.00112
LOCAL GOVERNMENT PASSENGER TRANS	519	.00005	.00004	.00005
OTHER STATE AND LOCAL GOVT ENTER	521	.00485	.00446	.00419
GOVERNMENT INDUSTRY	525	.00000	.00000	.00000
REST OF THE WORLD INDUSTRY	526	.00000	.00000	.00000
HOUSEHOLD INDUSTRY	527	.00147	.00183	.00277
INVENTORY VALUATION ADJUSTMENT	528	.00000	.00000	.00000
TOTAL FRACTION IN REGION:		.48908	.46886	.47651
REGIONAL FRACTION CHECK		.99999	1.00000	.99999

# APPENDIX C

## HARNEY COUNTY STATE AND LOCAL GOVERNMENT EXPENDITURE PATTERNS FRACTION OF TOTAL STATE & LOCAL GOVERNMENT SPENDING WITHIN REGION

INDUSTRY		SLG-EDU	SLG-NONED	SLG-TOTAL
DAIRY FARM PRODUCTS	1	.00000	.00000	.00000
POULTRY AND EGGS	2	.00000	.00001	.00001
RANCH FED CATTLE	3	.00000	.00000	.00000
RANGE FED CATTLE	4	.00000	.00000	.00000
CATTLE FEEDLOTS	5	.00001	.00003	.00002
SHEEP, LAMBS AND GOATS	6	.00000	.00000	.00000
HOGS, PIGS AND SWINE	7	.00000	.00000	.00000
OTHER MEAT ANIMAL PRODUCTS	8	.00000	.00000	.00000
MISCELLANEOUS LIVESTOCK	9	.00004	.00000	.00002
FOOD GRAINS	11	.00000	.00000	.00000
FEED GRAINS	12	.00000	.00000	.00000
HAY AND PASTURE	13	.00000	.00000	.00000
GRASS SEEDS	14	.00000	.00000	.00000
VEGETABLES	18	.00000	.00000	.00000
SUGAR CROPS	19	.00000	.00000	.00000
MISCELLANEOUS CROPS	20	.00000	.00000	.00000
FOREST PRODUCTS	22	.00000	.00000	.00000
GREENHOUSE AND NURSERY PRODUCTS	23	.00000	.00000	.00000
AGRICULTURAL, FORESTRY, FISHERY	26	.00000	.00000	.00000
LANDSCAPE AND HORTICULTURAL SERV	27	.00000	.00000	.00000
CRUSHED AND BROKEN LIMESTONE	45	.00000	.00000	.00000
CONSTRUCTION SAND AND GRAVEL	48	.00000	.00000	.00000
BENTONITE	50	.00000	.00000	.00000
MISC. NONMETALLIC MINERALS, N.E.	58	.00000	.00000	.00000
NEW RESIDENTIAL STRUCTURES	66	.00190	.00069	.00124
NEW INDUSTRIAL AND COMMERCIAL BU	67	.00631	.00789	.00717
NEW UTILITY STRUCTURES	68	.04431	.00000	.02008
NEW HIGHWAYS AND STREETS	69	.02593	.00000	.01175
NEW FARM STRUCTURES	70	.00000	.00000	.00000
NEW MINERAL EXTRACTION FACILITIE	71	.00000	.00000	.00000
NEW GOVERNMENT FACILITIES	72	.00453	.00000	.00205
MAINTENANCE AND REPAIR, RESIDENT	73	.00000	.00000	.00000
MAINTENANCE AND REPAIR OTHER FAC	74	.04093	.04135	.04116
MAINTENANCE AND REPAIR OIL AND G	75	.00000	.00000	.00000
SMALL ARMS	79	.00000	.00000	.00000
SMALL ARMS AMMUNITION	80	.00000	.00000	.00000
MEAT PACKING PLANTS	82	.00042	.00137	.00094
FLUID MILK	90	.00000	.00000	.00000
BREAD, CAKE, AND RELATED PRODUCT	106	.00000	.00000	.00000
BOTTLED AND CANNED SOFT DRINKS	116	.00000	.00000	.00000
ANIMAL AND MARINE FATS AND OILS	121	.00001	.00002	.00001
MANUFACTURED ICE	124	.00000	.00000	.00000
KNIT OUTERWEAR MILLS	147	.00000	.00000	.00000
APPAREL MADE FROM PURCHASED MATE	151	.00000	.00000	.00000
CURTAINS AND DRAPERIES	152	.00000	.00000	.00000
CANVAS PRODUCTS	155	.00000	.00000	.00000
PLEATING AND STITCHING	156	.00000	.00000	.00000

