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COMMUNITY HEAT-PUMP SYSTEM,  
KLAMATH COUNTY, OREGON

March 1982

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Geo-Heat Center  
Oregon Institute of Technology  
Klamath Falls, Oregon

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COMMUNITY HEAT PUMP SYSTEM  
KLAMATH COUNTY, OREGON

The following study is the result of a request to the Geo-Heat Center for Technical Assistance.

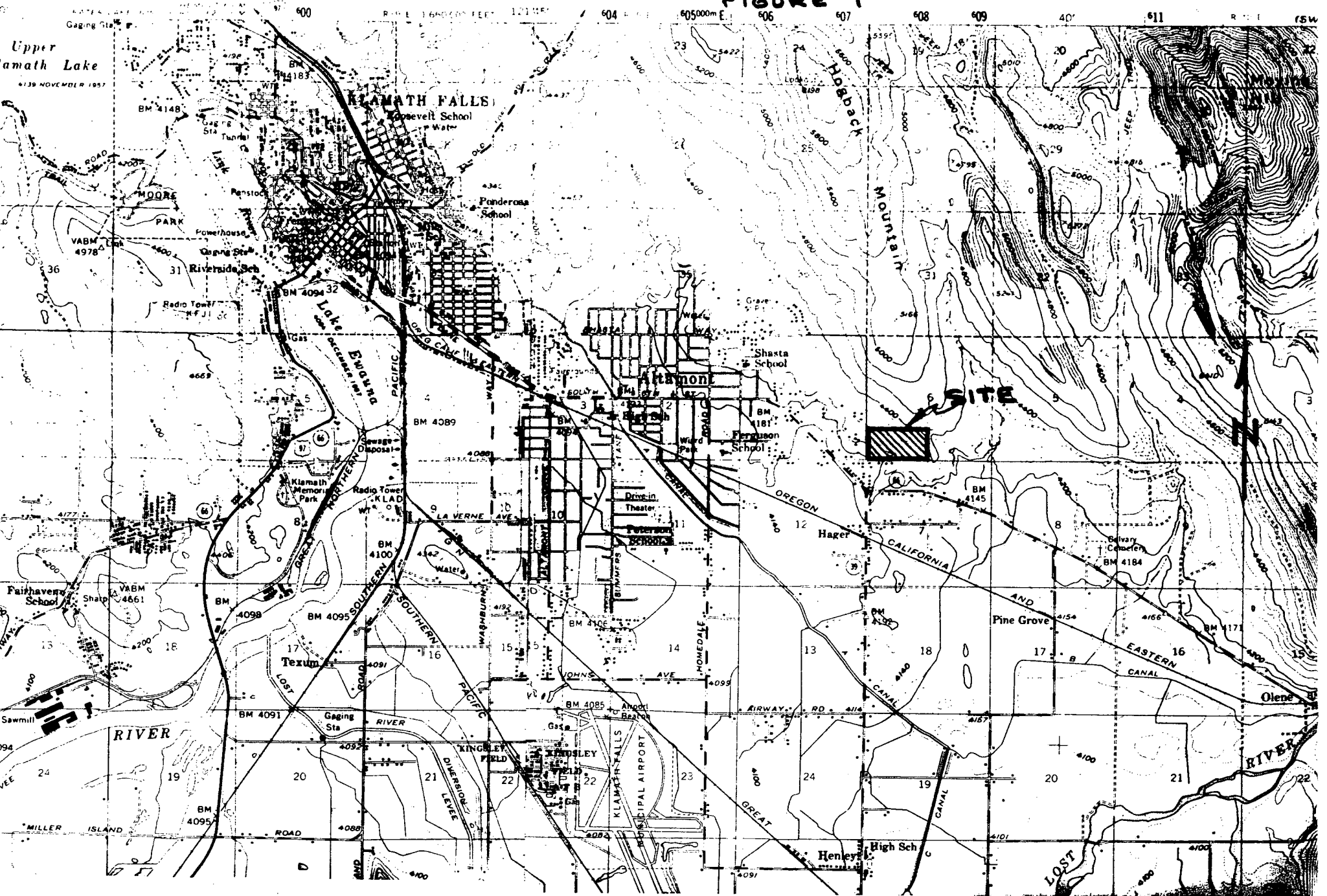
INTRODUCTION

On February 19, 1982, a meeting was held with a representative of Shield Crest, Inc. to discuss the possibility of heating 47 proposed homes on a new development site using ground water source heat pumps. The Shield Crest tract is located approximately five miles southeast of downtown Klamath Falls, Oregon (see Figure 1). Two moderate capacity (greater than 450 gpm) warm water wells are located on the property. The pumping temperatures are 78°F for #1 Well and 75°F for #2 Well, neither temperature is hot enough for direct space heating. Temperature profiles of the wells indicate that a temperature hot enough for direct heating (about 110°F or above) cannot be found at reasonable depth. Since direct geothermal heating is not a practical alternative, the tract will be all-electric since this is the only energy source in the area. This study addresses the economic feasibility of a community heat pump system that would reduce the amount of electrical energy required to service the homes.

SUMMARY OF CONCLUSIONS

The community heat pump system furnishing space heating and domestic hot water is technically and economically feasible. The economics are based on a 12% interest rate on the \$260,000 incremental capital investment, and a projected electricity cost of \$.0560 per kilowatt hour starting in 1983. The 20 year life cycle analysis (Table 3) indicates

# SITE LOCATION COMMUNITY HEAT PUMP SYSTEM FIGURE 1



the comparative cost of energy furnished. First year energy cost for the heat pump system is \$.0544/kwh versus \$.0560/kwh for the conventional all-electric, a savings of 2.86%. In the 20th year, the respective energy costs are \$.1579/kwh versus \$.2799/kwh, a savings of 43.59%. In addition, the heat pump system has a peak electrical requirement of 538 kw less than a conventional all-electric system. The estimated incremental capital investment for the heat pump system is \$260,000. This amounts to approximately \$483 per kw of peak electricity, which is about one third the cost of new electrical generating capacity.

