**User Manual for AQUASTOR: A
Computer Model for Cost Analysis
of Aquifer Thermal Energy
Storage Coupled with District
Heating or Cooling Systems**

Volume II - Appendices

April 1982

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USER MANUAL FOR AQUASTOR: A COMPUTER
MODEL FOR COST ANALYSIS OF AQUIFER
THERMAL ENERGY STORAGE COUPLED WITH
DISTRICT HEATING OR COOLING SYSTEMS

VOLUME II - APPENDICES

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PREFACE

For ease of handling, the AQUASTOR User Manual was broken into two volumes. Volume I contains the main text, including introduction, program description, input data instructions, and a description of the output. Volume II contains all the appendices, including supply and distribution system cost equations and models, descriptions of predefined residential districts, key equations for the cooling degree-hour methodology, and a listing of the sample case output. Both volumes include the complete table of contents and lists of figures and tables. In addition, both volumes include Appendix H, which contains the indices for supply input parameters, distribution input parameters, and AQUASTOR subroutines. The authors hope this organization has resulted in a manual which is easier to work with.

ABSTRACT

Pacific Northwest Laboratory has developed a computer model called AQUASTOR. The purpose of this model is to calculate the cost of district heating (cooling) using thermal energy supplied by an aquifer thermal energy storage (ATES) system. The AQUASTOR model is extremely flexible, and can simulate ATES district heating systems using stored hot water or ATES district cooling systems using stored chilled water.

AQUASTOR simulates the complete ATES district heating (cooling) system, which consists of two principal parts: the ATES supply system and the district heating (cooling) distribution system. The supply system submodel calculates the life-cycle cost of thermal energy supplied to the distribution system by simulating the technical design and cash flows for the exploration, development, and operation of the ATES supply system. This includes the construction and operation of a transmission pipeline for delivering the stored energy from the aquifer to the distribution system. The distribution system submodel calculates the life-cycle cost of heat (chill) delivered by the distribution system to the end-users by simulating the technical design and cash flows for the construction and operation of the distribution system.

AQUASTOR is a powerful analytical tool for cost analysis of district heating (cooling) systems using ATES. The model combines the technical characteristics of the supply system (such as aquifer efficiency parameters) and the technical characteristics of the distribution system (including climate, demographic factors, and thermal energy demands) with financial and tax conditions for the entities operating the two systems into one techno-economic model. This provides the flexibility to individually or collectively evaluate the impact of different economic and technical parameters, assumptions, and uncertainties on the cost of providing district heating (cooling) with an ATES system.⁽¹⁾

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APPENDIX A

PRE-DEVELOPMENT, DEVELOPMENT, AND OPERATION
COST EQUATIONS FOR ATEs SUPPLY

APPENDIX A

PRE-DEVELOPMENT, DEVELOPMENT, AND OPERATION COST EQUATIONS FOR ATES SUPPLY

The basic equations used in subroutine RESVOR to calculate the costs associated with the pre-development, development, and operation of the ATES supply system are given in this section to aid program users who may wish to change the default input values in Table 10A. The original list of 39 activities indexed by N in Table 10B are grouped in three different ways during the calculations in subroutine RESVOR by means of the internal arrays: GROUP(N), ITEX(N), and NTARG(N), N = 1, ..., 39. The array GROUP is used to consolidate the 39 activities into 31 activities according to the description of the activity. The array ITEX is used to group the activities according to the time the activities are scheduled to take place. The array NTARG is used to group the activities by the major decision points in the aquifer exploration process. Any changes contemplated for these arrays, such as adding activities or decision points, will require some slight reprogramming in subroutine RESVOR. For this reason, the above three arrays are not listed as input arrays.

The cost equations given in this section calculate the total, capitalized, and expensed costs for the activities in Tables 10A and 10B without breaking the costs down according to the time in which the activities occurred. The pre-development and development activities of the ATES supply system may start in any month during one year and end in any month during another year. Subroutine RESVOR uses the input time arrays LAGS(ITEX(N), 1) and LAGS(ITEX(N), 2), ITEX(N) = 1, ..., 22, to calculate total, capitalized, and expensed costs for the activities according to the months in which the activities are scheduled to occur. This enables the total, capitalized, and expensed costs of the activities to be accurately totaled on an annual basis. Annual statements can then be calculated for cash flow, deductible expenses, income, and payout of investments for the ATES supply system from the beginning of exploration through the economic life of the supply system. The expenditures for the activities are distributed uniformly over the months in which they are scheduled to occur.

The input array $FTF(NTARG(N)-1)$, $NTARG(N) = 2, \dots, 7$, is used by subroutine RESVOR to calculate the total number of target aquifer sites to be initially identified. This allows convergence on one aquifer site for development and operation after the final decision point.

(Expected number of target aquifer sites to identify) * (Fraction of sites retained after decision point I, $I = 1, \dots$, number of decision points) = 1. Substituting FORTRAN variables from subroutine RESVOR and solving this equation,

Expected number of target sites to identify is as follows:

$$FAVSIT(1) = 1 / [FTF(1) * FTF(2) \dots * FTF(NUMFTF)].$$

Since the default values of the FTF array are all 1 in the AQUASTOR code, $FAVSIT(1) = 1$.

The number of sites to retain after each decision point is calculated as follows:

Number of sites to retain after decision point J = (Expected number of target sites to identify) * (Fraction of sites retained after decision point I, $I = 1, \dots, J$).

Substituting FORTRAN variables from subroutine RESVOR, Number of sites to retain after decision point J =

$$FAVSIT(1) * FTF(1) * FTF(2) * \dots * FTF(J).$$

Of course, with the default values, this is simply equal to one; the default case assumes there is one favorable aquifer site available immediately to work with.

The FORTRAN variables that appear in the equations below, taken from subroutine RESVOR, are defined as follows:

$CSTNEW(IGP)$ = total dollars required by activity IGP

$FAVSIT(IGP)$ = number of favorable sites for activity IGP

$CAP(IGP)$ = capitalized dollars for activity IGP

$EXPENZ(IGP)$ = expensed dollars for activity IGP

where:

IGP = GROUP(N) as defined in Tables 10A and 10B.

Aquifer Pre-Development (Exploration) Activities Indexed by N = 1 to 5,
N = 9, and N = 13 to 17

$$CSTNEW(IGP) = \sum_{N \text{ in Group IGP}} UNITO(N) * FAVSIT(IGP)$$

$$CAP(IGP) = \sum_{N \text{ in Group IGP}} UNITO(N)$$

$$EXPENZ(IGP) = CSTNEW(IGP) - CAP(IGP)$$

where:

IGP is defined as GROUP(N) in Tables 10A and 10B; the default values of UNITO(N) are in Table 10A.

Lease Cost, N = 6,7,8; IGP = 6

$$CSTNEW(6) = \sum_{N \text{ in Group IGP}} UNITO(N) * ACRES * FAVSIT(6)$$

$$CAP(6) = \sum_{N \text{ in Group IGP}} UNITO(N) * ACRES$$

$$EXPENZ(6) = CSTNEW(6) - CAP(6)$$

where:

ACRES, input through NAMELIST, is the size of each aquifer site leased for exploration.

Preparation and Publication of Environmental Impact Statement, N =10, IGP = 8

$$CSTNEW(8) = (UNITO(10) + 5000. * WELLS) * FAVSIT(8)$$

$$CAP(8) = UNITO(10) + 5000. * WELLS$$

$$EXPENZ(8) = CSTNEW(8) - CAP(8)$$

where:

UNITO(10) is the cost per site, with default value of \$20,000 in Table 10A.

WELLS, calculated in subroutines INJECT and DESIGN, is the total number of storage and supply wells drilled into the aquifer. The additional cost of \$5,000 per well is set in subroutine RESVOR.

Exploratory Well Drilling, N = 18, 19, 20, 21; IGP = 15

$$\text{CSTNEW}(15) = 100. * \text{WDEPTH} * \text{FAVSIT}(15)$$

$$\text{CAP}(15) = \text{PERCNT}(1) * \text{CSTNEW}(15) / \text{FAVSIT}(15)$$

$$\text{EXPENZ}(15) = \text{CSTNEW}(15) - \text{CAP}(15)$$

where:

WDEPTH is the aquifer well depth in feet, input through NAMELIST as STRATA(2,1) in meters, and then converted internally to feet. The cost of drilling an exploratory well is set in subroutine RESVOR to \$100/ft.

PERCNT(1), input through NAMELIST, is the tangible fraction of the drilling cost. The default value of PERCNT(1) is 1.

SUPPLY SYSTEM DEVELOPMENT ACTIVITIES

Aquifer Well Drilling, N = 23, 24; IGP = 17

$$\text{CSTNEW}(17) = \text{DCPW} * \text{WELLS}$$

$$\text{CAP}(17) = \text{PERCNT}(1) * \text{CSTNEW}(17)$$

$$\text{EXPENZ}(17) = \text{CSTNEW}(17) - \text{CAP}(17)$$

where:

DCPW, input through NAMELIST or calculated by the drilling model, is the cost (dollars) of drilling one aquifer well.

WELLS, calculated in subroutine INJECT and DESIGN, is the number of required storage and supply aquifer wells.

PERCNT(1), input through NAMELIST, is the tangible fraction of the drilling cost.

Transmission Piping System for Lepa 1 and 2, Together With the Heat Exchanger at Node 1, N = 28, IGP = 20

$$\text{CSTNEW}(20) = \text{UNSTO}(28) * \text{TCCOST}$$

$$\text{CAP}(20) = \text{CSTNEW}(20)$$

$$\text{EXPENZ}(20) = 0.$$

where:

TCCOST, calculated in subroutine INJECT and TRANS, is the capital cost of

legs 1 and 2 of the fluid transmission system together with the heat exchanger at node 1. The default value of UNIT0(28) is 1.

Transmission Piping System for Legs 3 and 4 and Node 4, N = 29, IGP = 21

$$\text{CSTNEW}(21) = \text{UNIT0}(29) * \text{DCCOST}$$

$$\text{CAP}(21) = \text{CSTNEW}(21)$$

$$\text{EXPENZ}(21) = 0.$$

where:

DCCOST, calculated in subroutines INJECT and TRANS, is the capital cost of legs 3 and 4 and node 4 of the fluid transmission system. The default value of UNIT0(29) is 1.

SUPPLY SYSTEM OPERATION ACTIVITIES

Replacement Wells Based on Aquifer Well Life, N = 30, IGP = 22

$$\text{CSTNEW}(22) = \text{CSTNEW}(17) * \text{UNIT0}(30) / [(1. + \text{FRCEPW}) * \text{AVGWL}]$$

$$\text{CAP}(22) = \text{PERCNT}(1) * \text{CSTNEW}(22)$$

$$\text{EXPENZ}(22) = \text{CSTNEW}(22) - \text{CAP}(22)$$

where:

CSTNEW(17) is the aquifer well drilling cost.

AVGWL, input through NAMELIST, is the aquifer well life (years).

FRCEPW, input through NAMELIST, is the fraction excess wells to provide open wells.

PERCNT(1), input through NAMELIST, is the tangible fraction of the drilling cost. The default value of UNIT0(30) is 1.

Purchase of Thermal Energy From External Energy Source at Node 1 (\$/yr), N = 31, IGP = 23

$$\text{CSTNEW}(23) = \text{SHCOST} * \text{SAFLOW} * \text{Absolute Value of } (\text{TSRIN} - \text{TSROUT}) * 1.E-6$$

$$\text{CAP}(23) = 0.$$

$$\text{EXPENZ}(23) = \text{CSTNEW}(23)$$

where:

SHCOST, input through NAMELIST, is the cost of purchased thermal energy from the energy source (\$/MBtu) in January, PRINDX base year dollars.

SAFLOW, input through NAMELIST and adjusted by the code if necessary to try to match up the annual fluid supply with annual fluid demand, is the annual flow rate from the external energy source through the heat exchanger at node 1 (lb/yr).

TSRIN, input through NAMELIST, is the outlet temperature exiting the heat exchanger back to the energy source ($^{\circ}\text{F}$).

TSROUT, input through NAMELIST, is the outlet temperature exiting the heat exchanger back to the energy source ($^{\circ}\text{F}$). The specific heat of water is assumed to be 1.0 Btu/lb $^{\circ}\text{F}$ in the above equation.

Well Abandonment, N = 33, IGP = 24

$\text{CSTNEW}(24) = \text{UNITO}(32) * (\text{WELLS}/\text{AVGWL})$

$\text{CAP}(24) = 0.$

$\text{EXPENZ}(24) = \text{CSTNEW}(24)$

where:

WELLS, calculated in subroutines INJECT and DESIGN, is the number of required storage and supply aquifer wells.

AVGWL, input through NAMELIST, is the aquifer well life (years).

UNITO(32) is the cost per abandoned well with default value of \$1,000 in Table 10A.

Well Maintenance, N = 33, IGP = 25

$\text{CSTNEW}(25) = \text{UNITO}(33) * (\text{WELLS})$

$\text{CAP}(25) = 0.$

$\text{EXPENZ}(25) = \text{CSTNEW}(25)$

where:

WELLS, calculated in subroutines INJECT and DESIGN, is the number of required storage and supply aquifer wells.

UNITO(33) is the cost of maintenance per well, with default value of \$1,000 in Table 10A.

Overhead and Management, N = 34, IGP = 26

CSTNEW(26) = 0.01 * (Total development cost of supply system) +
0.10 * (total operation cost of supply system excluding
overhead and management)

CAP(26) = 0.

EXPENZ(26) = CSTNEW(26)

Replacement of Downhole Pumps, N = 35, IGP = 27

CSTNEW(27) = DHPCST/PMLIFE

CAP(27) = 0.

EXPENZ(27) = CSTNEW(27)

where:

DHPCST is the capital cost of the downhole pumps calculated in subroutine TRANS. PMLIFE, input through NAMELIST, is the downhole pump lifetime. The replacement of the downhole pumps is treated as an annual expensed item if PMLIFE < 1 year; otherwise, it is treated as an annual interim capital replacement for the supply system.

Source Heat Exchanger Operation, N = 36, IGP = 28

CSTNEW(28) = HXSROC

CAP(28) = 0.

EXPENZ(28) = CSTNEW(28)

where:

HXSROC is the annual operating cost of the heat exchanger at node 1, calculated in subroutine NODEPR as 2% of the capital cost of the heat exchanger.

Pumping Electricity Cost, N = 37, IGP = 29

CSTNEW(29) = BPKLOS * 8766. * COPUMP

CAP(29) = 0.

EXPENZ(29) = CSTNEW(29)

where:

BPKLOS is the annual booster pump kilowatt usage by the ATES supply system

calculated in subroutine NODEPR. The load factors have already been factored into the calculation of BPKLOS.

COPUMP, input through NAMELIST, is the electrical cost for pumping (\$/kWh).

System Maintenance for Legs 1 and 2, Node 2, and Source Heat Exchanger,
N = 38, IGP = 30

$CSTNEW(30) = UNITO(38) * TMCOST$

$CAP(30) = 0.$

$EXPENZ(30) = CSTNEW(30)$

where:

TMCOST is calculated in subroutine NODEPR as $DINPUT(28) * TCCOST$.

DINPUT(28), input through NAMELIST, is the transmission system maintenance rate (fractional).

TCCOST, calculated in subroutine NODEPR, is the capital cost of legs 1 and 2 and node 2 of the transmission system and the capital cost of the heat exchanger at node 1. The default value of UNITO(38) is 1.

System Maintenance for Legs 3 and 4 and Node 4, N = 39, IGP 31

$CSTNEW(31) = UNITO(39) * DMCOST$

$CAP(31) = 0.$

$EXPENZ(31) = CSTNEW(31)$

where:

DMCOST is calculated in subroutine NODEPR as $DINPUT(28) * DCCOST$.

DINPUT(28), input through NAMELIST, is the transmission system maintenance rate (fractional).

DCCOST, calculated in subroutine NODEPR, is the capital cost of legs 3 and 4 and node 4 of the transmission system. The default value of UNITO(39) is 1.

APPENDIX B

CAPITAL AND OPERATING COST MODELS FOR DISTRIBUTION SYSTEM

APPENDIX B

CAPITAL AND OPERATING COST MODELS FOR DISTRIBUTION SYSTEM

As pipes are sized for each segment of the distribution network, capital cost models are used to price the piping sections and associated components. The capital cost models are primarily functions of pipe size and design options, although other parameters are used in many of the models. Other capital cost models and operating cost models are used for pumps, instrumentation, operating expenses, and taxes.

This appendix describes the cost models in three sections: capital cost models, operating cost models, and cost model equations. The first two sections describe the bases and assumptions used in the models. The third section lists the equations or cost tables used. Each cost model is associated with an account in which the costs are accumulated.

CAPITAL COST MODELS

Costs are calculated for the entire piping system up to the outer wall of housing units. The basic design is a two-pipe network (Figure B-1). A two-pipe network includes both a supply and a return pipe for each building. The cost models also apply to one-pipe networks which have only a supply pipe for each building.

The total piping bundle is called a conduit. The conduit consists of one or more pipes, which may be insulated, enclosed by the casing.

Depending upon the pipe option, insulation option, conduit option, and material option chosen, applicable component cost models are selected, and costs generated. Component costs are then added to give total piping system capital costs. Fittings and valves are costed at each pipe intersection.

Pipe

Optimal pipe diameter is selected for each segment of the piping network by minimizing the sum of the annualized capital cost of pipe, fittings, insulation, casing, valves, pump capacity and the annual costs of thermal loss and pumping. Head losses are based on correlations for aged pipe. The default

FIGURE B-1. District Heating System Two-Pipe Network
(shown without expansion loops)

value assumes a pipe age of 10 years, but the value can be changed through the input data. Pipe may be either schedule 40 carbon steel or fiberglass reinforced plastic (FRP) depending on the pipe material option.

The pipe account includes only the material cost for straight lengths of pipe.

Insulation

Optimal insulation thickness is that which produces minimum annual costs of insulation and casing and thermal loss values. Either polyurethane foam, fiberglass, or calcium silicate insulation can be specified. Insulation is assumed to be factory installed unless foam insulation and field erected concrete casing is specified. For that situation, it is assumed that the insulation is foamed in place.

The insulation account includes material and labor cost for insulating straight pipe lengths and pipe fittings.

Casing

The smallest standard casing size that will contain the pipe(s), insulation, and annular air space is selected for each segment of the piping network. Casing may be either felt- and tar-wrapped steel, polyvinyl chloride (PVC) or concrete. Concrete casing is assumed to be a field constructed rectangular box.

The casing account includes costs of material, labor for placing the pipe(s) in the casing, warehousing, transportation, field placement, and alignment of the casing sections.

Fittings

Two pipe fittings and one casing fitting, sized according to the pipe and casing, are accumulated at each pipe intersection. Two additional fittings are accumulated for each pipe into a building.

The fitting account includes both material cost for the fittings and labor for field connection of the pipes and casing sections.

Expansion Loops

One expansion loop is located in each 300 ft segment of the piping network. The size of the loop is calculated as a function of pipe diameter. Expansion loop cost is the sum of the pipe, fitting, insulation casing, trench and installation costs. Each of these component costs for the expansion loops are calculated separately as described previously and then summed.

The expansion loop account includes all labor and material costs associated with the expansion loop.

Trench

The trench model assumes vertical slopes in a rock and dirt mixture. Sifted fill material is hauled to the site. The casing is laid on 2 in. of sifted fill and is covered to a depth of 2 in. with hand sifted fill material that is hand tamped in 8 in. lifts. The rest of the trench is then filled and packed by dozer. Resurfacing consists of 2 in. of pavement on top of 2 in. of gravel. The top of the casing will be at the specified burial depth below the surface. Costs for trenching, representing differences from the default values

in this model, can be easily adjusted by use of the NAMELIST input variables EXCC (excavation cost), BEDC (bedding fill cost), BACKC (back fill cost), FINC (finish fill cost), and RESRFC (resurfacing cost). A trenching difficulty factor (TRDF) may be specified through input to reflect unusual circumstances.

The trench account includes excavation, purchase and delivery of sifted fill, hand filling and tamping, and dozer filling and packing costs.

Valves

One valve, sized according to the larger pipe size, is located at each pipe intersection. Screwed valves are used when the nominal pipe size is less than 2.5 in. Larger sized valves are flanged. The valve is assumed to be a forged steel ball type.

The valve account includes valve, mating flange, bolt-up, handling, insulation, casing and field connection costs.

Meters

One meter is located at each building. Meters are sized according to the expected range of flowrates.

The meter account includes meter, connections, and installation labor costs.

Pumps

One pump and a standby pump are located in each district. The pump is sized to overcome the total head loss and pump the district fluid requirements. Pump motor size is determined from the hydraulic horsepower and the input pump and motor efficiency factors.

The pump account includes the main pump, standby pump, motors, vault, setting and installation, fittings, and labor costs.

Metering and Control

This account covers the cost of instrumentation, additional flow controllers, and sensors required to operate the distribution system. The metering and control account covers capital and installation costs, and is set equal to one percent of the piping system capital cost.

Building and Land Use

This account covers the expense of purchase or lease of land and the construction or modification of a building to house the system's instrumentation and control equipment. The costs are set equal to one percent of the piping system capital cost.

Building Retrofit

The user can specify retrofit costs for buildings in each district type to study total costs of district heating in old built-up areas. The user specifies the retrofit cost per building in input data. The retrofit account will consist of retrofit costs for all of the buildings in the distribution system.

Heat Exchanger

If the "user" heat exchanger option is specified, a shell and tube heat exchanger is designed to satisfy the input requirements. The costs appear in the distribution system account even though the heat exchanger lies between the end of the transmission line and the inlet to the distribution system.

The heat exchanger account includes material, installation, and indirect costs.

Engineering and Administration

The account is 12% of the piping system total cost to cover the engineering and administrative costs of building the distribution system.

OPERATING COST MODELS

The operating cost accounts consist of annual expenses and taxes. Meter reader and operating costs are related to the number of meters connected in the system. Maintenance cost is proportional to the capital investment and is based on estimates from water distribution systems. The pump operating, supplemental heat, and heat exchanger costs are derived from models that are controlled by the system design. The other accounts (interest, taxes, capital replacement and insurance) are percentages of capital investment or portions of annual revenue. The percentages are specified through the input data.

Operating

This account includes the personnel cost for operating the distribution system and administrative functions. The charges to this account depend on the number of meters connected to the system.

Maintenance

The maintenance account includes routine repair and maintenance of the distribution system. The charges depend on the pump size, the number of buildings connected, and the flow to each building.

Pump Operation

This account includes charges for the annual pumping costs, calculated from the input values for the cost of electricity, and pump and motor efficiencies.

Meter Readers

This account includes wages, benefits, and overhead for meter readers with an assumed productivity of 50 meters/day.

Supplemental Heat

The difference in heat demand at design temperature and the minimum temperature is met by purchasing heat and elevating the temperature of the circulating water. The charges to this account depend on the climatic data, the design temperature, and input value for the cost of supplemental heat.

Heat Exchanger

The annual operating cost of the heat exchanger is assumed to be 2% of the total capital cost of the heat exchanger.

Other Operating Cost Accounts

The following accounts are calculated as percentages of other accounts. The percentages are specified in the input data.

- Interim Capital Replacement - percent of total system capital cost
- Bond Interest - percent rate, charges assume compound interest on unpaid portion of debt and are calculated for each year
- Gross Revenue Tax - percent of annual revenue

- State Income Tax - percentage of taxable income (revenue less operating expenses including capital costs, energy costs, operating costs, interim capital replacement, property tax and insurance, interest and depreciation)
- Federal Income Tax - percentage of taxable income less state income tax
- Property Tax and Insurance - percentage of distribution system capital cost

COST MODEL EQUATIONS

Capital cost models are summarized in Table B-1, and operating cost models are summarized in Table B-2. The cost models use the equational form:

$$\text{Cost} = a + b(x)^{(s)}(t)$$

Equation coefficients reflect fixed costs (a), variable costs (b), and scale size (s) and (t). Costs are in January 1977 dollars.^(a) Where cost equations are not appropriate, cost tables (Tables B-3 through B-7) are used. Cost data were gathered from three sources: industry vendors, mechanical contractors, and architect-engineers.