LOGGING CAMPS AND LOGGING CONTRA	160	.00000	.00000	.00000
SAWMILLS AND PLANING MILLS, GENE	161	.00000	.00000	.00000
HARDWOOD DIMENSION AND FLOORING	162	.00000	.00000	.00000
SPECIAL PRODUCT SAWMILLS, N.E.C	163	.00000	.00000	.00000
MILLWORK	164	.00000	.00000	.00000
WOOD KITCHEN CABINETS	165	.00000	.00000	.00000
VENEER AND PLYWOOD	166	.00000	.00000	.00000
STRUCTURAL WOOD MEMBERS, N.E.C	167	.00000	.00000	.00000
WOOD PRESERVING	169	.00000	.00000	.00000
PARTICLEBOARD	171	.00000	.00000	.00000
WOOD PRODUCTS, N.E.C	172	.00000	.00000	.00000
WOOD HOUSEHOLD FURNITURE	174	.00000	.00000	.00000
WOOD PARTITIONS AND FIXTURES	183	.00000	.00000	.00000
FURNITURE AND FIXTURES, N.E.C	186	.00000	.00000	.00000
NEWSPAPERS	200	.00000	.00000	.00000
PERIODICALS	201	.00000	.00000	.00000
BOOK PUBLISHING	202	.00000	.00000	.00000
MISCELLANEOUS PUBLISHING	204	.00000	.00000	.00000
COMMERCIAL PRINTING	205	.00000	.00000	.00000
TYPESETTING	212	.00000	.00000	.00000
FERTILIZERS, MIXING ONLY	217	.00000	.00000	.00000
TOILET PREPARATIONS	233	.00000	.00000	.00000
FABRICATED RUBBER PRODUCTS, N.E.	243	.00000	.00000	.00000
MISCELLANEOUS PLASTICS PRODUCTS	244	.00000	.00000	.00000
LEATHER GLOVES AND MITTENS	250	.00000	.00000	.00000
WOMENS HANDBAGS AND PURSES	252	.00000	.00000	.00000
PERSONAL LEATHER GOODS	253	.00000	.00000	.00000
LEATHER GOODS, N.E.C	254	.00000	.00000	.00000
GLASS AND GLASS PRODUCTS, EXC CO	255	.00000	.00000	.00000
BRICK AND STRUCTURAL CLAY TILE	258	.00000	.00000	.00000
CLAY REFRACTORIES	260	.00000	.00000	.00000
POTTERY PRODUCTS, N.E.C	266	.00000	.00000	.00000
CONCRETE BLOCK AND BRICK	267	.00000	.00000	.00000
CONCRETE PRODUCTS, N.E.C	268	.00000	.00000	.00000
READY-MIXED CONCRETE	269	.00000	.00000	.00000
MINERALS, GROUND OR TREATED	276	.00000	.00000	.00000
HEATING EQUIPMENT, EXCEPT ELECTR	307	.00000	.00000	.00000
FABRICATED STRUCTURAL METAL	308	.00000	.00000	.00000
SHEET METAL WORK	311	.00000	.00000	.00000
ARCHITECTURAL METAL WORK	312	.00000	.00000	.00000
METAL STAMPINGS, N.E.C.	318	.00000	.00000	.00000
PLATING AND POLISHING	323	.00000	.00000	.00000
METAL COATING AND ALLIED SERVICE	324	.00000	.00000	.00000
FARM MACHINERY AND EQUIPMENT	332	.00000	.00000	.00000
CONSTRUCTION MACHINERY AND EQUIP	334	.00000	.00000	.00000
CONVEYORS AND CONVEYING EQUIPMEN	338	.00000	.00000	.00000
INDUSTRIAL TRUCKS AND TRACTORS	340	.00000	.00000	.00000
SPECIAL DIES AND TOOLS AND ACCES	343	.00000	.00000	.00000
WOODWORKING MACHINERY	349	.00000	.00000	.00000
PRINTING TRADES MACHINERY	351	.00000	.00000	.00000
SPECIAL INDUSTRY MACHINERY, N.E.	352	.00000	.00000	.00000
MACHINERY, EXCEPT ELECTRICAL, N.	361	.00000	.00000	.00000
ELECTRONIC COMPUTING EQUIPMENT	362	.00000	.00000	.00000
REFRIGERATION AND HEATING EQUIPM	368	.00000	.00000	.00000