During the 20 year life cycle, the community heat pump system will save over 18 million kilowatt hours of electricity.

#### COMMUNITY ENERGY LOAD

Energy is needed in the 47 home community for space heating and heating domestic hot water. Air conditioning loads are not considered, though the heat pumps will be capable of furnishing cooling if desired.

Peak space heating load was calculated based on 2,000 square feet homes of wood frame construction with R-30 insulation in the ceiling, R-11 in the walls, and R-19 in the floor. All windows are double glazed, and air infiltration amounts to about one air change per hour. With a design inside temperature of 65°F, and an outside design temperature of 3°F, the calculated space heating load is 43,160 Btu/hr per home.

Domestic hot water heating load was calculated based on HUD/FHA requirements for a 2 bath, 3 bedroom home of raising 66 gallons of water 100°F in temperature during a 3 hour period. This amounts to 18,326 Btu/hr per home.

Total peak energy load is 61,486 Btu/hr per house, or a total of 2,889,842 Btu/hr for the 47 homes. For conventional all-electric this would amount to a peak electrical load of slightly less than 847 kw. The heat pump system is based on a coefficient of performance of 3, which means that two-thirds of the energy required comes from the water, and only one-third from electricity. However, additional electricity is needed to pump the water out of the ground, through the piping, and through the heat pump. The following summarizes the peak electricity demand.

	<u>Conventional (kw)</u>	<u>Heat Pump (kw)</u>	<u>Savings (kw)</u>
Space heating	595	198	397
Hot water	252	84	168
Well pump	0	18	(18)
Circulating pump	<u>0</u>	<u>9</u>	<u>(9)</u>
	847	309	538

Annual space heating load was calculated on the basis of applying the peak load over 1876 hours. Hours were calculated using the degree day method (6623°F-day) correction factor (.732). Annual hot water heating load is based on an average usage of 84 gallons of hot water per day for each of the 47 homes. The following summarizes the annual electrical usage for space heating and hot water.

