GEOTHERMAL

Economic Impacts of Geothermal Development

Skamania County, Washington

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I. INTRODUCTION.

Development of electric generating facilities can have numerous impacts on local areas. Besides the potential for environmental impacts, development may also impact local economies. Large projects, for example, may lead to "boom town" effects resulting in a rapid increase in the demand for locally provided services such as housing, utilities, and schools. Once a project is completed, demand for these services can fall rapidly, placing further strain on a local economy. While these impacts may strain local economies, construction and operation of a new facility can also lead to long-term increases in employment, local tax collections, and economic activity. In economically distressed areas, development may have beneficial impacts by providing jobs to area inhabitants and providing revenues for improvements in area infrastructure.

This report estimates the local economic impacts that could be anticipated from the development of a 100 megawatt (MW) geothermal power plant in eastern Skamania County, Washington, near Mt. Adams, as shown in Figure 1. The study was commissioned by the Bonneville Power Administration to quantify such impacts as part of regional confirmation work recommended by the Northwest Power Planning Council. Skamania County was chosen due to both identified geothermal resources and developer interest.

The analysis will focus on two phases: a plant construction phase, including well field development, generating plant construction, and transmission line construction; and an operations phase. Economic impacts will occur to the extent that construction and operations affect the local economy. These impacts will depend on the existing structure of the Skamania County economy and estimates of revenues that may accrue to the county as a result of plant construction, operation, and maintenance. Specific impacts may include additional direct employment at the plant, secondary impacts from wage payments being used to purchase locally produced goods and services, and impacts due to expenditures of royalty and tax payments received by the county.

The basis for the analysis of economic impacts in this study is the U.S. Forest Service IMPLAN input-output modeling system. Using national and local data, IMPLAN traces economic impacts resulting from regional changes in the final demands for goods and services. These changes reverberate throughout a regional economy, leading to indirect changes in other industries as well as induced impacts from changes in household spending.

The outline of the report is as follows. Section II briefly describes the development phases of a geothermal generating facility and describes characteristics that these facilities share with other types of power plant developments and characteristics that are unique to geothermal plants. Next, Section III develops the assumptions for plant, well field, and operation and maintenance costs, which will form the basis for analyzing the impacts from the construction and operation phases of the hypothetical project. Section IV discusses the assumptions concerning plant operations and the sources of economic impacts from that phase. Section V provides a brief description of the IMPLAN modelling system. Section VI provides a brief overview of Skamania County and its existing economy and develops the modelling assumptions for the Skamania County analysis. Section VII presents the results of the study, including a comparison of the estimated impacts from geothermal development to the importance of existing major industries in the county. Section VIII offers some conclusions and recommendations for further analysis.

II. GEOTHERMAL PLANT DEVELOPMENT.

Geothermal energy is defined as natural heat from the earth. For the purposes of this study, geothermal energy is heat capable of generating electricity using currently available technologies. At present, existing generating technologies require steam or hot water over 220 degrees Fahrenheit.

Geothermal plant developers first locate and confirm developable geothermal resources using well-established techniques. First, passive exploration — including geologic mapping, geochemistry, and geophysical analysis, undertaken. Next, active drilling for temperature, fluid composition indicators, as well as flow is undertaken. Finally, if the first two steps show a favorable potential, drilling of production wells begins (Bloomquist, et al. 1985).

Once reservoir potential is established, power plant design based on resource chemistry, flow, and heat content begins. Currently, commercially available power plants range in size from 620 to 135,000 kilowatts (kW). The majority of existing power plants are in the range of 10,000 to 30,000 kW, or 10 to 30 MW.

Geothermal plant sizes refer to net power entering the utility grid, sometimes called busbar capacity. Most plants are typically designed to serve as baseload facilities which operate almost

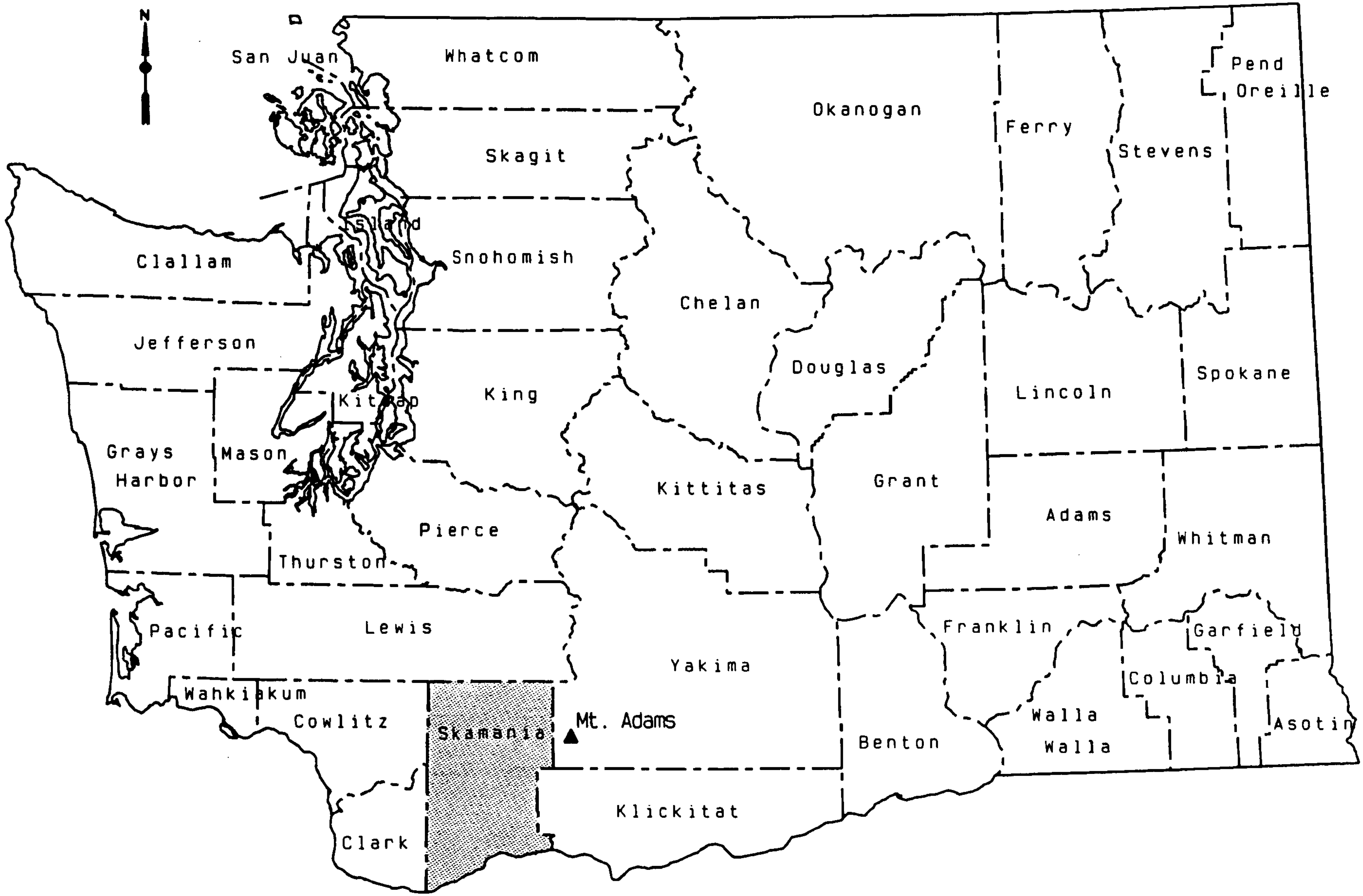

Figure 1: Location of Skamania County, Washington

continuously. Many operating plants have achieved availability and capacity factors of over 90 percent (Bloomquist, Geyer, and Sifford 1989).[1]

Geothermal plants share many construction and operating characteristics with other types of generating plants. In conventional power plants, fuel is first burned in a boiler to generate steam. The steam is then used to drive a turbine, which then turns a generator and produces electricity. Power generation components (e.g., turbines, generators, condensers, buildings, switchyards, etc.) are similar for all thermal power plants. (The major exception to this two step transfer process is hydroelectric generation.) Table 1 shows some example power plant equipment groupings. Labor force characteristics common to all power projects -- including geothermal projects -- include a large construction force of contractors and craftsmen. This is followed by a small staff of plant operators, engineers, mechanics, and clerical staff.

Table 1
Characteristics of Alternative Generating Plant Equipment

Plant Type	Steam Generation	Power Generation
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

Where geothermal plants differ is the source of their fuel for steam generation and, to a smaller extent, their size. Geothermal plants derive their steam not from boilers, but literally from the earth. The system of wells and piping which transfer the natural heat of the earth to the steam turbine replaces the need for burning fuel in a boiler.

Geothermal plants have been typically less than 80 average megawatts (MWa) in size due to past federal incentives. Clusters of small modular plants (less than 25 MW), such as those at Coso (9 units) and ORMESA (26 units) are a relatively new trend. Given the combination of clustered plant

[1]An availability factor refers to the percentage of time the plant is physically able to generate electricity. A capacity factor refers to the ratio of actual output of the plant to its rated maximum output.

development and conservative reservoir development, new projects may easily reach levels of 100 MWa or more, and mirror the hypothetical configuration used in this report. Furthering this size range are the added benefits of matching resource development to load growth over time since, in general, smaller power plants, regardless of fuel, can often reduce risks to developers, utilities, and, ultimately, ratepayers.

The size of existing geothermal plants has been strongly influenced by the Public Utility Regulatory Policy Act (PURPA) of 1978 (Sifford, Bloomquist, and Geyer 1987; Bloomquist, Geyer, and Sifford 1989). PURPA required utilities to purchase power from "qualifying facilities" (QFs) at a price equal to the utilities' alternative or avoided cost of power. Because PURPA limits QFs to 80 MW net output, designers have sought to maximize power production up to this limit with the highest achievable reliability (Bloomquist, Sifford, and Geyer 1989). The 80 MW size limit under PURPA, however, was recently amended to allow renewable resource development, including geothermal, to exceed this 80 MW cap (Smith 1990).[2] Thus, the size of future geothermal plants will not be constrained solely by legal requirements.

