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UTILIZATION OF WARM WELL WATER, EASTERN WASHINGTON STATE

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UTILIZATION OF WARM WELL WATER
EASTERN WASHINGTON STATE

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

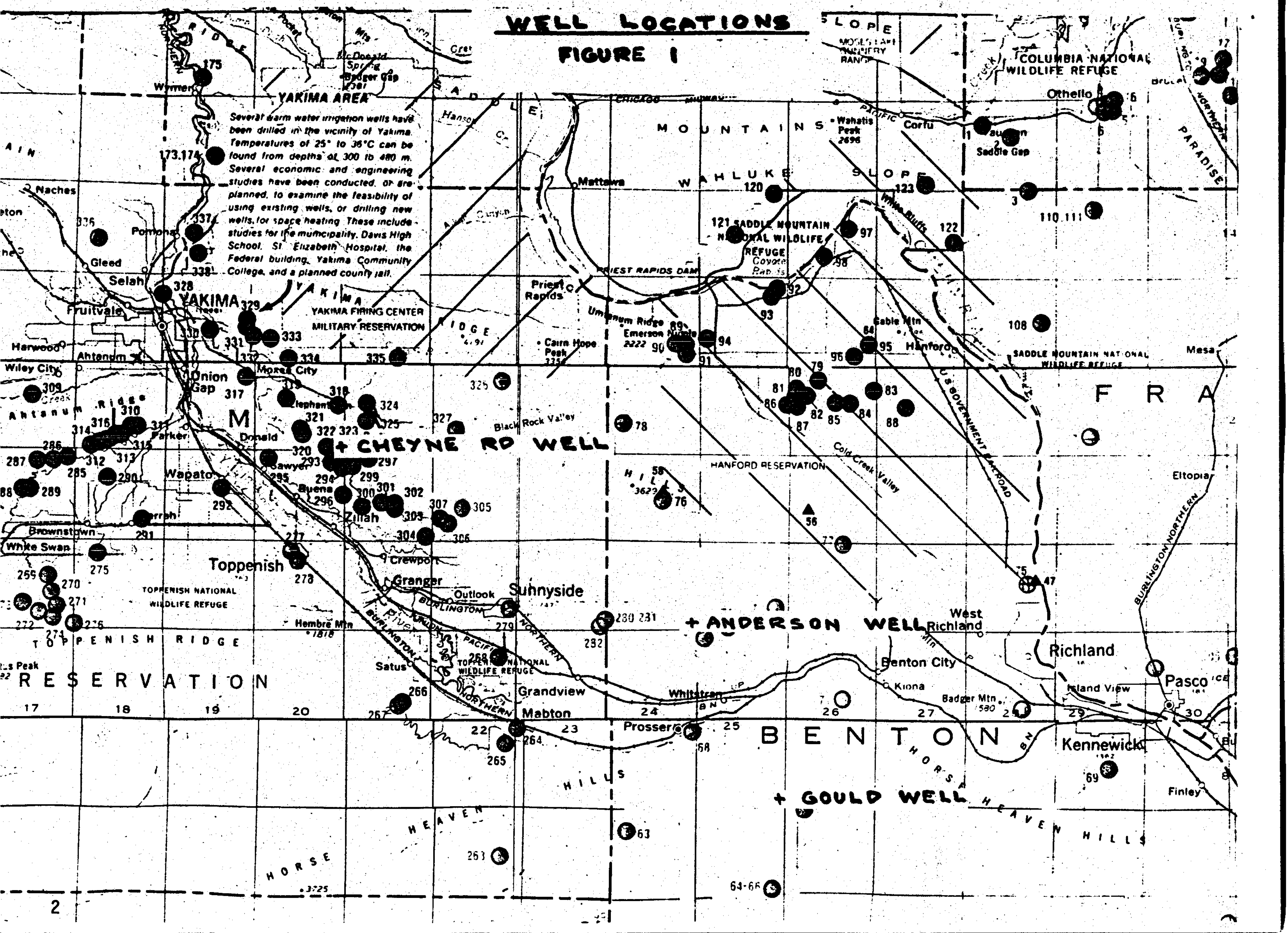
INTRODUCTION

In a letter dated January 15, 1982, an agency of The Department of Natural Resources, State of Washington, asked that the Geo-Heat Center investigate possible applications for using the warm water from three wells in Eastern Washington (see Figure 1). Water temperature of the three wells is between 82°F and 88°F. In their opinion, the water quality is such that it is not currently economically feasible to use the water for conventional irrigated agriculture. Two applications suggested for our investigation were heating of greenhouses and fresh water fish farming. The report addresses the technical and economical feasibility of these two applications.

SUMMARY OF CONCLUSIONS

Utilizing the warm well water for a geothermal greenhouse heating system is highly economically feasible. This is based on using the 88°F water from Anderson Well #1 to heat greenhouses totaling approximately 10.6 acres. The additional investment of $640,000 above the cost for a conventional electric boiler system shows a rate of return of 48.3% on a 20 year life cycle analysis. The simple payback is 3 years.

The 88°F well water is not warm enough for prawn (macrobrachium rosenbergii) aquaculture, since water flow requirements are excessive to maintain the desired 80°F pond temperature. However, the water is warm enough to maintain a 60°F pond temperature for trout farming.


WELL LOCATIONS
FIGURE 1
YAKIMA AREA
Several warm water irrigation wells have been drilled in the vicinity of Yakima. Temperatures of 25° to 36°C can be found from depths of 300 to 480 m. Several economic and engineering studies have been conducted, or are planned, to examine the feasibility of using existing wells, or drilling new wells, for space heating. These include studies for the municipality, Davis High School, St. Elizabeth Hospital, the Federal building, Yakima Community College, and a planned county jail.