Costs are factored to reflect lower unit costs for larger piping systems; such systems have reduced material unit costs because of quantity purchase discounts. Also the installation labor learning curve lowers unit labor costs for large systems. Costs are "factored" after they are generated from component cost models. Pipe, insulation, casing, expansion loop, and trenching labor costs are multiplied by FACTOR 1. Fitting, valve, and meter costs are multiplied by FACTOR 2. Table B-8 lists values for these factors.

(a) AQUASTOR employs cost indices to escalate costs estimated by the cost model equations to the price year designated by PRINDX. The cost model equations are based on 1980 data deflated to the January 1977 baseline.

TABLE B-1. Distribution System Capital Cost Coefficients (Jan 1977 Dollars)
 (NOTE: All measurements are in meter units) Cost = $a + b(x)^t$

Account No.	Component	Unit	a	b	x	s	t
1.0	<u>Pipe</u>						
	Carbon Steel Pipe	Meter	0	304.92	P	1.482	1
	FRP Pipe (Fiberglass reinforced plastic)	Meter	0	9.04	2.72 (=e)	9.09	P
2.0	<u>Insulation</u>						
	Calcium Silicate	Meter			see Tbl. B-3		
	Fiberglass	Meter	-5.45	53.14 +351.57	P R		
	Rigid Polyurethane	Meter	0	412.12	2.72 (=e)	2.514 +1.023	P ln(R)
	Foam-in-Place Polyurethane	Meter	0	188.0	$Y[(Q)(P)+(Q)(R)(2) - (P)^2(0.79)]$		
	Fitting Insulation	Each	0	0.91	F		
	Valve Insulation						
	- Nom. pipe size ≤ 0.0635 Meters	Each	0	0.61	F		
	- Nom. pipe size > 0.0635 Meters	Each	0	9	F		
3.0	<u>Casing</u>						
	Steel (One Pipe Conduit)	Meter	0	35.55	2.72(=e)	1.96 -0.067	U G
	Steel (Two Pipe Conduit)	Meter	0	38.17	2.72(=e)	1.98 -0.066	U G
	PVC (See Note 1)	Meter	0	5.54	2.72(=e)	5.09	U
	Concrete Box	Meter	18.87	49.73 +142.27 +284.54	Q P R		
	Placement Labor	Meter	0	110	U		
4.0	<u>Fittings</u>						
	Steel Pipe Fitting	Each			See Tbl B-4		
	FRP Pipe Fitting	Each			See Tbl B-4		
	Fitting Steel Casing	Each			See Tbl B-5		
	Fitting PVC Casing	Each			See Tbl B-6		
	Valve Casing						
	- Nom. Pipe size ≤ 0.0635 meters	Each	0	0.61	H		
	- Nom. Pipe size > 0.0635 meters	Each	0	9	H		

NOTE: (1) If U = 0.0266 meters and pipe is carbon steel then add \$3.50/meter to casing cost.
 If U = 0.0408 meters and pipe is carbon steel then add \$1.70/meter to casing cost.

F = Insulated Cost/Meter G = Casing Gauge H = Casing Cost/Meter P = Pipe Diameter Q = Outside Diameter
 of Pipe and Insulation R = Insulation Thickness U = Nominal Casing Size Y = Number of Insulated Pipes in Conduit

Casing Gauge G = 10 if U < 0.5012 meters
 Casing Gauge G = 6 if 0.5012 meters < U $\leq$ 0.6505 meters
 Casing Gauge G = 4 if U > 0.6505 meters

TABLE B-1. (Cont)

Account No.	Component	Unit	a	b	x	s	t
5.0	<u>Expansion Loop</u>						
	Expansion loop (see Note 2)	Each			(C)(D) +(4)(E) +(F)(C+3.66) +(4)(G) +(C)(H) +(4)(J) +(C)(K)		
6.0	<u>Trenching Costs</u> (see Note 3)						
	Excavation	Cu. Meter		TRD*TRW	EXCC		
	Bedding Fill	Cu. Meter		.0508*TRW	BEDC		
	Back Fill	Cu. Meter		(N+.05)*TRW	BACKC		
	Finish Fill	Cu. Meter		(DPH-.05)*TRW	FINC		
	Resurfacing	Sq. Meter		TRW	RESRFC		
7.0	<u>Valves</u>						
	Valve	Each			see Tbl B-4		
8.0	<u>Meters</u>						
	Water meter (1 per housing unit)	Each			see Tbl B-7		
9.0	<u>Pumps</u>						
	Basic Pump (2 per district)						
	- horsepower $\leq$ 26	Each	1269	80	M		
	- horsepower > 26	Each	4929	64	M		
	Accessory Pump (2 per district)	Each	0	81.53	2.72(=e)	6.08	P
10.0	<u>Metering and Control</u>		0	.01	CT		
11.0	<u>Building and Land Use</u>		0	.01	CT		
12.0	<u>Building Retrofit</u>		0	Input	NB		
13.0	<u>Not Used</u>						
14.0	<u>Not Used</u>						
15.0	<u>Heat Exchanger</u>			93.3	HTA	.78	
16.0	<u>Engineering & Administration</u>		0	.12	CT		

Note: (2) Expansion loop length = $(19.27)(\text{nom. pipe dia.})^{0.46} - (9)(\text{nom. pipe dia.})$.

(3)	TRD	TRW
Pipe options 1,2,3	$N+DPH+.1016$	$N+.2036$
Pipe option 4	$N+DPH+.1016$	$2*N+.3048$
Pipe option 5	$N+DPH+.1016$	$2*N+P+.31$
Conduit option 3	$2*R+P+DPH+.26$	$2*R+P+.3048$

C = Expansion loop length D = Pipe cost/meter E = Pipe fitting cost F = Insulated Cost/Meter G = Insulation fitting cost
H = Casing Cost/Meter J = Casing fitting cost K = Trenching cost/meter N = Casing Diameter P = Pipe diameter
R = Insulation thickness Q = Outside Diameter of pipe and insulation DPTH = Depth from surface to top of conduit (meters)
EXCC = Excavation cost (\$/m³) BEDC = Bedding fill cost (\$/m³) BACKC = Backfill cost (\$/m³) FINC = Finish fill cost (\$/m³)
RESRFC = Resurfacing cost (\$/m²) M = Horsepower CT = Piping system capital cost HTA = Heat transfer area (sq ft)
NB = Number of buildings connected to the system P = Pipe diameter

TABLE B-2. Operating Cost Models
 (Cost = $a + b(x)^s$)^t

Account	Component	a	b	x	s	t
1	Meter Operating Expense	25,000	5	NB		
2	Maintenance	500	.1	CP		
			+.05	CM		
3	Pump Operation		6537	$\frac{HP*CKW*PF}{ETA}$		
4	Meter Readers	25,000	2.1	NB		
5	Not Used					
6	Supplemental Heat		CSHEAT	SDD		
7	Heat Exchanger		.02	HEC		
8	Interim Capital Replacement		Input	CT		
9	Bond Interest		Input	UB		
10	Gross Revenue Tax		Input	REVENUE		
11	State Income Tax		Input	Revenue-(items 1-9 above, and energy costs)		
12	Federal Income Tax		Input	Revenue-(items 1-11 above, and energy costs)		
13	Property Tax and Insurance		Input	CT		

NB = Number of Connected Buildings
 CP = Total Cost of Pumps
 CM = Total Cost of Meters
 HP = Total Hydraulic Horsepower
 CKW = Cost of Electricity (\$/kWh)
 AD = Average Annual Heat Demand (MBTU/yr)
 COP = Coefficient of Performance
 CSHEAT = Cost of Supplemental Heat (\$/MBTU)

SDD = Supplemental Heat Requirements (MBtu/yr)
 HEC = Heat Exchanger Capital Cost
 CT = Total Distribution System Capital Cost
 UB = Amount of Unpaid Bonds

TABLE B-3. Calcium Silicate Insulation Cost Equations

<u>Insulation Thickness</u>	<u>Dollar per Linear Meter D = Nominal Pipe Diameter, Meters</u>
.5 in.	$3.719 + 35.02 D$
1.0 in.	$5.451 + 38.93 D$
1.5 in.	$5.658 + 63.26 D$
2.0 in.	$10.061 + 64.75 D$
2.5 in.	$12.310 + 77.20 D$
3.0 in.	$15.844 + 86.86 D$
3.5 in.	$18.647 + 115.40 D$
4.0 in.	$25.308 + 115.40 D$
4.5 in.	$30.223 + 123.70 D$
5.0 in.	$35.067 + 151.60 D$

TABLE B-4. Valves, FRP Fittings, and Carbon Steel Fittings

<u>Nominal Pipe Diameter (meters)</u>	<u>Cost/C. Steel Fitting (\$)</u>	<u>Cost/Valve (\$)</u>	<u>Cost/FRP Fitting^(a)</u>
0.0254	3	58	15
0.0381	3	70	17
0.0508	3	85	20
0.0635	4	118	22
0.0762	5	274	26
0.1016	9	375	33
0.1524	24	528	56
0.2032	41	776	95
0.2540	84	1,276	160
0.3048	109	1,687	270
0.3556	162	2,535	
0.4064	227	3,802	
0.4572	322	5,052	
0.5080	433	6,740	
0.6096	638	9,678	
0.762	1058	14,910	
0.914	1633	21,160	
1.067	2358	28,280	
1.219	3242	35,600	
1.372	4292	47,100	
1.524	5516	55,300	
1.677	6923	68,200	
1.829	8515	82,400	

(a) The current version of AQUASTOR limits FRP pipe to pipe diameters ≤ 12 inches. If pipe diameters above 12 inches are required, carbon steel pipe (PMO = 1 in the input data) should be used. If FRP pipe diameters exceed 12 inches, the code will stop and print the above message from subroutine SIZE.

TABLE B-5. Steel Casing Fitting

<u>Nominal Inside Casing Diameter (meters)</u>	<u>Cost/Fitting (\$)</u>
0.1614	145
0.2122	158
0.2662	189
0.3170	222
0.3488	238
0.3996	259
0.4504	295
0.5012	315
0.5489	340
0.5997	373
0.6505	406
0.6998	432
0.7506	436
0.8014	505
0.8522	550
0.9144	558
1.067	643
1.219	730
1.372	816
1.524	903
1.677	989
1.829	1076
1.981	1162
2.134	1248
2.286	1335
2.439	1421
2.591	1506

TABLE B-6. PVC Casing Fitting

<u>Nominal Inside Casing Diameter (meters)</u>	<u>Cost/Fitting (\$) ^(a)</u>
0.0762	27
0.1016	27
0.1143	35
0.1270	40
0.1524	40
0.1778	57
0.2032	76
0.2540	108
0.3048	143
0.3556	190
0.4064	247
0.4572	437
0.5080	591
0.6096	828

-
- (a) The current version of AQUASTOR limits PVC casing to casing diameters ≤ 24 inches. If casing diameters above 24 inches are required, steel (CO = 1 in the input data) or concrete (CO = 3) casings should be used. If PVC casing diameters exceed 24 inches, the code will stop and print the above message from subroutine SIZE.

TABLE B-7. Meter

<u>Minimum Flow (GPM)</u>	<u>Maximum Flow (GPM)</u>	<u>Cost/Meter (\$)</u>
0	7	144
7	30	209
30	50	313
50	100	608
100	160	921
160	360	2990
360	500	4589
500	1000	9400

TABLE B-8. Cost Factors

Housing Units in District	> 800	FACTOR 2 = 0.6
Housing Units in District	> 600 and $\leq$ 800	FACTOR 2 = 0.75
Housing Units in District	> 400 and $\leq$ 600	FACTOR 2 = 0.85
Housing Units in District	> 200 and $\leq$ 400	FACTOR 2 = 0.95
Housing Units in District	$\leq$ 200	FACTOR 2 = 1.00

Length of Same Diameter Pipe in District	$\geq$ 4000 m	FACTOR 1 = 0.85
Length of Same Diameter Pipe in District	$\geq$ 2500 m and < 4000 m	FACTOR 1 = 0.90
Length of Same Diameter Pipe in District	$\geq$ 1000 m and < 2500 m	FACTOR 1 = 0.95
Length of Same Diameter Pipe in District	< 1000 m	FACTOR 1 = 1.00

APPENDIX C

DESCRIPTION OF PREDEFINED RESIDENTIAL DISTRICT TYPES
FOR DEFAULT USE IN AQUASTOR

APPENDIX C

DESCRIPTION OF PREDEFINED RESIDENTIAL DISTRICT TYPES FOR DEFAULT USE IN AQUASTOR

Many residential areas in the United States can be described by one of five residential district types defined in the AQUASTOR model data base. These district types are:

- Suburban
- High-density single family
- Garden apartments
- Townhouses
- High-rise apartments

The district type parameters of peak space heat demand, sanitary hot water demand, density, reject temperature and diversity factor have been calculated for each of these district types. The user may use these district types as defined or may modify one or more parameters as required through the NAMELIST input data.

Peak space heat demand was calculated by designing typical residential units for each district type and calculating the heat loss according to ASHRAE procedures assuming -5⁰F outside temperature, 65⁰F inside temperature and a 15 mph wind. Floor plans, dimensions and construction parameters for each of these district types are summarized in Figures C.1 through C.5. Sanitary hot water demand is based on the number of residents in a typical building and ASHRAE design recommendations. Density data are averages of the values recommended in various planning books and zoning guides. The district type parameters used by AQUASTOR are also summarized in Tables C.1 through C.5.

FIGURE C-1. Plan of Suburban Residential House 54 x 30 ft. Attached garage not shown.

TABLE C-1. Design Basis for Suburban Residential House 54 x 30 ft

SUBURBAN RESIDENTIAL

NUMBER OF STORIES - 1

DIMENSIONS

FLOOR ft^2	1620
EXTERIOR WALL AREA ft^2	918 (NET OF GLASS)
GARAGE WALL AREA ft^2	240
WINDOW GLASS ft^2	186
DOOR AREA ft^2	21
CEILING ft^2	1620
STORY HEIGHT ft^2	8

CONSTRUCTION PARAMETERS

FLOOR	MAPLE FINISH FLOORING ON YELLOW PINE SUBFLOORING.
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER, 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS

DISTRICT TYPE PARAMETERS

PEAK HEAT DEMAND	53,000 BTU/hr
HOT WATER DEMAND	60 gallons/day
DENSITY	2560 HOUSES/SQ. MILES
REJECT TEMPERATURE	100 °F
DIVERSITY FACTOR	0.72

FIGURE C-2. Plan for High Density Single Family Home

TABLE C-2. Design Basis for High Density Single Family Home

<u>HIGH DENSITY</u>	
NUMBER OF STORIES 1	
<u>DIMENSIONS</u>	
FLOOR ft^2	1000
EXTERIOR WALLS ft^2	865
WINDOW ft^2	133
DOOR ft^2	42
CEILING ft^2	1000
STORY HEIGHT ft	8
<u>CONSTRUCTION PARAMETERS</u>	
FLOOR	MAPLE FINISH FLOORING ON YELLOW PINE SUBFLOORING
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER, 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS
<u>DISTRICT TYPE PARAMETERS</u>	
PEAK HEAT DEMAND	34,000 BTU / hr
HOT WATER DEMAND	55 gallons / day
DENSITY	4,480 HOUSES / SQ. MILE
REJECT TEMPERATURE	100°F
DIVERSITY FACTOR	0.72

FIGURE C-3. Plan for Garden Apartment Unit

TABLE C-3. Design Basis for Garden Apartment Unit

GARDEN APARTMENT

NUMBER OF STORIES - EACH APARTMENT IS ONE STORY AND
IS CONTAINED IN A 2 STORY BUILDING

DIMENSIONS

FLOOR ft^2	990
EXTERIOR WALLS ft^2	617
WINDOWS ft^2	82
DOOR ft^2	21
CEILING	1/2 (990) FOR HEAT LOSS
STORY HEIGHT ft	8

CONSTRUCTION PARAMETERS

FLOOR	MAPLE FINISH FLOORING ON YELLOW PINE SUBFLOORING
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS

DISTRICT TYPE PARAMETERS

PEAK HEAT DEMAND	1.38 MBTU/hr
HOT WATER DEMAND	3030 gallons /day
DENSITY	293 BUILDINGS / SQ. MILE
REJECT TEMPERATURE	100 °F
DIVERSITY FACTOR	0.72

FIGURE C-4. Plan for Townhouse Unit

TABLE C-4. Design Basis for Townhouse Unit

ROW HOUSE

NUMBER OF STORIES - 2

DIMENSIONS

FLOOR ft ²	506 (1st STORY)
FLOOR ft ²	506 (2nd STORY)
EXTERIOR WALL ft ²	582
WINDOW ft ²	124
DOOR ft ²	21
CEILING ft ²	506
STORY HEIGHT ft	8

CONSTRUCTION PARAMETERS

FLOOR	MAPLE FINISH FLOORING ON YELLOW PINE SUBFLOORING
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER, 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS

DISTRICT TYPE PARAMETERS

PEAK HEAT DEMAND	0.9 MBTU / hr
HOT WATER DEMAND	1515 gallons / day
DENSITY	373 BUILDINGS / SQ. MILE
REJECT TEMPERATURE	100 °F
DIVERSITY FACTOR	0.72

FIGURE C-5. Plan for High Rise Apartment Unit
Twelve Apartments per Floor

TABLE C-5. Design Basis for High Rise Apartment Unit

HIGH RISE APARTMENT

NUMBER OF STORIES - EACH APARTMENT IS ONE STORY
AND IS CONTAINED IN A 9 STORY
BUILDING.

DIMENSIONS

FLOOR ft ²	780
EXTERIOR WALL ft ²	370
WINDOWS ft ²	78
DOOR ft ²	21
ROOF ft ²	1/9 (780) FOR HEAT LOSS
STORY HEIGHT ft	8

CONSTRUCTION PARAMETERS

EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER, 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS

DISTRICT TYPE PARAMETERS

PEAK HEAT DEMAND	1.73 MBTU / hr
HOT WATER DEMAND	5400 gallons / day
DENSITY	385 BUILDINGS / SQ. MILES
REJECT TEMPERATURE	100°F
DIVERSITY FACTOR	0.72

APPENDIX D

CAPITAL COST MODELS FOR ATEs SUPPLY SYSTEM

APPENDIX D

CAPITAL COST MODELS FOR ATES SUPPLY SYSTEM

Transmission system cost models estimate costs for the fluid transmission pipelines connecting the major components of the ATES supply system shown in Figure 2 of Section 2.1. Only transport of single-phase fluids can be simulated using these cost models. The assumed configuration for transmission leg 1 (from the external energy source), node 2 (storage wellfield), and transmission leg 2 (to distribution system) was shown for the Richland sample case in Figure 15 of Section 4.0. The configuration for transmission leg 3, node 4 (supply wellfield), and transmission leg 4 is analogous. The wellfield piping layout is based on the well and manifold spacing that is input by the user, depending upon the quality of the aquifer. The system is treated as an above ground pipeline over the entire transmission distance.

Table D.1 is a listing of transmission system components and their respective cost accounts. Allowances for indirect expense, contractor's fee, and contingency costs are accumulated within component accounts themselves. Cost data were obtained from numerous industry suppliers and cost estimating manuals.

Capital cost models are summarized in Table D.2. The cost models use the equation: $\text{cost} = a + b(x)^s$. Equation coefficients reflect fixed costs (a), variable costs (b), and scale size (s). Costs are in January 1977 dollars, except for the downhole pumps, which are in January 1979 dollars. AQUASTOR updates all costs to base year dollars (January, PRINDX dollars) using the nine CE plant cost indices described in Section 3.5.5.1. The cost equations for pipes were reviewed and updated in October 1980 and then deflated to January 1977 dollars (using the CE cost index for pipe) for internal storage in the code.

1.0 Pipe

Transmission pipe costs are calculated as a function of pipe diameter and pipe schedule (wall thickness). The pipe diameter depends on flow rates and is determined by minimizing pump operating costs, piping capital costs, and fluid friction losses. Pipe schedule depends on fluid pressure and is calculated using the rules listed in Table D.3.

TABLE D.1. Categorization of Transmission System Components into Cost Accounts

<u>Account</u>	<u>Components</u>	<u>Computational Subroutine</u>
1. Pipe	Pipe Material Pipe Fitting Material Welded Pipe Connections Valves	TICOST
2. Insulation	Insulation Material Insulation Installation	INSUL, TICOST
3. Casing	Casing Material Casing Installation	INSUL, TICOST
4. Site Work	Pipe Installation (handling) Concrete Anchor Pad Material Pipe Support Material Support Installation Site Clearing & Grading	TICOST
5. Surface Pumps (legs & at heat exchangers)	Pump Material Pump Installation	PUMP, TBCOST, TICOST
6. Downhole Pumps (nodes 2 & 4)	Pump Material Pump Installation	PUMP, TRANS
7. Wellhead Equipment (nodes 2 & 4)	Wellhead Valves Instrumentation Solids Separators	EQCOST
8. Engineering and Design		TRANS, INJECT

TABLE D.2. Transmission System Capital Cost Coefficients
(January 1977 dollars) Cost = a + b (x)^s

<u>Account</u>	<u>Cost/Unit</u>	<u>a</u>	<u>b</u>	<u>s</u>	<u>x</u>
1. Carbon Steel Pipe					
a. Pipe Schedule ≤ 80	Cost/Foot	0	0.209 x 1	0.322 1.356	Pipe Schedule Nominal Pipe Dia. (in.)
b. Pipe Schedule ≤ 80	Cost/Foot	0	0.367 x 1	0.170 0.493	Pipe Schedule Nominal Pipe Dia (in.)
2. Insulation					
a. Calcium Silicate	Cost/Foot	-6.42	1.538	0.59	Insulation Cross- Sectional Area (in ²)
b. Polyurethane	Cost/Foot	2.84	0.152	0.91	Insulation Cross- Sectional Area (in ²)
3. Casing	Cost/Foot	0.26	0.0166	2.024	Outside Insulation Diameter (in.)
4. Site Work	Cost/Foot	14.0	1.07	1	Nominal Pipe Dia. (in.)
5. Surface Pumps	Cost/Pump	6035	0.022	1	Pump Capacity (gpm) x Head (ft)
6. Downhole Pumps (January 1979\$)	Cost/Pump	0	7335.36	1	Exp[3.3 x 10 ⁻⁶ Pump Capacity (gpm) x Head (ft)]
7. Wellhead Equipment					
a. Wellhead Valves	5000/wellhead				
b. Instrumentation	1000/wellhead				
c. Solids Separator	5000/wellhead				
8. Engineering & Design	12% of Above Total Capital Costs				

TABLE D.3. Transmission System Pipe Schedules

<u>Fluid Pressures (psia)</u>	<u>Pipe Schedule</u>
0-350	10
350-550	20
550-650	30
650-1000	40
1000-1050	60
1050-1600	80
1600-1925	100
1925-2250	120
2250-2575	140
2575-2900	160

Carbon steel pipe with welded connections at 30-ft intervals is the assumed design for the pipeline. Expansion loops at 200-ft intervals along the pipeline are used to allow for pipe contraction when the system is not operating and cold. Pipe materials, fitting materials, and welding labor for the expansion loops are included in this account.

2.0 INSULATION

Two insulation materials are used in the cost models when the parameter TRINSL (see Section 3.3.4) is non-zero in the NAMELIST input data: calcium silicate and polyurethane foam. For this account, AQUASTOR generally determines optimal insulation thickness first. In determining costs for the optimal thickness, cost for a 2-inch thickness of calcium silicate is considered first as the initial insulation layer. Cost of polyurethane foam insulation, which has a maximum heat exposure of 250°F, is then calculated over the remaining thickness required to bring total insulation thickness to the optimal level. Expansion loop insulation requirements are included in this account.