In addition to this legal incentive for maximum availability, geothermal wells run the risk of failing if frequently shut off. Existing plants in California have achieved high levels of availability. The Santa Fe plant located in northern California, for example, had a plant availability factor of 99.9 percent and a capacity factor of 98.6 percent after 2 years of operation (Fesmire 1985). Such high availability and capacity factors are almost unheard of with larger, traditional thermal resources.

In addition to size and source of steam, ownership of geothermal facilities often differs from traditional generating facilities. Utilities can own the entire geothermal facility, including the steam field, allowing them to earn a rate of return on their investment, or they can purchase steam from a third party developer.[3] A third party developer can also own the entire facility, selling electricity produced to one or more utilities. For the purposes of this report, it is assumed that ownership is vertically integrated under one non-utility entity.

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[2]The amendment to PURPA is contained in H.R. 4808, passed by the U.S. House of Representatives on 23 October 1990.

[3]In the case of non-utility ownership, the utility will treat the steam as a direct expense, and will be unable to earn a rate of return on the steam. A discussion of utility regulation and determination of allowable rates of return is, however, beyond the scope of this report.

Royalty payments are not unique to geothermal resources, but are often focused on due to the proximity of the steam resource to the generating plant. Unlike coal, natural gas, or oil-fired resources, where the fuel source is often hundreds or thousands of miles from the plant, geothermal generating facilities are integrated with nearby steam gathering systems. Thus, analogous to mineral royalties paid to the resource owner, geothermal plant development and operation will often involve payment of royalties to the underlying land owner where well field development occurs.

Because most high temperature geothermal resources in the Pacific Northwest are located on federal land, this report assumes that plant and well field development takes place on federally owned land. As such, in accordance with the Geothermal Steam Act of 1970[4], a 10 percent royalty is assumed to accrue to the federal government. Fifty percent of the federal royalty is returned to the state of origin. Washington state then returns 40 percent of the state royalties to the local county where development occurs.

III. CONSTRUCTION AND WORK FORCE ESTIMATES.

There is a great deal of data available for geothermal development at The Geysers in northern California. It is the largest developed geothermal field in the world, with over 1,800 MW of capacity. The first plant there was completed in 1960; the most recent plant completed in 1989. This data, in conjunction with data from other geothermal developments in California, Nevada, and Utah, is the basis for the cost and workforce estimates presented below.

Generating power from geothermal resources is normally done in several major stages. Environmental permitting occurs before each stage. The typical stages are as follows:

- Exploring for the resource;
- Developing the well field and gathering systems;
- Constructing the power plant and related facilities;
- Operating and maintaining resource supplies, and;
- Operating and maintaining plant facilities.

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[4] 30 U.S.C. 1001 et seq.

Some of these activities may overlap. Some well drilling, steam line construction, and plant building will occur concurrently. Some of the workers may move between these stages in the course of the development and operation of the facilities.

III.A. Construction Cost Estimates.

The cost of constructing a geothermal plant will vary widely depending on the location and size. Costs will depend on the accessibility of the site, depth of drilling required for wells, the number of wells required for a given plant capacity, and the prevailing wages of engineering and construction personnel. Overall estimates of plant construction costs for the Mt. Adams site in Skamania County range from $2,700 - $3100 per net kW (McClain 1990; Yueh 1990), on the assumption that the plant would consist of four 25 MWa modular units to achieve the overall 100 MWa goal. These cost estimates are consistent with prior studies that have shown a range of costs from between $1,550 to $3,778 per net kilowatt for recently built plants (Bloomquist, Geyer, and Sifford 1989; OESI 1991).

The costs for more remote plants, or those which are more efficient, will likely fall in the higher end of the range. Due to the relative remoteness of the site considered in this study, as well as the existing uncertainty about the quality of the steam field, it was assumed that well field development costs would be about $1,100/kW, while actual plant construction costs would be about $1,700/kW (McClain 1990). Pollution control costs for geothermal plants should be similar to other types of power plants.

Estimated construction time is about 3 years, including site development and generating plant construction (Yueh 1990). Typically, the costs of development in a more mountainous site, such as near Mt. Adams, would be expected to cost more than desert sites such as those previously developed in Nevada and southern California.

Construction costs would also include engineering, administrative, and environmental costs. Engineering costs would include the costs of conceptual and contract design, as well as field engineering. Administrative costs would incorporate the costs of project management, legal support, and securing of project financing. Environmental costs would include costs associated with baseline studies, environmental impact statements, siting, permits, and compliance costs. Lastly, construction costs should also incorporate the costs of building a transmission line to connect the plant to the regional grid. For the purposes of this study, a 10 mile transmission line was chosen as representative. Total costs for such a line were estimated to be about $2.6 million, of which about $1.1 million was for materials (wood poles, insulators, conductor, and miscellaneous construction materials) and $1.5 million for labor (Hubsky 1990).

III.B. Work Force Estimates.

III.B.1. Exploration.

Work force estimates can be determined based on the separate development steps of the geothermal plant and well field, as well as estimates of operation and maintenance requirements. In this section, the work force requirements for the development and operation phases are first reviewed. Specific employment estimates for the hypothetical project, including local employment estimates, are then discussed.

Development of geothermal energy usually begins with passive exploration, including geologic field surveys, mapping, and geochemical and geophysical analysis to reduce the size of the prospect area. This is followed by exploratory drilling to determine the location, quantity, and quality of underground steam or hot water.

Generally, geothermal development companies maintain a small local office to manage local operations. Staff size in local offices depends on the amount of leased land, the extent of development activities, and the level of subcontracted work.

Developers also maintain both office and field staff. Office staff may include clerical workers, administrative managers, professionals such as geologists and other earth scientists, land agents, and workers involved in securing necessary environmental permits. Field staff will include drilling supervisors, field engineers, and geologists. Some staff may perform both office and field duties, as well as manage a number of subcontractor activities, such as preparation of well pads and access roads, and exploration and well drilling. The majority of these workers will probably be located outside the local county.

Local office employees tend to be long-term residents of the local area (Matthews 1983). This makes sense, given the relatively long time between resource leasing and initial electricity production. In addition, many of the skills required for local office work will be available in the local work force, since these jobs require much less specialization than field work-related positions.

III.B.2 Field Development.

Once exploration is completed, site development and drilling the steam field can begin. Initially, the work will involve construction of access roads, site clearance, and preparation. Then, actual drilling begins.

The amount of steam required will depend on the quality of the steam and the efficiency of the generating plant. Older plants in The Geysers area, for example, require about one million lbs / hr to produce 55 MW of power, or about 18,000 lbs / hr / MWa (Matthews 1983). This translates into between 10 - 15 steam wells. Newer Geysers plants, however, are more efficient, requiring 10 to 20 percent less steam per MW of capacity (Bloomquist 1987; Nolte 1987). If the efficiency of the hypothetical plant were 15 percent greater than an older Geysers plant, it would require about 1,600,000 lbs / hr, or 16,000 lbs / hr / MWa.

The range of steam flows and number of wells is due to variations in reservoir characteristics (pressure and temperature) and steam quality. Hotter and higher pressure reservoirs of steam or hot water will require fewer wells to produce a given amount of power. Since each well is unique, different steam characteristics for wells in the same leasehold are common.

Given the current uncertainty of Pacific Northwest steam resource characteristics, this report uses an estimate of 20 - 30 wells to provide power for a 100 MWa development. For the purposes of this study, a total of 25 wells is assumed. Because well performance tends to decline over time, an additional 20 - 30 wells would be drilled to maintain the necessary steam supply over the assumed 30 year lifetime of the plant.

Development of each steam well normally takes between 30 - 90 days, with drilling crews working around the clock. The actual time will depend on the depth required and the difficulty of working at the site. For the purposes of this study, a 60 day drilling period per well is assumed. A typical drill rig is operated by four crews of 5 - 6 persons during each 24-hour period (Matthews 1983). For the purposes of this study, six-person drill crews are assumed, due to the remoteness of the site. Overseeing each drill rig is a drilling superintendent employed by the geothermal developer. With four drilling crews and the drilling superintendent, the work force associated with each drilling rig is assumed to equal 25 persons. Since two drilling rigs are assumed to operate at the site, a total of 50 drilling-related workers is assumed.

Workers needed during the steam field development stage include drillers, derrick men, roughnecks, roustabouts, floor hands, tool pushers, and rig superintendents (Cornelison cited in Matthews 1983). Information provided by geothermal developers indicated that the drilling work force at The Geysers development tended to be long term residents of the local area (Matthews 1983). However, many of the workers in Washington might not be local since, unlike The Geysers, there are no established steam fields in Washington at this time. 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 drilling rig to function. Once a rig and crew are active in an area, developers tend to keep it busy there, since the crews become familiar with the geologic idiosyncrasies of the area.

In addition, periodically throughout the lifetime of the facility, the steam wells supplying the generating plant require re-drilling to clear obstructions or to regain full steam flow potential. Occasionally, new wells must be drilled if an existing supply well cannot maintain required output.

For the purposes of this study, it is assumed that, on average, 50 drilling-related workers will be employed for the project through the end of 1998, when the last unit is assumed to come on-line.

III.B.3 Steam Gathering System.

Once the majority of the wells are completed and plant construction is underway, work begins on the steam/brine gathering system. The gathering system is a network of pipelines that collects steam or hot water from the wells and delivers it to the plant. Steam line workers will be different from drilling crews and plant construction personnel. The work force involved in gathering system construction may include plumbers, pipe fitters, welders, foreman, and laborers involved in preparing foundations and footings.

The number of workers constructing steam gathering systems for each power plant varies with the design of the routing and interconnection plan for the pipelines. The work force may be as few as 4 or as many as 50, and the construction period may last anywhere from several weeks to several months. The work force involved in the construction of the steam gathering system is less likely to be composed of long-term residents of the area, since the duration of the work is short and months may elapse between jobs (Matthews 1983). Peak steam field plant and gathering system workers for the 27 MW West Ford plant completed in 1988 were estimated at 35 (Nolte 1987). For this study, it is assumed that construction of the steam gathering system will not commence until 1995, and will employee 20 workers for 6 months of each year, for an annual average of 10 workers.

III.B.4. Plant Construction.