+ CHEYNE RD WELL
+ ANDERSON WELL
+ GOULD WELL
YAKIMA FIRING CENTER MILITARY RESERVATION
HANFORD RESERVATION
SADDLE MOUNTAIN NATIONAL WILDLIFE REFUGE
COLUMBIA NATIONAL WILDLIFE REFUGE
TOPPENISH NATIONAL WILDLIFE REFUGE
MOUNTAINS
WAHLUKE SLOPE
TOPPENISH RIDGE
RESERVATION
BENTON
HORSE HEAVEN HILLS
Yakima
Selah
Fruitvale
Union Gap
Moxee City
Wapato
Toppenish
Zillah
Granger
Sunnyside
Grandview
Mabton
Prosser
Benton City
West Richland
Richland
Kennewick
Pasco
Finley
Othello
Mattawa
Hanford
Priest Rapids
PRIEST RAPIDS DAM
Umtanum Ridge
Black Rock Valley
Cold Creek Valley
U S GOVERNMENT RAILROAD
BURLINGTON NORTHERN
2

Trout farming using the 88°F well water directly is probably not economically feasible due to high electrical pumping cost ($34,626 per year) for the seven 1/2 acre ponds that could be heated. Trout farming using the 75°F effluent water from the 10.6 acre greenhouse to heat four 1/2 acre ponds may be economically feasible since the water booster pumping cost is low ($1189 per year).

WELL INFORMATION

Table 1, Well Data & Water Analysis, is a summary of the information available on the three Eastern Washington wells. The water analysis for the Oregon Institute of Technology Well #5 has been included for comparison purposes. Also, the estimated maximum well pumping rates are shown, and the estimated pumping water levels.

The chemical water analysis indicates that any of these three waters could be used in a geothermal heating system without any unusual difficulties. Also, comparing the three waters to the OIT #5 Well suggests that there is a good probability the Washington well water is suitable for aquaculture. Both prawns and trout have been raised in the OIT water. However, additional analysis for flouride, boron, radon and heavy metals would be necessary for a positive determination. The ultimate test is a bioassay using the actual water to be used in the ponds.

Anderson Well #1 has the warmest water (88°F) and the largest estimated pumping capacity (3500 pgm). The greenhouse evaluation is based on using this water.