3.0 CASING

The casing (insulation covering) is a 0.016-inch aluminum jacketing. All sections of the pipeline including expansion loops are covered with a casing

unless the parameter TRCASE (see Section 3.3.4) is set to 0 in the NAMELIST input data.

4.0 SITE WORK

The site work account includes costs for clearing and grading the pipeline right-of-way, erecting pipe supports, installing anchor pads, and handling and aligning the pipe sections onto the supports. Pipe supports are located every 25 feet along the run of the pipeline.

5.0 SURFACE PUMPS

Booster pump stations are used along the transmission legs and at the tube-side and shell-side of the heat exchangers to keep fluids pressurized as single-phase liquid. Pump costs are based upon the pump capacity (gpm) and the amount of pressure loss (head loss in feet of water) occurring due to friction in the fluid flow.

6.0 DOWNHOLE PUMPS

Downhole pumps are located at the bottom of each storage well (node 2) and supply well (node 4) to provide the vertical lift to the surface and provide sufficient pump head to keep the fluid pressurized as single-phase liquid in the surface wellfield piping. Pump costs are based upon the pump capacity (gpm) and the amount of pump head (ft of water).

APPENDIX E

KEY EQUATIONS FOR COOLING DEGREE HOUR METHODOLOGY

APPENDIX E

KEY EQUATIONS FOR COOLING DEGREE HOUR METHODOLOGY

The key equations used in subroutine COOLHR of the code to calculate the cooling degree hour methodology are summarized below:

(1) Building Peak Cooling Demands in MBtu/hr-bldg of Chill

Suburban:
$$CQ(1) = NRES(1) \cdot 10^{-6} \cdot \left\{ 489.5 \cdot [TDES(2) - TINDES(2)] + 5.23 \cdot 10^5 \cdot [HDES(2) - .01] + 9323.6 \right\}$$

High-Density:
$$CQ(2) = NRES(2) \cdot 10^{-6} \cdot \left\{ 330.5 \cdot [TDES(2) - TINDES(2)] + 3.24 \cdot 10^5 \cdot [HDES(2) - .01] + 7779.2 \right\}$$

Garden Apts:
$$CQ(3) = NRES(3) \cdot 10^{-6} \cdot \left\{ 223.6 \cdot [TDES(2) - TINDES(2)] + 3.19 \cdot 10^5 \cdot [HDES(2) - .01] + 5362.5 \right\}$$

Townhouse:
$$CQ(4) = NRES(4) \cdot 10^{-6} \cdot \left\{ 256.4 \cdot [TDES(2) - TINDES(2)] + 3.24 \cdot 10^5 \cdot [HDES(2) - .01] + 6871.6 \right\}$$

High Rise:
$$CQ(5) = NRES(5) \cdot 10^{-6} \cdot \left\{ 164.8 \cdot [TDES(2) - TINDES(2)] + 2.52 \cdot 10^5 \cdot [HDES(2) - .01] + 5352.8 \right\}$$

Pt Demand:
$$CQ(6) = 1$$

Dist. Type 7:
$$CQ(7) = 0$$

Dist. Type 8:
$$CQ(8) = 0$$

where:

$CQ(N)$ = peak chill demand for each building in district type N (MBtu/hr-bldg of chill)

$TDES(2)$ = summer outdoor design dry-bulb temperature ($^{\circ}F$)

$TINDES(2)$ = indoor design temperature ($^{\circ}F$)

$HDES(2)$ = absolute humidity at temperature $TDES(2)$ in lbs H_2O/lb air

$NRES(N)$ = number of residences per building in district type N

The values for CQ(7) and CQ(8) were arbitrarily set to zero. Currently, the code will print an appropriate message and stop if district types 7 and 8 are used with the cooling degree-hour methodology. The rationale is that we really can't define equations for CQ(7) and CQ(8) ahead of time without knowing the characteristics of the buildings in these two district types. The user will have to modify this part of subroutine COOLHR if district types 7 and 8 are used in the input data with the cooling degree hour methodology.

The equations for CQ(1) through CQ(5) were derived based on heat transfer principles and the physical layout of the buildings in each district type shown in Figures C.1 to C.5 in Appendix C.

(2) Annual Cooling Degree-Hours per Year at the Simulated Site

$$ACDGHR = \sum_{K=1}^{NTMINT} [TAOD(K) - TINDES(2)] * HROD(K)$$

where:

ACDGHR = annual cooling degree-hours per year between the indoor design temperature TINDES(2) and the summer outdoor design temperatures TDES(2) (°F-hrs/yr)

TINDES(2) = indoor design temperature (°F)

NTMINT = number of outdoor dry-bulb temperature intervals spanning the range from the indoor design temperature TINDES(2) to the peak outdoor summer temperature.

TAOD(K) = midpoint of outdoor dry-bulb temperature interval K in °F

HROD(K) = number of hourly temperature observations per year in temperature interval K

The cooling degree-hours are set to 0 by the code for intervals entirely below the indoor design temperature. The observed hours in an interval that includes the indoor design temperature are prorated by the code and a new temperature midpoint is calculated for the reduced temperature interval from the indoor design temperature to the upper bound of the interval. The cooling degree-hours for that interval are calculated by the code as follows:

$$\text{PROHRS} = \frac{[\text{TAOD}(K) + \text{TWIDTH}/2.] - \text{TINDES}(2)]}{\text{TWIDTH}} * \text{HROD}(K)$$

$$\text{AVE} = \frac{[\text{TINDES}(2) + (\text{TAOD}(K) + \text{TWIDTH}/2.)]}{2.}$$

$$\text{ACDGHR}(K) = [\text{AVE} - \text{TINDES}(2)] * \text{PROHRS}$$

For temperature intervals above the outdoor design temperature $\text{TDES}(2)$, the user should enter 0 for the number of hourly temperature observations $\text{HROD}(K)$ in those intervals.

(3) Annual Cooling Demand for Each Building in District Type N

$$\text{ANNCD}(N) = \frac{\text{CQ}(N)}{[\text{TDES}(2) - \text{TINDES}(2)]} * \text{ACDGHR}$$

where:

$\text{ANNCD}(N)$ = annual cooling demand for each building in district type N
in MBtu/yr-bldg of chill

$\text{CQ}(N)$ = peak cooling demand for each building in district type N
in MBtu/hr-bldg of chill

$\text{TDES}(2)$ = summer outdoor design dry-bulb temperature ($^{\circ}\text{F}$)

$\text{TINDES}(2)$ = indoor design temperature ($^{\circ}\text{F}$)

ACDGHR = annual cooling degree-hours per year in $^{\circ}\text{F}$ -hrs/yr between
the indoor design temperature and summer outdoor design
temperature

(4) Average Cooling Demand for Each Building in District Type N

$$\text{AVECD}(N) = \frac{\text{ANNCD}(N)}{24.*365.25}$$

where:

$\text{AVECD}(N)$ = average cooling demand for each building in district type N
in MBtu/hr-bldg of chill

$\text{ANNCD}(N)$ = annual cooling demand for each building in district type N
in MBtu/yr-bldg of chill

(5) Load Factor for District Type N

$$PF(N) = \frac{DENSE(N)*AREA(N)*AVECD(N)}{DIVF(N)*DENSE(N)*AREA(N)*CQ(N)}$$

where:

PF(N) = load factor for district type N

Numerator = average chill demand in district type N in MBtu/hr of chill

Denominator = peak chill demand reduced by the diversity factor in district type N in MBtu/hr of chill

APPENDIX F
TROUBLE-SHOOTING GUIDE

APPENDIX F

TROUBLE-SHOOTING GUIDE

The conversion of any newly developed code to a new computer environment or its application to a multiplicity of different input data sets raises the possibility of abnormal terminations during the execution of the code. The most useful aid for debugging the AQUASTOR code in the unlikely event this should occur is to set the print switch LL6 to 2 in the \$RESVOR input data. Selection of this output option will print all techno-economic iterations between the supply system and distribution system submodels; the default option (LL6=1) prints only the final iteration upon convergence between these two submodels. The printout of all iterations makes it far easier to locate potential aberrant calculations or transfers of data between subroutines in tracking the computational flow through the code's subroutines shown in Figure 4.

In addition, error messages generated by AQUASTOR print out the names of the routines in which they are generated to assist the user to quickly focus attention on the proper routines. Debugging options are also available with the standard FORTRAN compilers to assist the user in the event of abnormal terminations. Finally, the dimensional restrictions on arrays in the code are discussed below in the event they are exceeded or need to be changed.

The economic arrays beginning with CAP and ending with TAXCR in the blank common array CCC (e.g., see subroutine LOAD in the code) are dimensioned by 50 to allow the lifetimes of the supply and distribution systems to be each simulated up to 50 years.

The district type arrays defined in Section 3.4.5.2 are dimensioned by 8 in labeled common DHEAT to accomodate up to 8 different district types in the distribution system. The district geometric arrays defined in Section 3.4.5.1 are dimensioned by 20 in labeled common DHEAT to allow up to 20 different districts in the distribution system.

The transmission nodal arrays beginning with NODE and ending with EWH in subroutine TRANS, which are used in modeling the fluid conduction and degradation in the supply system, are dimensioned 25x25 to accomodate a maximum supply

or storage wellfield size of 625 wells. Since no economically viable ATES district heating (cooling) system is likely to require 625 wells, these dimensions could be reduced to 20x20 or 15x15 if memory size is a problem at the user's computing facilities.

The transmission nodal arrays are currently equivalenced to 9475 decimal locations in the blank common array CCC (e.g., see subroutine TRANS in the code). A set of economic arrays beginning with CAP and ending with TAXCR, which are used in the supply and distribution cash flow submodels, are equivalenced to the first 7050 decimal locations in the blank common array CCC (e.g., see subroutine LOAD). The transmission nodal arrays and economic arrays are permitted to share the same locations in blank common to conserve memory, since they are required at different times during the program execution and need not be saved. A reduction in the dimension of the wellfield to 15x15 (225 wells) would permit equivalencing the transmission nodal arrays to the first 3390 decimal locations in the array CCC. The dimension of the CCC array could then be reduced to 7050 decimal words, the maximum size based upon the economic arrays. The result would be a reduction in memory requirements of 2425 decimal (4571 octal) words. The following changes would also be necessary in the code:

- 1) Reset MD and KD to 15 in subroutine NODEPR
- 2) Reset NDUP used in subroutine TRANS to 15 in BLOCK DATA
- 3) Change the FORTRAN statement, CALL CLEAR [CCC(1276), MK], to read CALL CLEAR [CCC(466), MK] in subroutine TSTRT.

APPENDIX G

LISTING OF SAMPLE CASE OUTPUT

A Q S T O R I N P U T P A R A M E T E R S

1.0 TECHNICAL DESCRIPTION

1.1 AQUIFER SYSTEM PARAMETERS

PARAMETERS	DESCRIPTION OF PARAMETERS		PARAMETERS	DESCRIPTION OF PARAMETERS	
ENERGY SOURCE DESCRIPTION			SOURCE HEAT EXCHANGER		
SHCOST	ENERGY COST FROM SOURCE (\$/MHTU)	3.	HTEXSH	HEAT EXCHANGER AT SOURCE? (0=NO,1=YES)	1.
SMFLOW	SOURCE MAXIMUM FLOW RATE (LB/HR)	3565100.	APPHX	APPROACH TEMPERATURE (F)	17.5
SDFLOW	SOURCE DAILY FLOW RATE (LB/DAY)	85563000.	DIAL	INNER TUBE DIAMETER (FT)	.1000
SAFLOW	SOURCE ANNUAL FLOW RATE (LB/YR)	10267000000.	DIAOL	OUTER TUBE DIAMETER (FT)	.1104
TSRIN	SOURCE INPUT TEMPERATURE (F)	325.0	FOULFI	INNER FOUL FACTOR (HR-SFT-F/HTU)	.0010
TSROUT	SOURCE RETURN TEMPERATURE (F)	117.0	FOULFO	OUTER FOUL FACTOR (HR-SFT-F/HTU)	.0010
SMXFLW	AHS MAXIMUM FLOW RATE (LB/HR)	1.000000.099	WVELL	SOURCE FLUID VELOCITY (FT/HR)	28800.0
AQUIFER AND WELL DESCRIPTION			TRANSMISSION SYSTEM		
ACRES	ACRES FOR EXPLORATION	1000.	IADVWEL	REDUCE NODAL RECOMPUTATION (0=NO,1=YES)	0
STAOEF	STORAGE AQF THERMAL EFF FRACT	.60	PLMANF	DISTANCE WELL TO MANIFOLD (M)	1.0
SPAQEF	SUPPLY AQF THERMAL EFF FRACT	.85	PRFACT	PUMP PRESSURIZATION FACTOR	1.00
AVGWL	AVERAGE WELL LIFE (YRS)	30.	PSALVG	PIPE SALVAGABLE FRACTION	.20
CASFRC	FRACTION OF WELL CASED	1.00	PLNGTH(1)	DISTANCE SOURCE/STORAGE (LEG1,M)	9600.0
OIA	AVERAGE WELL DIAMETER (CM)	22.22	PLNGTH(2)	DISTANCE STORAGE/LOAD (LEG2,M)	9600.0
FLORAT	MAXIMUM WELL FLOW RATE (LB/HR)	150000.	PLNGTH(3)	DISTANCE LOAD/SUPPLY (LEG3,M)	9600.0
FRCEPW	FRAC EXCESS PRODUCING WELLS	.00	PLNGTH(4)	DISTANCE SUPPLY/SOURCE (LEG4,M)	9600.0
FRCNPW	FRACTIONAL DRY WELLS	.00	TENV(1)	ENVIRON. TEMP. DURING STORAGE (F)	70.0
NUMTYP	NUMBER OF ROCK HARDNESS	1	TENV(2)	ENVIRON. TEMP. DURING DELIVERY (F)	35.0
PRDRAT	RATIO INJECT/PROD. FLOW	1.00	IPUMP	DOWNHOLE AQUIFER PUMPS (1=SR,2=DH)	2
STRATA(1,1)	ROCK HARDNESS TO DRILL	3.0	TRINSL	OPTION TO INPUT INSULATION THICKNESS (IN)	-1.0
STRATA(2,1)	WELL DEPTH (METERS)	400.0	TRCASE	CASING OPTION (0=NO CASING)	-1.0
TAOIF	NATURAL AQUIFER TEMPERATURE (F)	55.0	PMLIFF	DOWNHOLE PUMP LIFETIME (YRS)	10.0
WELSPC	WELL SPACING (ACRES)	25.			
STFREC	STORAGE AQF FLUID RECOVERY FRACT	.40			

1.2 DISTRIBUTION SYSTEM PARAMETERS

PARAMETERS	USER HEAT EXCHANGER	PARAMETERS	DEMAND CHARACTERISTICS
HTEXOP	HEAT EXCHANGER AT USER? (0-NO,1-YES)	1.	MODE
DIAL	INNER TUBE DIAMETER (FT)	.1000	ADGDAY(1)
DIAOL	OUTER TUBE DIAMETER(FT)	.1104	ADGDAY(2)
FOULFI	INNER FOUL. FACTOR (HR-SFT-F/HTU)	.0010	DDGDAY(1)
FOULFO	OUTER FOUL. FACTOR (HR-SFT-F/HTU)	.0010	DDGDAY(2)
UAPTIN	USER INLET APPROACH TEMP (F)	17.5	IDES(1)
UAPOUT	USER OUTLET APPROACH TEMP (F)	17.5	IDES(2)
WVELL	SOURCE FLUID VELOCITY (FT/HR)	28000.0	TMAX
			TMIN
			TWATC
			TWATH
			OPERATIONAL MODE
			ANNUAL HEATING DG DAYS (F DAYS)
			SEE COOLING DEGREE-HOUR DATA INSTEAD
			DESIGN HEATING DG DAYS (F DAYS)
			SEE COOLING DEGREE-HOUR DATA INSTEAD
			DESIGN HEATING OUTDOOR TEMP (F)
			DESIGN COOLING OUTDOOR TEMP (F)
			MAXIMUM OUTDOOR TEMP (F)
			MINIMUM OUTDOOR TEMP (F)
			SANITARY COLD WATER TEMP (F)
			SANITARY HOT WATER TEMP(F)

DISTRICT GEOMETRY

PARAMETERS	DESCRIPTION OF PARAMETERS
NDTR	NUMBER OF DISTRICTS
IDTYPE	DISTRICT TYPE
MAINOP	USER INPUT MAIN LENGTHS?(0-NO,1-YFS)
NYGRO	NUMBER OF YEARS OF GROWTH

* IDTR(M)	TYPE OF DISTRICT M (INTEGER)	SEE BELOW
AREA(M)	AREA OF DISTRICT M (SQ MI)	SEE BELOW
WIDTH(M)	WIDTH OF DISTRICT M (MI)	SEE BELOW
XLNGTH(M)	LENGTH OF DISTRICT M (MI)	SEE BELOW
DDTR(M)	MAIN LENGTH TO DISTRICT M (MI)	SEE BELOW
ELDIFF(M)	ELEVATION OF DISTRICT M (FT)	SEE BELOW
GROWTH(M)	ENERGY GROWTH IN DISTRICT M (FK)	SEE BELOW
CSF(M)	CROOKED STREET FACTOR	SEE BELOW

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IDTR(M)	4	3	3	3	3	3	4	3	2	3	2	2	5	2	2	5	4	1	0	0
AREA(M)	.08	.29	.08	.06	.20	.04	.15	.15	.26	.68	.14	.16	.02	.14	.45	.03	.05	.19	.00	.00
WIDTH(M)	.12	.62	.18	.27	.51	.15	.27	.42	.23	.53	.40	.39	.21	.48	.28	.24	.09	.16	.00	.00
XLNGTH(M)	.62	.70	.60	.32	.58	.40	.48	.53	1.69	2.02	.58	.61	.26	.57	2.35	.30	.42	1.71	.00	.00
DDTR(M)	.41	1.59	1.48	.43	.56	.38	.45	.50	.42	1.27	.43	.43	.56	.40	.40	.21	.51	.87	.00	.00
ELDIFF(M)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
GROWTH(M)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
CSF(M)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

*-NOTE: 1 = SUBURBAN
 2 = HIGH DENSITY SINGLE FAMILY
 3 = GARDEN APARTMENTS
 4 = TOWNHOUSES OR ROWHOUSES
 5 = HIGH RISE APARTMENTS
 6 = POINT DEMAND

PARAMETERS DISTRICT TYPE CHARACTERISTICS

		DISTRICT TYPE N							
		1	2	3	4	5	6	7	8
CO(N)	PK DESIGN CHILL DEMAND(MBTU/HR/BD)	.021	.016	.664	.392	1.020	1.000	.021	.021
TREJC(N)	COOLING RETURN TEMP (F)	55.000	55.000	55.000	55.000	55.000	55.000	.000	.000
HO(N)	PK DESIGN HEAT DEMAND(MBTU/HR/BD)	.053	.044	.034	.480	.034	.000	.000	.000
HW(N)	DAILY HOT WATER DEMAND (GAL/DAY/BD)	60.000	60.000	60.000	1260.000	60.000	.000	.000	.000
TREJ(N)	HEATING RETURN TEMP (F)	100.000	100.000	100.000	100.000	100.000	.000	.000	.000
DENSE(N)	DENSITY OF BUILDINGS (BLDG/SQ MI)	1568.000	2093.000	3837.000	376.000	7898.000	.000	.000	.000
DIVF(N)	DIVERSITY FACTOR (FRACT)	.720	.720	.720	.720	.720	.000	.000	.000
CRTF(N)	RETROFITTING COST (\$/BLDG)	1000.000	1000.000	1000.000	21000.000	1000.000	.000	.000	.000
POPHSE(N)	PEOPLE PER BUILDING	2.660	2.660	2.660	55.860	2.660	.000	.000	.000
NRESU(N)	RESIDENCES PER BUILDING	1	1	60	30	108	1	1	1

PARAMETERS DISTRIBUTION PIPE DESIGN

AC	ANNUALIZED COST FACTOR (FR,CALC.)	.17
CG	GROUND THERMAL COND (J/SEC-M-C)	.3600
CO	CASING OPTION (SEE BELOW)*	STEEL
CP	PIPE THERMAL COND (J/SEC-M-C)	3.5600
DPTH	CASING BURIAL DEPTH (M)	.50
IO	INSULATION OPTION (SEE BELOW)*	CA SILC
KINS	INSUL THERMAL COND (J/SEC-M-C)	.0418
PMO	PIPE MATERIAL TYPE (1=STEEL,2=FHP)	STEEL
PO	PIPE OPTION (SEE BELOW)*	1.
TA	ANNULAR AIR SPACE (M)	.00
TG	GROUND TEMPERATURE (K)	283.0
VMBTU	VALUE OF LOST HEAT (%/MHTU)	3.00

PARAMETERS MISCELLANFOUS COST FACTORS

AGFACT(I)	AGE FACTOR FOR PIPE PRESS DROP	1.0	1.0	1.0
HACKC	TRENCH BACKFILL COST (\$/CU M)			13.10
BEDC	TRENCH BEDDING COST (\$/CU M)			13.10
CSBTU	COST OF SUPPLM HEAT (\$/MHTU)			6.00
EXCC	TRENCH EXCAVATION COST (\$/CU M)			26.16
FINC	TRENCH FINISH COST (\$/CU M)			1.30
RESRFC	TRENCH RESURFACE COST (\$/SQ M)			8.40
TROF	TRENCH DIFFICULTY FACTOR (FR)			1.00
WLEAK	FRACTION FLUID LEAKAGE IN PIPES			.01

- *-NOTE: PO #1 - TWO PIPES, ONLY SUPPLY INSULATED, SUPPLY AND RETURN IN COMMON CASING
 2 - TWO PIPES, SUPPLY AND RETURN IN COMMON INSULATION AND CASING
 3 - TWO PIPES, SUPPLY AND RETURN INSULATED SEPARATELY IN COMMON CASING
 4 - TWO PIPES, SUPPLY AND RETURN INSULATED SEPARATELY IN SEPARATE CASINGS
 5 - TWO PIPES, SUPPLY INSULATED ONLY AND IN SEPARATE CASING FROM RETURN
 6 - SINGLE PIPE, SUPPLY INSULATED IN CASING
- *-NOTE: CO #1 - STEEL
 2 - PVC
 3 - CONCRETE
- *-NOTE: IO #1 - CALCIUM SILICATE
 2 - POLYURETHENE FOAM
 3 - FIBERGLASS

COOLING CHARACTERISTICS

PARAMETERS	COOLING DEGREE-HOUR DATA									
-----	-----									
*MCOOL	COOLING CALCULATION MODE									
TINDES(2)	INDOOR DESIGN TEMPERATURE (F)									
TDES(2)	OUTDOOR DESIGN DRY-BULB TEMP. (F)									
HDES(2)	OUT. DESIGN ABS. HUMIDITY (LB H2O/LB AIR)									
NTMINT	NUMBER OF OUTDOOR TEMP. INTERVALS									
TWIDTH	WIDTH OF TEMPERATURE INTERVAL (F)									
TAOD(K)	MIDPT OF OUTDOOR TEMP. INTERVALS (F)									
HROD(K)	NO. OF HOURS IN ABOVE TEMP. INTERVALS									
ACDGHM	ANNUAL COOLING UG-HRS (F-HRS/YR)									
	1	2	3	4	5	6	7	8	9	10
	-	-	-	-	-	-	-	-	-	-
TAOD(K)	77.	82.	87.	92.	97.	102.	107.	112.	117.	122.
HROD(K)	982.	788.	596.	440.	246.	54.	3.	0.	0.	0.