Actual construction time for 55 - 110 MW geothermal plants in The Geysers has been about 28 - 30 months (Matthews 1983). However, site clearance and preparation or other construction activities involving earth movement cannot occur during the rainy season (generally November through March). Thus, the actual construction period could extend up to 36 months or more, depending on realized weather conditions. Newer plants at The Geysers have shortened the construction period considerably. The Bear Canyon, plant, for example, was built in 20 months, instead of the projected 24 months (Phair 1989). The West Ford plant came on-line only 8 months after groundbreaking (Urbank 1989). Other plants in California, Nevada, and Utah, had construction periods of less than 2 years due to significant fabrication of similar or standard "off-the-shelf" units.

The snow season in the Mt. Adams area, where geothermal development in Skamania County would be assumed to take place, is analogous to the rainy season in The Geysers area. For the purposes of this report, a 36 month construction period for the first 25 MWa module is therefore assumed. Construction periods for the subsequent modules would likely take less time, perhaps only 24 months. These construction periods are assumed to overlap such that one module comes on-line per year beginning in 1996.

Construction of the power plant and related facilities is usually managed by one general contractor and several subcontractors. Work tasks (after site preparation) include: placement of foundations and pads; construction of the power plant buildings; placement of the generating units and associated piping and electrical work; construction of related facilities (e.g., hydrogen sulfide control systems, cooling towers and basins, switch yard and transmission systems), and final site and facility finish work.

Workers needed for these diverse tasks include pipe fitters, welders, electricians, concrete workers, equipment operators, laborers, and supervisory personnel. Many of the work tasks throughout the construction period are of relatively short duration, ranging between several weeks and months. Some of the craft skills required are specialized, and the number of workers in the entire state, let alone a small county like Skamania, who are qualified to perform the work is likely to be small. However, a worker with a wide range of abilities and a high degree of skill in those various areas could maintain relatively continuous employment on a progression of geothermal plants.

Information supplied to the California Energy Commission (CEC) by geothermal developers indicated that the maximum number of construction workers for a 110 MW plant would range between 75 - 205 workers (Matthews 1983; CEC 1985). This is equivalent to 0.54 to 1.47 workers per MW. The maximum number of workers at the 27 MW West Ford Flat plant in California were estimated to be only 40 (Nolte 1987), equivalent to 1.48 workers per MW. Unfortunately, a direct correlation between number of workers per MW and size of the plant cannot be made. There may be a wide disparity in total workers required for construction due to different characteristics of individual plants. However, modular designed plants will, in general, require fewer construction workers than strictly site-designed facilities.

During power plant construction, the peak force is active on site after the foundations and pads are set and the work begins on installation of the generating units. The majority of the work force during this period will be composed of electricians and pipe fitters who are usually dispatched through union hiring halls. The number of electrical workers during the peak period usually ranges between 5 - 35, but has been as high as 55 for a single project (Matthews 1983). The number of pipe fitters active during the peak period may range between 6 - 50, and has been as high as 110 for a single project. The peak construction period generally lasts for 1 year, with the largest number of workers needed for 6 to 8 months (Matthews 1983).

For the purposes of this study, it is assumed that plant construction will require an average of 40 workers in 1994 for the first module. This figure is assumed to increase to 80 workers from 1995 - 1997, when construction of multiple units overlaps. In 1998, as construction on the last unit is completed, the work force is assumed to drop to 40 workers. Thus, combining the steam field development, gathering, and plant construction tasks, a maximum of 140 construction-related workers is assumed during the peak construction period between 1995 - 1997.

III.B.5. Steam Field Maintenance.

Once a geothermal power plant comes on line, it will most likely operate at full capacity unless there are technical or mechanical problems.[5] The size of the work force necessary to maintain adequate steam supplies for each well field and power plant is similar to that required during the steam field development phase. For example, the California Division of Oil and Gas (CDOG) estimated that the number of drilling rigs required over the lifetime of generating plants that are part of The Geysers development will remain relatively constant (Matthews 1983).

For the purposes of this study, it is assumed that one drilling rig would be required to redrill wells. However, this drilling rig would only be required about 3 months of the year. Thus, while the drilling rig would employ 25 persons when operating, over the year there would be only about 6 full time equivalents (FTE).

It is assumed that one drilling rig would be operated on a relatively continuous basis, employing 5 - 6 persons. In addition, it is assumed that 2 office staff would be required, for a total of 8 personnel devoted to steam field maintenance.

III.B.6. Power Plant Operation and Maintenance.

In the final months of the construction phase for each unit, personnel from the plant developer-operator begin testing equipment and systems in the new generating facility. These personnel 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 involved in the operation and maintenance of the generating plant and related facilities varies with the operator. Pacific Gas and Electric's (PG&E) operation and maintenance work force in 1981 for 17 Geysers plants, for example, was about 130. Since the units are relatively close to one another, PG&E operates various units by remote control from a

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[5]Some plants may be designed to operate in a load following manner, i.e., with output that changes in relation to the hourly daily loads placed on a utility's system. For the purposes of this study, it is assumed that the plant will be operated to the maximum extent possible.

single point. Periodic checking of daily operations is performed by roving crews (Matthews 1983). Current staff numbers about 210 persons, responsible for 1302 MW of capacity. This results in an average of 0.16 plant O&M employees per MW. This number is low due to the enormous size of development at The Geysers, and provides the low end of the range of plant O&M staff levels.

In the last decade, other developers began operating plants in The Geysers. Some of these developers have estimated that they will need an initial operation and maintenance work force of 10 - 20 workers per plant. Fewer workers would be required to operate subsequent plants, since the basic work force would already be involved in their initial operation. This workforce economy of scale holds true at the recently built Bear Canyon and West Ford Flat plants built by Calpine Corporation. Approximately 12 plant staff operate and maintain these plants (49 MW total), for an average of 0.24 employees per MW (Sifford 1991). There are an additional 8 field staff at this facility, raising total employment to about 0.41 employees per MW.

The recently completed Coso complex, for example, uses an average of 90 employees in plant operations and 170 people total (Sifford 1991) for the entire 240 MW plant complex. This translates to about 0.38 operations workers per MW and 0.73 total employees per MW. Table 2 provides a summary of the estimated ranges of employment for the different plant phases, from which Skamania County assumptions were chosen.

Table 2
Range of Employee Estimates

Phase	Number per MW	Number per 25 MW
Drilling	25 per rig	25 per rig
Well Field Construction	0.04 - 1.30	4 - 33
Plant Construction	0.68 - 1.87	17 - 47
Total Construction	0.72 - 3.17	21 - 79
Well Field Maintenance	25 per rig	25 per rig
Plant Operation	0.16 - 0.38	4 - 10
Total Operation	0.41 - 0.73	10 - 18

For the purposes of this study, it is assumed that a total of 12 plant operation and maintenance workers will be required for all of the units, and that this number of workers will be required whether only one or all four generating units are on-line. Thus, a total of 20 operation and maintenance workers is assumed once the first plant is on-line. This number is expected to remain constant over the lifetime of the plants.

For the entire 100 MWa development assumed for this study, 20 operation and maintenance workers is equivalent to 0.20 workers per MWa, less than half as many as used at the Coso complex. These estimates, together with the estimates for construction employment may be subject to some variation. However, it is believed that the employment estimates used in this analysis are conservative. In that way, the potential local employment impacts that might result from development will not be overestimated.

III.B.7. Local Work Force Assumptions for Skamania County Development.

The Skamania County geothermal plant development will be assumed to take place over a period of 6 years, beginning in 1993. By the end of 1998, four 25 MWa units will be assumed to be operational. Drilling the well field will commence in 1993, with construction of the first generating unit beginning 1 year later. The first unit will be assumed to be on-line at the beginning of 1996, after a 36 month construction period. Subsequent units will come on-line in one year intervals until the full 100 MWa complex is completed. Operation and maintenance employment will begin in the latter half of 1995, as workers begin training to operate the first completed unit.

Local employment impacts are important to consider, since not all of the workers required to build and maintain the plants will live in Skamania County. It is likely that many workers will commute from neighboring counties and metropolitan areas. The fraction of workers commuting or choosing to become long-term residents of the county will depend on the work tasks involved.

It is assumed that for steam field gathering, 60 percent of the work force will be local; for well drilling, 20 percent of the work force will be local; and for actual plant construction, 75 percent of the work force will be local. The differences in the local employment percentages stem from the degree of specialized training required to perform the tasks. It is unlikely, for example, that many Skamania County workers will have previous well drilling experience. On the other hand, a relatively large percentage of plant construction workers are assumed to arise from the local work force, since the skills required to construct a geothermal facility are similar to other construction projects.

For operations and maintenance (O&M), it is assumed that 50 percent of both the plant and well field O&M workers will be local. These assumptions are meant to be conservative. The actual fraction of workers choosing to become residents of a county would depend on local economic conditions, the strength of the overall economy, whether similar development was taking place in nearby regions, and other factors. Local employment share estimates are summarized in Table 3.

Table 3
Local Employment Share Estimates

Labor	Local	Non-Local
Drilling Crew	20%	80%
Pipeline	60%	40%
Construction	75%	25%
Operations	50%	50%
Maintenance	50%	50%

Using the estimates of the local employment fractions, the total number of additional local workers can be estimated. These estimates are summarized in Table 4. As the table indicates, local employment impacts would be only 10 workers in 1993, increasing to 86 in 1996 - 1998, reduced to 56 in 1998 as construction winds down, and finally, reverting back to a long-term level of 10 local O&M personnel.

Table 4
Local Work Force Estimates

	1993	1994	1995	1996	1997	1998	1999
Construction							
Steam Drilling	10	10	10	10	10	10	0
Steam Gathering	0	0	6	6	6	6	0
Plant	0	30	60	60	60	30	0
Total Construction	10	40	76	76	76	46	0
O & M							
Plant	0	0	3	6	6	6	6
Well Field	0	0	3	4	4	4	4
Total O&M	0	0	6	10	10	10	10
Total	10	40	82	86	86	56	10

III.C. Wage Rate Estimates.

Local workers will spend some fraction of their wages in the local economy, which will have an economic impact. Thus, it is important to estimate wage rates for the different classes of workers that will be hired.