WELL DATA & WATER ANALYSIS

Table 1

WELL DATA

	County	Town	Range	Sec.	Depth (ft)	Temp. (°F)	Est. Max. Flow (gpm)	Static Level (ft)	Est. Pumping Level (ft)
Cheyne Rd.	Yakima	12 N	20 E	36	1400	80	950	400	690
Gould #1	Benton	18 N	25 E	36	1000	82	2000	739	753
Anderson #1	Benton	10 N	24 E	36	1400	88	3500	762	797

WATER ANALYSIS

	K (Mg/l)	Na (Mg/l)	Ca (Mg/l)	Mg (Mg/l)	HCO_3 (Mg/l)	SO_4 (Mg/l)	pH	SAR
Cheyne Rd.	9.34	67	1.27	0.47	167	0.72	8.5	13
Gould #1	11.50	79	0.23	0.14	183	0.94	8.5	32
Anderson #1	13.20	133	0.01	0.52	288	1.80	8.7	39.4
OIT #5	3.50	331	25.10	1.04	44	3.84	8.2	17.6

GREENHOUSE SYSTEM

The peak heat available from the Anderson Well #1 at 3500 gpm is 22.76 million Btu/hour when the water is cooled to 75°F. For the climatic conditions at the well, calculations show that 10.6 acres of greenhouses can be heated. A flow diagram of the conceptual geothermal heating system is shown on Figure 3. Heating is accomplished by transferring the heat to the greenhouses by forcing air over finned coils in which the warm water is flowing. Figure 3 shows the key flows and temperatures. 160 of the centrifugal fan/finned coil units are required. The units are located at each of the outside ends, with the 78°F warm air distributed using a large diameter plastic tube that runs overhead along the 96 foot length. Air circulation rate amounts to 2.5 SCFM of air per square foot of floor space. Descriptions of the greenhouses and the piping layout are shown on Figure 2.

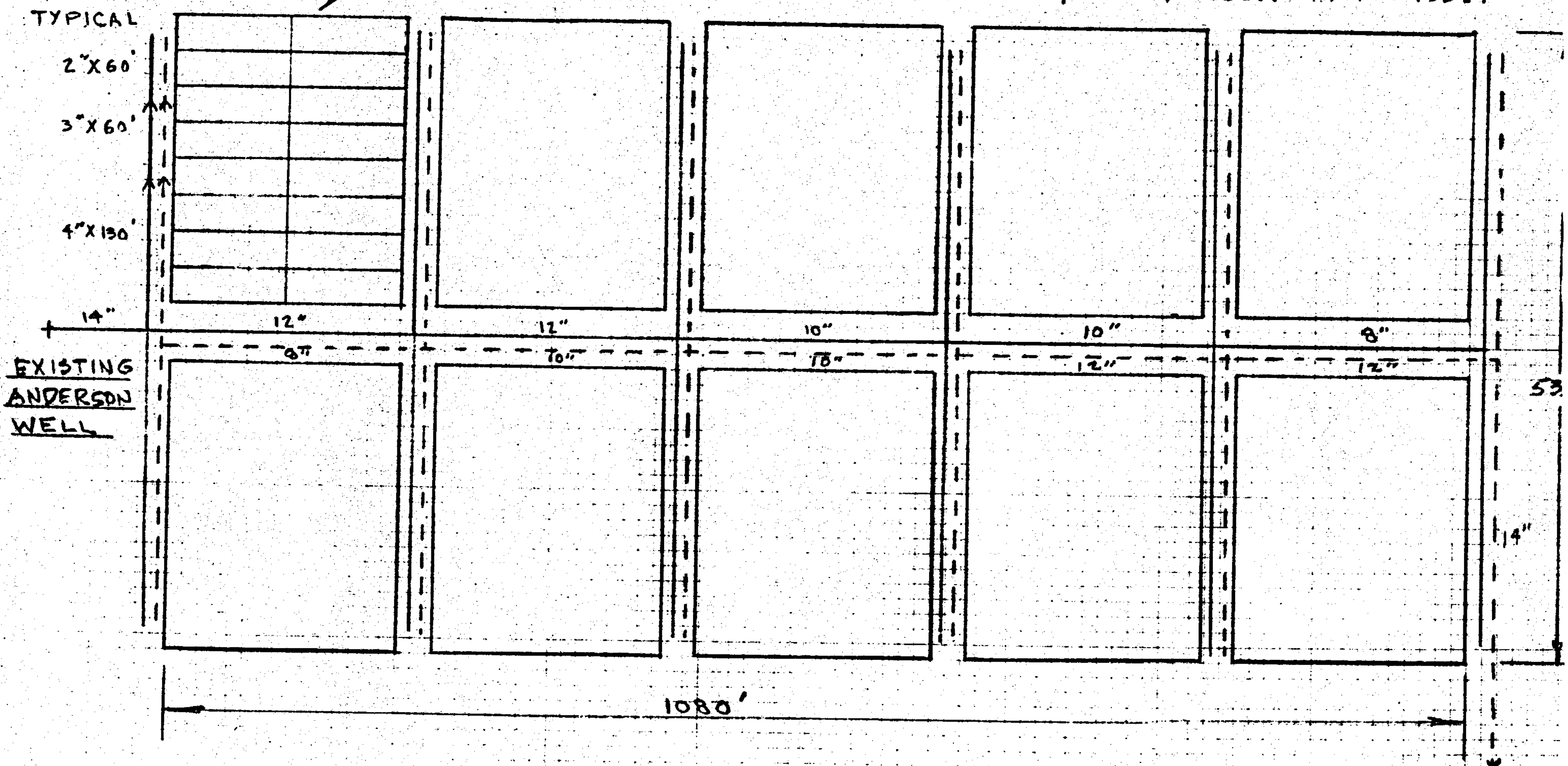
Surface disposal of the 75°F effluent greenhouse water is assumed, and amounts to 1,200 acre feet per year. An alternate method of disposal may be necessary.