*-NOTE: MCOOL = 0 - CALCULATE COOLING ENERGY REQUIREMENTS USING COOLING DEGREE-HOURS WITH BOTH PEAK BUILDING LOADS (CQ(N)) AND ANNUAL COOLING DEGREE-HOURS (ACDGHM) AT A SITE CALCULATED IN THE CODE
 1 - SAME AS MCOOL = 0 EXCEPT ANNUAL COOLING DEGREE-HOURS (ACDGHM) AT A SITE ARE INPUT BY USER
 2 - SAME AS MCOOL = 0 EXCEPT BOTH PEAK BUILDING LOADS (CQ(N)) AND ANNUAL COOLING DEGREE-HOURS (ACDGHM) AT A SITE ARE INPUT BY USER

BRANCHING MAINS MATRIX

DNET(M,MM)*

		MAIN NUMBER MM																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DISTRICT NUMBER M	1	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	3	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	4	1.	0.	1.	0.	1.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	5	1.	0.	1.	0.	1.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	6	1.	0.	1.	0.	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	7	1.	0.	1.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	8	1.	0.	1.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	9	1.	0.	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	10	1.	0.	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	11	1.	0.	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	12	1.	0.	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	13	1.	0.	1.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	14	1.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	15	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	16	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	17	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	18	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

* NOTE: DNET(M,MM) = 0 - MAIN NUMBER MM DOES NOT TRANSPORT FLOW TO DISTRICT NUMBER M IN ANY WAY

1 - MAIN NUMBER MM TRANSPORTS FLOW TO DISTRICT NUMBER M BUT DOES NOT CONNECT DIRECTLY TO DISTRICT NUMBER M

2 - MAIN NUMBER MM CONNECTS DIRECTLY TO DISTRICT NUMBER M

2.0 FINANCIAL PARAMETERS

2.1 INPUT(N) FOR VALUES OF N BELOW

AQUIFER SYSTEM

4 FRACTION INVESTMENT IN BONDS	1.0000
5 BOND INTEREST RATE (FR)	.1000
6 RETURN ON EQUITY (FR)	.0000
7 FEDERAL INCOME TAX RATE (FR)	.0000
9 WELL DEPRECIABLE LIFE (YRS)	30.
14 DISTRIBUTION STARTUP YEAR	1990.
15 STATE INCOME TAX RATE (FR)	.0000
16 STATE REVENUE TAX RATE (FR)	.0000
17 PROPERTY TAX RATE (FR)	.0000
18 TRANSMISSION INT CAP REPL RATE (FR)	.0150
1 PROPERTY INSURANCE RATE (FR)	.0012
26 TRANSMISSION DEPRECIABLE LIFE (YRS)	15.
28 TRANS MAINTENANCE RATE (FR)	.0500

0A DEPLETION ALLOWANCE (%)	.00
1EXPNS EXPENSE ALL EXPLORATION COSTS?	0
PIVTCR INVESTMENT TAX CREDIT (%)	.00

DISTRIBUTION SYSTEM

39 FRACTION INVESTMENT IN BONDS	1.0000
40 BOND INTEREST RATE (FR)	.1000
41 RETURN ON EQUITY (FR)	.0000
42 FEDERAL INCOME TAX RATE (FR)	.0000
44 DISTRIBUTION DEPRECIABLE LIFE (YRS)	15.
49 DISTRIBUTION SYSTEM STARTUP YEAR	1990.
50 STATE INCOME TAX RATE (FR)	.0000
51 STATE REVENUE TAX RATE (FR)	.0400
52 PROPERTY TAX RATE (FR)	.0000
53 DISTRIBUTION INT CAP REPL RATE (FR)	.0150
54 PROPERTY INSURANCE RATE (FR)	.0012
61 DISTRIBUTION OPERATING LIFE (YRS)	30.0000
63 DISTRIBUTION MAINTENANCE RATE (FR)	.0500

NYC DISTRIBUTION CONSTRUCTION YEARS	3
PIVTCR INVESTMENT TAX CREDIT (%)	.00

PARAMETERS	2.2 WELL DRILLING COSTS	
-----	-----	
IDRILL	USE DRILL MODEL?	NO
IDRPNT	PRINT DRILLING MODEL OUTPUT	NO
DCPW	PRODUCING WELL DRILL COST (\$/WELL)	100000.
OCNPW	DRY WELL DRILL COST (\$/WELL)	0.
PERCNT(1)	FRACTION TANGIBLE DRILL COSTS	1.00
PERCNT(2)	FRACTION INTANGIBLE DRILL COSTS	.00

	2.3 GENERAL ECONOMIC PARAMETERS	
-----	-----	
COPUMP	PUMP ELECTRICITY COST (\$/KWH)	.0200
ETA	COMBINED MOTOR-PUMP EFF (FR)	.65
ICOST	USE CURRENT DOLLAR COSTS?(0-N,1-Y)	1
LL2	DEPRECIATION OPTION	SL
PIFALL	OVERALL INFLATION RATE (%)	6.00
PIFCAP	CAPITAL ESCALATION RATE (%)	6.00
PIFCSE	ENERGY ESCALATION RATE (%)	6.00
PIFELR	ELECTRICITY ESCALATION RATE (%)	7.00
PIFOM	O&M ESCALATION RATE (%)	6.00
PRINDX	BASE YEAR OF CAPITAL COSTS	1980.
PF	POINT DEMAND (ONLY) LOAD FACTOR	.0000

	3.0 OUTPUT SELECTION KEYS	
-----	-----	
LL6	PRINT TRANS-DISTRB ITERATIONS	LAST
LL11,LL12	PRINT ALL ECONOMIC OUTPUT?	YFS
IPLOT	GENERATE PRINTER PLOTS OF INTERNAL DATA BASES ON FOLLOWING PAGES?	YFS
PRFLAG	SUMMARY OUTPUT ONLY?	NO

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

CAPITAL COST (\$/M) OF CARBON STEEL PIPE AS A FUNCTION OF PIPE DIAMETER (IN)

T	*0*****1*****2*****3*****4*****5*****6*****7*****8*****9*****10	C
1.	*C	.17697+001
2.	*C	.49434+001
3.	*C	.90156+001
4.	*C	.13809+002
5.	*C	.19221+002
6.	*C	.25184+002
7.	*C	.31647+002
8.	*C	.38573+002
9.	*C	.45929+002
10.	*C	.53691+002
11.	*C	.61837+002
12.	*C	.70347+002
13.	*C	.79207+002
14.	*C	.88402+002
15.	*C	.97920+002
16.	*C	.10775+003
17.	*C	.11788+003
18.	*C	.12830+003
19.	*C	.13900+003
20.	*C	.14998+003
21.	*C	.16122+003
22.	*C	.17273+003
23.	*C	.18449+003
24.	*C	.19651+003
25.	*C	.20876+003
26.	*C	.22125+003
27.	*C	.23398+003
28.	*C	.24694+003
29.	*C	.26012+003
30.	*C	.27352+003
31.	*C	.28714+003
32.	*C	.30098+003
33.	*C	.31502+003
34.	*C	.32927+003
35.	*C	.34372+003
36.	*C	.35838+003
37.	*C	.37323+003
38.	*C	.38828+003
39.	*C	.40352+003
40.	*C	.41894+003
*0*****1*****2*****3*****4*****5*****6*****7*****8*****9*****10		
		MAXIMUM 4.18943+002
		MINIMUM 1.76971+000
		RANGE 4.17173+002

ROTATE PAGE 90 DEGREES

X-AXIS (LEFT-HAND COLUMN) = PIPE DIAMETER (IN)

Y-AXIS (RIGHT-HAND ROW) = NORMALIZED CAPITAL COST (% OF RANGE)

(CORRESPONDING \$/LINEAR METER FOR Y-AXIS CAN ALSO BE READ IN RIGHT-HAND COLUMN)

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

CAPITAL COST (\$/M) OF FRP PIPE AS A FUNCTION OF PIPE DIAMETER (IN)

T	*0****1****2****3****4****5****6****7****8****9****10	F
1.	*F	.15282+002
2.	*F	.19252+002
3.	*F	.24251+002
4.	*F	.30550+002
5.	*F	.38484+002
6.	*F	.48479+002
7.	*F	.61070+002
8.	*F	.76931+002
9.	*F	.96911+002
10.	*F	.12208+003
11.	*F	.15379+003
12.	*F	.19373+003
13.	*F	.24404+003
14.	*F	.30742+003
15.	*F	.38727+003
16.	*F	.48784+003
17.	*F	.61455+003
18.	*F	.77415+003
19.	*F	.97521+003
20.	*F	.12285+004
21.	* F	.15475+004
22.	* F	.19495+004
23.	* F	.24558+004
24.	* F	.30936+004
25.	* F	.38970+004
26.	* F	.49092+004
27.	* F	.61841+004
28.	* F	.77902+004
29.	* F	.98135+004
30.	* F	.12362+005
31.	* F	.15573+005
32.	* F F	.19617+005
33.	* F F	.24712+005
34.	* F F	.31131+005
35.	* F F	.39216+005
36.	* F F	.49401+005
37.	* F F	.62231+005
38.	* F F	.78393+005
39.	* F F	.98753+005
40.	* F F	.12440+006
*0****1****2****3****4****5****6****7****8****9****10		
MAXIMUM		1.24400+005
MINIMUM		1.52825+001
RANGE		1.24385+005

ROTATE PAGE 90 DEGREES

X-AXIS (LEFT-HAND COLUMN) = PIPE DIAMETER (IN)

Y-AXIS (RIGHT-HAND ROW) = NORMALIZED CAPITAL COST (% OF RANGE)

(CORRESPONDING \$/LINEAR METER FOR Y-AXIS CAN ALSO BE READ IN RIGHT-HAND COLUMN)

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

CAPITAL COST (\$/M) OF 2 IN THICK CALCIUM SILICATE INSULATION AS FUNCTION OF PIPE DIAMETER (IN)

T	*0****1****2****3****4****5****6****7****8****9****10	S
1.	*S	.15241+002
2.	*S	.17382+002
3.	*S	.19523+002
4.	*S	.21665+002
5.	*S	.23806+002
6.	*S	.25947+002
7.	*S	.28089+002
8.	*S	.30230+002
9.	*S	.32371+002
10.	*S	.34513+002
11.	*S	.36654+002
12.	*S	.38795+002
13.	*S	.40937+002
14.	*S	.43078+002
15.	*S	.45219+002
16.	*S	.47361+002
17.	*S	.49502+002
18.	*S	.51643+002
19.	*S	.53785+002
20.	*S	.55926+002
21.	*S	.58067+002
22.	*S	.60209+002
23.	*S	.62350+002
24.	*S	.64491+002
25.	*S	.66633+002
26.	*S	.68774+002
27.	*S	.70915+002
28.	*S	.73057+002
29.	*S	.75198+002
30.	*S	.77339+002
31.	*S	.79481+002
32.	*S	.81622+002
33.	*S	.83763+002
34.	*S	.85905+002
35.	*S	.88046+002
36.	*S	.90187+002
37.	*S	.92329+002
38.	*S	.94470+002
39.	*S	.96611+002
40.	*S	.98753+002
	*0****1****2****3****4****5****6****7****8****9****10	
		MAXIMUM 9.87528+001
		MINIMUM 1.52408+001
		RANGE 8.35120+001

ROTATE PAGE 90 DEGREES

X-AXIS (LEFT-HAND COLUMN) = PIPE DIAMETER (IN)

Y-AXIS (RIGHT-HAND ROW) = NORMALIZED CAPITAL COST (% OF RANGE)

(CORRESPONDING \$/LINEAR METER FOR Y-AXIS CAN ALSO BE READ IN RIGHT-HAND COLUMN)

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

CAPITAL COST (\$/M) OF 2 IN THICK FIBERGLASS INSULATION AS FUNCTION OF PIPE DIAMETER (IN)

T	*0****1****2****3****4****5****6****7****8****9****10	F
1.	*F	.17915+002
2.	*F	.19672+002
3.	* . F	.21430+002
4.	* . F	.23187+002
5.	* . F	.24944+002
6.	* . F	.26702+002
7.	* . F	.28459+002
8.	* . F	.30217+002
9.	* . F	.31974+002
10.	* . F	.33731+002
11.	* . F	.35489+002
12.	* . F	.37246+002
13.	* . F	.39003+002
14.	* . F	.40761+002
15.	* . F	.42518+002
16.	* . F	.44276+002
17.	* . F	.46033+002
18.	* . F	.47790+002
19.	* . F	.49548+002
20.	* . F	.51305+002
21.	* . F	.53063+002
22.	* . F	.54820+002
23.	* . F	.56577+002
24.	* . F	.58335+002
25.	* . F	.60092+002
26.	* . F	.61849+002
27.	* . F	.63607+002
28.	* . F	.65364+002
29.	* . F	.67122+002
30.	* . F	.68879+002
31.	* . F	.70636+002
32.	* . F	.72394+002
33.	* . F	.74151+002
34.	* . F	.75908+002
35.	* . F	.77666+002
36.	* . F	.79423+002
37.	* . F	.81181+002
38.	* . F	.82938+002
39.	* . F	.84695+002
40.	* . F	.86453+002
*0****1****2****3****4****5****6****7****8****9****10		
		MAXIMUM 8.64528+001
		MINIMUM 1.79149+001
		RANGE 6.85379+001

ROTATE PAGE 90 DEGREES

X-AXIS (LEFT-HAND COLUMN) = PIPE DIAMETER (IN)

Y-AXIS (RIGHT-HAND ROW) = NORMALIZED CAPITAL COST (% OF RANGE)

(CORRESPONDING \$/LINEAR METER FOR Y-AXIS CAN ALSO BE READ IN RIGHT-HAND COLUMN)

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

CAPITAL COST (\$/M) OF 2 IN THICK POLYURETHANE RIGID INSULATION AS FUNCTION OF PIPE DIAMETER (IN)

T	*0****1****2****3****4****5****6****7****8****9****10	P
1.	*P	.27131+002
2.	*P	.28920+002
3.	* P	.30827+002
4.	* P	.32860+002
5.	* P	.35026+002
6.	* P	.37336+002
7.	* P	.39794+002
8.	* P	.42422+002
9.	* P	.45219+002
10.	* P	.48201+002
11.	* P	.51379+002
12.	* P	.54767+002
13.	* P	.58378+002
14.	* P	.62228+002
15.	* P	.66331+002
16.	* P	.70705+002
17.	* P	.75367+002
18.	* P	.80336+002
19.	* P	.85634+002
20.	* P	.91280+002
21.	* P	.97299+002
22.	* P	.10371+003
23.	* P	.11055+003
24.	* P	.11784+003
25.	* P	.12561+003
26.	* P	.13390+003
27.	* P	.14273+003
28.	* P	.15214+003
29.	* P	.16217+003
30.	* P	.17286+003
31.	* P	.18426+003
32.	* P	.19641+003
33.	* P	.20936+003
34.	* P	.22316+003
35.	* P	.23788+003
36.	* P	.25357+003
37.	* P	.27029+003
38.	* P	.28811+003
39.	* P	.30710+003
40.	* P	.32735+003
	*0****1****2****3****4****5****6****7****8****9****10	
		MAXIMUM 3.27355+002
		MINIMUM 2.71310+001
		RANGE 3.00225+002

ROTATE PAGE 90 DEGREES

X-AXIS (LEFT-HAND COLUMN) = PIPE DIAMETER (IN)

Y-AXIS (RIGHT-HAND ROW) = NORMALIZED CAPITAL COST (% OF RANGE)

(CORRESPONDING \$/LINEAR METER FOR Y-AXIS CAN ALSO BE READ IN RIGHT-HAND COLUMN)

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

CAPITAL COST (\$/M) OF STEEL CASING (ONE PIPE CONDUIT WITH 2 IN INSULATION) AS FUNCTION OF PIPE DIAMETER (IN)

T	0	1	2	3	4	5	6	7	8	9	10	S
1.	S	.	.	.	.	.	.	.	.	.	.	.30262+002
2.	S	.	.	.	.	.	.	.	.	.	.	.31806+002
3.	S	.	.	.	.	.	.	.	.	.	.	.33429+002
4.	S	.	.	.	.	.	.	.	.	.	.	.35134+002
5.	S	.	.	.	.	.	.	.	.	.	.	.36927+002
6.	S	.	.	.	.	.	.	.	.	.	.	.38810+002
7.	S	.	.	.	.	.	.	.	.	.	.	.40790+002
8.	S	.	.	.	.	.	.	.	.	.	.	.42871+002
9.	S	.	.	.	.	.	.	.	.	.	.	.45058+002
10.	S	.	.	.	.	.	.	.	.	.	.	.47357+002
11.	S	.	.	.	.	.	.	.	.	.	.	.49773+002
12.	S	.	.	.	.	.	.	.	.	.	.	.52312+002
13.	S	.	.	.	.	.	.	.	.	.	.	.54981+002
14.	S	.	.	.	.	.	.	.	.	.	.	.57785+002
15.	S	.	.	.	.	.	.	.	.	.	.	.60733+002
16.	S	S	.	.	.	.	.	.	.	.	.	.83577+002
17.	S	S	.	.	.	.	.	.	.	.	.	.87841+002
18.	S	S	S	.	.	.	.	.	.	.	.	.92322+002
19.	S	S	S	.	.	.	.	.	.	.	.	.97031+002
20.	S	S	S	.	.	.	.	.	.	.	.	.10198+003
21.	S	S	S	.	.	.	.	.	.	.	.	.10718+003
22.	S	S	S	S	.	.	.	.	.	.	.	.12890+003
23.	S	S	S	S	.	.	.	.	.	.	.	.13548+003
24.	S	S	S	S	.	.	.	.	.	.	.	.14239+003
25.	S	S	S	S	S	.	.	.	.	.	.	.14965+003
26.	S	S	S	S	S	.	.	.	.	.	.	.15729+003
27.	S	S	S	S	S	.	.	.	.	.	.	.16531+003
28.	S	S	S	S	S	.	.	.	.	.	.	.17375+003
29.	S	S	S	S	S	.	.	.	.	.	.	.18261+003
30.	S	S	S	S	S	.	.	.	.	.	.	.19193+003
31.	S	S	S	S	S	.	.	.	.	.	.	.20172+003
32.	S	S	S	S	S	S	.	.	.	.	.	.21201+003
33.	S	S	S	S	S	S	.	.	.	.	.	.22282+003
34.	S	S	S	S	S	S	.	.	.	.	.	.23419+003
35.	S	S	S	S	S	S	.	.	.	.	.	.24614+003
36.	S	S	S	S	S	S	.	.	.	.	.	.25869+003
37.	S	S	S	S	S	S	.	.	.	.	.	.27189+003
38.	S	S	S	S	S	S	.	.	.	.	.	.28576+003
39.	S	S	S	S	S	S	.	.	.	.	.	.30034+003
40.	S	S	S	S	S	S	.	.	.	.	.	.31566+003
0*****1*****2*****3*****4*****5*****6*****7*****8*****9*****10												
												MAXIMUM
												3.15662+002
												MINIMUM
												3.02624+001
												RANGE
												2.85+00+002

ROTATE PAGE 90 DEGREES

X-AXIS (LEFT-HAND COLUMN) = PIPE DIAMETER (IN)

Y-AXIS (RIGHT-HAND ROW) = NORMALIZED CAPITAL COST (% OF RANGE)

(CORRESPONDING \$/LINEAR METER FOR Y-AXIS CAN ALSO BE READ IN RIGHT-HAND COLUMN)

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

CAPITAL COST (\$/M) OF PVC CASING (2 IN INSULATION) AS FUNCTION OF PIPE DIAMETER (IN)

T	*0*****1*****2*****3*****4*****5*****6*****7*****8*****9*****10	P
1.	*P	.96982+001
2.	*P	.10041+002
3.	*P	.10432+002
4.	*P	.10876+002
5.	*P	.11381+002
6.	*P	.11957+002
7.	*P	.12611+002
8.	*P	.13356+002
9.	*P	.14204+002
10.	*P	.15169+002
11.	*P	.16267+002
12.	*P	.17517+002
13.	*P	.18939+002
14.	*P	.20557+002
15.	*P	.22398+002
16.	*P	.24494+002
17.	*P	.26879+002
18.	*P	.29594+002
19.	*P	.32683+002
20.	*P	.36198+002
21.	*P	.40198+002
22.	*P	.44750+002
23.	*P	.49931+002
24.	*P	.55827+002
25.	*P	.62536+002
26.	*P	.70172+002
27.	*P	.78861+002
28.	*P	.88750+002
29.	*P	.10000+003
30.	*P	.11281+003
31.	*P	.12738+003
32.	*P	.14397+003
33.	*P	.16284+003
34.	*P	.18432+003
35.	*P	.20877+003
36.	*P	.23658+003
37.	*P	.26824+003
38.	*P	.30427+003
39.	*P	.34526+003
40.	*P	.39192+003
*0*****1*****2*****3*****4*****5*****6*****7*****8*****9*****10		
MAXIMUM		3.91921+002
MINIMUM		9.69823+000
RANGE		3.82223+002

ROTATE PAGE 90 DEGREES

X-AXIS (LEFT-HAND COLUMN) = PIPE DIAMETER (IN)

Y-AXIS (RIGHT-HAND ROW) = NORMALIZED CAPITAL COST (% OF RANGE)

(CORRESPONDING \$/LINEAR METER FOR Y-AXIS CAN ALSO BE READ IN RIGHT-HAND COLUMN)

 NOTE: ALL COSTS PRINTED ON THE FOLLOWING PAGES ARE ESCALATED TO THE MIDPOINT OF THE FIRST YEAR OF CONSTRUCTION OF THE
 DISTRIBUTION SYSTEM. THE PAGE THAT PRINTS THE AQUIFER PREDEVELOPMENT, DEVELOPMENT, AND OPERATION COSTS IS DEFLATED
 TO THE BASE YEAR (PRINDX). THEREAFTER IN THE CASH FLOW ACCOUNTING PAGES, THE COSTS ARE ESCALATED ANNUALLY.