Using data from cost estimation handbooks (Cleveland, et al. 1990; Kiley and Moselle 1990), covered employee wage rate averages (WESD 1990), and published current plant operator wages at federal facilities (BPA 1988), average annual wages for well field, plant construction, and plant and well field O&M were determined for the 1993 - 2000 period. Overall average well field construction wages were estimated at $34,000 per job in 1991, while average plant construction wages were estimated to be $40,000 per job. Plant O&M wages were estimated to be $35,000 per job in 1991, while steam field O&M wages were estimated to be $40,000 per job.

These figures were inflated at an annual rate of 5 percent between 1991 - 1999. The resulting nominal wages figures are shown in Table 5.[6] Using the assumed local employment percentages

[6]As will be discussed below, modelling of the economic impacts required conversion of wage payments to 1982 dollars. This was done using a published Implicit Price Deflator for 1982 - 1991 (OFC 1990).

shown in Table 3, the local employment estimates in Table 4, and the nominal wage assumptions of Table 5, local wage impacts are then summarized in Table 6. Local wage impacts would rise rapidly after 1993, peaking in 1997 at about $4.1 million.[7] Once plant construction was completed, local wage impacts would drop down to a long-term level of about $550,000 and likely increase with the rate of inflation.

Table 5
Local Wage Assumptions
($/Job)

	1993	1994	1995	1996	1997	1998	1999
Construction							
Avg. Well Field	$44,100	$46,305	$48,620	$51,051	$53,604	$56,284	$59,098
Avg. Plant	$37,485	$39,399	$41,327	$43,394	$45,563	$47,841	$50,233
O&M							
Well Field	$44,100	$46,305	$48,620	$51,051	$53,604	$56,284	$59,098
Plant	$38,588	$40,517	$42,543	$44,670	$46,903	$49,249	$51,711

Table 6
Local Wage Impacts
(1000$/Year)

	1993	1994	1995	1996	1997	1998	1999
Construction							
Well Field	441	463	778	817	858	901	0
Plant	0	1,181	2,480	2,604	2,734	1,435	0
Total[a]	441	1,644	3,158	3,421	3,592	2,336	0
O&M							
Well Field	0	0	146	204	214	225	236
Plant	0	0	128	268	281	296	311
Total[a]	0	0	274	472	495	521	546
Overall Total	441	1,644	3,432	3,893	4,087	2,856	547

a- totals may not sum due to rounding

[7]This wage figure assumes that wage rates will increase with the rate of inflation.

IV. PLANT OPERATING ASSUMPTIONS.

The operating efficiency of the generating plant will have an important impact on total royalty payments collected and distributed to the county. Consistent with operating data from existing plants, the actual output from each 25 MW unit is assumed to be 90 percent of capacity. Thus, each unit will produce about 200,000 MWh of electricity annually.

Total royalty payments to the federal government will be determined by the efficiency with which the generators utilize steam. Steam cost values are estimated from two-party contractual data. A power plant steam utilization rate of 14 lbs / kWh, consistent with one of the most efficient plants operating in The Geysers is also assumed in order to provide a conservative estimate of total royalty payments. Lastly, a 1991 steam value of $1.52 / 1,000 lbs, also consistent with payments made by generators to steam suppliers in California, is assumed.[8] The net result is a value of steam of about $0.02/kWh. Less efficient plants may be built for slightly lower capital costs, but will experience higher operations and maintenance, and royalty costs.

Under the Geothermal Steam Act of 1970, royalty payments to the federal government are equal to 10 percent of the steam value. Of the total collected by the federal government, 50 percent is returned to the state where development occurs. Existing Washington State law then provides that 40 percent of the royalties returned to the state are distributed to the specific county of origin.[9] Based on these assumptions, total steam royalties returning to Skamania County would equal $84,000 (1991$) for each 25 MWa unit. Thus, royalty payments to the county are assumed to increase to about $335,500 beginning in 1999, when all four 25 MWa units are completed.

Lastly, after the plant is operating, it will be required to pay property taxes to the county. In 1991, property tax rates near the Mt. Adams area, where the plant is assumed to be built, were $11.08/$1,000 of assessed value. Using the book value construction cost estimate as a basis for calculating property taxes, the complete 100 MWa facility will have an assessed value of $280 million 1991 dollars. This translates to an annual property tax bill of about $3.1 million 1991 dollars. Total state and county revenues from the fully operational plant are summarized in Table

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[8]The figure chosen represents a low value of the steam cost at several Stone and Webster geothermal plants (Bloomquist, Geyer, and Sifford 1989). This value was chosen so as to conservatively estimate royalty payments that would accrue back to the county.

[9]Royalty payments to the county of origin are spelled out in the RCW 43.140.040 (1989).

7. (These figures are adjusted for inflation.) Annual projections of plant development, electricity production, and royalty payments are summarized in Table 8.

Table 7
State and Local Projected Revenues
100 MW Facility
(1991$)

Source	State (Net of County)	Skamania County	Total[a]
Federal Royalties	$503,300	$335,500	$838,900
Property Tax Collections	$0	$3,100,000	$3,100,000
Total	$503,300	$3,435,500	$3,938,900

a- totals may not sum due to rounding.

Table 8
Geothermal Development Projections

	1993	1994	1995	1996	1997	1998	1999
Plant Size (MW)	0	0	0	25	50	75	100
Plant Cost ($/kW)	3,087	3,241	3,403	3,574	3,752	3,940	4,137
Plant Value (1000$)	0	0	0	89,350	187,600	295,500	413,700
Tax Rate ($/1000)	11.08	11.08	11.08	11.08	11.08	11.08	11.08
Prop. Taxes (1000$)	0	0	0	990	2,079	3,274	4,584
Power Sales (MWh)	0	0	0	197,100	394,200	591,300	788,400
Steam Eff. (#/kWh)	14	14	14	14	14	14	14
Steam Price ($/#)	1.68	1.76	1.85	1.94	2.04	2.14	2.25
Steam Price ($/kWh)	0.023	0.025	0.026	0.027	0.029	0.030	0.031
Steam Value (1000$)	0	0	0	5,362	11,260	17,734	24,828
Royalty Rate	10%	10%	10%	10%	10%	10%	10%
Federal Royalties (1000$)	0	0	0	536	1,126	1,773	2,483
State Royalties (1000$)	0	0	0	268	563	887	1,241
County Royalties (1000$)	0	0	0	107	225	355	497

V. MODELLING ECONOMIC IMPACTS.

Impact analysis is commonly used in regional policy making to predict the economic changes that may result from a project. These changes, or impacts, are realized as increases or decreases in the magnitudes of selected economic components, such as employment, industrial output, income, or value added.

The purpose of this study is to estimate the economic impacts from geothermal development in Skamania County. There are three types of economic impacts that are commonly discussed: direct, indirect, and induced impacts.

Direct impacts refer to the initial purchase within an economy that result from a project's activities. Thus, the *direct* impacts of geothermal development will include all of the expenditures associated with construction and maintenance of the plants. Examples of direct purchases include concrete, steam pipe, sheet metal, electric turbines, and wire during the construction phase, and special lubricants during the operational phase.

The production and sale of goods and services that result in direct impacts require inputs from other business sectors. For example, to produce the electric turbines used by the generating plants requires the purchase of many different inputs (e.g., steel, wire, sheet metal, etc.) from other industries. This second level of activity is the source of indirect impacts, so called because purchase of the direct impacts will have an *indirect* impact on demands for goods and services produced by these other industries.

Industries that experience both direct and indirect impacts will often change their employment levels to meet the new level of demand. These employment changes *induce* changes in income that are spent in the region to purchase consumer goods and services. This income effect is the source of induced impacts. For example, wages paid to local construction workers will be spent on food, housing, and other consumer goods. Local spending of this additional income is the basis of an induced effect. Induced impacts lead to further rounds of indirect and induced impacts.

The *total* economic impact is found by summing all three levels of impact for each sector of the local economy. The larger the magnitude of local purchases, the larger will be the total economic impact. The amount spent outside the region does not affect the local economy. These expenditures outside the local economy are called *leakages*. With each round of spending, some portion usually leaks outside the local economy. Leakages of successive rounds of spending eventually reduce further rounds of respending to zero. The larger the region, the more slowly leakages are likely to occur and, therefore, the larger will be the total economic impacts.

As a result of the rounds of indirect and induced impacts, the initial direct impacts will be multiplied, resulting in a total impact larger than the initial direct impact. This so-called *multiplier* shows the relationship of direct impacts to total impacts. In a general sense, the multiplier can be estimated as the ratio of total impacts to direct impacts. This ratio holds true whether the impacts are measured in dollars from changes in income, or whether the impacts are measured in other units such as jobs created. If, for example, the direct impact is $1,000 and the total measured impact is $2,000, then the multiplier equals $2,000/$1,000 = 2. To accurately assess multiplier effects in an economy, estimates are often derived for each sector of the economy using a computer model.

The type of model chosen to derive the multiplicative effects for this study is called an input-output model. The input-output model used for this study is the IMPLAN model developed by the U.S. Forest Service, because IMPLAN is one of the few non-survey based models capable of modelling impacts at the county level. (More detailed discussions of input-output modelling in general and IMPLAN are provided in Appendix A.)

VI. THE SKAMANIA COUNTY ECONOMY.

To model the potential impacts from geothermal development on the Skamania County economy, it is useful to first discuss the county's economic base as it has evolved. This leads into a discussion of the county's current industry structure and the likelihood of that structure providing inputs for geothermal development.

VI.A. History.

The development of the Skamania County economy began in earnest in the mid 1800's as settlers turned to the resources of the Columbia River to provide them with a livelihood (WESD 1989). There was rapid growth in the fishing industry, as large amounts of salmon were harvested from the river, and a complementary growth in the canning industry. Unfortunately, due to a combination of overfishing and poor industrial practices which damaged spawning grounds, the industry declined considerably after the 1880s.

The logging industry also became an important part of the Skamania County economy. Harvesting was increased to satisfy the demands for building supplies as well as fuelwood for steamboats that travelled the Columbia River.

Later on, in the 1930s, the local economy received a tremendous boost from the construction of Bonneville Dam. Construction of the dam, begun in the midst of the Great Depression in 1933 as a means of creating jobs, lasted 4 years until 1937. The dam did provide much needed employment in the region at the time.