INSTRUMENTS TO MEASURE ELECTRICI	371	.00000	.00000	.00000
RADIO AND TV RECEIVING SETS	389	.00000	.00000	.00000
TELEPHONE AND TELEGRAPH APPARATU	391	.00000	.00000	.00000
RADIO AND TV COMMUNICATION EQUIP	392	.00000	.00000	.00000
TRUCK TRAILERS	402	.00000	.00000	.00000
MOTOR VEHICLE PARTS AND ACCESSOR	404	.00000	.00000	.00000
AIRCRAFT AND MISSILE EQUIPMENT,	407	.00000	.00000	.00000
BOAT BUILDING AND REPAIRING	409	.00000	.00000	.00000
MOTORCYCLES, BICYCLES, AND PARTS	411	.00000	.00000	.00000
TRAVEL TRAILERS AND CAMPERS	412	.00000	.00000	.00000
MOBILE HOMES	413	.00000	.00000	.00000
MOTOR HOMES	414	.00000	.00000	.00000
SURGICAL APPLIANCES AND SUPPLIES	420	.00000	.00000	.00000
DENTAL EQUIPMENT AND SUPPLIES	421	.00000	.00000	.00000
SILVERWARE AND PLATED WARE	428	.00000	.00000	.00000
GAMES, TOYS, AND CHILDRENS VEHIC	431	.00000	.00000	.00000
SPORTING AND ATHLETIC GOODS, N.E	433	.00000	.00000	.00000
LEAD PENCILS AND ART GOODS	435	.00000	.00000	.00000
SIGNS AND ADVERTISING DISPLAYS	444	.00000	.00000	.00000
MANUFACTURING INDUSTRIES, N.E.C.	445	.00000	.00000	.00000
RAILROADS AND RELATED SERVICES	446	.00000	.00000	.00000
LOCAL, INTERURBAN PASSENGER TRAN	447	.00000	.00000	.00000
MOTOR FREIGHT TRANSPORT AND WARE	448	.00000	.00000	.00000
AIR TRANSPORTATION	450	.00236	.00389	.00320
TRANSPORTATION SERVICES	452	.00001	.00001	.00001
ARRANGEMENT OF PASSENGER TRANSPO	453	.00000	.00000	.00000
COMMUNICATIONS, EXCEPT RADIO AND	454	.00519	.01061	.00815
RADIO AND TV BROADCASTING	455	.00000	.00000	.00000
GAS PRODUCTION AND DISTRIBUTION	457	.00000	.00000	.00000
WATER SUPPLY AND SEWERAGE SYSTEM	458	.00000	.00000	.00000
SANITARY SERVICES AND STEAM SUPP	459	.00000	.00000	.00000
OTHER WHOLESALE TRADE	461	.00000	.00000	.00000
RECREATIONAL RELATED RETAIL TRAD	462	.00000	.00005	.00003
OTHER RETAIL TRADE	463	.00000	.00000	.00000
BANKING	464	.01925	.00000	.00872
CREDIT AGENCIES	465	.00000	.00000	.00000
SECURITY AND COMMODITY BROKERS	466	.00360	.00000	.00163
INSURANCE CARRIERS	467	.00000	.00000	.00000
INSURANCE AGENTS AND BROKERS	468	.00000	.00000	.00000
OWNER-OCCUPIED DWELLINGS	469	.00000	.00000	.00000
REAL ESTATE	470	.00000	.00000	.00000
HOTELS AND LODGING PLACES	471	.00000	.00000	.00000
LAUNDRY, CLEANING AND SHOE REPAI	472	.00000	.00000	.00000
FUNERAL SERVICE AND CREMATORIES	473	.00000	.00000	.00000
PORTRAIT AND PHOTOGRAPHIC STUDIO	474	.00000	.00000	.00000
ELECTRICAL REPAIR SERVICES	475	.00000	.00000	.00000
WATCH, CLOCK, JEWELRY AND FURNIT	476	.00000	.00000	.00000
BEAUTY AND BARBER SHOPS	477	.00000	.00000	.00000
MISCELLANEOUS REPAIR SHOPS	478	.00000	.00000	.00000
SERVICES TO BUILDINGS	479	.00000	.00000	.00000
PERSONNEL SUPPLY SERVICES	480	.00000	.00000	.00000
COMPUTER AND DATA PROCESSING SER	481	.00000	.00000	.00000
MANAGEMENT AND CONSULTING SERVIC	482	.00000	.00000	.00000
DETECTIVE AND PROTECTIVE SERVICE	483	.00000	.00000	.00000