N O D E 1 ... E N E R G Y S O U R C E

ENERGY SOURCE DESCRIPTION

TEMPERATURE FROM ENERGY SOURCE (F)	3.250000+002	MAXIMUM FLOW RATE FROM ENERGY SOURCE (LB/HR)	3.407674+006
TEMPERATURE RETURN (F)	1.170000+002	DAILY FLOW RATE FROM ENERGY SOURCE (LB/DAY)	8.178475+007
COST OF PURCHASED ENERGY (\$/MBTU)	3.000000+000	ANNUAL FLOW RATE FROM ENERGY SOURCE (LB/YR)	9.813634+009
HEAT EXCHANGER OPTION AT ENERGY SOURCE	1.0		

FLUID CONDITIONS AT HEAT EXCHANGER

APPROACH TEMPERATURE OF HEAT EXCHANGER (F)	1.750000+001	FLUID TEMPERATURE AT HEAT EXCHANGER OUTLET (F)	3.075000+002
INITIAL TEMPERATURE FROM SUPPLY AQUIFER (F)	1.011513+002	FLUID PRESSURE AT HEAT EXCHANGER OUTLET (F)	7.484243+001
INITIAL ENTHALPY FROM SUPPLY AQUIFER (BTU/LB)	6.914812+001	FLUID ENTHALPY AT HEAT EXCHANGER OUTLET (BTU/LB)	2.774536+002
HEAT(CHILL) AT HEAT EXCHANGER OUTLET (BTU/HR)	9.541507+008	MAXIMUM FLOW RATE HEAT EXCHANGER OUTLET (LB/HR)	3.438956+006

HEAT EXCHANGER PRESSURE DROP ... TUBE SIDE

TUBE LENGTH (FT)	1.594058+003	TUBE INTERNAL DIAMETER (FT)	1.000000+001
RELATIVE ROUGHNESS RATIO	2.000000+003	CROSS-SECTIONAL FLOW AREA (SQ FT)	9.572550+003
REYNOLDS NUMBER	2.687085+005	FRICTION FACTOR	2.164886+002
TOTAL FLOW RATE (LB/HR)	3.407674+006	FLOW VELOCITY (FT/SEC)	8.000000+000
FLUID DENSITY (LBM/CU FT)	5.981351+001	ENTRANCE AREA (SQ FT)	5.279169+000
EXIT AREA (SQ FT)	5.279169+000	ENTRANCE PRESSURE DROP (PSI)	3.447182+003
EXIT PRESSURE DROP (PSI)	6.881863+003	TUBE PRESSURE DROP (PSI)	1.425676+002
TOTAL PRESSURE DROP (PSI)	1.425779+002		

HEAT EXCHANGER PRESSURE DROP ... SHELL SIDE

TUBE LENGTH (FT)	1.594058+003	SHELL EQUIVALENT INT. DIAM. (FT)	1.079814+001
RELATIVE ROUGHNESS RATIO	1.853888+003	CROSS-SECTIONAL FLOW AREA (SQ FT)	2.866886+000
REYNOLDS NUMBER	1.832062+005	FRICTION FACTOR	2.301704+002
TOTAL FLOW RATE (LB/HR)	3.438956+006	FLOW VELOCITY (FT/SEC)	5.533892+000
FLUID DENSITY (LBM/CU FT)	6.021199+001	ENTRANCE AREA (SQ FT)	5.279169+000
EXIT AREA (SQ FT)	5.279169+000	ENTRANCE PRESSURE DROP (PSI)	7.550861+004
EXIT PRESSURE DROP (PSI)	6.900636+004	SHELL-SIDE PRESSURE DROP (PSI)	6.767900+001
TOTAL PRESSURE DROP (PSI)	6.768045+001		

PUMP CAPITAL COST AND ENERGY REQUIREMENT ... TUBE SIDE OF HX

FLUID FLOW RATE (LBM/HR)	3.407674+006
PRESSURE DROP RESTORED (PSI)	1.425779+002
PUMP HEAD (FT OF H ₂ O)	3.635905+002
PUMP EFFICIENCY (FRACT)	6.500000-001
INLET FLUID TEMPERATURE (F)	3.250000+002
PUMP CAPITAL COST (\$)	1.283428+005
NON-ELECTRIC OPERATING COST (\$)	.000000
ENERGY CONSUMPTION (KWS)	7.173531+002

PUMP CAPITAL COST AND ENERGY REQUIREMENT ... SHELL SIDE OF HX

FLUID FLOW RATE (LBM/HR)	3.438950+006
PRESSURE DROP RESTORED (PSI)	6.768045+001
PUMP HEAD (FT OF H ₂ O)	1.572399+002
PUMP EFFICIENCY (FRACT)	6.500000-001
INLET FLUID TEMPERATURE (F)	1.011513+002
PUMP CAPITAL COST (\$)	5.807660+004
NON-ELECTRIC OPERATING COST (\$)	.000000
ENERGY CONSUMPTION (KWS)	3.130774+002

HEAT EXCHANGER DESIGN AND COST

INSIDE TUBE DIAMETER (FT)	1.000000-001	INSIDE HEAT TRANSFER COEFF. (BTU/HR/SQ FT/F)	2.317136+003
OUTSIDE TUBE DIAMETER (FT)	1.104000-001	OUTSIDE HEAT TRANSFER COEFF. (BTU/HR/SQ FT/F)	1.718673+003
NUMBER OF TUBES	2.520000+002	OVERALL HEAT TRANSFER COEFF. (BTU/HR/SQ FT/F)	3.086092+002
EQUIVALENT OUTSIDE DIAMETER (FT)	1.078814-001	HEAT TRANSFER AREA (SQ FT)	1.393236+005
CAPITAL COST (\$)	1.961502+006	HEAT TRANSFER LENGTH (FT)	1.594058+003
OTHER OPERATING COST (\$)	3.923004+004	SOURCE VELOCITY IN TUBES (FT/SEC)	8.000000+000
HX PUMP CAPITAL COST (\$)	1.864194+005	WATER VELOCITY IN TUBES (FT/SEC)	5.470746+000
ANNUAL PUMP OPERATING COST (\$)	5.935133+004	PUMP ENERGY CONSUMPTION (KWS)	1.030431+003

L E G 1 ... TRANSMISSION TO STORAGE AQUIFER ... ENTERING AND EXIT CONDITIONS AND CAPITAL COSTS

ABOVE GROUND PIPING ... AVERAGE SEASONAL AIR TEMPERATURE (F) = 70.0

NODE I	J	ITR	STEAM FRACT	FLOW RATE (LB/SEC)	VELOCITY (FT/SEC)	HEAT LOSS (BTU/SEC-FT)	TEMP (F)	PRES(Psia)	SATURATION PRES(Psia)	ENTHALPY (BTU/LB)	PIPE SCHD	INTER DIAM(IN)	EXTER DIAM(IN)	INSUL THK(IN)
1	1	1	.0000	955.	7.200	.026	307.500	183.660	74.882	277.650	10.	20.644	22	4.000
1	1	2	.0000	955.	7.198	.030	306.537	183.660	73.832	276.658	10.	20.643	22	4.000
1	1	3	.0000	955.	7.198	.030	306.537	183.660	73.832	276.658	10.	20.643	22	4.000

PIPING SYSTEM EQUIPMENT

CAPITAL COST (\$)

PIPE	1897904.
INSULATION	2721818.
CASING	1045618.
SITE	2042719.
TRANSMISSION SURFACE PUMPS	53619.
TOTAL PIPING SYSTEM	7761678.
ENGINEERING AND DESIGN (12 PCT)	931401.
TOTAL CAPITAL COST	8693079.

TRANSMISSION MAINTENANCE (\$)	434654.
TRANSMISSION CAP. REPL. RATE	.0150
TRANSMISSION SURFACE PUMP KILOWATTS	323.43
NUMBER OF TRANSMISSION LFG PUMPS	1
TRANSMISSION LEG PRESSURE DROP (PSI)	77.19

N O D E 2 . . . S T O R A G E A Q U I F E R - E N T E R I N G C O N D I T I O N S

ABOVE GROUND PIPING . . . AVERAGE SEASONAL AIR TEMPERATURE (F) = 70.0

NODE I	J	ITR	STEAM FRACT	FLOW RATE (LR/SEC)	VELOCITY (FT/SEC)	HEAT LOSS (BTU/SEC-FT)	TEMP (F)	PRES(PSIA)	SATURATION PRES(PSIA)	ENTHALPY (BTU/LR)	PIPF SCHD	INTER DIAM(IN)	EXTER DIAM(IN)	INSUL THK(IN)
1	2	1	.0000	249.	6.508	.030	306.537	183.660	73.832	276.658	10.	11.088	12	4.000
1	2	2	.0000	249.	6.508	.018	306.537	183.660	73.831	276.658	10.	11.088	12	4.000
1	3	1	.0000	208.	6.418	.018	306.537	183.660	73.831	276.658	10.	10.192	12	4.000
1	3	2	.0000	208.	6.418	.018	306.441	183.660	73.727	276.558	10.	10.192	12	4.000
1	4	1	.0000	166.	6.309	.018	306.441	183.660	73.727	276.558	10.	9.194	10	4.000
1	4	2	.0000	166.	6.309	.016	306.335	183.660	73.613	276.450	10.	9.194	10	4.000
1	5	1	.0000	125.	6.171	.016	306.335	183.660	73.613	276.450	10.	8.050	10	4.000
1	5	2	.0000	125.	6.171	.016	306.196	183.660	73.462	276.306	10.	8.050	10	4.000
1	6	1	.0000	83.	5.981	.016	306.196	183.660	73.462	276.306	10.	6.677	8	4.000
1	6	2	.0000	83.	5.981	.014	306.017	183.660	73.269	276.122	10.	6.677	8	4.000
1	7	1	.0000	42.	5.666	.014	306.017	183.660	73.269	276.122	10.	4.850	6	4.000
1	7	2	.0000	42.	5.665	.011	305.723	183.660	72.953	275.819	10.	4.850	6	4.000
1	7	3	.0000	42.	5.665	.011	305.723	183.660	72.953	275.819	10.	4.850	6	4.000
2	1	1	.0000	706.	7.037	.011	306.537	183.660	73.832	276.658	10.	17.947	18	4.000
2	1	2	.0000	706.	7.037	.025	306.498	183.660	73.789	276.617	10.	17.947	18	4.000
2	2	1	.0000	208.	6.418	.025	306.498	183.660	73.789	276.617	10.	10.192	12	4.000
2	2	2	.0000	208.	6.418	.018	306.498	183.660	73.789	276.617	10.	10.192	12	4.000
2	3	1	.0000	166.	6.310	.018	306.498	183.660	73.789	276.617	10.	9.194	10	4.000
2	3	2	.0000	166.	6.310	.016	306.392	183.660	73.675	276.509	10.	9.194	10	4.000
2	4	1	.0000	125.	6.172	.016	306.392	183.660	73.675	276.509	10.	8.050	10	4.000
2	4	2	.0000	125.	6.172	.016	306.253	183.660	73.523	276.365	10.	8.050	10	4.000
2	5	1	.0000	83.	5.981	.016	306.253	183.660	73.523	276.365	10.	6.677	8	4.000
2	5	2	.0000	83.	5.981	.014	306.074	183.660	73.330	276.180	10.	6.677	8	4.000
2	6	1	.0000	42.	5.666	.014	306.074	183.660	73.330	276.180	10.	4.850	6	4.000
2	6	2	.0000	42.	5.666	.011	305.780	183.660	73.014	275.878	10.	4.850	6	4.000

2	6	3	.0000	42.	5.666	.011	305.780	183.660	73.014	275.878	10.	4.850	6	4.000
3	1	1	.0000	498.	6.856	.011	306.498	183.660	73.789	276.617	10.	15.276	16	4.000
3	1	2	.0000	498.	6.856	.023	306.448	183.660	73.734	276.545	10.	15.276	16	4.000
3	2	1	.0000	166.	6.309	.023	306.448	183.660	73.734	276.565	10.	9.194	10	4.000
3	2	2	.0000	166.	6.309	.016	306.447	183.660	73.734	276.565	10.	9.194	10	4.000
3	3	1	.0000	125.	6.172	.016	306.447	183.660	73.734	276.565	10.	8.050	10	4.000
3	3	2	.0000	125.	6.172	.016	306.307	183.660	73.583	276.421	10.	8.050	10	4.000
3	4	1	.0000	83.	5.981	.016	306.307	183.660	73.583	276.421	10.	6.677	8	4.000
3	4	2	.0000	83.	5.981	.014	306.129	183.660	73.389	276.237	10.	6.677	8	4.000
3	5	1	.0000	42.	5.666	.014	306.129	183.660	73.389	276.237	10.	4.850	6	4.000
3	5	2	.0000	42.	5.666	.011	305.835	183.660	73.073	275.934	10.	4.850	6	4.000
3	5	3	.0000	42.	5.666	.011	305.835	183.660	73.073	275.934	10.	4.850	6	4.000
4	1	1	.0000	332.	6.650	.011	306.448	183.660	73.734	276.565	10.	12.664	14	4.000
4	1	2	.0000	332.	6.650	.021	306.380	183.660	73.661	276.496	10.	12.664	14	4.000
4	2	1	.0000	125.	6.172	.021	306.380	183.660	73.661	276.496	10.	8.050	10	4.000
4	2	2	.0000	125.	6.172	.016	306.379	183.660	73.660	276.495	10.	8.050	10	4.000
4	3	1	.0000	83.	5.981	.016	306.379	183.660	73.660	276.495	10.	6.677	8	4.000
4	3	2	.0000	83.	5.981	.014	306.200	183.660	73.467	276.311	10.	6.677	8	4.000
4	4	1	.0000	42.	5.666	.014	306.200	183.660	73.467	276.311	10.	4.850	6	4.000
4	4	2	.0000	42.	5.666	.011	305.907	183.660	73.150	276.008	10.	4.850	6	4.000
4	4	3	.0000	42.	5.666	.011	305.907	183.660	73.150	276.008	10.	4.850	6	4.000
5	1	1	.0000	204.	6.418	.011	306.380	183.660	73.661	276.496	10.	10.192	12	4.000
5	1	2	.0000	204.	6.418	.018	306.283	183.660	73.557	276.396	10.	10.192	12	4.000
5	2	1	.0000	83.	5.981	.018	306.283	183.660	73.557	276.396	10.	6.677	8	4.000
5	2	2	.0000	83.	5.981	.014	306.283	183.660	73.556	276.396	10.	6.677	8	4.000
5	3	1	.0000	42.	5.666	.014	306.283	183.660	73.556	276.396	10.	4.850	6	4.000
5	3	2	.0000	42.	5.666	.011	305.949	183.660	73.239	276.093	10.	4.850	6	4.000
5	3	3	.0000	42.	5.666	.011	305.949	183.660	73.239	276.093	10.	4.850	6	4.000
6	1	1	.0000	125.	6.171	.011	306.283	183.660	73.557	276.396	10.	8.050	10	4.000
6	1	2	.0000	125.	6.171	.016	306.144	183.660	73.405	276.252	10.	8.050	10	4.000
6	2	1	.0000	83.	5.981	.016	306.144	183.660	73.405	276.252	10.	6.677	8	4.000
6	2	2	.0000	83.	5.981	.014	306.143	183.660	73.405	276.252	10.	6.677	8	4.000
6	3	1	.0000	42.	5.666	.014	306.143	183.660	73.405	276.252	10.	4.850	6	4.000
6	3	2	.0000	42.	5.666	.011	305.849	183.660	73.088	275.949	10.	4.850	6	4.000
6	3	3	.0000	42.	5.666	.011	305.849	183.660	73.088	275.949	10.	4.850	6	4.000
7	1	1	.0000	42.	5.666	.011	306.144	183.660	73.405	276.252	10.	4.850	6	4.000
7	1	2	.0000	42.	5.666	.011	305.850	183.660	73.089	275.950	10.	4.850	6	4.000
7	1	3	.0000	42.	5.666	.011	305.850	183.660	73.089	275.950	10.	4.850	6	4.000
7	2	1	.0000	42.	5.666	.011	305.850	183.660	73.089	275.950	10.	4.850	6	4.000
7	2	2	.0000	42.	5.666	.011	305.849	183.660	73.088	275.949	10.	4.850	6	4.000

N O D E 2 . . . S T O R A G E A Q U I F E R - W E L L F I E L D D E S C R I P T I O N

AQUIFER INPUT DATA

MAXIMUM FLOW RATE/WELL (LB/HR)	1.500000+005	DISTANCE STORAGE AQUIFER TO CITY (M)	9.600000+003
RATIO INJECTION/PRODUCT. WELL FLOW RATE (LB/HR)	1.000000+000	DISTANCE CITY TO SUPPLY AQUIFER (M)	9.600000+003
FRACTION EXCESS PRODUCING WELLS	.000000	ENVIRONMENTAL TEMPERATURE DURING STORAGE (F)	7.000000+001
FRACTION NONPRODUCING WELLS	.000000	ENVIRONMENTAL TEMPERATURE DURING USEAGE (F)	3.500000+001
WELL SPACING (ACRES)	2.500000+001	DEPTH OF WELLS (M)	4.000000+002
AVERAGE WELL LIFE (YRS)	3.000000+001	DRILLING COST PER PRODUCING WELL	1.000000+005
AQUIFER EFFICIENCY (FRACTION)	6.000000+001		
AQUIFER FLUID RECOVERY FACTOR (FRACTION)	9.000000+001		

CALCULATIONS AT AQUIFER WELLS

NUMBER OF WELLS	23	EFFECTIVE WELL SPACING (ACRES)	2.500000+001
OUTLET WELLHEAD TEMPERATURE (F)	2.234655+002	PIPE LENGTH BETWEEN WELL NODES (M)	3.417931+002
OUTLET WELLHEAD PRESSURE (PSIA)	1.836807+001	OUTLET WELLHEAD STEAM FRACTION	.000000
OUTLET WELLHEAD ENTHALPY (BTU/LB)	1.917290+002	WELLHEAD PRESSURIZATION FACTOR (PRFACT)	1.519559+000
OUTLET WELLHEAD PRESSURE AT SATURATION (PSIA)	1.836807+001	INLET ACTUAL FLOW RATE/WELL (LB/HR)	1.495198+005
OUTLET ACTUAL FLOW RATE/WELL (LB/HR)	1.434372+005	TOTAL PEAK HEAT(CHILL) INTO AQUIFER (BTU/HR)	9.500596+008
TOTAL PEAK HEAT(CHILL) OUT OF AQUIFER (BTU/HR)	6.325247+008	TOTAL PEAK FLOW RATE INTO AQUIFER (LB/HR)	3.438956+006
TOTAL PEAK FLOW RATE OUT OF AQUIFER (LB/HR)	3.299056+006	TEMPERATURE OF SURROUNDING AQUIFER WATER (F)	5.500000+001
PEAK FLOW TO CITY DISTR. SYSTEM (LB/HR)	3.299056+006		

N O D E 2 . . . S T O R A G E A Q U I F E R - E X I T C O N D I T I O N S

ABOVE GROUND PIPING . . . AVERAGE SEASONAL AIR TEMPERATURE (I) = 35.0

NODE I	J	ITR	MIX	STEAM FRACT	FLOW RATE (LB/SEC)	VELOCITY (FT/SEC)	HEAT LOSS (BTU/SEC-FT)	TEMP (F)	PRES(PSIA)	SATURATION PRES(PSIA)	ENTHALPY (BTU/LB)	PIPE SCHD	INTER DIAM(IN)	EXTR DIAM(IN)	INSUL THK(IN)
7	2	1		.0000	40.	5.216	.000	223.466	48.482	18.368	191.729	10.	4.850	6	3.500
7	2	2		.0000	40.	5.216	.010	223.400	48.482	18.345	191.728	10.	4.850	6	3.500
7	1	1		.0000	40.	5.216	.000	223.400	48.482	18.345	191.728	10.	4.850	6	3.500
7	1	2		.0000	40.	5.216	.010	223.129	48.482	18.250	191.455	10.	4.850	6	3.500
7	1	3		.0000	40.	5.216	.010	223.129	48.482	18.250	191.455	10.	4.850	6	3.500
6	3	1		.0000	40.	5.216	.000	223.466	48.482	18.368	191.729	10.	4.850	6	3.500
6	3	2		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
6	3	3		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
6	2	1	M	.0000	80.	5.505	.000	223.265	48.482	18.298	191.592	10.	6.677	8	3.500
6	2	2	M	.0000	80.	5.505	.012	223.264	48.482	18.298	191.592	10.	6.677	8	3.500
6	1	1	M	.0000	120.	5.680	.000	223.219	48.482	18.282	191.546	10.	8.050	10	3.500
6	1	2	M	.0000	120.	5.680	.014	223.089	48.482	18.237	191.415	10.	8.050	10	3.500
5	3	1		.0000	40.	5.216	.000	223.466	48.482	18.368	191.729	10.	4.850	6	3.500
5	3	2		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
5	3	3		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
5	2	1	M	.0000	80.	5.505	.000	223.265	48.482	18.298	191.592	10.	6.677	8	3.500
5	2	2	M	.0000	80.	5.505	.012	223.264	48.482	18.298	191.592	10.	6.677	8	3.500
5	1	1	M	.0000	199.	5.906	.000	223.159	48.482	18.261	191.486	10.	10.192	12	3.500
5	1	2	M	.0000	199.	5.906	.016	223.070	48.482	18.230	191.345	10.	10.192	12	3.500
4	4	1		.0000	40.	5.216	.000	223.466	48.482	18.368	191.729	10.	4.850	6	3.500
4	4	2		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
4	4	3		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
4	3	1	M	.0000	80.	5.505	.000	223.265	48.482	18.298	191.592	10.	6.677	8	3.500
4	3	2	M	.0000	80.	5.505	.012	223.099	48.482	18.240	191.425	10.	6.677	8	3.500
4	2	1	M	.0000	120.	5.680	.000	223.200	48.482	18.275	191.526	10.	8.050	10	3.500
4	2	2	M	.0000	120.	5.680	.014	223.199	48.482	18.275	191.526	10.	8.050	10	3.500

4	1	1	M	.0000	319.	6.121	.000	223.118	48.482	18.247	191.444	10.	12.664	14	3.500
4	1	2	M	.0000	319.	6.121	.018	223.055	48.482	18.225	191.380	10.	12.664	14	3.500
3	5	1		.0000	40.	5.216	.000	223.466	48.482	18.368	191.729	10.	4.850	6	3.500
3	5	2		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
3	5	3		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
3	4	1	M	.0000	80.	5.505	.000	223.265	48.482	18.298	191.592	10.	6.677	8	3.500
3	4	2	M	.0000	80.	5.505	.012	223.099	48.482	18.240	191.425	10.	6.677	8	3.500
3	3	1	M	.0000	120.	5.680	.000	223.200	48.482	18.275	191.526	10.	8.050	10	3.500
3	3	2	M	.0000	120.	5.680	.014	223.070	48.482	18.230	191.395	10.	8.050	10	3.500
3	2	1	M	.0000	159.	5.807	.000	223.152	48.482	18.259	191.479	10.	9.194	10	3.500
3	2	2	M	.0000	159.	5.807	.014	223.152	48.482	18.259	191.479	10.	9.194	10	3.500
3	1	1	M	.0000	478.	6.310	.000	223.087	48.482	18.236	191.413	10.	15.276	16	3.500
3	1	2	M	.0000	478.	6.310	.020	223.040	48.482	18.219	191.366	10.	15.276	16	3.500
2	6	1		.0000	40.	5.216	.000	223.466	48.482	18.368	191.729	10.	4.850	6	3.500
2	6	2		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
2	6	3		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
2	5	1	M	.0000	80.	5.505	.000	223.265	48.482	18.298	191.592	10.	6.677	8	3.500
2	5	2	M	.0000	80.	5.505	.012	223.099	48.482	18.240	191.425	10.	6.677	8	3.500
2	4	1	M	.0000	120.	5.680	.000	223.200	48.482	18.275	191.526	10.	8.050	10	3.500
2	4	2	M	.0000	120.	5.680	.014	223.070	48.482	18.230	191.395	10.	8.050	10	3.500
2	3	1	M	.0000	159.	5.807	.000	223.152	48.482	18.259	191.479	10.	9.194	10	3.500
2	3	2	M	.0000	159.	5.807	.014	223.055	48.482	18.225	191.380	10.	9.194	10	3.500
2	2	1	M	.0000	199.	5.906	.000	223.124	48.482	18.249	191.450	10.	10.192	12	3.500
2	2	2	M	.0000	199.	5.906	.016	223.124	48.482	18.249	191.450	10.	10.192	12	3.500
2	1	1	M	.0000	677.	6.476	.000	223.065	48.482	18.228	191.390	10.	17.947	18	3.500
2	1	2	M	.0000	677.	6.476	.022	223.028	48.482	18.215	191.353	10.	17.947	18	3.500
1	7	1		.0000	40.	5.216	.000	223.466	48.482	18.368	191.729	10.	4.850	6	3.500
1	7	2		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
1	7	3		.0000	40.	5.216	.010	223.129	48.482	18.251	191.456	10.	4.850	6	3.500
1	6	1	M	.0000	80.	5.505	.000	223.265	48.482	18.298	191.592	10.	6.677	8	3.500

1	6	2	M	.0000	80.	5.505	.012	223.099	48.482	18.240	191.425	10.	6.677	8	3.500
1	5	1	M	.0000	120.	5.680	.000	223.200	48.482	18.275	191.526	10.	8.050	10	3.500
1	5	2	M	.0000	120.	5.680	.014	223.070	48.482	18.230	191.395	10.	8.050	10	3.500
1	4	1	M	.0000	159.	5.807	.000	223.152	48.482	18.259	191.479	10.	9.194	10	3.500
1	4	2	M	.0000	159.	5.807	.014	223.055	48.482	18.225	191.380	10.	9.194	10	3.500
1	3	1	M	.0000	199.	5.906	.000	223.124	48.482	18.249	191.450	10.	10.192	12	3.500
1	3	2	M	.0000	199.	5.906	.016	223.034	48.482	18.217	191.359	10.	10.192	12	3.500
1	2	1	M	.0000	239.	5.989	.000	223.095	48.482	18.239	191.421	10.	11.088	12	3.500
1	2	2	M	.0000	239.	5.989	.016	223.095	48.482	18.239	191.421	10.	11.088	12	3.500

TRANSMISSION SYSTEM AND AQUIFER WELL PRESSURE DROPS FOR DOWNHOLE PUMPS

MINIMUM TRANS PRESSURE DROP (PSI)	1.299144-002
MAXIMUM TRANS PRESSURE DROP (PSI)	2.988780+001
MEDIAN TRANS PRESSURE DROP (PSI)	2.988780+001
WELL DEPTH (FT)	1.312333+003
WELL DIAMETER (FT)	7.291667-001
ELEVATION PRESSURE DROP (PSI)	5.424423+002
WELL REYNOLDS NUMBER	3.960825+005
WELL FRICTION FACTOR	2.034578-002
WELL FRICTION PRESSURE DROP (PSI)	6.044421-001
WELL FLOW RATE (LBM/SEC)	3.984368+001
WELL FLUID VELOCITY (FT/SEC)	1.603040+000
WELL VELOCITY PRESSURE DROP (PSI)	1.646379-002
TOTAL WELL PRESSURE DROP (PSI)	5.430632+002
TOTAL TRANS AND WELL PRESSURE DROP (PSI)	5.729510+002

PUMP CAPITAL COST AND ENERGY REQUIREMENT ... DOWNHOLE PUMP

FLUID FLOW RATE (LBM/HR)	1.434372+005
PRESSURE DROP RESTORED (PSI)	5.729510+002
PUMP HEAD (FT OF H ₂ O)	1.386143+003
PUMP EFFICIENCY (FRACT)	6.500000-001
INLET FLUID TEMPERATURE (F)	2.234655+002
PUMP CAPITAL COST (\$)	5.281037+004
NON-ELECTRIC OPERATING COST (\$)	.000000
ENERGY CONSUMPTION (KWS)	1.151151+002

N O D E 2 . . . S T O R A G E A Q U I F E R - C A P I T A L C O S T S

PIPING SYSTEM EQUIPMENT	CAPITAL COST (\$)
PIPE	480788.
INSULATION	1123306.
CASING	259649.
SITF	1024687.
WELLHEAD VALVES	238916.
INSTRUMENTATION	47783.
SOLIDS SEPARATORS	234999.
STORAGE AND DELIVERY SURFACE PUMPS	0.
DELIVERY DOWNHOLE PUMPS	1214638.
TOTAL PIPING SYSTEM	4624766.
ENGINEERING AND DESIGN (12 PCT)	554972.
TOTAL CAPITAL COST	5179738.