In 1975, to meet the region's growing energy needs, the Bonneville Power Administration (BPA) authorized construction of a second powerhouse at Bonneville Dam. The project doubled the energy production capacity of the dam to over 1,000 MW. This project, which lasted 5 years, also created a significant, but temporary, boom to the county's economy.

Today, the Skamania County economy is based largely on federal employment and the lumber and wood products industries (WESD 1989). Federal employees manage both the hydroelectric generating facilities and the national forests. There is a significant amount of logging activity with several large wood processing facilities that account for about one-third of total employment within the county (WESD 1990). (This activity may be curtailed to an unknown degree, however, due to recovery plans for the northern spotted owl under the requirements of the Endangered Species Act.) Since the mid-1980's, additional economic activity has been generated by tourism and recreation with the increasing popularity of the Columbia Gorge as a recreation area.[10] Lastly, some light manufacturing has begun to appear in the county.

Table 9 summarizes the overall industry and employment structure in the county in 1972, 1982, and 1988. As the table shows, there was a 5 percent increase in total employment in the county between 1982 and 1988. Much of that growth occurred in the services, and wholesale and retail trade sectors. Mining employment has also increased due to gold mining operations. Construction employment, on the other hand, has declined by over 50 percent since 1982, following its

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[10]See, for example, ERA (1988).

expansion due to construction of the second powerhouse at Bonneville Dam in the late 1970's and early 1980's.[11]

Table 9

Skamania County Employment and Earnings

Year: 1972	Employment (1)	Total Earnings (2)	Earnings/Employee (2)	
Farm	79	$1,412,000	$10,200	(3)
Total Non-Farm	2,078	$54,046,000	$26,000	
Ag. Services, Forestry, Fishing	8	$82,000	$10,300	
Mining	62	$1,248,000	$20,100	
Construction	88	$3,988,000	$45,300	
Manufacturing	819	$26,178,000	$32,000	
Transp., Utilities	80	$3,040,000	$38,000	
W&R Trade	172	$2,596,000	$15,100	
Fins, Ins., Real Estate (FIRE)	38	$1,075,000	$28,300	
Services	198	$2,3554,000	$11,900	
Government	613	$13,485,000	$22,000	
Totals:	2,157	$55,458,000	$25,700	

Year: 1982	Employment (1)	Total Earnings (2)	Earnings/Employee (2)	
Farm	104	$1,039,000	$8,800	(3)
Total Non-Farm	2,364	$55,491,000	$23,500	
Ag. Services, Forestry, Fishing	120	$177,000	$1,500	
Mining	7	$335,000	$47,900	
Construction	204	$8,339,000	$40,900	
Manufacturing	679	$19,236,000	$28,300	
Transp., Utilities	551	$1,906,000	$37,400	
W&R Trade	249	$2,818,000	$11,300	
Fins, Ins., Real Estate (FIRE)	47	$751,000	$16,000	
Services	218	$2,237,000	$10,300	
Government	893	$19,843,000	$22,200	
Totals:	2,468	$55,642,000	$22,500	

(continued on next page)

[11] Construction employment peaked in 1980 at over 1,500. Many of those employed, however, did not live in Skamania County.

Table 9 (cont.)

Year: 1988	Employment (1)	Total Earnings (2)	Earnings/Employee (2)	
Farm	105	($1,643,000)	$6,700	(3)
Total Non-Farm	2,493	$49,774,000	$18,820	
Ag. Services, Forestry, Fishing	125	(W)	--	
Mining	39	(W)	--	
Construction	86	$1,974,000	$18,820	
Manufacturing	716	$18,326,000	$21,290	
Transp., Utilities	71	$2,120,000	$16,360	
W&R Trade	320	$2,733,000	$6,860	
Fins, Ins., Real Estate	42	$241,000	$10,010	
Services	297	$3,597,000	$8,160	
Government	902	$19,931,000	$20,160	
Totals:	2,598	$48,922,800	$18,830	

Source: U.S. Dept of Commerce, Bureau of Economic Analysis; Washington State Employment Security Dept.
(W) - Withheld to avoid disclosure of confidential information.
(1) - Includes full- and part-time wage and salary employment, plus proprietors.
(2) - 1990$ equivalents.
(3) - Wages/employee only. Does not include proprietor's net income or employment.

Despite growth in several major employment sectors, Skamania County remains economically distressed. Since 1970, unemployment in the county has consistently been above the state average. The recession in 1981-1982 significantly affected the county due to the large percentage of jobs in the lumber and wood products industries. In 1982, unemployment in the county peaked at over 27 percent. Since then, unemployment has declined somewhat, but as late as 1988 remained over 20 percent (WESD 1989). This is probably not surprising, since such a large portion of the county's employment base remains concentrated in seasonal and cyclical industries.

VI.B. Existing Industry Structure and Geothermal Development.

To estimate the overall economic impacts from geothermal development, it is necessary to first assess the direct impacts that will occur within Skamania County. A review of the county's industrial structure and major employers (WESD 1989) reveals that Skamania County has few major employers that would be directly impacted from purchases of goods and services for the project.[12] For example, none of the pipe needed for the steam field is manufactured within the

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[12]Some lumber products, such as wood transmission line poles, might also be purchased locally. However, there is no definitive way of knowing this in advance.

county, nor are there sheet metal or concrete industries within the county. Only one sand and gravel dealer has been identified within the county, and the size of that firm is quite small.

Because it has not been possible to obtain the precise "recipe" for a geothermal plant, it is conservatively assumed that none of the direct industry purchases will be made locally, with the exception of locally-hired construction and operation and maintenance workers. As a result, there are assumed to be no indirect impacts from inter-industry purchases. The only economic impacts that will occur are assumed to result from the wage payments of the additional local employees being spent and respent within the economy. Thus, for the purposes of this study, economic impacts associated with plant construction are focused solely on the induced impacts from increased income within the county.

During the operations phase, there will be two separate impacts. As in the construction phase, there will be economic impacts due to wage payments being spent and respent within the local economy. There will also be, however, impacts from expenditures of royalty and property tax payments to the county.

VII. ANALYTICAL RESULTS.

Because there are assumed to be no inter-industry impacts associated with geothermal development in the county, any economic impacts from plant construction and operation will arise due to the induced wage, royalty, and property tax expenditures. For the purposes of this study, however, these impacts may be referred to as "direct" impacts to distinguish them from subsequent rounds of induced spending impacts. The magnitude of these impacts will depend on the overall proportion of funds spent within the county (i.e., the expenditure fraction), and the pattern of those within-county expenditures.

Data from IMPLAN was used to develop expenditure patterns and local expenditure fractions for Skamania County, which were then used to analyze the overall economic impacts from plant development. It was assumed that some portion of local wages paid to both construction and O&M workers would be spent within the county.[13] Based on the IMPLAN database, about

[13]The expenditure patterns were calculated using a FORTRAN program written by the author. Wage income was reduced by 25 percent to account for the effects of federal income and social security taxes. The remainder of wage income was then shared out on an industry basis to local industries. Copies of this program are available on request from the author.

one-third of disposable wages would be spent locally within the county. (This expenditure pattern is shown in Appendix B.1) It was also assumed that these additional revenues would be used to purchase additional goods and services for the county. Thus, a similar expenditure pattern was developed for state and local government expenditures resulting from the royalty payments and additional property tax collections. This expenditure pattern showed that just under 30 percent of government expenditures would remain within the county. (This expenditure pattern is shown in Appendix B.2.)

To better estimate county level impacts, unsuppressed 1989 covered employment and wage data was used to update the IMPLAN database.[14] This was combined with data on total earnings and employment from the Bureau of Economic Analysis (BEA) to develop a more accurate database for the IMPLAN model.[15]

The total economic impacts of geothermal development in the county are summarized in Tables 10 and 11.[16] Table 10 reports the estimated increases in total county income between the year 1993, when construction is assumed to begin and the year 1999, when the 100 MWa facility is assumed to be in its first full year of operation. These are nominal dollar impacts which include the effects of the assumed inflation during the period, estimated using the local wage impacts and response coefficients (i.e., measures of the impacts per million dollars of wage payment or property tax and royalty payment expenditures) developed using IMPLAN. (Aggregated response coefficients are presented in Appendix C.)[17]

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[14]Published data is suppressed to avoid disclosure of individual firms. Due to the small size of the Skamania County economy, much of the employment and wage data is suppressed. Covered employment and wages refers to employees who are covered under the state's unemployment insurance program.

[15]The BEA data includes sole proprietors and other non-covered employment and establishments.

[16]Total economic impacts would be larger if a larger region were considered. For example, if the total economic impacts to the entire state of Washington were estimated, there would be fewer leakages from the defined region, resulting in larger direct, indirect, and induced impacts.

[17]To use IMPLAN correctly, impacts such as wage payments, etc., must all be first converted to 1982 dollars. Use of response coefficients automatically adjusts for the effects of inflation, however.

Table 10

Estimated Annual Changes in Total County Income
(1,000$)

Construction	1993	1994	1995	1996	1997	1998	1999
Agriculture	0.3	1.1	2.2	2.3	2.4	1.6	0.0
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	441.6	1,646.0	3,262.0	3,425.1	3,596.3	2,338.9	0.0
Manufacturing	0.5	1.7	3.4	3.6	3.8	2.5	0.0
Transp., Utilities	2.2	8.1	16.1	16.9	17.8	11.6	0.0
W&R Trade	4.4	16.4	32.5	34.1	35.8	23.3	0.0
Fins, Ins., Real Estate	32.6	121.4	240.7	252.7	265.3	172.6	0.0
Services	8.1	30.2	59.9	62.9	66.0	42.9	0.0
Government	16.7	62.1	123.1	129.3	135.8	88.3	0.0
Total Construction	506.4	1,887.0	3,739.9	3,926.9	4,123.2	2,681.7	0.0
Oper. and Maint.	1993	1994	1995	1996	1997	1998	1999
Agriculture	0.0	0.0	0.2	0.3	0.3	0.4	0.4
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	273.9	472.9	496.5	521.3	547.4
Manufacturing	0.0	0.0	0.3	0.5	0.5	0.5	0.6
Transp., Utilities	0.0	0.0	2.7	4.7	4.9	5.2	5.5
W&R Trade	0.0	0.0	1.4	2.3	2.5	2.6	2.7
Fins, Ins., Real Estate	0.0	0.0	20.2	34.9	36.6	38.5	40.4
Services	0.0	0.0	5.0	8.7	9.1	9.6	10.0
Government	0.0	0.0	10.3	17.9	18.7	19.7	20.7
Total Oper. & Maint.	0.0	0.0	314.0	542.2	569.1	597.8	627.7

Table 10 (cont.)