EQUIPMENT REPAIR AND LEASING	484	.00000	.00000	.00000
PHOTOFINISHING, COMMERCIAL PHOTO	485	.00000	.00000	.00000
OTHER BUSINESS SERVICES	486	.00000	.00000	.00000
ADVERTISING	487	.00000	.00000	.00000
LEGAL SERVICES	488	.00000	.00000	.00000
ENGINEERING, ARCHITECTURAL SERVI	489	.00000	.00000	.00000
ACCOUNTING, AUDITING AND BOOKKEE	490	.00000	.00000	.00000
EATING AND DRINKING PLACES	491	.00000	.00000	.00000
AUTOMOBILE RENTAL AND LEASING	492	.00000	.00000	.00000
AUTOMOBILE REPAIR AND SERVICES	493	.00000	.00000	.00000
MOTION PICTURES	495	.00000	.00000	.00000
DANCE HALLS, STUDIOS AND SCHOOLS	496	.00000	.00000	.00000
BOWLING ALLEYS AND POOL HALLS	498	.00000	.00000	.00000
COMMERCIAL SPORTS EXCEPT RACING	499	.00000	.00000	.00000
MEMBERSHIP SPORTS AND RECREATION	501	.00000	.00000	.00000
AMUSEMENT AND RECREATION SERVICE	502	.00000	.00000	.00000
DOCTORS AND DENTISTS	503	.00000	.00000	.00000
HOSPITALS	504	.00000	.00000	.00000
NURSING AND PROTECTIVE CARE	505	.00000	.00000	.00000
OTHER MEDICAL AND HEALTH SERVICE	506	.00000	.00000	.00000
ELEMENTARY AND SECONDARY SCHOOLS	507	.00000	.00000	.00000
COLLEGES, UNIVERSITIES, SCHOOLS	508	.00000	.00015	.00008
OTHER EDUCATIONAL SERVICES	509	.00000	.00000	.00000
BUSINESS ASSOCIATIONS	510	.00002	.00000	.00001
LABOR AND CIVIC ORGANIZATIONS	511	.00000	.00000	.00000
RELIGIOUS ORGANIZATIONS	512	.00000	.00000	.00000
OTHER NONPROFIT ORGANIZATIONS	513	.00000	.00000	.00000
RESIDENTIAL CARE	514	.00000	.00000	.00000
SOCIAL SERVICES, N.E.C.	515	.00000	.00000	.00000
U.S. POSTAL SERVICE	516	.00371	.00094	.00220
OTHER FEDERAL GOVERNMENT ENTERPR	518	.00000	.00001	.00001
LOCAL GOVERNMENT PASSENGER TRANS	519	.00000	.00000	.00000
OTHER STATE AND LOCAL GOVT ENTER	521	.00005	.00005	.00005
GOVERNMENT INDUSTRY	525	.55277	.39210	.46492
REST OF THE WORLD INDUSTRY	526	.00000	.00000	.00000
HOUSEHOLD INDUSTRY	527	.00000	.00000	.00000
INVENTORY VALUATION ADJUSTMENT	528	.00000	.00000	.00000
TOTAL FRACTION IN REGION:		.71135	.45918	.57346
REGIONAL FRACTION CHECK		1.00000	1.00000	