STORAGE AND DELIVERY MAINTENANCE (\$)
258987.

STORAGE AND DELIVERY CAP. REPL. RATE
.0150

STORAGE AND DELIVERY SURFACE PUMPS KILOWATTS
76.98

DELIVERY DOWNHOLE PUMPS KILOWATTS
2647.65

LEG 2 ... TRANSMISSION TO DISTRIBUTION SYSTEM ... ENTERING AND EXIT CONDITIONS AND CAPITAL COSTS

ABOVE GROUND PIPING ... AVERAGE SEASONAL AIR TEMPERATURE (F) = 35.0

NODE I	J	ITR	MIX	STEAM FRACT	FLOW RATE (LB/SEC)	VELOCITY (FT/SEC)	HEAT LOSS (BTU/SEC-FT)	TEMP (F)	PRES(PSIA)	SATURATION PRES(PSIA)	ENTHALPY (BTU/LB)	PIPE INTER SCHD	DIAM(IN)	EXTER DIAM(IN)	INSUL THK(IN)
1	1	1	M	.0000	916.	6.930	.000	223.045	99.565	18.221	191.371	10.	20.178	22	3.500
1	1	2		.0000	916.	6.928	.026	222.036	99.565	17.873	190.464	10.	20.178	22	3.500
1	1	3		.0000	916.	6.928	.026	222.036	99.565	17.873	190.464	10.	20.178	22	3.500

PIPING SYSTEM EQUIPMENT

CAPITAL COST (\$)

PIPE	1897904.
INSULATION	2462942.
CASING	477372.
SITE	2042719.
TRANSMISSION SURFACE PUMPS	50734.
TOTAL PIPING SYSTEM	7431671.
ENGINEERING AND DESIGN (12 PCT)	891801.
TOTAL CAPITAL COST	8323472.

TRANSMISSION MAINTENANCE (\$)

416174.

TRANSMISSION CAP. REPL. RATE

.0150

TRANSMISSION SURFACE PUMP KILOWATTS

314.02

NUMBER OF TRANSMISSION LEG PUMPS

1

TRANSMISSION LEG PRESSURE DROP (PSI)

81.49

CITY DISTRICT HEATING/COOLING REQUIREMENTS
HEATING/COOLING DEMANDS AND FLUID REQUIREMENTS - PREPROCESSOR CALQNA

CITY INPUT DATA

OPERATIONAL MODE	HEATING	DESIGN OUTDOOR TEMP. FOR HEATING (F)	-5.000000+000
TOTAL ANNUAL HEATING DEGREE DAYS (F DAYS)	5.267000+003	MINIMUM OUTDOOR TEMPERATURE (F)	-1.000000+001
DEGREE DAYS AT DESIGN TEMP. FOR HEATING	5.109000+003	FRACTION OF FLUID LOST BY LEAKAGE IN PIPING	1.000000+002
FRACTION OF HEATING LOST IN CITY PIPING	5.000000+002		

CITY HEATING AND FLUID REQUIREMENTS CALCULATIONS

ANNUAL AVERAGE HEATING DEMAND (MBTU/HR)	1.004321+002	ANNUAL HEATING DEMAND AT DESIGN TEMP (MBTU/YR)	8.803877+005
PEAK HEATING DEMAND (MBTU/HR)	3.254439+002	PEAK FLOW RATE INSIDE CITY DISTRB SYSTEM (LB/HR)	3.297675+006
CITY LOAD FACTOR	3.046003+001	PEAK FLOW RATE FROM STORAGE AQUIFER (LB/HR)	3.297675+006
ANNUAL FLOW RATE FROM STORAGE AQUIFER (LB/YR)	8.920838+009		

HEAT EXCHANGER CONDITIONS AT INLET TO CITY

INLET TEMP DELIVERED FROM STORAGE AQUIFER (F)	2.220357+002	CLEAN WATER TEMP. OUT OF HEAT EXCHANGER (F)	2.045357+002
TEMPERATURE DROP IN HEAT EXCHANGER (F)	1.045357+002	RETURN TEMPERATURE AT CITY OUTLET (F)	1.000000+002
TEMPERATURE AT HEAT EXCHANGER OUTLET (F)	1.175000+002		
PRESSURE AT HEAT EXCHANGER OUTLET (PSIA)	1.500000+001		

D I S T R I B U T I O N - F L U I D T R A N S M I S S I O N C O N V E R G E N C E T E S T

PREVIOUS ANNUAL FLOW RATE DEMANDED BY DISTRIBUTION SYSTEM (LH	8.924575+009
CURRENT ANNUAL FLOW RATE DEMANDED BY DISTRIBUTION SYSTEM (LHM	8.920838+009
DIFFERENCE (LRM/HR)	-3.737060+006
DIFFERENCE (PER CENT)	4.189135-002
CONVERGENCE CRITERION (PER CENT)	2.000000+000
DISTRIBUTION SYSTEM DEMAND SUBROUTINE CALQNA AND FLUID TRANSMISSION SUBMODEL SATISFY CONVERGENCE CRITERION	
NUMBER OF DISTRIBUTION - TRANSMISSION ITERATIONS	3

HEAT EXCHANGER AT INLET TO NODE 3

HEAT EXCHANGER PRESSURE DROP ... TUBE SIDE

TUBE LENGTH (FT)	7.492386+002	TUBE INTERNAL DIAMETER (FT)	1.000000-001
RELATIVE ROUGHNESS RATIO	2.000000-003	CROSS-SECTIONAL FLOW AREA (SQ FT)	9.572550-003
REYNOLDS NUMBER	1.977998+005	FRICTION FACTOR	2.273651-002
TOTAL FLOW RATE (LB/HR)	3.297675+006	FLOW VELOCITY (FT/SEC)	8.000000+000
FLUID DENSITY (LBM/CU FT)	6.095093+001	ENTRANCE AREA (SQ FT)	5.027780+000
EXIT AREA (SQ FT)	5.027780+000	ENTRANCE PRESSURE DROP (PSI)	3.446869-003
EXIT PRESSURE DROP (PSI)	6.880613-003	TUBE PRESSURE DROP (PSI)	7.171448+001
TOTAL PRESSURE DROP (PSI)	7.172480+001		

HEAT EXCHANGER PRESSURE DROP ... SHELL SIDE

TUBE LENGTH (FT)	7.492386+002	SHELL EQUIVALENT INT. DIAM. (FT)	1.078814-001
RELATIVE ROUGHNESS RATIO	1.853888-003	CROSS-SECTIONAL FLOW AREA (SQ FT)	2.730368+000
REYNOLDS NUMBER	1.260847+005	FRICTION FACTOR	2.443509-002
TOTAL FLOW RATE (LB/HR)	3.297675+006	FLOW VELOCITY (FT/SEC)	5.470746+000
FLUID DENSITY (LBM/CU FT)	6.132502+001	ENTRANCE AREA (SQ FT)	5.027780+000
EXIT AREA (SQ FT)	5.027780+000	ENTRANCE PRESSURE DROP (PSI)	7.379521-004
EXIT PRESSURE DROP (PSI)	6.744051-004	SHELL-SIDE PRESSURE DROP (PSI)	3.361406+001
TOTAL PRESSURE DROP (PSI)	3.361547+001		

PUMP CAPITAL COST AND ENERGY REQUIREMENT ... TUBE SIDE OF HX

FLUID FLOW RATE (LBM/HR)	3.297675+006
PRESSURE DROP RESTORED (PSI)	7.172480+001
PUMP HEAD (FT OF H2O)	1.734162+002
PUMP EFFICIENCY (FRACT)	6.500000-001
INLET FLUID TEMPERATURE (F)	2.220357+002
PUMP CAPITAL COST (\$)	6.274231+004
NON-ELECTRIC OPERATING COST (\$)	.000000
ENERGY CONSUMPTION (KWS)	3.311005+002

PUMP CAPITAL COST AND ENERGY REQUIREMENT ... SHELL SIDE OF HX

FLUID FLOW RATE (LBM/HR)	3.297675+006
PRESSURE DROP RESTORED (PSI)	3.361547+001
PUMP HEAD (FT OF H2O)	7.800106+001
PUMP EFFICIENCY (FRACT)	6.500000-001
INLET FLUID TEMPERATURE (F)	9.500000+001
PUMP CAPITAL COST (\$)	3.373175+004
NON-ELECTRIC OPERATING COST (\$)	.000000
ENERGY CONSUMPTION (KWS)	1.489261+002

S U P P L E M E N T A L H E A T I N G / C O O L I N G R E Q U I R E M E N T S

S U P P L E M E N T A L R E Q U I R E M E N T S T O B A L A N C E A N N U A L S U P P L Y A N D A N N U A L D E M A N D

PEAK SUPPLY FLOW TO STORAGE AQUIFER (LB/HR)	3.438956+006	PEAK FLUID SOURCE FLOW AT NODE 1 (LB/HR)	3.407674+006
ANNUAL SUPPLY FLOW TO STORAGE AQUIFER (LB/YR)	9.903722+009	ANNUAL FLUID SOURCE FLOW AT NODE 1 (LB/YR)	9.813634+009
PEAK CITY DEMAND FLOW FROM AQUIFER (LB/HR)	3.297675+006	FLUID SOURCE ANNUAL LOAD FACTOR AT NODE 1	3.285265-001
ANNUAL CITY DEMAND FLOW FROM AQUIFER (LB/YR)	8.920838+009	CITY ANNUAL LOAD FACTOR	3.086003-001
ANNUAL SUPPLY / DEMAND FLOW RATIO, INC. LOSSES	9.991606-001	WATER TEMPERATURE AT CITY INLET (F)	2.045357+002
ANNUAL SUPPLY FLOW SHORTAGE, INC. LOSSES (LB/YR)	7.488589+006	WATER TEMPERATURE AT CITY OUTLET (F)	1.000000+002
ANNUAL SUPPLEMENTAL HEAT (CHILL) NEEDS (BTU/YR)	.000000	TEMPERATURE DELTA ACROSS CITY (F)	1.045357+002
ANNUAL COST OF SUPPLEMENTAL HEAT (CHILL) (\$/YR)	.000000	ABS MAXIMUM FLUID SOURCE FLOW AT NODE 1 (LB/HR)	1.000000+049
NO OF SUPPLY AQUIFER TEMP ITERATIONS	3	STORAGE AQUIFER FLUID RECOVERY FRACTION	9.000000-001
NESTED NO OF SUPPLY/DEMAND MATCHUP ITERATIONS	2		
NESTED NO OF TRANS/DEMAND MATCHUP ITERATIONS	3		

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

N O D E 3 ... DETAILED CITY DISTRIBUTION SYSTEM FOR DISTRICT HEATING (COOLING)

DEFINITION OF DISTRIBUTION DISTRICTS

DIST NO	DIST TYPE	DIS TO DISTRB (MI)	DENSITY (UN/SMI)	AREA (SMI)	LENGTH (MI)	WIDTH (MI)	DIVERS FACTOR	PEAK HEAT DEMAND/UN (MBTU/HR)	HOT WATER DEMAND (GAL./DAY)	HOUSE SPACING (MI)	STREET SPACING (MI)	GROWTH FACTOR (%)	REJECT TEMP (DEG F)	PEOPLE PER UNIT
01	04	.410	376.00	.078	.620	.120	.72	.480000	1260.0	.0516	.103	0	100.0	55.9
02	03	1.590	3837.00	.290	.700	.620	.72	.034000	60.0	.0161	.032	0	100.0	2.7
03	03	1.480	3837.00	.080	.600	.180	.72	.034000	60.0	.0161	.032	0	100.0	2.7
04	03	.430	3837.00	.060	.320	.270	.72	.034000	60.0	.0161	.032	0	100.0	2.7
05	03	.560	3837.00	.200	.580	.510	.72	.034000	60.0	.0161	.032	0	100.0	2.7
06	03	.380	3837.00	.040	.400	.150	.72	.034000	60.0	.0161	.032	0	100.0	2.7
07	04	.450	376.00	.146	.480	.270	.72	.480000	1260.0	.0516	.103	0	100.0	55.9
08	03	.500	3837.00	.150	.530	.420	.72	.034000	60.0	.0161	.032	0	100.0	2.7
09	02	.420	2093.00	.260	1.690	.230	.72	.044000	60.0	.0219	.044	0	100.0	2.7
10	03	1.270	3837.00	.680	2.020	.530	.72	.034000	60.0	.0161	.032	0	100.0	2.7
11	02	.430	2093.00	.140	.580	.400	.72	.044000	60.0	.0219	.044	0	100.0	2.7
12	02	.430	2093.00	.160	.610	.390	.72	.044000	60.0	.0219	.044	0	100.0	2.7
13	05	.560	7898.00	.023	.260	.210	.72	.034000	60.0	.0113	.023	0	100.0	2.7
14	02	.400	2093.00	.140	.570	.480	.72	.044000	60.0	.0219	.044	0	100.0	2.7
15	02	.400	2093.00	.450	2.350	.280	.72	.044000	60.0	.0219	.044	0	100.0	2.7
16	05	.210	7898.00	.034	.300	.240	.72	.034000	60.0	.0113	.023	0	100.0	2.7
17	04	.510	376.00	.049	.420	.090	.72	.480000	1260.0	.0516	.103	0	100.0	55.9
18	01	.870	1568.00	.190	1.710	.160	.72	.053000	60.0	.0253	.051	0	100.0	2.7

METRIC EQUIVALENTS

DIST NO	DIST TYPE	DIST TO DISTANCE (KM)	DENSITY (UN/SKM)	AREA (SKM)	LENGTH (KM)	WIDTH (KM)	DIVERS FACTOR	PEAK HEAT DEMAND/UN (MCAL/HR)	HOT WATER DEMAND (LITERS/DAY)	HOUSE SPACING (KM)	STREET SPACING (KM)	GROWTH FACTOR (%)	REJECT TEMP (DEG C)	PEOPLE PER UNIT
01	04	.660	145.17	.20	1.00	.19	.72	120.96	4769.1	.0830	.1660	0	37.8	55.9
02	03	2.558	1481.47	.75	1.13	1.00	.72	8.57	227.1	.0260	.0520	0	37.8	2.7
03	03	2.361	1481.47	.21	.97	.29	.72	8.57	227.1	.0260	.0520	0	37.8	2.7
04	03	.692	1481.47	.16	.51	.43	.72	8.57	227.1	.0260	.0520	0	37.8	2.7
05	03	.901	1481.47	.52	.93	.82	.72	8.57	227.1	.0260	.0520	0	37.8	2.7
06	03	.611	1481.47	.10	.64	.24	.72	8.57	227.1	.0260	.0520	0	37.8	2.7
07	04	.724	145.17	.38	.77	.43	.72	120.96	4769.1	.0830	.1660	0	37.8	55.9
08	03	.804	1481.47	.39	.85	.68	.72	8.57	227.1	.0260	.0520	0	37.8	2.7
09	02	.676	808.11	.67	2.72	.37	.72	11.09	227.1	.0352	.0703	0	37.8	2.7
10	03	2.643	1481.47	1.76	3.25	.85	.72	8.57	227.1	.0260	.0520	0	37.8	2.7
11	02	.692	808.11	.36	.93	.64	.72	11.09	227.1	.0352	.0703	0	37.8	2.7
12	02	.692	808.11	.41	.98	.63	.72	11.09	227.1	.0352	.0703	0	37.8	2.7
13	05	.901	3049.42	.06	.42	.34	.72	8.57	227.1	.0181	.0362	0	37.8	2.7
14	02	.644	808.11	.36	.92	.77	.72	11.09	227.1	.0352	.0703	0	37.8	2.7
15	02	.644	808.11	1.17	3.78	.45	.72	11.09	227.1	.0352	.0703	0	37.8	2.7
16	05	.338	3049.42	.09	.48	.39	.72	8.57	227.1	.0181	.0362	0	37.8	2.7
17	04	.821	145.17	.13	.68	.14	.72	120.96	4769.1	.0830	.1660	0	37.8	55.9
18	01	1.400	605.41	.49	2.75	.26	.72	13.36	227.1	.0406	.0813	0	37.8	2.7

NOTE--IF THE INPUT OUTDOOR DESIGN TEMPERATURE TDES(1) IS DIFFERENT FROM THE DEFAULT VALUE OF -5 F
AQSTOR HAS AUTOMATICALLY PRORATED (RATIOED) THE INPUT BUILDING PEAK HEAT DEMANDS
BASED ON THE NEW INPUT OUTDOOR DESIGN TEMPERATURE TDES(1)

D I S T R I C T P O P U L A T I O N S

DISTRICT TYPE	DISTRICT NUM	NUM OF HOUSES	PEOPLE/HOUSE	NUM OF PEOPLE
1	18	297.9	2.7	792.
	TOTAL	297.9		792.
2	9	544.2	2.7	1448.
	11	293.0	2.7	779.
	12	334.9	2.7	891.
	14	293.0	2.7	779.
	15	941.8	2.7	2505.
	TOTAL	2406.9		6402.
3	2	1112.7	2.7	2960.
	3	307.0	2.7	817.
	4	230.2	2.7	612.
	5	767.4	2.7	2041.
	6	153.5	2.7	408.
	8	575.5	2.7	1531.
	10	2609.2	2.7	6940.
	TOTAL	5755.5		15310.
4	1	29.3	55.9	1638.
	7	54.9	55.9	3066.
	17	18.4	55.9	1029.
	TOTAL	102.6		5734.
5	13	181.7	2.7	483.
	16	268.5	2.7	714.
	TOTAL	450.2		1197.