S&L Government	1993	1994	1995	1996	1997	1998	1999
Agriculture	0.0	0.0	0.0	0.5	1.1	1.8	2.5
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	40.5	85.1	134.0	187.6
Manufacturing	0.0	0.0	0.0	2.6	5.5	8.7	12.1
Transp., Utilities	0.0	0.0	0.0	7.0	14.7	23.1	32.4
W&R Trade	0.0	0.0	0.0	3.4	7.1	11.2	15.7
Fins, Ins., Real Estate	0.0	0.0	0.0	28.3	59.4	93.5	131.0
Services	0.0	0.0	0.0	25.7	53.9	84.9	118.8
Government	0.0	0.0	0.0	1,134.9	2,383.4	3,753.8	5,255.3
Total S&L Governement	0.0	0.0	0.0	1,242.9	2,610.2	4,111.0	5,755.4
Grand Total	506.4	1,887.0	4,053.9	5,712.0	7,302.5	7,390.5	6,383.1

Table 11

Estimated Annual Changes in Total County Employment

Construction	1993	1994	1995	1996	1997	1998	1999
Agriculture	0.0	0.1	0.2	0.2	0.2	0.1	0.0
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	10.0	40.1	76.2	76.2	76.2	46.1	0.0
Manufacturing	0.0	0.1	0.2	0.2	0.2	0.1	0.0
Transp., Utilities	0.1	0.2	0.4	0.4	0.4	0.2	0.0
W&R Trade	0.3	1.1	12.1	12.1	12.1	1.3	0.0
Fins, Ins., Real Estate	0.1	0.4	0.8	0.8	0.8	0.5	0.0
Services	0.6	2.0	3.7	3.7	3.7	2.3	0.0
Government	0.7	2.5	4.7	4.7	4.7	2.9	0.0
Total Construction	11.8	46.5	88.2	88.2	88.2	53.6	0.0
Oper. and Maint.	1993	1994	1995	1996	1997	1998	1999
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	6.0	10.0	10.0	10.0	10.0
Manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transp., Utilities	0.0	0.0	0.0	0.1	0.1	0.1	0.1
W&R Trade	0.0	0.0	0.2	0.3	0.3	0.3	0.3
Fins, Ins., Real Estate	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Services	0.0	0.0	0.3	0.5	0.5	0.5	0.5
Government	0.0	0.0	0.4	0.6	0.6	0.6	0.6
Total Oper. & Maint.	0.0	0.0	7.0	11.7	11.7	11.7	11.7

Table 11 (cont.)

S&L Government	1993	1994	1995	1996	1997	1998	1999
Agriculture	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.5	1.1	1.6	2.1
Manufacturing	0.0	0.0	0.0	0.1	0.3	0.4	0.5
Transp., Utilities	0.0	0.0	0.0	0.2	0.4	0.6	0.8
W&R Trade	0.0	0.0	0.0	0.2	0.4	0.5	0.7
Fins, Ins., Real Estate	0.0	0.0	0.0	0.1	0.3	0.4	0.5
Services	0.0	0.0	0.0	1.6	3.2	4.8	6.4
Government	0.0	0.0	0.0	2.1	4.2	6.2	8.3
Total S&L Governement	0.0	0.0	0.0	4.9	9.9	14.6	19.7
Grand Total	11.8	46.5	95.3	104.8	109.7	79.9	31.2

The results presented in Table 10 indicate that a maximum of about $2.7 million of additional income related to construction of the facilities will accrue within the county during the peak construction period. Ongoing operations and maintenance, plus royalty and property tax payments will contribute an increasing amount during the construction phase as well. The largest estimated increase to county income occurs in 1998, when a total of about $7.4 million is generated. These estimates include the direct wage payments to local workers plus the subsequent indirect and induced impacts this spending will engender. Lastly, when the facility is fully operational in 1999, royalty and property tax payments will generate an additional $6 million dollars each year, due to the direct royalty and property tax payments, plus the additional indirect and induced impacts generated by state and local government spending.[18]

Total employment impacts, including direct employment impacts, are summarized in Table 11. The results of the analysis indicate that indirect job creation beyond those workers hired directly for plant construction and operation and maintenance will be relatively small. The largest employment impact is estimated to occur in 1997, when about 110 additional jobs are added as a result of the facility. The relatively small employment impact is not surprising, given the narrow industrial base of the county. It should be noted, however, that many of the jobs created will be transitory: construction-related job creation will occur only between 1993 - 1998.

In the long term, operation of the facility is expected to generate an additional 31 jobs within the county. The largest indirect and induced job creation is likely to occur as a result of steam royalty and property tax expenditures by state and local government entities within the county. These expenditures are expected to lead to about 20 additional jobs within the county. The remaining 12 jobs will be due to direct employment for operations and maintenance at the facility, and indirect and induced employment as a result of wage spending.

Thus, in the long term, the largest estimated employment and income impacts will likely be a result of the royalty and property tax payments that are assumed to accrue to the county. Once the plants are fully operational, these impacts will account for over 90 percent of the estimated increase in total county income and about 60 percent of the new jobs created.

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[18] These estimates are not discounted for inflation. It is assumed that all payments, including wages, will increase at the rate of inflation from 1999 onward.

To gauge the magnitude of these impacts, it is useful to compare them with the existing industry structure in the county presented in Table 12. For example, property tax payments from the fully developed geothermal facility are estimated to be about $3 million (1990$) by the year 1999, when the plant is completed. This may be compared with total 1990 property tax collections in the county of about $2.8 million on taxable property assessed at a value of about $293 million (DOR 1990).

Table 12
Selected Skamania County Revenues
(1990$)

Gilford - Pinchot National Forest	
FY 1989 Timber Receipts	$10,732,099
FY 1990 Timber Receipts	$8,613,236
Pacificorp - 1990 Property Taxes	$430,231
Stevenson Co-Ply - 1990 Property Taxes	$150,047
Burlington Northern Co. - 1990 Property Taxes	$111,991
Hambleton Bros. Lumber Co. - 1990 Property Taxes	$66,964
Total Skamania County - 1990 Property Tax Payments	$2,429,367
100 MW Geothermal Plant (1)	
Royalties	$338,720
Property Taxes	$2,955,000
Total	$3,437,293

Source: Skamania County Assessor's Office
Washington State Dept. of Revenue
WSEO Estimates

Compared to the revenue impacts from existing county activities, a geothermal facility would add a significant dimension to the Skamania County economy. As Table 11 shows, property tax collections and royalty payments dwarf payments by existing industries. Stevenson Co-Ply, for example, the largest private employer in Skamania County, had a property tax bill of only about $150,000 in 1990. The largest property tax payer in the county, Pacificorp, had a 1990 tax bill of about $430,000. In fact, only returned receipts from sales of federal timber represent a larger income source for the county than would geothermal plant taxes and royalties.[19] Thus, development of a geothermal facility would more than double total assessed value and total property tax collections within the county. This additional revenue, as well as the revenue from returned steam royalties, would be available to the county for further expenditures. The additional revenue would also be especially important to the county if timber receipts from logging activities continue to decrease, as is likely.

On an employment basis, however, the impacts of geothermal plant development are quite small relative to existing industries. The modular design of many geothermal plants has reduced both the construction and the operating workforces required. Development would lead to only marginal increases in total employment, and much of that impact would occur only during the construction phase. However, unlike many service sector jobs, the jobs that were created through construction and operation of the geothermal facility would tend to be higher paying, resulting in greater economic impacts per job.

VIII. CONCLUSIONS AND LIMITATIONS.

One reason that the inter-industry impacts are relatively small is due to the lack of a geothermal industry infrastructure within the county. If major geothermal resource development were to occur over time, it is more likely that this infrastructure would develop. In that case, more of the materials and employees for development would come from local sources, resulting in larger economic impacts to the county.

VIII.A. Limitations of the Study.

This study has presented estimates of the economic impacts of geothermal development in Skamania County. However, the study does not constitute a true benefit-cost analysis of geothermal development within the county. For example, potentially adverse environmental impacts that might accompany development were not estimated. Nor was an attempt made to estimate the potential for adverse economic impacts due to development, such as reductions in tourism expenditures as a result of plant development, or the costs associated with "boom-town" impacts on the local infrastructure. Development might be accompanied by a corresponding need to increase public services in the county (e.g., schools, highways, medical services, etc.). While

[19] This does not include aggregate property tax collections from individual homeowners, however.

these would register as economic impacts, it is not clear whether they would be counted as benefits or costs.[20]

No attempt has been made to formally assess the value of plant development in comparison with other types of electric resources, whether efficiency or generation resources, nor was an attempt made to compare the quantifiable benefits of plant development with the quantifiable costs. Such an analysis would be quite complex and time consuming.

Lastly, the economic impacts estimated may differ significantly from actual impacts, depending on the actual nature of the plant constructed, the presence of similar development in other areas of the state or region, and the health of the economy in Skamania and surrounding counties. The methodology used in this study also assumes a static economy. Estimating economic impacts over time would ideally use a dynamic specification that preserved the detail available with the input-output framework.

Thus, the limitations of this study point to the need for further work if geothermal plant development becomes imminent within Skamania County. Such work would include identification and quantification of environmental impacts, more detailed estimation of the benefits and the costs of development, and an improved dynamic input-output specification to estimate long-term economic impacts on the Skamania County economy.

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[20] An example may clarify this point. Suppose there is a rash of forest fires, requiring an increase in the number of firefighters hired. There would certainly be an economic impacts associated with this hiring. However, it is doubtful that we would conclude from the increased demand for firefighters that forest fires benefit society.

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APPENDIX A: INPUT - OUTPUT MODELS.