GREENHOUSE COSTS

Capital and operating costs for the geothermal heating system for the 10.6 acre greenhouse complex is shown on Table 2. Capital cost is $1,100,000 and first year annual operating cost is $78,435. Table 3 summarizes the capital and operating costs that would occur if the same greenhouse complex was heated with an electric boiler with overhead water convective units. Capital cost is $460,000 and annual op-

GREENHOUSE & PIPING LAYOUT
UTILIZATION OF WARM WELL WATER
FIGURE 2

TYPICAL - 12' HIGH SEMI-CIRCULAR X 30' WIDE AT BASE X 96' LONG. 2 END TO END, 8 PAIR GUTTER CONECTED, GROUND SPACE 192' X 240', 1.058 ACRE, 6 MIL DOUBLE POLYETHYLENE COVER, ROOF/FLOOR RATIO 1.3:1



TO SUREAC DISPOSAL 3500 GPM (PEAK)

NOTE:
ALL PIPING UNINSULATED PVC.
BURY 3 FT DEEP.

PIPING LEGEND:
SUPPLY WATER ————
DISCHARGE WATER - - - -

SCALE:
0 50' 100' 200' 300'

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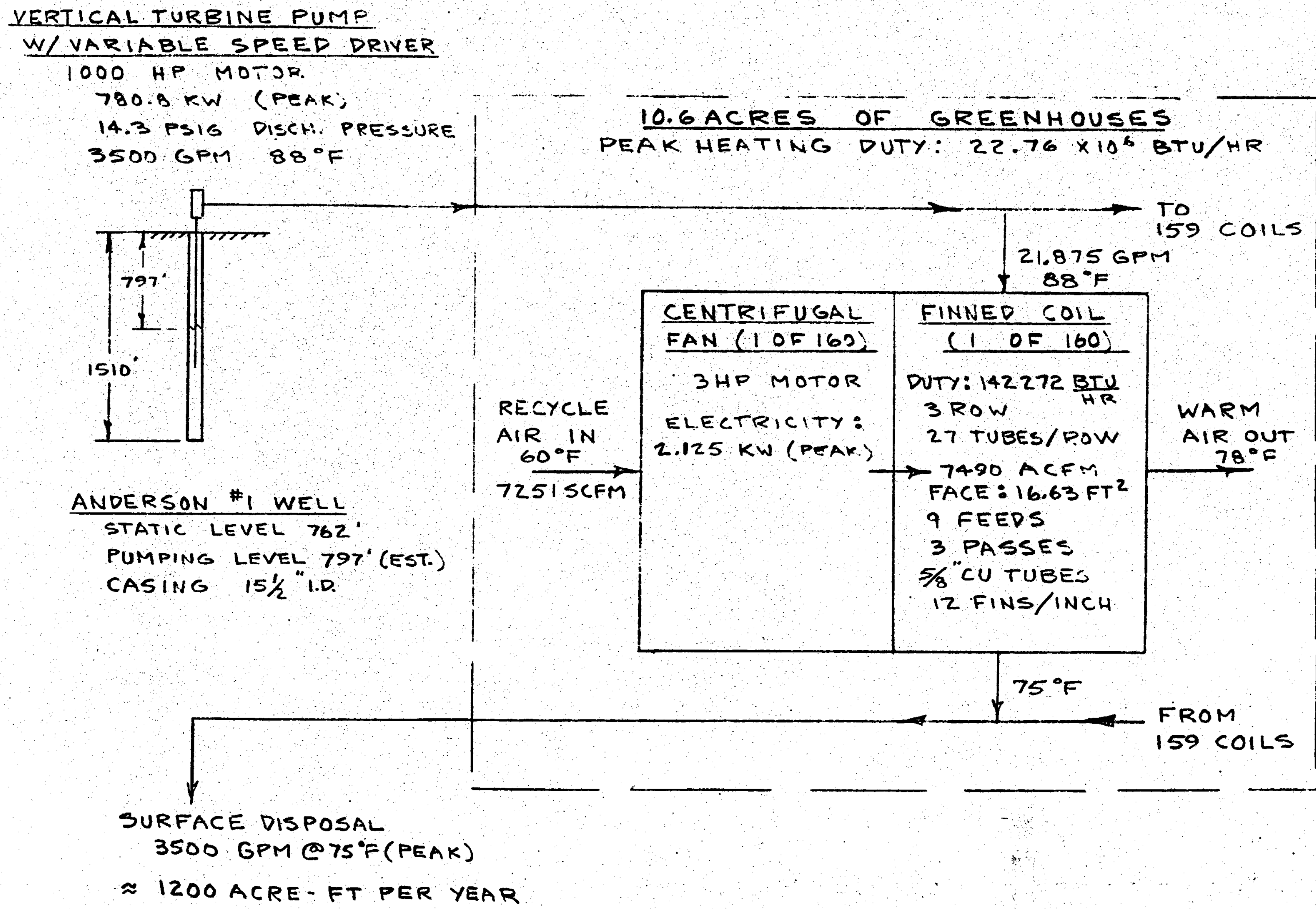
FLOW DIAGRAM – GREENHOUSE SYSTEM
UTILIZATION OF WARM WELL WATER
FIGURE 3



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SUMMARY OF CAPITAL AND OPERATING COSTS
GREENHOUSE USING ANDERSON WELL
1982 Dollars

Table 2

CAPITAL

Vertical turbine pump w/variable speed drive (1000 hp motor)	$150,000
Piping (PVC, uninsulated)	200,000
Centrifugal fans, 3 hp motors (160)	290,000
Finned coils in fan discharge (160)	160,000
Ducting and discharge tubing	90,000
Misc. mechanical and electrical	60,000
SUBTOTAL	950,000
Contingency & Engineers fee	150,000
TOTAL CAPITAL	$1,100,000

OPERATING COST (1st Year)