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 1 TWO PIPE SYSTEM
 BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VEL (FT/SEC)
				SUPPLY	RETURN				
HOUSE		1.7	-1.7551	199.	100.	28.93	1.00	1.0	4.7
STREET DESCRIPTION									
STREET	HOUSE								
1	1	3.4	-1.6234	200.	99.	5.97	1.50	1.0	4.0
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	1.2	-6.4375	200.	99.	3.64	1.50	1.0	1.4
	2	6.1	-6.3915	203.	97.	70.40	1.50	1.0	7.2
	3	11.1	-6.3793	203.	96.	207.62	1.50	1.0	12.9
	4	16.0	-7.2492	204.	96.	51.65	2.50	1.0	8.0
	5	18.4	.0000	204.	96.	.00	2.50	1.0	8.0
MAIN DESCRIPTION									
MAIN		36.9	-31.3663	204.	96.	334.52	3.00	1.0	11.9

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 1 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	9871	7.4	116	18.2	58.	7.0	18.3	122.8	32	.0	54.2	23.09
1.5	10892	14.9	88	13.8	44.	6.6	21.7	135.5	36	60.8	59.8	28.75
2.5	2178	7.1	16	2.8	8.	2.1	5.4	35.8	7	16.4	15.9	39.22
3.0	4329	17.5	4	.8	2.	2.3	10.7	79.4	14	38.1	35.6	42.61
TOTALS	27271	46.9		35.6		18.1	56.2	373.5		115.3	165.5	29.74

COST OF 29. METERS OF FLOW RATING 30. GPM IS \$ 1239. (THOUSAND)
COST OF PUMPS WITH 51. HORSEPOWER CAPACITY IS \$ 16. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	46.92
INSULATION	56.19
CASING	373.51
FITTINGS	35.58
EXPANSION LOOP	115.33
TRENCH	165.46
VALVES	18.07
METERS	12.39
HEAT PUMP	.00
PUMP	16.15

TOTAL SYSTEM CAPITAL COST 839.60

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 2 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F) SUPPLY RETURN		HEAD LOSS FEET	NOMINAL DIAM (IN)	INSUL (IN)	VEL (FT/SEC)
HOUSE		.1	-.5318	193.	100.	12.25	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-.8409	195.	97.	.20	1.00	1.0	.6
	2	.4	-.8344	197.	95.	.72	1.00	1.0	1.2
	3	.7	-.8307	198.	95.	1.51	1.00	1.0	1.9
	4	.9	-.8281	199.	94.	2.57	1.00	1.0	2.5
	5	1.1	-.8261	199.	94.	3.88	1.00	1.0	3.1
	6	1.3	-.8245	200.	93.	5.42	1.00	1.0	3.7
	7	1.6	-.8231	200.	93.	7.20	1.00	1.0	4.4
	8	1.8	-.8219	200.	93.	9.20	1.00	1.0	5.0
	9	2.0	-.8209	201.	93.	11.43	1.00	1.0	5.6
	10	2.2	-.8200	201.	92.	13.88	1.00	1.0	6.2
	11	2.5	-.8191	201.	92.	16.54	1.00	1.0	6.8
	12	2.7	-.8184	201.	92.	19.41	1.00	1.0	7.5
	13	2.9	-.8189	201.	92.	11.24	1.00	1.0	8.1
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.8	-1.6290	202.	92.	4.24	1.00	1.0	2.2
	2	5.0	-1.8917	203.	91.	15.16	1.50	1.0	5.9
	3	9.2	-1.8908	203.	91.	46.48	1.50	1.0	10.8
	4	13.4	-2.1548	203.	91.	11.74	2.50	1.0	6.7
	5	17.6	-2.1544	203.	91.	19.38	2.50	1.0	8.8
	6	21.8	-2.1540	203.	91.	28.73	2.50	1.0	10.9
	7	26.1	-2.1537	203.	90.	39.72	2.50	1.0	13.0
	8	30.3	-2.1535	203.	90.	52.32	2.50	1.0	15.1
	9	34.5	-2.3495	203.	90.	23.25	3.00	1.0	11.1
	10	38.7	-2.3493	203.	90.	28.74	3.00	1.0	12.5
	11	42.9	-2.3492	203.	90.	34.75	3.00	1.0	13.8
	12	45.0	.0000	203.	90.	.00	3.00	1.0	13.8
MAIN DESCRIPTION									
MAIN		90.0	-163.8671	203.	90.	463.59	6.00	1.0	10.5

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 2 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	212937	151.1	6744	634.7	3372.	244.3	394.9	2502.2	709	467.6	1103.5	25.82
1.5	1363	2.1	16	1.5	8.	.8	3.1	18.9	4	8.5	8.3	31.55
2.5	3409	10.5	40	4.1	20.	3.1	8.1	53.2	11	24.4	23.6	37.31
3.0	2045	8.7	32	4.0	16.	8.3	5.6	39.5	6	18.9	17.7	50.18
6.0	16791	169.6	4	.8	2.	2.3	50.2	384.3	55	228.7	177.2	60.33
TOTALS	236547	342.0		645.1		258.8	461.9	2998.0		748.1	1330.4	28.68

COST OF 1112. METERS OF FLOW RATING 7. GPM IS \$ 19633. (THOUSAND)
COST OF PUMPS WITH 142. HORSEPOWER CAPACITY IS \$ 28. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE 342.02
INSULATION 461.89
CASING 2998.01
FITTINGS 645.07
EXPANSION LOOP 748.11
TRENCH 1330.35
VALVES 258.76
METERS 196.33
HEAT PUMP .00
PUMP 27.60

TOTAL SYSTEM CAPITAL COST 7008.14

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 3 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	----	-----
HOUSE		.1	-.5358	195.	100.	12.25	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-.8474	198.	97.	.20	1.00	1.0	.6
	2	.4	-.8410	200.	95.	.72	1.00	1.0	1.2
	3	.7	-.8374	201.	95.	1.51	1.00	1.0	1.9
	4	.9	-.8348	201.	94.	2.57	1.00	1.0	2.5
	5	1.0	.0000	202.	94.	.00	1.00	1.0	2.5
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	1.5	-1.6650	202.	94.	12.49	1.00	1.0	4.0
	2	2.9	-1.6612	202.	93.	44.72	1.00	1.0	8.1
	3	4.4	-1.9292	203.	93.	11.75	1.50	1.0	5.1
	4	5.8	-1.9277	203.	93.	19.96	1.50	1.0	6.8
	5	7.3	-1.9264	203.	92.	30.09	1.50	1.0	8.5
	6	8.7	-1.9254	203.	92.	42.08	1.50	1.0	10.2
	7	10.2	-1.9246	203.	92.	55.88	1.50	1.0	11.9
	8	11.7	-1.9238	204.	92.	71.45	1.50	1.0	13.6
	9	12.4	.0000	204.	92.	.00	1.50	1.0	13.6
MAIN DESCRIPTION									
MAIN		24.8	-154.9588	204.	92.	599.05	6.00	1.0	12.5

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 3 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBR OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBR OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1.0	58519	41.5	1960	292.1	980.	112.6	109.1	687.6	195	128.3	303.3	28.61
1.5	4091	5.9	56	8.3	28.	4.2	8.8	53.7	13	24.1	23.7	31.48
6.0	15629	157.9	4	1.2	2.	3.6	46.8	357.7	52	212.9	164.9	60.46
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	78240	205.3		301.6		120.5	164.6	1099.1		365.3	491.9	35.13

COST OF 306. METERS OF FLOW MATING 7. GPM IS \$ 8554. (THOUSAND)
COST OF PUMPS WITH 29. HORSEPOWER CAPACITY IS \$ 14. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	205.32
INSULATION	164.58
CASING	1099.09
FITTINGS	301.62
EXPANSION LOOP	365.28
TRENCH	491.88
VALVES	120.49
METERS	85.54
HEAT PUMP	.00
PUMP	13.51

TOTAL SYSTEM CAPITAL COST 2847.31

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 4 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (RTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VEL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	----	-----
HOUSE		.1	-.5342	195.	100.	12.25	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-.8449	197.	97.	.70	1.00	1.0	.6
	2	.4	-.8385	199.	95.	.72	1.00	1.0	1.2
	3	.7	-.8348	200.	95.	1.51	1.00	1.0	1.9
	4	.9	-.8323	200.	94.	2.57	1.00	1.0	2.5
	5	1.1	-.8303	201.	94.	3.88	1.00	1.0	3.1
	6	1.3	-.8286	201.	93.	5.42	1.00	1.0	3.7
	7	1.5	.0000	202.	93.	.00	1.00	1.0	3.7
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.9	-1.6504	202.	93.	5.05	1.00	1.0	2.5
	2	3.0	-1.6457	203.	92.	47.03	1.00	1.0	8.3
	3	5.1	-1.9126	203.	92.	15.61	1.50	1.0	6.0
	4	7.2	-1.9114	203.	92.	29.48	1.50	1.0	8.4
	5	9.3	-.9554	203.	92.	23.62	1.50	1.0	10.9
MAIN DESCRIPTION									
MAIN		18.6	-28.9586	203.	92.	284.82	2.50	1.0	9.3

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 4 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	42237	30.0	1384	206.2	692.	79.8	78.6	496.3	140	87.8	218.9	28.35
1.5	1704	2.6	24	3.6	12.	1.8	3.8	23.6	5	10.6	10.4	33.07
2.5	4541	14.0	4	.7	2.	.5	10.5	70.9	15	32.5	31.5	35.36
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	48483	46.6		210.5		82.1	92.9	590.8		130.9	260.8	29.17

COST OF 230. METERS OF FLOW RATING 7. GPM IS \$ 6430. (THOUSAND)
COST OF PUMPS WITH 11. HORSEPOWER CAPACITY IS \$ 4. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	46.58
INSULATION	92.89
CASING	590.76
FITTINGS	210.46
EXPANSION LOOP	130.88
TRENCH	260.77
VALVES	82.10
METERS	64.30
HEAT PUMP	.00
PUMP	4.41

TOTAL SYSTEM CAPITAL COST 1483.15

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 5 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F) SUPPLY RETURN		HEAD LOSS FEET	NOMINAL DIAM (IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	-----		----	-----	----	-----
HOUSE		.1	-.5329	194.	100.	12.25	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-.8428	196.	97.	.20	1.00	1.0	.6
	2	.4	-.8364	198.	95.	.72	1.00	1.0	1.2
	3	.7	-.8327	199.	95.	1.51	1.00	1.0	1.9
	4	.9	-.8301	200.	94.	2.57	1.00	1.0	2.5
	5	1.1	-.8281	200.	94.	3.88	1.00	1.0	3.1
	6	1.3	-.8265	201.	93.	5.42	1.00	1.0	3.7
	7	1.6	-.8251	201.	93.	7.20	1.00	1.0	4.4
	8	1.8	-.8239	201.	93.	9.20	1.00	1.0	5.0
	9	2.0	-.8229	201.	93.	11.43	1.00	1.0	5.6
	10	2.2	-.8219	202.	92.	13.88	1.00	1.0	6.2
	11	2.5	-.8107	202.	92.	18.27	1.00	1.0	6.8
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.8	-1.6359	202.	92.	4.24	1.00	1.0	2.2
	2	4.4	-1.8993	203.	91.	11.75	1.50	1.0	5.1
	3	7.9	-1.8982	203.	91.	35.19	1.50	1.0	9.3
	4	11.5	-1.8975	203.	91.	69.63	1.50	1.0	13.4
	5	15.1	-2.1625	203.	91.	14.47	2.50	1.0	7.5
	6	18.6	-2.1621	204.	91.	21.39	2.50	1.0	9.3
	7	22.2	-2.1617	204.	91.	29.51	2.50	1.0	11.0
	8	25.7	-2.1614	204.	91.	38.82	2.50	1.0	12.8
	9	29.3	-2.1612	204.	91.	49.27	2.50	1.0	14.6
	10	31.1	.0000	204.	91.	.00	2.50	1.0	14.6
MAIN DESCRIPTION									
MAIN		62.1	-57.9272	204.	91.	71.11	6.00	1.0	6.7

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 5 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1.0	146852	104.2	4660	548.2	2330.	211.1	272.4	1725.6	489	322.4	761.0	26.86
1.5	2045	3.1	24	2.8	12.	1.4	4.6	28.3	6	12.7	12.5	31.97
2.5	3409	10.5	48	6.2	24.	4.7	8.2	53.2	11	24.4	23.6	38.39
6.0	5913	66.8	4	1.0	2.	2.4	19.8	151.3	19	90.0	69.7	67.88
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	158221	184.6		558.2		220.1	304.9	1958.4		449.6	866.9	28.71

COST OF 767. METERS OF FLOW MATING 7. GPM IS \$ 16927. (THOUSAND)
COST OF PUMPS WITH 83. HORSEPOWER CAPACITY IS \$ 20. (THOUSAND)

PIPING SYSTEM(\$X1000)

-----	-----
PIPE	184.62
INSULATION	304.95
CASING	1958.39
FITTINGS	558.19
EXPANSION LOOP	449.55
TRENCH	866.89
VALVES	220.14
METERS	169.27
HEAT PUMP	.00
PUMP	20.20

TOTAL SYSTEM CAPITAL COST 4732.19

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 6 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VEL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	----	-----
HOUSE		.1	-.5337	194.	100.	12.25	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-.8440	197.	97.	.20	1.00	1.0	.6
	2	.4	-.8376	198.	95.	.72	1.00	1.0	1.2
	3	.7	-.8339	199.	95.	1.51	1.00	1.0	1.9
	4	.8	.0000	200.	94.	.00	1.00	1.0	1.9
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.6	-1.6565	200.	94.	2.20	1.00	1.0	1.6
	2	1.7	-1.6483	202.	93.	16.59	1.00	1.0	4.7
	3	2.8	-1.6449	202.	92.	42.46	1.00	1.0	7.8
	4	4.0	-1.9109	202.	92.	9.83	1.50	1.0	4.6
	5	5.1	-1.9092	203.	92.	15.61	1.50	1.0	6.0
	6	6.2	-.9541	203.	92.	11.29	1.50	1.0	7.3
MAIN DESCRIPTION									
MAIN		12.5	-25.5431	203.	92.	120.32	2.50	1.0	6.2

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 6 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	28577	20.3	956	150.0	478.	58.1	53.3	335.8	95	60.8	148.1	28.91
1.5	1704	2.6	24	3.8	12.	1.9	3.8	23.6	5	10.6	10.4	33.23
2.5	4012	12.4	4	.7	2.	.6	9.3	62.6	13	28.7	27.8	35.41
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	34295	35.3		154.4		60.5	66.4	422.0		100.1	186.3	29.89

COST OF 153. METERS OF FLOW RATING 7. GPM IS \$ 4502. (THOUSAND)
COST OF PUMPS WITH 6. HORSEPOWER CAPACITY IS \$ 4. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE 35.26
INSULATION 66.37
CASING 422.00
FITTINGS 154.41
EXPANSION LOOP 100.09
TRENCH 186.32
VALVES 60.52
METERS 45.02
HEAT PUMP .00
PUMP 3.58

TOTAL SYSTEM CAPITAL COST 1073.57

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 7 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM (IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	SUPPLY RETURN		----	-----	----	-----
HOUSE		1.7	-1.7690	201.	100.	28.93	1.00	1.0	4.7
STREET DESCRIPTION									
STREET	HOUSE								
1	1	3.4	-3.2716	202.	99.	11.94	1.50	1.0	4.0
	2	6.8	-3.2662	202.	99.	42.73	1.50	1.0	8.0
	3	10.2	-1.6319	203.	99.	45.05	1.50	1.0	12.0
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	3.7	-6.5086	203.	98.	27.50	1.50	1.0	4.3
	2	18.4	-7.3829	204.	98.	67.21	2.50	1.0	9.2
	3	33.2	-4.0188	204.	97.	34.66	3.00	1.0	10.7
MAIN DESCRIPTION									
MAIN		66.4	-49.3433	204.	97.	200.19	6.00	1.0	13.2

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 7 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	18380	13.0	216	33.9	104	13.1	32.2	216.0	61	.0	95.3	21.95
1.5	13070	17.9	104	16.3	52	7.8	26.1	162.6	43	73.0	71.7	28.72
2.5	2178	7.1	8	1.4	4	1.0	5.3	35.8	7	16.4	15.9	38.08
3.0	1089	4.6	8	1.7	4	3.4	2.9	21.0	3	10.1	9.4	48.82
6.0	4752	53.6	4	1.3	2	3.8	15.9	121.6	15	72.3	56.0	68.31
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	39471	96.3		54.5		29.2	82.4	557.0		171.8	248.4	31.40

COST OF 54. METERS OF FLOW RATING 30. GPM IS \$ 2306. (THOUSAND)
COST OF PUMPS WITH 71. HORSEPOWER CAPACITY IS \$ 19. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE 96.31
INSULATION 82.44
CASING 556.98
FITTINGS 54.50
EXPANSION LOOP 171.83
TRENCH 248.36
VALVES 29.17
METERS 23.06
HEAT PUMP .00
PUMP 18.71

TOTAL SYSTEM CAPITAL COST 1281.37

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 8 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FFET	NOMINAL DIAM(IN)	INSUL (IN)	VEL (FT/SEC)
		-----	-----	SUPPLY	RETURN	-----	-----	-----	-----
HOUSE		.1	-.5349	195.	100.	12.25	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-.8460	197.	97.	.20	1.00	1.0	.6
	2	.4	-.8396	199.	95.	.72	1.00	1.0	1.2
	3	.7	-.8359	200.	95.	1.51	1.00	1.0	1.9
	4	.9	-.8334	201.	94.	2.57	1.00	1.0	2.5
	5	1.1	-.8314	201.	94.	3.88	1.00	1.0	3.1
	6	1.3	-.8297	202.	93.	5.42	1.00	1.0	3.7
	7	1.6	-.8284	202.	93.	7.20	1.00	1.0	4.4
	8	1.8	-.8272	202.	93.	9.20	1.00	1.0	5.0
	9	2.0	-.4132	203.	93.	5.72	1.00	1.0	5.6
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	1.5	-1.6492	203.	92.	12.49	1.00	1.0	4.0
	2	4.4	-1.9155	203.	92.	11.75	1.50	1.0	5.1
	3	7.3	-1.9143	203.	92.	30.09	1.50	1.0	8.5
	4	10.2	-1.9135	204.	92.	55.88	1.50	1.0	11.9
	5	13.1	-2.1799	204.	92.	11.22	2.50	1.0	6.5
	6	16.0	-2.1794	204.	91.	16.23	2.50	1.0	8.0
	7	18.9	-2.1790	204.	91.	22.08	2.50	1.0	9.4
	8	21.8	-2.1787	204.	91.	28.73	2.50	1.0	10.9
	9	23.3	.0000	204.	91.	.00	2.50	1.0	10.9
MAIN DESCRIPTION									
MAIN		46.6	-60.5455	204.	91.	94.56	8.00	1.0	9.8

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 8 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	1 IN.FT. COST (\$/FT)
1.0	108322	76.9	3460	461.3	1730.	177.7	201.0	1272.9	361	233.0	561.4	27.55
1.5	2045	3.1	24	3.2	12.	1.6	4.6	28.3	6	12.7	12.5	32.25
2.5	2727	8.9	40	5.9	20.	4.5	6.9	44.8	9	20.6	19.9	40.83
8.0	5280	91.3	4	1.4	2.	4.4	20.6	167.3	17	108.9	78.4	89.46
TOTALS	118376	180.1		471.8		188.3	233.1	1513.3		375.1	672.2	30.70

COST OF 575. METERS OF FLOW RATING 7. GPM IS \$ 14382. (THOUSAND)
COST OF PUMPS WITH 43. HORSEPOWER CAPACITY IS \$ 15. (THOUSAND)

PIPING SYSTEM (\$X1000)

PIPE	180.15
INSULATION	233.12
CASING	1513.27
FITTINGS	471.77
EXPANSION LOOP	375.07
TRENCH	672.17
VALVES	168.25
METERS	143.82
HEAT PUMP	.00
PUMP	15.42

TOTAL SYSTEM CAPITAL COST 3793.04

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 9 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FFET	NOMINAL DIA4(IN)	INSUL (IN)	VEL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	-----	-----
HOUSE		.1	-0.7229	194.	100.	12.29	1.00	1.0	.4
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.3	-1.1413	197.	97.	.41	1.00	1.0	.8
	2	.6	-1.1316	199.	95.	1.46	1.00	1.0	1.6
	3	.8	-1.1261	200.	94.	3.08	1.00	1.0	2.3
	4	1.1	-0.5616	201.	94.	2.62	1.00	1.0	3.1
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	1.6	-2.2403	201.	93.	20.47	1.00	1.0	4.5
	2	3.2	-2.2339	202.	93.	73.28	1.00	1.0	8.9
	3	4.8	-2.5939	202.	92.	19.26	1.50	1.0	5.7
	4	6.5	-2.5912	202.	92.	32.70	1.50	1.0	7.6
	5	8.1	-2.5892	203.	92.	49.31	1.50	1.0	9.4
	6	9.7	-2.5875	203.	92.	68.96	1.50	1.0	11.3
	7	11.3	-2.5861	203.	92.	91.57	1.50	1.0	13.2
	8	12.9	-2.9455	203.	92.	14.81	2.50	1.0	6.4
	9	14.5	-2.9444	203.	92.	18.39	2.50	1.0	7.2
	10	16.2	-2.9434	203.	91.	22.32	2.50	1.0	8.0
	11	17.8	-2.9426	203.	91.	26.60	2.50	1.0	8.8
	12	19.4	-2.9418	203.	91.	31.22	2.50	1.0	9.7
	13	21.0	-2.9410	204.	91.	36.18	2.50	1.0	10.5
	14	22.6	-2.9403	204.	91.	41.46	2.50	1.0	11.3
	15	24.2	-2.9397	204.	91.	47.07	2.50	1.0	12.1
	16	25.9	-2.9391	204.	91.	53.01	2.50	1.0	12.9
	17	27.5	-1.4694	204.	91.	29.63	2.50	1.0	13.7
MAIN DESCRIPTION									
MAIN		54.9	-35.4457	204.	91.	190.66	4.00	1.0	10.3

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 9 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	135268	96.0	3280	437.3	1640.	168.3	245.8	1589.5	450	281.1	701.0	26.01
1.5	4616	6.7	40	5.3	20.	2.7	4.7	60.6	15	27.2	26.7	30.12
2.5	8771	25.6	80	11.7	40.	8.9	19.7	129.7	29	59.5	57.6	35.65
4.0	4435	27.5	4	.8	2.	2.5	12.2	93.2	14	48.8	42.3	51.23
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	153092	155.8		455.2		182.4	287.4	1873.0		416.7	827.6	27.42

COST OF 544. METERS OF FLOW MATING 7. GPM IS \$ 13607.. (THOUSAND)
COST OF PUMPS WITH 142. HORSEPOWER CAPACITY IS \$ 27. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE 155.77
INSULATION 287.39
CASING 1872.97
FITTINGS 455.21
EXPANSION LOOP 416.65
TRENCH 827.61
VALVES 182.39
METERS 136.07
HEAT PUMP .00
PUMP 27.40

TOTAL SYSTEM CAPITAL COST 4361.47

ATES DISTRICT HEATING TEST CASE FOR HIGHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 10 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (MTU/SEC)	TEMPERATURE (F)		HEAD LOSS FFET	NOMINAL DIAM (IN)	INSUL (IN)	VEL (FT/SEC)
		-----	-----	SUPPLY	RETURN	-----	-----	-----	-----
HOUSE		.1	-.5276	191.	100.	12.25	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-.8341	193.	97.	.20	1.00	1.0	.6
	2	.4	-.8275	195.	95.	.72	1.00	1.0	1.2
	3	.7	-.8238	196.	95.	1.51	1.00	1.0	1.9
	4	.9	-.8212	197.	94.	2.57	1.00	1.0	2.5
	5	1.1	-.8192	197.	94.	3.88	1.00	1.0	3.1
	6	1.3	-.8175	197.	93.	5.42	1.00	1.0	3.7
	7	1.6	-.8161	198.	93.	7.20	1.00	1.0	4.4
	8	1.8	-.8149	198.	93.	9.20	1.00	1.0	5.0
	9	2.0	-.8139	198.	93.	11.43	1.00	1.0	5.6
	10	2.2	-.8129	199.	92.	13.88	1.00	1.0	6.2
	11	2.4	.0000	199.	92.	.00	1.00	1.0	6.2
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.2	-1.6040	199.	92.	.46	1.00	1.0	.7
	2	3.6	-1.8554	202.	89.	8.40	1.50	1.0	4.3
	3	7.0	-1.8543	203.	89.	28.27	1.50	1.0	8.2
	4	10.4	-1.8536	203.	89.	58.35	1.50	1.0	12.2
	5	13.8	-2.1142	203.	89.	12.40	2.50	1.0	6.9
	6	17.2	-2.1138	203.	89.	18.57	2.50	1.0	8.6
	7	20.6	-2.1135	203.	89.	25.86	2.50	1.0	10.3
	8	24.0	-2.1132	203.	89.	34.23	2.50	1.0	12.0
	9	27.4	-2.1130	203.	89.	43.66	2.50	1.0	13.7
	10	30.8	-2.1128	203.	89.	54.13	2.50	1.0	15.3
	11	34.2	-2.3063	203.	89.	22.95	3.00	1.0	11.0
	12	37.6	-2.3062	203.	89.	27.32	3.00	1.0	12.1
	13	41.0	-2.3060	203.	88.	32.03	3.00	1.0	13.2
	14	44.4	-2.6571	203.	88.	9.92	4.00	1.0	8.3
	15	47.8	-2.6570	203.	88.	11.36	4.00	1.0	8.9
	16	51.2	-2.6569	203.	88.	12.89	4.00	1.0	9.6
	17	54.6	-2.6568	203.	88.	14.50	4.00	1.0	10.2
	18	58.0	-2.6568	204.	88.	16.21	4.00	1.0	10.8
	19	61.4	-2.6567	204.	88.	18.00	4.00	1.0	11.5
	20	64.8	-2.6566	204.	88.	19.87	4.00	1.0	12.1
	21	68.2	-2.6565	204.	88.	21.83	4.00	1.0	12.8
	22	71.6	-2.6565	204.	88.	23.87	4.00	1.0	13.4
	23	75.0	-2.6564	204.	88.	26.00	4.00	1.0	14.0
	24	78.4	-2.6564	204.	88.	28.21	4.00	1.0	14.7
	25	81.8	-3.2726	204.	88.	4.20	6.00	1.0	6.7
	26	85.2	-3.2726	204.	88.	4.53	6.00	1.0	7.0
	27	88.6	-3.2726	204.	88.	4.86	6.00	1.0	7.3
	28	92.0	-3.2726	204.	88.	5.21	6.00	1.0	7.6
	29	95.4	-3.2726	204.	88.	5.57	6.00	1.0	7.9
	30	98.8	-3.2726	204.	88.	5.94	6.00	1.0	8.1
	31	102.2	-3.2726	204.	88.	6.32	6.00	1.0	8.4
	32	105.6	-1.6363	204.	88.	3.36	6.00	1.0	8.7
MAIN DESCRIPTION									
MAIN		211.2	-149.7744	204.	88.	383.97	8.00	1.0	12.7