# APPENDIX D

## HARNEY COUNTY EXPENDITURE IMPACTS AGGREGATED IMPLAN MODEL OUTPUT (Impacts in dollars per thousand dollars)

SECTOR	FINAL DEMAND	TIO	EMPLOYEE INCOME	PROPERTY INCOME	TOTAL INCOME	VALUE ADDED	EMPLOYMENT JOBS/MILLION \$
HOUSEHOLD EXPENDITURES							
Agriculture	6	9	1	1	2	2	0.1
Construction	0	6	2	0	2	2	0.1
Manufacturing	3	4	1	0	1	1	0.0
Transp & Utilities	15	17	7	5	13	14	0.3
W&R Trade	86	87	40	10	50	63	3.8
FIRE	147	157	8	91	99	125	0.6
Services	145	149	53	19	72	76	5.9
<u>Government</u>	<u>18</u>	<u>21</u>	<u>10</u>	<u>2</u>	<u>12</u>	<u>12</u>	<u>0.7</u>
TOTAL*	419	449	122	129	251	295	11.6
EDUCATION SERVICE EXPENDITURES							
Agriculture	6	8	1	1	1	2	0.1
Construction	22	28	10	1	11	11	0.6
Manufacturing	2	4	1	0	2	2	0.0
Transp & Utilities	18	20	9	7	15	17	0.3
W&R Trade	80	81	38	9	47	59	3.6
FIRE	152	162	12	90	102	127	0.8
Services	134	138	49	18	67	71	5.5
<u>Government</u>	<u>647</u>	<u>650</u>	<u>640</u>	<u>1</u>	<u>641</u>	<u>641</u>	<u>36.6**</u>
TOTAL*	1061	1093	759	127	886	928	47.5 (23.0)**
OTHER GOVERNMENT SERVICE EXPENDITURES							
Agriculture	5	7	0	1	1	1	0.1
Construction	18	22	8	1	9	9	0.5
Manufacturing	2	3	1	0	1	1	0.0
Transp & Utilities	18	20	9	7	15	17	0.3
W&R Trade	56	57	27	6	33	42	2.5
FIRE	100	107	6	62	68	85	0.4
Services	95	98	35	13	48	50	3.9
<u>Government</u>	<u>458</u>	<u>460</u>	<u>452</u>	<u>1</u>	<u>453</u>	<u>453</u>	<u>25.9**</u>
TOTAL*	752	774	537	91	628	658	33.6 (17.0)**

\* Totals may not equal sums due to rounding errors.

\*\* For this study, IMPLAN results for employment impacts were adjusted downward for government employment impacts related to education expenditures. The authors felt that assuming fixed proportions of teacher salaries and associated increases in employment for teachers and other government services employees when population increases were small would be invalid. Income increases were assumed to benefit existing staff. The IMPLAN estimates of new hires were reduced by about two-thirds.