Maintenance		
Piping, ducting and finned coils	$2,781	
Centrifugal fans	10,753	
Well pump and driver	9,269	
	TOTAL MAINTENANCE	$22,803
Insurances		5,500
Electric power @ 1789 hrs/yr & $.025/kwh		
Pumping 780.8		
Fans 340.1		
1120.9 kw		
1120.9 X 1789 X .025 =		50,132
	TOTAL OPERATING COST (1st YEAR)	$78,435

SUMMARY OF CAPITAL AND OPERATING COSTS

GREENHOUSE WITH CONVENTIONAL HEATING SYSTEM

1982 Dollars

Table 3

CAPITAL

Electric boiler with overhead water units @ $\$1.00/ft^2$

160 X 30 X 96 X 1.00 =		$460,000

OPERATING COST (1st Year)

Maintenance			
Boiler & water treatment	5,600		
Piping	1,560		
Unit heaters	6,640		
	TOTAL MAINTENANCE		13,800
Insurance			2,300
Electric power @ 1789 hrs/yr & $.025/kwh			
Circulating pump		42.3	
Feed water pump		4.2	
Space heat $22.76 \times 10^6 \frac{\text{Btu}}{\text{hr}} \times \frac{\text{kwh}}{3413 \text{ Btu}}$ =		6,668.6	