	<u>Conventional (kwh)</u>	<u>Heat Pump (kwh)</u>	<u>Savings (kwh)</u>
Space heating	1,115,002	371,589	743,413
Hot water	351,707	117,211	234,496
Well pump	0	46,426	(46,426)
Circulating pump	<u>0</u>	<u>23,348</u>	<u>(23,348)</u>
	1,466,709	558,574	908,135

In the above tables, the kw and kwh figures for heat pump space heating and hot water have been prorated for comparison purposes. In actuality, they are not separate, but a total figure dependent on refrigerant pumping and compression.

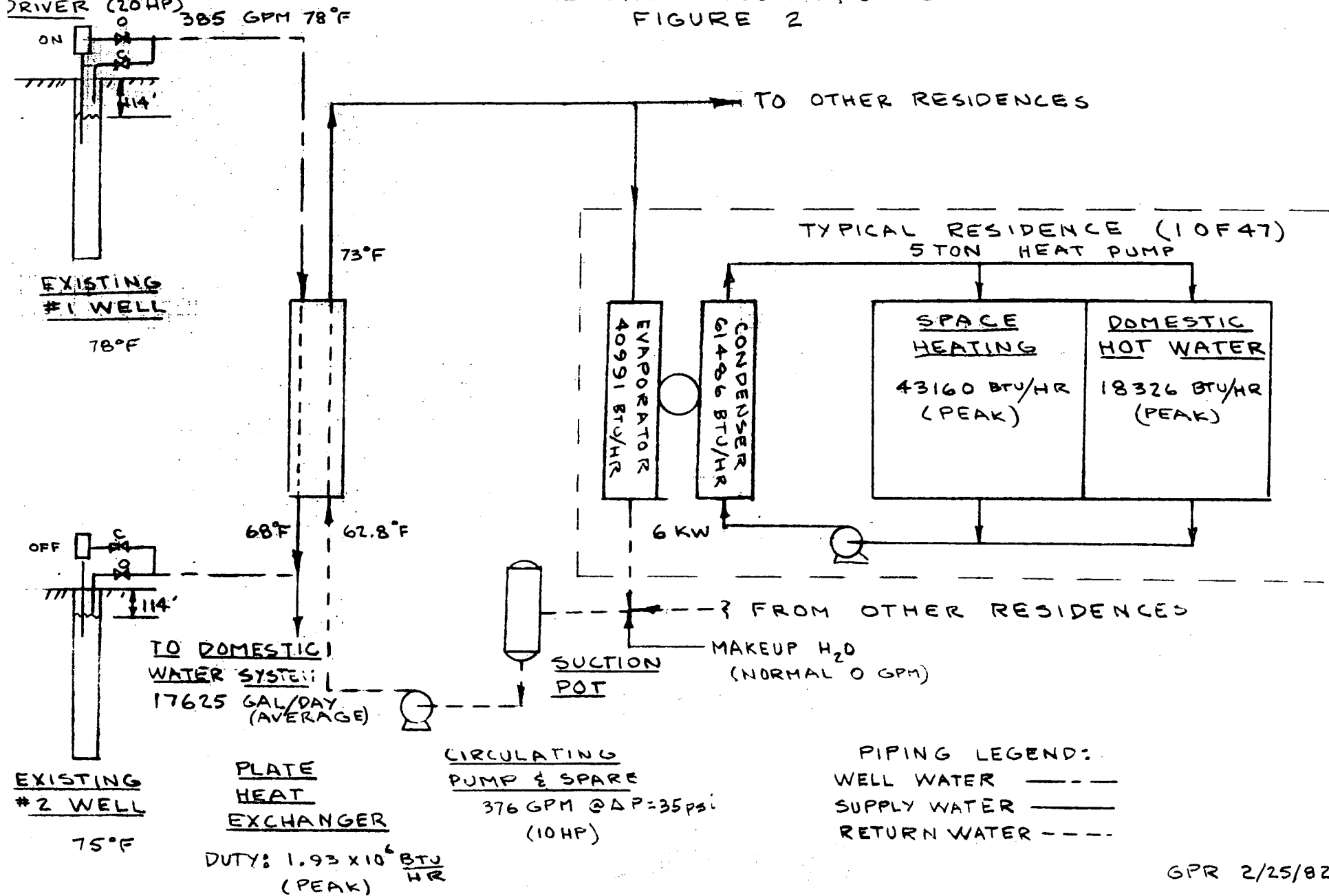
The annual electrical savings resulting from the heat pump system is approximately 62%.