This section begins with a brief overview of input-output analysis fundamentals and then describes the Micro IMPLAN software used for the actual analysis. For a thorough discussion of input-output analysis, the interested reader is referred to Miller and Blair (1985) and references cited therein.

Input-output analysis is the name given to an analytical framework developed by Professor Wassily Leontief in the late 1930s. In its most basic form, an input-output model consists of a system of linear equations, each one of which describes the distribution of an industry's product throughout the economy (Miller and Blair 1985). The basic Leontief model is usually constructed from observed economic data for a specific country or region. The primary focus is industries which both produce goods and services (outputs) while simultaneously consuming goods and services from other industries (inputs). This basic information from which an input-output (I/O) model is developed is contained in an inter-industry transactions table. From this information, economic relationships about the linkages between industries can be developed. In addition, input-output models can incorporate the further economic interactions associated with consumers, government spending, exports, and imports into an economy.

Each industry in an economy sells its output to other industries, as well as to final consumers of products. Thus, if there are N industries in an economy, let X_J represents industry J's total output. Then, we may write

$$\begin{aligned} X_1 &= Z_{11} + Z_{12} + \ldots + Z_{1N} + Y_1, \\ &\;\vdots \\ X_I &= Z_{I1} + Z_{I2} + \ldots + Z_{IN} + Y_I, \\ &\;\vdots \\ X_N &= Z_{N1} + Z_{N2} + \ldots + Z_{NN} + Y_N, \end{aligned} \qquad (1)$$

where the Z_I represent inter-industry sales or output in dollars. In addition to inter-industry sales, there are also sales to final demand (households, government, and foreign trade), which is incorporated into Y_I.

Industries must also purchase inputs. These inputs will consist of purchases from itself and other industries, plus payments for labor and capital, inventories, etc.. These latter items are sometimes lumped together and called value-added. They are represented by V_J. The sum of any given industry's inter-industry purchases, plus value added equal its total outlays. The sum of that industry's inter-industry sales, plus sales to final demand, equal the industry's total output. Thus, we can also write:

$$X_1 = Z_{11} + Z_{12} + \ldots + Z_{1N} + V_1,$$
$$\cdot$$
$$X_J = Z_{JI} + Z_{J2} + \ldots + Z_{JN} + V_J, \qquad (2)$$
$$\cdot$$
$$X_N = Z_{N1} + Z_{N2} + \ldots + Z_{NN} + V_N,$$

Each column $[Z_{1K}, Z_{.2K} \ldots, Z_{NK}]'$ represents the total purchases of industry J from the other N industries. To this is added total value added V_J, equaling total industry outlays.

By definition, total industry output equals total industry purchases. The magnitudes of these inter-industry flows, together with final demand payments and value-added can be recorded in a table, called the transactions table. An example for a simple two industry economy is shown in Table 1. In the table, industry 1 purchases output from itself and from industry 2. These purchases are represented by Z_{11} and Z_{21}, respectively. Industry one also contributes value added to its product equal to an amount V_1. The sum of Z_{11}, Z_{21}, and V_1 equal industry one's total outlays, X_1.

Industry 1 also sells its output to itself and industry 2, as well as to consumers. The sum of the purchases equal $Z_{11} + Z_{12} + Y_1$ and must equal total output X_1.

Table A-1

Flow Table for A Two Sector Economy

	Industry		Final Demand (Y)	Total Output
Industry	Z_{11}	Z_{12}	Y_1	X_1
	Z_{21}	Z_{22}	Y_2	X_2
Valued Added (V)	V_1	V_2		Y_{tot}
Total Expenditures	X_1	X_2	Y_{tot}	X_{tot}

Input-output analysis also assumes that inter-industry flows from I to J depend entirely on the output in sector J. Input-output analysis assumes that the ratio of these flows is fixed. Thus, if we know industry J's output, we can immediately know Z_{IJ}, the flow of industry I's output to industry J. The ratio of the inter-industry flow Z_{IJ} to X_J (i.e., the ratio of input to output) is called the technical or direct coefficient, A_{IJ} Thus,

$$A_{IJ} = Z_{IJ} / X_J. \tag{3}$$

Further, input-output analysis assumes that these relationships are fixed. Thus, to produce a good, an industry will use fixed proportions of goods 1, 2, . . ., N. Thus, we may write

$$X_J = Z_{1J} / A_{1J} = Z_{2J} / A_{2J} = \ldots = Z_{NJ} / A_{NJ}.$$

Using this assumption, (1) can be rewritten as:

$$\begin{aligned} &X_1 - A_{11}X_1 - A_{12}X_2 - \ldots - A_{1N}X_N = Y_1, \\ &. \\ &X_I - A_{I1}X_1 - A_{I2}X_2 - \ldots - A_{IN}X_N = Y_I, \\ &. \\ &X_N - A_{N1}X_1 - A_{N2}X_2 - \ldots - A_{NN}X_N = Y_N, \end{aligned} \tag{4}$$

or in matrix form,

$$(\mathbf{I} - \mathbf{A})\mathbf{X} = \mathbf{Y}. \tag{5}$$

Equation (2) shows the interdependence of the industries in an economy. Thus, changes in the total demand for any single industry Xi may affect the total output in all other industries. Assuming a solution can be found to (3), we can solve for X. Thus,

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{Y} = \mathbf{BY}. \tag{6}$$

The matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is called the Leontief inverse and forms the basis for analyzing the impacts of final demand changes on total output, income, and employment in a region that occur due to changes in specific industry outputs. The elements B_{IJ} of the Leontief inverse matrix reveal the degree of interdependence within an economy. These elements are also used to develop multipliers that determine total changes in an economy for given changes in the demand for specific goods and services.

The main strength of an I/O model is its level of detail, which allows for estimates of industry specific impacts. This level of detail will be different for each model, depending on the resources available to construct the model and the requirements of policy makers.[21] Its weaknesses are its static nature and the degree of detail required for the input data. Despite its static nature, however, the model can be used as a baseline for projections as long as the underlying production relationships within an economy do not change over the production period.

Another potential weakness associated with the level of detail required for an I/O model to be constructed is the cost of data collection. The Washington State Input-Output Model (Bourque 1987), for example, cost several hundred thousand dollars and took several years to produce, yet breaks the economy into only 52 distinct industry sectors. One alternative to survey-based models are non-survey models. Non-survey models are relatively inexpensive to develop and are considered to be reasonably accurate. (For a comparison of widely used models, see Bruckner, Hastings, and Latham 1987). One widely used non-survey model is the U.S. Forest Service Micro IMPLAN model, which adapts a national input-output table to the local economy by using national production coefficients and local employment data. IMPLAN includes a data base of information

[21] For example, the Washington state I/O model is broken down into 52 separate industries (Bourque 1987).

from secondary sources (e.g., County Business Patterns, Census of Manufacturers, etc.) and software that allows regional models to be constructed down to the individual county level.[22]

Micro IMPLAN uses this basic framework to develop an economic model for the region in question. Thus, given information about the Skamania County economy, IMPLAN develops a set of multipliers that can be used to gauge the impacts from geothermal plant development, or other changes in the local economy. In general, these changes are modeled as changes in the final demands for specific goods and services consumed within the modelling region. The IMPLAN database includes a matrix of technical coefficients that describe the production functions for each of 528 industries. These technical coefficients are based on 1977 data, price updated to 1982 dollars. Using this data, a model specific to Skamania County is constructed. The model will estimate multipliers specific to the county. Then, using the assumptions about construction and operation of the geothermal facilities, estimates of the total economic impacts on Skamania County can be determined.

[22]A recent study done for the Bonneville Power Administration to assess the impacts of fishery enhancement in Washington State used IMPLAN for part of its analysis. See Mack, et al. (1989). Some of the description of the distinct economic impacts, as well as IMPLAN, are taken from this report.

APPENDIX B: EXPENDITURE PATTERNS - SKAMANIA COUNTY.

Appendix B.1: Wage Expenditure Patterns.

PERSONAL CONSUMPTION EXPENDITURE PATTERNS
FRACTION OF TOTAL CONSUMER SPENDING WITHIN REGION
NOTE: INDUSTRY BASED
MODEL:: SKAMANIA

INDUSTRY		PCE - LOW	PCE - MED	PCE -HI
POULTRY AND EGGS	2	.00001	.00001	.00000
CATTLE FEEDLOTS	5	.00000	.00001	.00000
MISCELLANEOUS LIVESTOCK	9	.00020	.00020	.00015
HAY AND PASTURE	13	.00000	.00001	.00001
FRUITS	16	.00179	.00136	.00111
VEGETABLES	18	.00004	.00003	.00002
AGRICULTURAL, FORESTRY, FISHERY	26	.00020	.00020	.00020
LANDSCAPE AND HORTICULTURAL SERV	27	.00000	.00001	.00000
SAWMILLS AND PLANING MILLS, GENE	161	.00025	.00027	.00026
VENEER AND PLYWOOD	166	.00002	.00003	.00004
WOOD PRODUCTS, N.E.C	172	.00014	.00017	.00023
WOOD CONTAINERS	173	.00014	.00019	.00023
NEWSPAPERS	200	.00087	.00088	.00087
FABRICATED STRUCTURAL METAL	308	.00001	.00001	.00002
PIPE, VALVES, AND PIPE FITTINGS	327	.00002	.00002	.00002
ELECTRON TUBES	393	.00007	.00007	.00007
ELECTRONIC COMPONENTS, N.E.C.	395	.00037	.00036	.00035
MOTOR VEHICLE PARTS AND ACCESSOR	404	.00004	.00005	.00006
SPORTING AND ATHLETIC GOODS, N.E	433	.00033	.00053	.00058
RAILROADS AND RELATED SERVICES	446	.00112	.00081	.00110
MOTOR FREIGHT TRANSPORT AND WARE	448	.00346	.00249	.00247
WATER TRANSPORTATION	449	.00117	.00084	.00114
COMMUNICATIONS, EXCEPT RADIO AND	454	.00216	.00172	.00128
ELECTRIC SERVICES	456	.00783	.00777	.00573
WATER SUPPLY AND SEWERAGE SYSTEM	458	.00007	.00007	.00006
OTHER WHOLESALE TRADE	461	.00206	.00202	.00197
RECREATIONAL RELATED RETAIL TRAD	462	.00025	.00038	.00047
OTHER RETAIL TRADE	463	.02793	.02739	.02681
BANKING	464	.01182	.01277	.01455
CREDIT AGENCIES	465	.00024	.00026	.00030
INSURANCE CARRIERS	467	.00035	.00052	.00067
OWNER-OCCUPIED DWELLINGS	469	.07204	.10129	.13735
REAL ESTATE	470	.02228	.01221	.00422
HOTELS AND LODGING PLACES	471	.00353	.00325	.00568
FUNERAL SERVICE AND CREMATORIES	473	.00050	.00054	.00062
ELECTRICAL REPAIR SERVICES	475	.00028	.00019	.00019
BEAUTY AND BARBER SHOPS	477	.00053	.00049	.00049
OTHER BUSINESS SERVICES	486	.00011	.00011	.00011
LEGAL SERVICES	488	.00376	.00406	.00463
ACCOUNTING, AUDITING AND BOOKKEE	490	.00005	.00002	.00001