		6,715.1 kw	
6,715.1 X 1789 X .025			300,333
	TOTAL OPERATING (1st Year)		$316,433

erating costs for the first year are $300,333.

AQUACULTURE SYSTEM

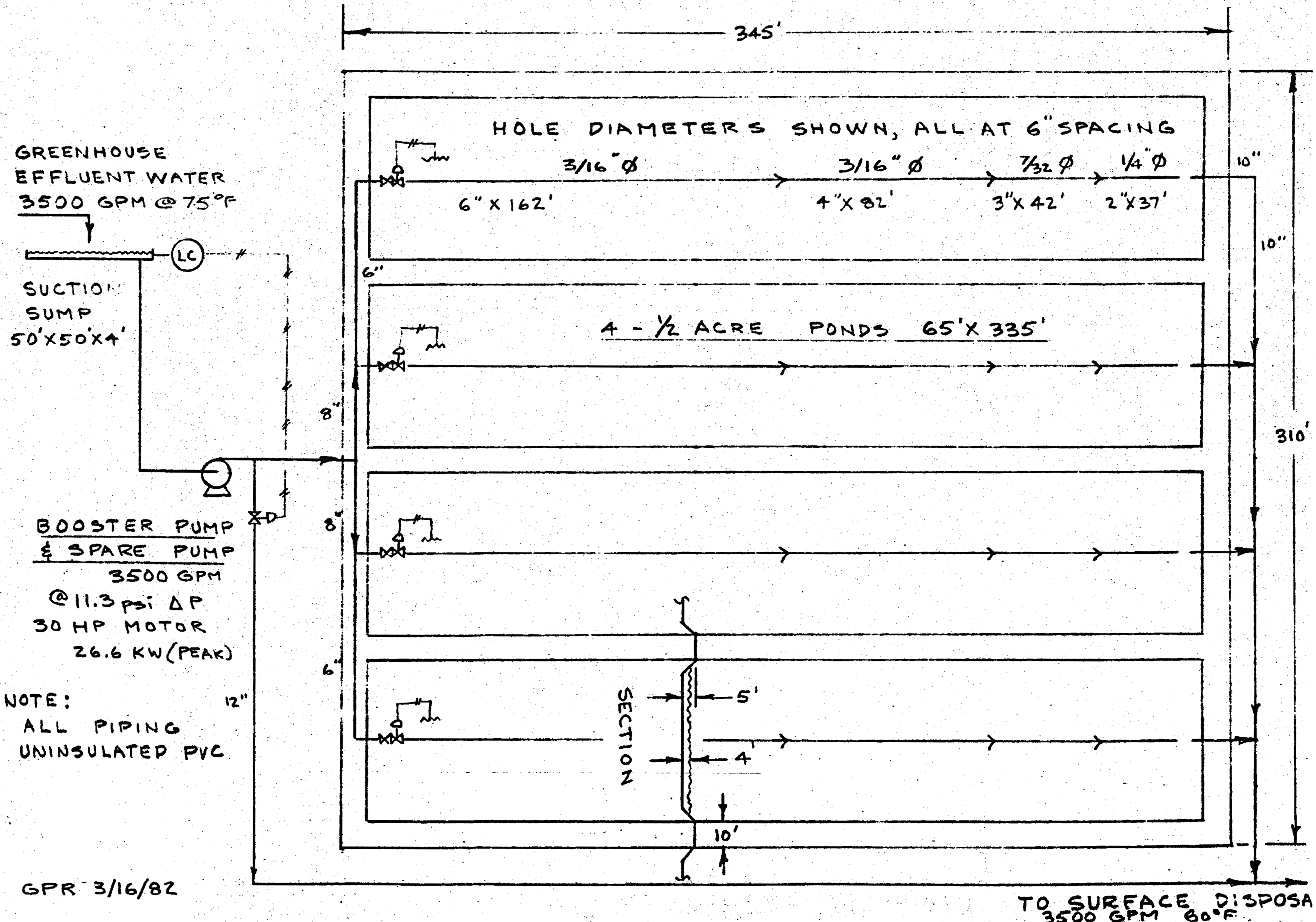
Figure 4 is a layout of the ponds and related piping. This is a cascading concept, using the 75°F effluent water from the greenhouse complex as the heat source for the ponds. This water will maintain a 60°F pond temperature needed for trout farming. It is not hot enough for prawns (macrobrachium rosenbergii) which like 80°F water. The cascading concept will avoid the high well pumping costs. Direct use of the 88°F water probably is not economical due to high pumping cost. A 30 hp booster pump is needed to move the water from the sump through the piping and distributing system in the ponds. Water disposal to the surface is assumed to be acceptable, but would have to be investigated.