#### DESCRIPTION OF SYSTEM

Figure 2, Flow Diagram, shows the key components involved in this conceptual system. Each house is equipped with an individual water source heat pump with a nominal capacity of five tons. The heat pump is capable of space heating and furnishing domestic hot water. If desired, the heat pump could also provide space cooling. A circulating supply/return system provides the maximum of 8 gpm needed by each of the 47 individual heat pumps. Circulation is maintained by a 375 gpm pump that develops a differential pressure of 35 psig using a 10 hp electric motor driver. The pump is spared. The circulating stream enters the  $1.93 \times 10^6$  Btu/hr plate heat exchanger at 62.8°F and leaves at 73°F. On the other side of the plate heat exchanger, 385 gpm of well water is cooled from 78°F to 68°F. As shown on Figure 2, a turbine pump

TURBINE PUMP (2)  
 N/VARIABLE SPEED  
 DRIVER (20HP)

FLOW DIAGRAM  
 COMMUNITY HEAT PUMP SYSTEM  
 KLAMATH COUNTY, OREGON  
 FIGURE 2



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with variable speed driver is set in each well. The electric motor is 20 HP. Well water can be pumped in either direction, drawing from one well and injecting into the other. During the peak heating system, the warmer water will be used from #1 Well. The coefficient of performance is slightly higher with the warmer water. Both wells are existing, with 10" casing set to 188 feet in #1 Well, and 8" casing set to 46 feet in #2 Well.

Figure 3, Piping Layout, shows the proposed routing and size of the circulating supply and return piping. Also shown is the location of the two pump buildings, the heat exchanger/circulating pump building, and routing and size of the well water piping.

This conceptual design utilizes a plate heat exchanger, heat pump supply and return piping entirely separate from the potable water piping. Some states, other than Oregon, have approved the direct use of drinking water as heat pump water. This should be investigated in the final design since approval would permit the use of properly specified supply/return piping for potable water use. The necessity of chlorinating domestic water and the acceptability of injecting this water would have to be considered.