INDUSTRY		PCE - LOW	PCE - MED	PCE - HI
EATING AND DRINKING PLACES	491	.00706	.00868	.00827
AUTOMOBILE REPAIR AND SERVICES	493	.00572	.00712	.00635
MOTION PICTURES	495	.00006	.00008	.00011
MEMBERSHIP SPORTS AND RECREATION	501	.00028	.00033	.00048
AMUSEMENT AND RECREATION SERVICE	502	.00140	.00244	.00265
DOCTORS AND DENTISTS	503	.01126	.00834	.00688
HOSPITALS	504	.01923	.01426	.01175
OTHER MEDICAL AND HEALTH SERVICE	506	.00071	.00052	.00043
ELEMENTARY AND SECONDARY SCHOOLS	507	.00245	.00267	.00302
COLLEGES, UNIVERSITIES, SCHOOLS	508	.00028	.00029	.00033
BUSINESS ASSOCIATIONS	510	.00008	.00009	.00011
LABOR AND CIVIC ORGANIZATIONS	511	.00187	.00202	.00230
OTHER NONPROFIT ORGANIZATIONS	513	.00056	.00033	.00059
RESIDENTIAL CARE	514	.00105	.00132	.00201
SOCIAL SERVICES, N.E.C.	515	.00249	.00202	.00323
U.S. POSTAL SERVICE	516	.00138	.00135	.00132
FEDERAL ELECTRIC UTILITIES	517	.00075	.00072	.00051
OTHER FEDERAL GOVERNMENT ENTERPR	518	.07737	.07979	.07625
LOCAL GOVERNMENT PASSENGER TRANS	519	.00199	.00142	.00194
STATE AND LOCAL ELECTRIC UTILITI	520	.01021	.01007	.00738
OTHER STATE AND LOCAL GOVT ENTER	521	.03973	.02888	.02228
HOUSEHOLD INDUSTRY	527	.00116	.00147	.00223
TOTAL FRACTION IN REGION:		.35313	.35782	.37449

Appendix B.2: State and Local Government Expenditure Patterns.

STATE AND LOCAL GOVERNMENT EXPENDITURE PATTERNS
FRACTION OF TOTAL SLG SPENDING WITHIN REGION
NOTE: INDUSTRY BASED
MODEL:: SKAMANIA

INDUSTRY		SLG-NONED	SLG - ED	SLG-TOTAL
FRUITS	16	.00013	.00077	.00034
VEGETABLES	18	.00000	.00005	.00002
LANDSCAPE AND HORTICULTURAL SERV	27	.00066	.00127	.00086
NEW RESIDENTIAL STRUCTURES	66	.00087	.00058	.00077
NEW INDUSTRIAL AND COMMERCIAL BU	67	.00497	.01182	.00722
NEW UTILITY STRUCTURES	68	.06825	.00000	.04582
NEW HIGHWAYS AND STREETS	69	.02042	.00000	.01371
NEW GOVERNMENT FACILITIES	72	.05308	.00000	.03564
LOGGING CAMPS AND LOGGING CONTRA	160	.00000	.00008	.00003
SAWMILLS AND PLANING MILLS, GENE	161	.00021	.00106	.00049
VENEER AND PLYWOOD	166	.00001	.00021	.00008
WOOD PRODUCTS, N.E.C	172	.00010	.00056	.00025
WOOD CONTAINERS	173	.00004	.00019	.00009
NEWSPAPERS	200	.00610	.01145	.00785
FABRICATED STRUCTURAL METAL	308	.00001	.00003	.00002
PIPE, VALVES, AND PIPE FITTINGS	327	.00004	.00008	.00005
ELECTRON TUBES	393	.00013	.00040	.00022
ELECTRONIC COMPONENTS, N.E.C.	395	.00013	.00029	.00018
MOTOR VEHICLE PARTS AND ACCESSOR	404	.00006	.00013	.00009
SPORTING AND ATHLETIC GOODS, N.E	433	.00004	.00016	.00008
RAILROADS AND RELATED SERVICES	446	.00120	.00320	.00186
MOTOR FREIGHT TRANSPORT AND WARE	448	.00282	.00970	.00508
WATER TRANSPORTATION	449	.00084	.00204	.00123
ELECTRIC SERVICES	456	.00001	.00005	.00003
WATER SUPPLY AND SEWERAGE SYSTEM	458	.00006	.00042	.00018
OTHER WHOLESALE TRADE	461	.00070	.00122	.00087
OTHER RETAIL TRADE	463	.00078	.00000	.00052
BANKING	464	.00012	.00040	.00021
INSURANCE CARRIERS	467	.00005	.00071	.00027
REAL ESTATE	470	.01400	.01007	.01271
HOTELS AND LODGING PLACES	471	.03251	.00008	.02185
ELECTRICAL REPAIR SERVICES	475	.00004	.00008	.00005
COMPUTER AND DATA PROCESSING SER	481	.00056	.00185	.00098
MANAGEMENT AND CONSULTING SERVIC	482	.00038	.00050	.00042
OTHER BUSINESS SERVICES	486	.00115	.00378	.00202
LEGAL SERVICES	488	.01233	.01568	.01343
ACCOUNTING, AUDITING AND BOOKKEE	490	.00113	.00185	.00136
EATING AND DRINKING PLACES	491	.00087	.00000	.00058

INDUSTRY		SLG-NONED	SLG - ED	SLG-TOTAL
AUTOMOBILE REPAIR AND SERVICES	493	.00100	.00172	.00123
MOTION PICTURES	495	.00003	.00016	.00007
AMUSEMENT AND RECREATION SERVICE	502	.00000	.00045	.00015
DOCTORS AND DENTISTS	503	.00481	.00000	.00323
HOSPITALS	504	.03304	.00000	.02218
OTHER MEDICAL AND HEALTH SERVICE	506	.00148	.00000	.00099
COLLEGES, UNIVERSITIES, SCHOOLS	508	.00019	.00019	.00019
BUSINESS ASSOCIATIONS	510	.00005	.00045	.00018
FEDERAL ELECTRIC UTILITIES	517	.00005	.00003	.00004
OTHER FEDERAL GOVERNMENT ENTERPR	518	.00824	.00561	.00738
LOCAL GOVERNMENT PASSENGER TRANS	519	.00551	.11425	.04124
STATE AND LOCAL ELECTRIC UTILITI	520	.00009	.00005	.00008
OTHER STATE AND LOCAL GOVT ENTER	521	.01972	.03292	.02406
TOTAL FRACTION IN REGION:		.29901	.23659	.27848

APPENDIX C: ESTIMATED AGGREGATED RESPONSE COEFFICIENTS

Skamania County Model
Impacts per $1,000,000 Wage Expenditures
Analysis of Change in Final Demand
Total Change in Standard TIO - Related Flows

Date: 91-3-19

Sector	Change in Final Demand (MM$)	Change in TIO (MM$)	Change in Employee Compensation (MM$)	Change in Property Income (MM$)	Change in Total Income (MM$)	Change in Value Added (MM$)	Change in Employment (Number of Jobs)
2 Agriculture	.0020	.0026	.0005	.0005	.0009	.0010	.1200
32 Mining	.0000	.0000	.0000	.0000	.0000	.0000	.0000
66 Construction	.0000	.0091	.0016	.0002	.0018	.0018	.1200
160 Manufacturing	.0029	.0081	.0012	.0002	.0014	.0014	.1100
446 Transp & Utilities	.0162	.0234	.0046	.0020	.0066	.0078	.2700
461 W&R Trade	.0355	.0366	.0090	.0043	.0133	.0188	1.4600
464 FIRE	.1530	.1606	.0075	.0911	.0985	.1241	.5300
471 Services	.0704	.0773	.0197	.0048	.0245	.0254	2.5700
516 Government	.1467	.1734	.0487	.0017	.0504	.0504	3.2200
TOTAL	.4267	.4911	.0928	.1048	.1974	.2307	8.4000

Skamania County Model
Impacts per $1,000,000 SLG Expenditures
Analysis of Change in Final Demand
Total Change in Standard TIO - Related Flows

Date: 91-3-19

Sector	Change in Final Demand (MM$)	Change in TIO (MM$)	Change in Employee Compensation (MM$)	Change in Property Income (MM$)	Change in Total Income (MM$)	Change in Value Added (MM$)	Change in Employment (Number of Jobs)
2 Agriculture	.0015	.0016	.0003	.0002	.0005	.0005	.0600
32 Mining	.0000	.0003	.0000	.0000	.0000	.0001	.0000
66 Construction	.1031	.1078	.0341	.0032	.0371	.0386	.9000
160 Manufacturing	.0098	.0161	.0017	.0007	.0024	.0025	.2200
446 Transp & Utilities	.0109	.0195	.0042	.0023	.0064	.0072	.3200
461 W&R Trade	.0069	.0082	.0020	.0010	.0031	.0044	.3000
464 FIRE	.0387	.0441	.0022	.0236	.0259	.0320	.2200
471 Services	.0802	.0934	.0176	.0058	.0235	.0245	2.6800
516 Government	.0956	.1170	.0422	-.0029	.0393	.0393	3.5100
TOTAL	.3467	.4080	.1043	.0339	.1382	.1491	8.2100