AQUACULTURE COSTS

Table 4 is a summary of capital and operating costs for the four 1/2 acre aquaculture ponds. Capital cost is $160,000 and operating cost $7,160. Not included are any costs related to stocking or feeding the fish. It is believed that the pond could be operated by the greenhouse staff if some properly trained employees were included in that staff.

The electrical power pumping cost for the cascaded greenhouse is $1189 per year. If the Anderson Well #1 water was used directly, without the greenhouse, the electrical cost to pump the well would cost $34,626 per year. The economics probably would not justify this expenditure, even though more ponds (seven 1/2 acre ponds) could be heated.

AQUACULTURE PONDS & PIPING LAYOUT
UTILIZATION OF WARM WELL WATER
FIGURE 4



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SUMMARY OF CAPITAL AND OPERATING COSTS
FOUR 1/2 ACRE AQUACULTURE PONDS

Table 4

CAPITAL

Ponds four 1/2 acre (65' X 335')		$40,000
Feed/equipment building (12' X 15')		4,000
Piping & pumping sump		55,000
Booster pump (30 hp) & spare pump		20,000
Electrical and instrument installation		8,000
Miscellaneous equipment & supplies		5,000
Miscellaneous mechanical		8,000
	SUBTOTAL	$140,000
	Engineers fee & contingency	20,000
	TOTAL CAPITAL	$160,000

OPERATING COST (Excludes fish feed)

Maintenance			
Piping & pumping sump	314		
Ponds & remainder	4,857		
		TOTAL MAINTENANCE	5,171
Insurance			800
Electric pumping power @ 1789 hrs/yr & $.025/kwh			
Booster pump 26.6 kw			
26.6 X 1789 X .025			1,189
		TOTAL OPERATING COST (1st Year)	$7,160

Additional work would be necessary to determine fish yields and feed costs before an economic evaluation of the aquaculture operation could be made.

LIFE CYCLE COST ANALYSIS

Life cycle cost analysis for the conceptual geothermal greenhouse heating system at Sunnyside, Washington appears in Table 5.