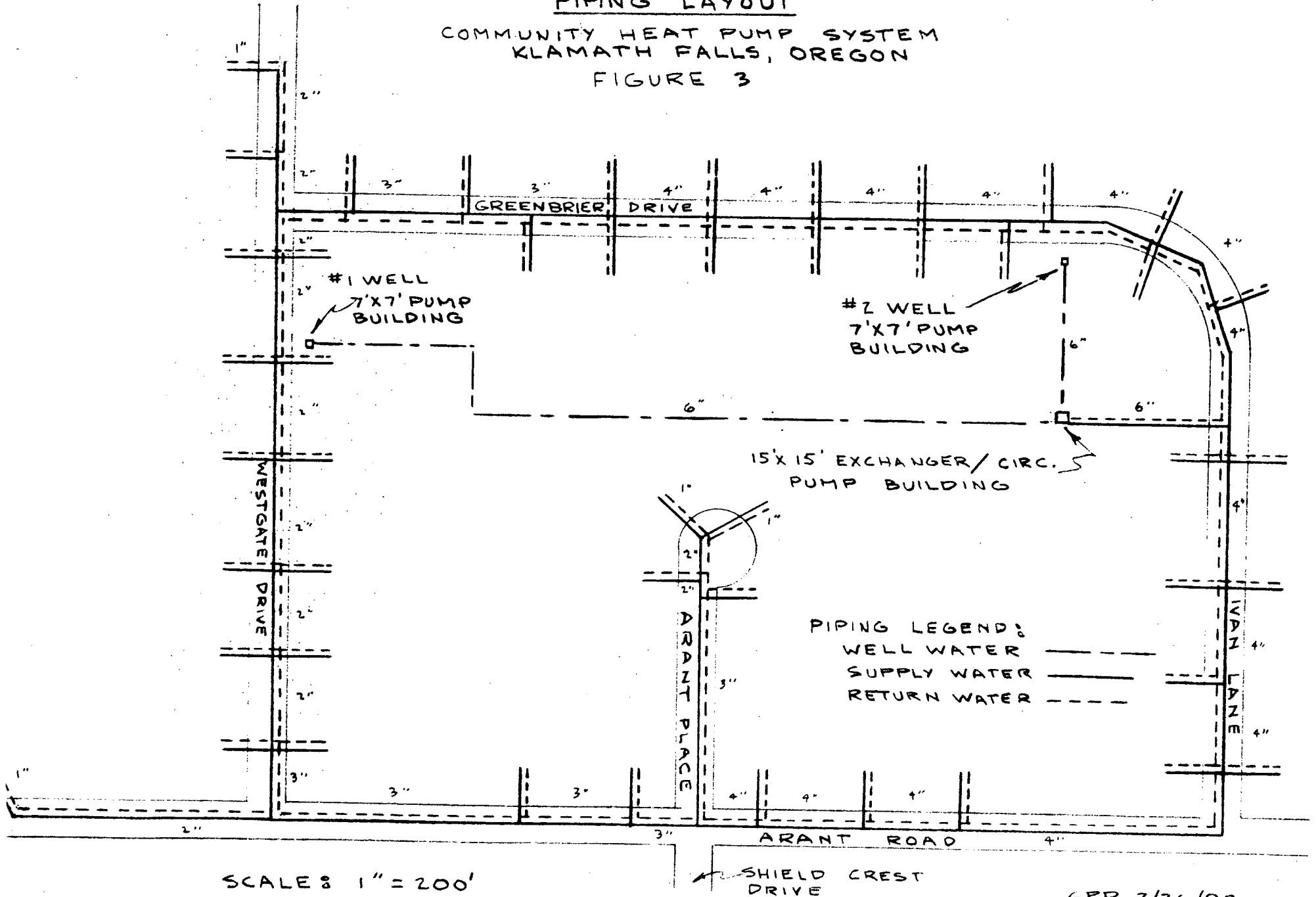
#### WATER USAGE

From Figure 2, the peak well water usage is 385 gpm. This is based on extracting  $1.93 \times 10^6$  Btu/hr from 78°F water by reducing the temperature by 10°F. Optimizing the design may indicate that it is de-

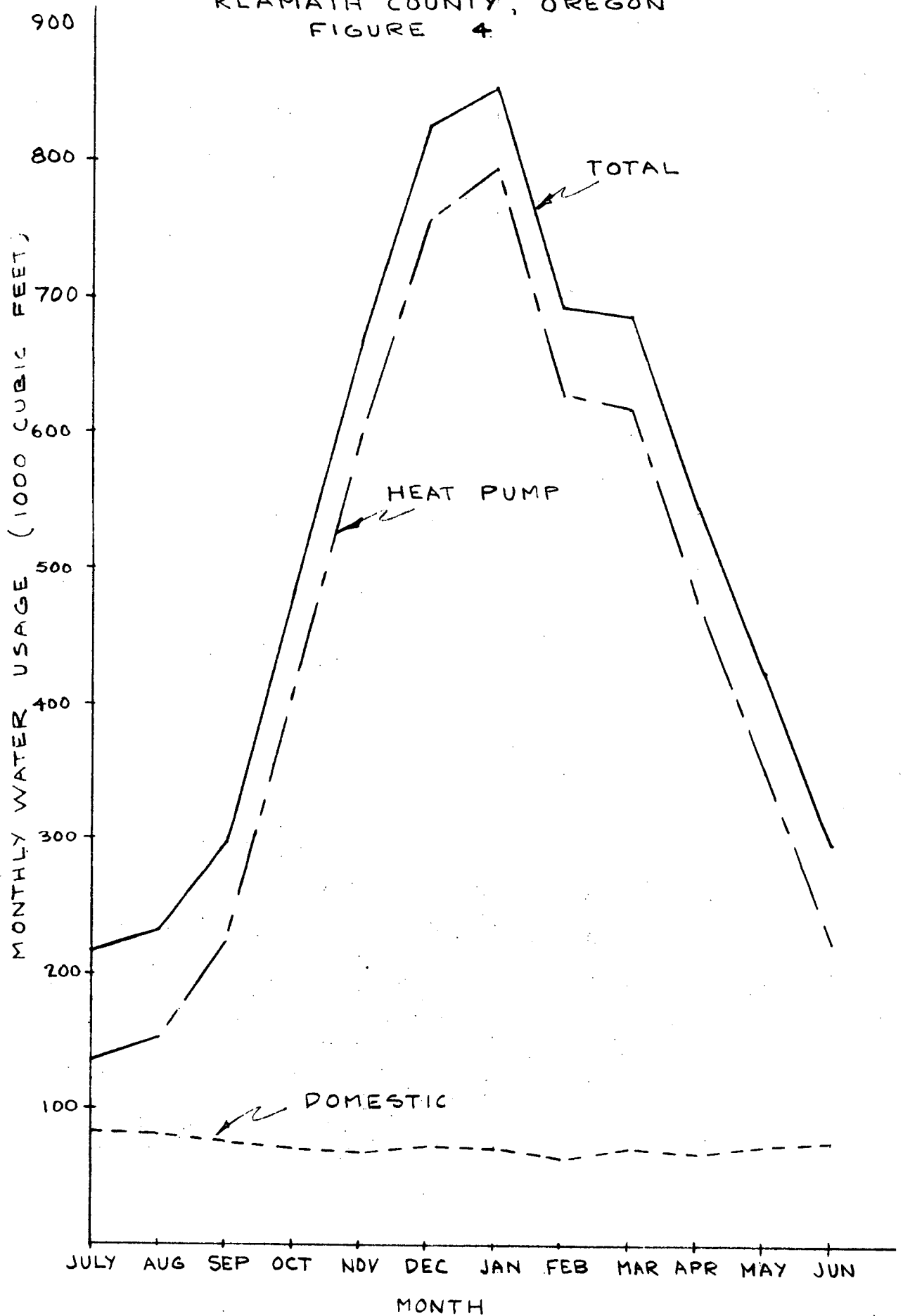
# PIPING LAYOUT

COMMUNITY HEAT PUMP SYSTEM  
KLAMATH FALLS, OREGON

FIGURE 3



MONTHLY WELL WATER USAGE  
 COMMUNITY HEAT PUMP SYSTEM  
 KLAMATH COUNTY, OREGON  
 FIGURE 4



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sirable to reduce the flowing quantity and increase the temperature drop, still supplying the  $1.93 \times 10^6$  Btu/hr. However, based on a 10°F temperature drop, Figure 4 shows the monthly water needed by the heat pump system. The monthly domestic water usage is also shown. Heat pump water requirements far exceed domestic water requirements.

#### CAPITAL AND OPERATING COST

Table 1 summarizes capital and operating costs. Total capital cost in 1982 dollars is \$260,000. This is an incremental investment, since credit was taken for electrical furnaces (47) and domestic water pumps (2) that will not be needed if the heat pump system is installed.

Piping cost is based on using PVC pipe throughout. Polypropylene pipe can be used if desired, or other pipe that can meet service requirements and local specifications. It is assumed that the supply and return pipes are buried in the same trench with domestic water lines.

Operating costs, after a credit for lifting the domestic water to the surface, total \$32,639 per year.

#### LIFE CYCLE COST ANALYSIS

Life cycle cost analysis for the conceptual community heat pump system at the Shield Crest Tract, Klamath Falls, Oregon, appears in Tables 2 and 3.