It was assumed that the system would come on line in 1982. The 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

7.86% through 1987
9.10% through 2001

In Table 5:

Column one provides the 20 year cost of electricity for heating the greenhouse with an electrical boiler.

Column two forecasts the maintenance costs for the conventional system inflating at 7% per annum.

Column three projects the insurance costs for the conventional system inflating at 2% per annum.

Column four sums the total annual costs of operating the conventional system.

Column five provides the 20 year cost of electricity for heating the greenhouse with the geothermal system.

Column six forecasts the maintenance costs for the geothermal system inflating at 7% per annum.

Column seven projects the insurance costs for the geothermal system.

Column eight shows the 20 year cash flows after all costs of the geothermal system are subtracted from projected costs of the conventional heating system.

Column nine discounts the cash flow from column eight to arrive at a net present value for these cash flows. A rate of return was sought such that the discounted cash flow would exactly equal the additional capital investment required for the geothermal heating system. That is the $1,100,000 minus $460,000 for the conventional boiler system equals the incremental investment of $640,000 for the geothermal system. As the table indicates, the rate of return on the additional investment is over 48%. Economically, the project is highly feasible.

LIFE CYCLE COST ANALYSIS
FOR
LOW TEMPERATURE GREENHOUSES
DEPARTMENT OF NATURAL RESOURCES, ELLENSBURG, WASHINGTON

DATE: FEB. 02, 1982

Table 5

RATE OF RETURN	48.34154%
TOTAL CAPITAL COST	640000
NET PRESENT VALUE	640000

	1	2	3	4	5	6	7	8	9	
	ELECTRICITY CONVENTIONAL SYSTEM	MAINTENANCE CONVENTIONAL SYSTEM	INSURANCE CONVENTIONAL SYSTEM	TOTAL COST CONVENTIONAL SYSTEM	ELECTRICITY GEOTHERMAL SYSTEM	MAINTENANCE GEOTHERMAL SYSTEM	INSURANCE GEOTHERMAL SYSTEM	NET ENERGY SAVINGS	DISCOUNTED CASH FLOW 48.34154%	
PRESENT COST	300333	13800	2300		50132	22803	5500			YEAR
YEAR										
1982	324059	14766	2346	341171	54093	24400	5610	257069	173295	1
1983	349660	15800	2393	367852	58366	26108	5722	277657	126178	2
1984	377283	16906	2441	396629	62977	27935	5837	299881	91867	3
1985	407088	18089	2490	427667	67952	29891	5953	323871	66884	4
1986	439248	19355	2539	461143	73320	31983	6072	349767	48693	5
1987	473949	20710	2590	497249	79113	34222	6194	377721	35448	6
1988	517078	22160	2642	541880	86312	36617	6318	412633	26105	7
1989	564132	23711	2695	590538	94166	39180	6444	450747	19223	8
1990	615468	25371	2749	643588	102735	41923	6573	492356	14155	9
1991	671476	27147	2804	701426	112084	44858	6704	537780	10423	10
1992	732580	29047	2860	764487	122284	47998	6839	587367	7674	11
1993	799245	31080	2917	833242	133412	51358	6975	641498	5650	12
1994	871976	33256	2975	908208	145552	54953	7115	700588	4160	13
1995	951326	35584	3035	989945	158798	58799	7257	765091	3062	14
1996	1037897	38075	3095	1079067	173248	62915	7402	835501	2254	15
1997	1132346	40740	3157	1176243	189014	67319	7550	912360	1659	16
1998	1235389	43592	3221	1282201	206214	72032	7701	996254	1222	17
1999	1347809	46643	3285	1397738	224979	77074	7855	1087829	899	18
2000	1470460	49908	3351	1523719	245453	82469	8012	1187785	662	19
2001	1604272	53402	3418	1661091	267789	88242	8173	1296888	487	20
TOTAL	15922744	605339	57002	16585085	2657861	1000274	136308	12790642	640000	

SIMPLE PAYBACK	3 YEARS
DISCOUNTED PAYBACK	20 YEARS