It was assumed that the system would come on line in 1983. The

SUMMARY OF CAPITAL AND OPERATING COSTS

SHIELD CREST TRACT

1982 Dollars

TABLE 1

Capital

Piping	70,000
Turbine pumps w/variable speed drivers (2 20hp)	50,000
Circulating pump & spare (2 10hp)	5,000
Plate heat exchanger	6,000
Heat pumps (47 5 ton units)	127,000
Well head buildings (2) & pump/exchanger building	10,000
Miscellaneous mechanical & electrical	<u>10,000</u>
Subtotal	\$278,000
Less credits:	
Electric furnaces (47 43,160 Btu/hr units)	(30,000)
Domestic water pumps (2)	<u>(10,000)</u>
Subtotal	\$238,000
Contingency & engineering fees	<u>22,000</u>
TOTAL CAPITAL COST	\$260,000

Operating Cost (1st 100% year)

Maintenance

Piping & plate heat exchanger	398
Pumps, buildings & heat pumps	<u>9,016</u>
Total maintenance	\$9,414
Insurance & taxes	3,900

Power

System pumping & heat pumps	558,574 kwh
less for pumping domestic water	<u>(6,431)</u>
	552,143 kwh
552,143 kwh @ \$.035/kwh =	<u>19,325</u>
TOTAL OPERATING COST	\$32,639

20 year forecasts assume a 7% economic inflation rate over the project life, and additional inflation rates for conventional fuels as forecast by the Oregon Department of Energy "Fifth Annual Report" as follows:

Electrical Power

7.9% through 1987

9.1% through 2001

Column one provides the 20 year cost of electricity that would be required to heat the community with conventional electric forced air heat.

Column two subtracts the electrical operating costs for the ground water heat pump system.

Column three projects the additional annual costs for property taxes and insurance for the heat pump system, inflation at 2% per annum. These costs are then subtracted from column one.

Column four projects the maintenance costs of the heat pump system inflating at 7% per year and subtracts these costs.

Column five assumes 100% financing of the project and the resulting loan payment that would be required at 12% per year.

Column six shows the 20 year cash flow after all costs of the ground water heat pump system are subtracted from the conventional heating system.

Table 2 uses the current rate for electrical power of \$.035 per kwh. Tabel 3 assumes a rate of \$.052 per kwh which causes the 1983 rate to inflate to \$.056 per kwh. This rate coincides with the rate announced by Pacific Power and Light in conjunction with Title II of the Public Utility Regulatory Policies Act of 1978 as amended by the Energy Security Act of 1980. Notice that with the lower rate, the cost per kwh for the conventional system versus the heat pump system causes the price of the heat pump system to be the most expensive in the early years of the project. However, when the base rate for electrical power is increased to the announced 1983 rate, the heat pump system is more favorable throughout the 20 year project life. The cost of the heat pump system will improve even greater in the 21st and subsequent years due to the fact that the bank loan is retired and annual loan payments are no longer required.

Table 2

LIFE CYCLE COST ANALYSIS  
FOR  
COMMUNITY HEAT PUMP SYSTEM

Date: Mar. 09, 1982

INVESTMENT  
TAX CREDIT 0

STRAIGHT LINE  
DEPRECIATION 0

Co-operative development with no tax credit or depreciation

EQUITY FINANCING 0  
DEBT FINANCING 260000  
COST OF CAPITAL 12%  
TOTAL CAPITAL COST 260000

	1	2	3	4	5	6	7	8	9	
	ELECTRICITY CONVENTIONAL SYSTEM	ELECTRICITY GEOTHERMAL SYSTEM	GEOTHERMAL INSURANCE & PROP. TAX	O & M GEOTHERMAL SYSTEM	ANNUAL BANK LOAN PAYMENT	TOTAL ANNUAL OPERATING EXPENSES	NET ANNUAL SAVINGS	CENTS/KWH CONVENTIONAL SYSTEM	CENTS/KWH HEAT PUMP SYSTEM	
YEAR ZERO	@\$0.035/kwh.									YEAR
AMOUNT	51335	19325	3900	9415						0
YEAR										
1983	55370	20844	3978	10074	34808	69704	-14334	3.78	4.75	1
1984	59722	22482	4058	10779	34808	72127	-12405	4.07	4.92	2
1985	64416	24249	4139	11533	34808	74730	-10314	4.39	5.10	3
1986	69479	26155	4221	12341	34808	77526	-8047	4.74	5.29	4
1987	74940	28211	4306	13204	34808	80530	-5590	5.11	5.49	5
1988	81760	30778	4392	14129	34808	84108	-2348	5.57	5.73	6
1989	89200	33579	4480	15118	34808	87985	1215	6.08	6.00	7
1990	97317	36635	4569	16176	34808	92189	5128	6.64	6.29	8
1991	106173	39969	4661	17308	34808	96746	9427	7.24	6.60	9
1992	115835	43606	4754	18520	34808	101688	14147	7.90	6.93	10
1993	126376	47574	4849	19816	34808	107048	19328	8.62	7.30	11
1994	137876	51903	4946	21203	34808	112861	25015	9.40	7.69	12
1995	150423	56626	5045	22688	34808	119168	31255	10.26	8.12	13
1996	164111	61779	5146	24276	34808	126010	38102	11.19	8.59	14
1997	179045	67401	5249	25975	34808	133438	45612	12.21	9.10	15
1998	195339	73535	5354	27793	34808	141491	53848	13.32	9.65	16
1999	213114	80227	5461	29739	34808	150235	62880	14.53	10.24	17
2000	232508	87527	5570	31820	34808	159726	72781	15.85	10.89	18
2001	253666	95492	5682	34048	34808	170030	83636	17.29	11.59	19
2002	276750	104182	5795	36431	34808	181217	95533	18.87	12.36	20
TOTAL	2743420	1032757	96655	412970	696170	2238552	504869			

Table 3

LIFE CYCLE COST ANALYSIS  
FOR  
COMMUNITY HEAT PUMP SYSTEM

Date: Mar. 09, 1982

INVESTMENT  
TAX CREDIT 0

STRAIGHT LINE  
DEPRECIATION 0

Co-operative development with no tax credit or depreciation

EQUITY FINANCING 0  
DEBT FINANCING 260000  
COST OF CAPITAL 12%  
TOTAL CAPITAL COST 260000

YEAR ZERO	1	2	3	4	5	6	7	8	9	YEAR
AMOUNT	ELECTRICITY CONVENTIONAL SYSTEM @90.052/kwh	ELECTRICITY GEOTHERMAL SYSTEM	GEOTHERMAL INSURANCE & PROP. TAX	O & M GEOTHERMAL SYSTEM	ANNUAL BANK LOAN PAYMENT	TOTAL ANNUAL OPERATING EXPENSES	NET ANNUAL SAVINGS	CENTS/KWH CONVENTIONAL SYSTEM	CENTS/KWH HEAT PUMP SYSTEM	0
	76151	28667	3900	9415						
YEAR										
1983	82136	30920	3978	10074	34808	79780	2356	5.60	5.44	1
1984	88592	33351	4058	10779	34808	82995	5597	6.04	5.66	2
1985	95556	35972	4139	11533	34808	86452	9103	6.51	5.89	3
1986	103066	38799	4221	12341	34808	90170	12897	7.03	6.15	4
1987	111167	41849	4306	13204	34808	94168	17000	7.58	6.42	5
1988	121284	45657	4392	14129	34808	98986	22297	8.27	6.75	6
1989	132321	49812	4480	15118	34808	104218	28103	9.02	7.11	7
1990	144362	54345	4569	16176	34808	109899	34463	9.84	7.49	8
1991	157499	59290	4661	17308	34808	116068	41431	10.74	7.91	9
1992	171831	64686	4754	18520	34808	122768	49063	11.72	8.37	10
1993	187468	70572	4849	19816	34808	130046	57422	12.78	8.87	11
1994	204527	76994	4946	21203	34808	137952	66575	13.94	9.41	12
1995	223139	84001	5045	22688	34808	146542	76597	15.21	9.99	13
1996	243445	91645	5146	24276	34808	155875	87570	16.60	10.63	14
1997	265598	99984	5249	25975	34808	166017	99582	18.11	11.32	15
1998	289768	109083	5354	27793	34808	177038	112729	19.76	12.07	16
1999	316137	119009	5461	29739	34808	189018	127119	21.55	12.89	17
2000	344905	129839	5570	31820	34808	202038	142867	23.52	13.77	18
2001	376291	141655	5682	34048	34808	216195	160099	25.66	14.74	19
2002	410534	154545	5795	36431	34808	231580	178954	27.99	15.79	20
TOTAL	4069625	1532008	96655	412970	696170	2737802	1331823			