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 10 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	490083	347.8	15900	1496.4	7950.	575.2	910.8	5758.8	1633	1050.0	2539.7	25.87
1.5	2045	3.1	24	2.3	12.	1.1	4.6	28.3	6	12.7	12.5	31.55
2.5	4091	12.6	48	5.0	24.	3.8	9.8	63.9	13	29.3	28.4	37.31
3.0	2045	8.7	24	3.0	12.	6.2	5.5	39.5	6	18.9	17.7	48.66
4.0	7501	46.4	88	13.2	44.	29.4	21.4	157.5	25	82.5	71.5	56.24
6.0	5114	57.7	64	12.2	32.	28.9	17.7	130.8	17	77.9	60.3	75.39
8.0	13411	207.5	4	1.0	2.	3.1	46.8	380.2	44	247.4	178.2	79.35
TOTALS	524295	683.9		1533.0		647.7	1016.5	6559.0		1518.7	2908.3	28.36

COST OF 2609. METERS OF FLOW MATING 7. GPM IS \$ 46063. (THOUSAND)
COST OF PUMPS WITH 530. HORSEPOWER CAPACITY IS \$ 76. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	683.92
INSULATION	1016.50
CASING	6559.05
FITTINGS	1532.98
EXPANSION LOOP	1518.71
TRENCH	2908.32
VALVES	647.70
METERS	460.63
HEAT PUMP	.00
PUMP	75.84

TOTAL SYSTEM CAPITAL COST15403.66

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 11 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	----	-----
HOUSE		.1	-7.162	192.	100.	12.29	1.00	1.0	.4
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.3	-1.1305	194.	97.	.41	1.00	1.0	.8
	2	.6	-1.1206	196.	95.	1.46	1.00	1.0	1.6
	3	.8	-1.1151	197.	94.	3.08	1.00	1.0	2.3
	4	1.1	-1.1112	198.	94.	5.23	1.00	1.0	3.1
	5	1.4	-1.1082	199.	93.	7.89	1.00	1.0	3.9
	6	1.7	-1.5532	199.	93.	5.52	1.00	1.0	4.7
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.3	-2.1827	199.	93.	.44	1.00	1.0	.8
	2	2.7	-2.1626	203.	89.	53.61	1.00	1.0	7.5
	3	5.2	-2.5166	203.	89.	21.53	1.50	1.0	6.0
	4	7.6	-2.5147	204.	89.	43.78	1.50	1.0	8.9
	5	10.0	-2.5133	204.	89.	72.98	1.50	1.0	11.7
	6	12.4	-2.7743	204.	89.	32.49	2.00	1.0	8.8
	7	14.8	-1.4331	204.	88.	9.55	2.50	1.0	7.4
MAIN DESCRIPTION									
MAIN		29.7	-50.8560	204.	88.	157.93	8.00	1.0	14.1

ATES DISTRICT HEATING TEST CASE FOR HIGHLAND, WASHINGTON

DISTRICT 11 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	74588	52.9	1764	262.9	882.	101.4	135.3	876.5	248	160.0	386.5	26.49
1.5	2770	4.2	24	3.6	12.	1.8	6.1	38.3	9	17.2	16.9	31.82
2.0	923	2.2	8	1.3	4.	.7	2.2	15.2	3	6.6	6.7	37.80
2.5	461	1.5	8	1.3	4.	1.0	1.2	7.6	1	3.5	3.4	42.06
8.0	4541	78.5	4	1.6	2.	5.0	17.7	143.9	15	93.6	67.5	89.79
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	83284	139.3		270.6		110.0	162.5	1081.4		280.9	481.0	30.33

COST OF 293. METERS OF FLOW RATING 7. GPM IS \$ 8191. (THOUSAND)
COST OF PUMPS WITH 31. HORSEPOWER CAPACITY IS \$ 14. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	139.32
INSULATION	162.52
CASING	1081.40
FITTINGS	270.60
EXPANSION LOOP	280.91
TRENCH	480.98
VALVES	109.97
METERS	81.91
HEAT PUMP	.00
PUMP	13.90

TOTAL SYSTEM CAPITAL COST 2621.52

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 12 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VEL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	-----	-----
HOUSE		.1	-.7230	194.	100.	12.29	1.00	1.0	.4
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.3	-1.1415	197.	97.	.41	1.00	1.0	.8
	2	.6	-1.1317	199.	95.	1.46	1.00	1.0	1.6
	3	.8	-1.1263	200.	94.	3.08	1.00	1.0	2.3
	4	1.1	-1.1224	201.	94.	5.23	1.00	1.0	3.1
	5	1.4	-1.1195	201.	93.	7.89	1.00	1.0	3.9
	6	1.7	-1.1171	202.	93.	11.03	1.00	1.0	4.7
	7	1.8	.0000	202.	92.	.00	1.00	1.0	4.7
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	1.1	-2.2246	202.	92.	10.27	1.00	1.0	3.1
	2	3.7	-2.5805	203.	92.	11.93	1.50	1.0	4.4
	3	6.4	-2.5778	203.	91.	31.77	1.50	1.0	7.4
	4	9.0	-2.5761	204.	91.	59.99	1.50	1.0	10.5
	5	11.6	-2.5747	204.	91.	96.14	1.50	1.0	13.6
	6	14.2	-2.9340	204.	91.	17.69	2.50	1.0	7.1
	7	16.9	-1.4667	204.	91.	12.08	2.50	1.0	8.4
MAIN DESCRIPTION									
MAIN		33.7	-51.8382	204.	91.	192.64	8.00	1.0	15.7

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 12 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FITINGS	FITINGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	82350	58.4	2016	300.4	1008.	115.9	149.7	967.7	274	169.1	426.8	26.57
1.5	3693	5.3	32	4.8	16.	2.4	7.8	48.5	12	21.8	21.4	30.32
2.5	1385	4.5	16	2.6	8.	2.0	3.5	22.8	4	10.4	10.1	40.35
8.0	4541	78.5	4	1.6	2.	5.0	17.7	143.9	15	93.6	67.5	89.79
TOTALS	91969	146.8		309.4		125.3	178.7	1182.8		295.0	525.7	30.05

COST OF 334. METERS OF FLOW METERING 7. GPM IS \$ 9337. (THOUSAND)
COST OF PUMPS WITH 37. HORSEPOWER CAPACITY IS \$ 15. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE 146.80
INSULATION 178.70
CASING 1182.82
FITTINGS 309.36
EXPANSION LOOP 294.97
TRENCH 525.71
VALVES 125.26
METERS 93.37
HEAT PUMP .00
PUMP 14.66

TOTAL SYSTEM CAPITAL COST 2811.64

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 13 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VEL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	----	-----
HOUSE		.1	-.3754	196.	100.	12.24	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-.5963	198.	98.	.14	1.00	1.0	.6
	2	.4	-.5934	199.	97.	.50	1.00	1.0	1.2
	3	.7	-.5916	200.	96.	1.06	1.00	1.0	1.9
	4	.9	-.2953	200.	96.	.90	1.00	1.0	2.5
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.2	-1.1690	200.	96.	.32	1.00	1.0	.7
	2	1.5	-1.1622	203.	93.	9.62	1.00	1.0	4.3
	3	2.8	-1.1605	203.	93.	29.60	1.00	1.0	7.8
	4	4.1	-1.3485	204.	93.	7.37	1.50	1.0	4.8
	5	5.4	-1.3477	204.	93.	12.18	1.50	1.0	4.3
	6	6.7	-1.3471	204.	92.	18.07	1.50	1.0	7.9
	7	7.4	.0000	204.	92.	.00	1.50	1.0	7.9
MAIN DESCRIPTION									
MAIN		14.7	-84.6739	204.	92.	38.73	12.00	1.0	7.3

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 14 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	24850	17.6	1132	177.6	566.	68.7	47.8	292.0	82	56.5	128.8	31.75
1.5	1425	2.2	32	5.0	16.	2.6	3.3	19.7	4	8.8	8.7	35.27
12.0	5913	186.5	4	3.1	2.	9.3	29.8	213.6	19	207.2	117.1	129.62
TOTALS		32190	206.3	185.6		80.5	81.0	525.3		272.5	254.6	49.89

COST OF 181. METERS OF FLOW MATING 7. GPM IS \$ 5326. (THOUSAND)
COST OF PUMPS WITH 6. HORSEPOWER CAPACITY IS \$ 4. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	206.29
INSULATION	80.97
CASING	525.29
FITTINGS	185.64
EXPANSION LOOP	272.51
TRENCH	254.60
VALVES	80.51
METERS	53.26
HEAT PUMP	.00
PUMP	4.34

TOTAL SYSTEM CAPITAL COST 1663.42

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 14 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM (IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	-----		----	-----	----	-----
HOUSE		.1	-0.7163	192.	100.	12.29	1.00	1.0	.4
STREET DESCRIPTION									
STREET	HOUSE								
I	1	.3	-1.1307	194.	97.	.41	1.00	1.0	.8
	2	.6	-1.1208	196.	95.	1.46	1.00	1.0	1.6
	3	.8	-1.1152	197.	94.	3.08	1.00	1.0	2.3
	4	1.1	-1.1114	198.	94.	5.23	1.00	1.0	3.1
	5	1.4	-1.1084	198.	93.	7.89	1.00	1.0	3.9
	6	1.7	-1.5533	199.	93.	5.52	1.00	1.0	4.7
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.3	-2.1831	199.	89.	.94	1.00	1.0	.8
	2	2.7	-2.1630	203.	89.	53.61	1.00	1.0	7.5
	3	5.2	-2.5170	203.	89.	21.53	1.50	1.0	6.0
	4	7.6	-2.5151	204.	89.	43.78	1.50	1.0	8.9
	5	10.0	-2.5137	204.	89.	72.98	1.50	1.0	11.7
	6	12.4	-2.7748	204.	89.	32.49	2.00	1.0	8.8
	7	14.8	-1.4333	204.	88.	9.55	2.50	1.0	7.4
MAIN DESCRIPTION									
MAIN		29.7	-58.6770	204.	88.	72.27	12.00	1.0	12.3

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 14 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	74588	52.9	1764	262.9	882.	101.4	135.3	876.5	248	160.0	386.5	26.49
1.5	2770	4.2	24	3.6	12.	1.8	6.1	38.3	9	17.2	16.9	31.82
2.0	423	2.2	8	1.3	4.	.7	2.2	15.2	3	6.6	6.7	37.80
2.5	461	1.5	8	1.3	4.	1.0	1.2	7.6	1	3.5	3.4	42.06
12.0	4224	133.2	4	2.9	2.	8.8	21.3	152.6	14	148.0	83.7	130.32
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	82967	194.0		271.9		113.8	166.1	1090.1		335.3	497.2	32.16

COST OF 293. METERS OF FLOW RATING 7. GPM IS \$ 8191. (THOUSAND)
COST OF PUMPS WITH 31. HORSEPOWER CAPACITY IS \$ 14. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	194.01
INSULATION	166.12
CASING	1090.06
FITTINGS	271.94
EXPANSION LOOP	335.28
TRENCH	497.19
VALVES	113.84
METERS	81.91
HEAT PUMP	.00
PUMP	14.36

TOTAL SYSTEM CAPITAL COST 2764.72

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT IS TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	SUPPLY RETURN		----	-----	----	-----
HOUSE		.1	-0.7137	191.	100.	12.29	1.00	1.0	.4
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.3	-1.1264	193.	97.	.41	1.00	1.0	.8
	2	.6	-1.1164	195.	95.	1.46	1.00	1.0	1.6
	3	.8	-1.1108	196.	94.	3.08	1.00	1.0	2.3
	4	1.1	-1.1070	197.	94.	5.23	1.00	1.0	3.1
	5	1.3	.0000	197.	93.	.00	1.00	1.0	3.1
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.3	-2.1814	197.	93.	.94	1.00	1.0	.8
	2	2.1	-2.1597	201.	90.	33.76	1.00	1.0	5.9
	3	3.9	-2.5107	202.	89.	13.15	1.50	1.0	4.6
	4	5.8	-2.5081	202.	89.	26.43	1.50	1.0	6.7
	5	7.6	-2.5063	202.	89.	43.78	1.50	1.0	8.9
	6	9.4	-2.5048	203.	89.	65.05	1.50	1.0	11.0
	7	11.2	-2.5035	203.	89.	90.07	1.50	1.0	13.1
	8	13.0	-2.8553	203.	89.	15.02	2.50	1.0	6.5
	9	14.8	-2.8544	203.	88.	19.10	2.50	1.0	7.4
	10	16.7	-2.8537	203.	88.	23.62	2.50	1.0	8.3
	11	18.5	-2.8530	203.	88.	28.58	2.50	1.0	9.2
	12	20.3	-2.8523	203.	88.	33.97	2.50	1.0	10.1
	13	22.1	-2.8518	203.	88.	39.77	2.50	1.0	11.0
	14	23.9	-2.8512	203.	88.	45.99	2.50	1.0	11.9
	15	25.8	-2.8507	204.	88.	52.63	2.50	1.0	12.8
	16	27.6	-2.8503	204.	88.	59.66	2.50	1.0	13.7
	17	29.4	-2.8499	204.	88.	67.10	2.50	1.0	14.6
	18	31.2	-3.1114	204.	88.	26.21	3.00	1.0	10.1
	19	33.0	-3.1110	204.	88.	29.09	3.00	1.0	10.6
	20	34.8	-3.1107	204.	88.	32.10	3.00	1.0	11.2
	21	36.7	-3.1104	204.	88.	35.25	3.00	1.0	11.8
	22	38.5	-3.1101	204.	88.	38.53	3.00	1.0	12.4
	23	40.3	-3.1098	204.	88.	41.95	3.00	1.0	13.0
	24	42.1	-3.1095	204.	88.	45.49	3.00	1.0	13.6
	25	43.9	-3.5843	204.	88.	13.15	4.00	1.0	8.2
	26	45.7	-3.5841	204.	88.	14.17	4.00	1.0	8.6
	27	47.6	-1.7920	204.	88.	7.61	4.00	1.0	8.9
MAIN DESCRIPTION									
MAIN		95.1	-63.1355	204.	88.	87.61	14.00	1.0	14.6

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 15 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	233633	165.8	5860	551.5	2930.	212.1	425.4	2745.3	778	484.5	1210.7	24.81
1.5	4616	6.7	40	3.8	20.	1.9	9.7	60.6	15	27.2	26.7	29.60
2.5	9233	27.0	80	8.3	40.	6.3	20.7	136.5	30	62.6	60.7	34.88
3.0	6463	26.1	56	6.9	28.	14.5	16.4	118.5	21	56.9	53.2	45.25
4.0	2308	15.0	24	3.6	12.	8.0	6.9	51.0	7	26.7	23.1	58.25
14.0	4224	167.4	4	2.1	2.	7.7	22.8	155.3	14	169.1	85.9	144.47
TOTALS	260479	408.0		576.2		250.5	501.9	3267.3		827.1	1460.4	27.99

COST OF 941. METERS OF FLOW RATING 1. GPM IS \$ 16614. (THOUSAND)
COST OF PUMPS WITH 338. HORSEPOWER CAPACITY IS \$ 53. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	408.03
INSULATION	501.95
CASING	3267.32
FITTINGS	576.17
EXPANSION LOOP	827.09
TRENCH	1460.35
VALVES	250.50
METERS	166.14
HEAT PUMP	.00
PUMP	52.84

TOTAL SYSTEM CAPITAL COST 7510.39

ATES DISTRICT HEATING TEST CASE FOR HIGHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 16 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	----	-----
HOUSE		.1	-1.3733	194.	100.	12.24	1.00	1.0	.3
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.2	-1.5928	196.	98.	.14	1.00	1.0	.6
	2	.4	-1.5899	197.	97.	.50	1.00	1.0	1.2
	3	.7	-1.5881	198.	96.	1.06	1.00	1.0	1.9
	4	.9	-1.5868	199.	96.	1.79	1.00	1.0	2.5
	5	1.1	-1.5858	199.	95.	2.70	1.00	1.0	3.1
	6	1.2	.0000	199.	95.	.00	1.00	1.0	3.1
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.2	-1.1531	199.	95.	.15	1.00	1.0	.4
	2	1.9	-1.1445	203.	92.	14.78	1.00	1.0	5.4
	3	3.7	-1.3304	203.	92.	6.10	1.50	1.0	4.4
	4	5.5	-1.3297	204.	91.	12.52	1.50	1.0	6.4
	5	7.3	-1.3292	204.	91.	20.97	1.50	1.0	8.5
	6	9.1	-1.3288	204.	91.	31.36	1.50	1.0	10.6
	7	10.8	-1.6642	204.	91.	21.81	1.50	1.0	12.7
MAIN DESCRIPTION									
MAIN		21.7	-14.1232	204.	91.	184.29	2.50	1.0	10.8

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 16 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	35114	24.9	1664	248.0	832.	95.7	67.9	412.6	117	75.3	182.0	31.51
1.5	2138	3.3	40	6.0	20.	3.0	4.9	29.6	7	13.3	13.0	34.14
2.5	2217	7.2	4	.7	2.	.5	5.4	36.4	7	16.7	16.2	37.48
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	39470	35.4		254.6		99.3	78.2	478.6		105.3	211.2	31.99

COST OF 268. METERS OF FLOW METERING 7. GPM IS \$ 7492. (THOUSAND)
COST OF PUMPS WITH 11. HORSEPOWER CAPACITY IS \$ 4. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	35.38
INSULATION	78.21
CASING	478.62
FITTINGS	254.57
EXPANSION LOOP	105.29
TRENCH	211.20
VALVES	99.29
METERS	74.92
HEAT PUMP	.00
PUMP	4.40

TOTAL SYSTEM CAPITAL COST 1341.87

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 17 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	----	-----
HOUSE		1.7	-1.7567	199.	100.	28.93	1.00	1.0	4.7
STREET DESCRIPTION									
STREET	HOUSE								
1	1	3.4	-1.6250	200.	99.	5.97	1.50	1.0	4.0
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	1.2	-6.4441	200.	99.	3.64	1.50	1.0	1.4
	2	6.1	-6.3981	203.	97.	70.40	1.50	1.0	7.2
	3	11.1	-3.1941	203.	96.	103.81	1.50	1.0	12.9
MAIN DESCRIPTION									
MAIN		22.1	-44.9362	204.	96.	152.75	4.00	1.0	8.2

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 1/ CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	6126	4.9	72	11.3	36.	4.4	12.0	80.5	20	.0	35.5	24.24
1.5	7624	11.0	56	8.8	28.	4.3	16.0	100.1	25	44.9	44.2	30.08
4.0	5385	33.3	4	1.0	2.	2.9	14.9	113.1	17	59.3	51.3	51.20
TOTALS	19137	49.2		21.1		11.6	42.9	293.7		104.2	131.0	34.15

COST OF 18. METERS OF FLOW RATING 30. GPM IS \$ 769. (THOUSAND)
COST OF PUMPS WITH 18. HORSEPOWER CAPACITY IS \$ 6. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE	49.23
INSULATION	42.88
CASING	293.71
FITTINGS	21.07
EXPANSION LOOP	104.20
TRENCH	130.95
VALVES	11.59
METERS	7.69
HEAT PUMP	.00
PUMP	5.61

TOTAL SYSTEM CAPITAL COST 666.93

ATES DISTRICT HEATING TEST CASE FOR HIGHLAND, WASHINGTON

DISTRIBUTION SYSTEM OF DISTRICT 18 TWO PIPE SYSTEM
BURIED PIPING ... AVERAGE YEAR-ROUND GROUND TEMPERATURE (F) = 50.0

HOUSE DESCRIPTION		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F)		HEAD LOSS FEET	NOMINAL DIAM (IN)	INSUL (IN)	VFL (FT/SEC)
		-----	-----	SUPPLY	RETURN	----	-----	----	-----
HOUSE		.2	-1.8297	192.	100.	12.33	1.00	1.0	.5
STREET DESCRIPTION									
STREET	HOUSE								
1	1	.3	-1.3096	195.	97.	.64	1.00	1.0	.9
	2	.7	-1.2982	197.	95.	2.29	1.00	1.0	1.8
	3	.8	.0000	198.	94.	.00	1.00	1.0	1.8
LATERAL DESCRIPTION									
LATERAL	STREET								
1	1	.5	-2.5646	198.	94.	2.50	1.00	1.0	1.3
	2	1.7	-2.5406	200.	92.	25.04	1.00	1.0	4.6
	3	2.9	-2.5321	201.	91.	67.50	1.00	1.0	7.9
	4	4.0	-2.9412	202.	91.	15.97	1.50	1.0	4.7
	5	5.2	-2.9371	202.	90.	25.66	1.50	1.0	6.1
	6	6.4	-2.9340	202.	90.	37.41	1.50	1.0	7.5
	7	7.6	-2.9314	203.	90.	51.14	1.50	1.0	8.9
	8	8.8	-2.9291	203.	90.	66.80	1.50	1.0	10.3
	9	10.0	-2.9272	203.	90.	84.34	1.50	1.0	11.7
	10	11.2	-2.9255	203.	90.	103.74	1.50	1.0	13.1
	11	12.4	-3.2279	203.	89.	37.32	2.00	1.0	8.8
	12	13.6	-3.3338	204.	89.	18.71	2.50	1.0	6.8
	13	14.8	-3.3326	204.	89.	21.84	2.50	1.0	7.3
	14	16.0	-3.3314	204.	89.	25.19	2.50	1.0	7.9
	15	17.1	-3.3304	204.	89.	28.76	2.50	1.0	8.5
	16	17.7	.0000	204.	89.	.00	2.50	1.0	8.5
MAIN DESCRIPTION									
MAIN		35.5	-148.5820	204.	89.	118.22	16.00	1.0	12.2

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DISTRICT 18 CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST \$X1000	NUMBER OF FTNGS	FTNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN.FT. COST (\$/FT)
1.0	84708	60.1	1932	287.9	966.	111.0	153.3	995.4	282	174.3	439.0	26.22
1.5	7467	10.8	56	8.3	28.	4.2	15.7	98.1	24	44.0	43.3	30.05
2.0	1066	2.5	8	1.3	4.	.7	2.5	17.5	3	7.7	7.8	37.50
2.5	4267	13.2	40	6.6	20.	5.0	10.1	66.6	14	30.6	29.6	37.86
16.0	9187	420.4	4	4.1	2.	17.5	51.6	355.6	30	425.5	201.2	160.64
TOTALS	106697	507.0		308.2		138.4	233.2	1533.2		682.0	720.8	38.64

COST OF 297. METERS OF FLOW RATING 7. GPM IS \$ 8303. (THOUSAND)
COST OF PUMPS WITH 83. HORSEPOWER CAPACITY IS \$ 22. (THOUSAND)

PIPING SYSTEM(\$X1000)

PIPE 506.96
INSULATION 233.17
CASING 1533.16
FITTINGS 308.20
EXPANSION LOOP 682.05
TRENCH 720.82
VALVES 138.39
METERS 83.03
HEAT PUMP .00
PUMP 21.67

TOTAL SYSTEM CAPITAL COST 4227.44

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

DESCRIPTION OF MAINS SERVING THE DISTRICTS

MAIN NUMBER	DISTRICT NUMBER	FLOWRATE	HEAT LOSS	TEMPERATURE (F)		HEAD LOSS	NOMINAL	INSUL	CUMULATIVE FLOWRATE (LB/SEC)
		(LB/SEC)	(BTU/SEC)	SUPPLY	RETURN	FEET	DIAM (IN)	(IN)	
1	18	35.5	-148.5420	204.	89.	118.22	16.00	1.0	906.3
2	16	21.7	-14.1232	204.	91.	184.29	2.50	1.0	21.7
	17	22.1	-44.9362	204.	96.	152.75	4.00	1.0	43.8
3	15	95.1	-63.1355	204.	88.	87.61	14.00	1.0	827.0
4	1	36.9	-31.3663	204.	98.	334.52	3.00	1.0	36.9
	2	90.0	-163.8671	203.	90.	463.59	6.00	1.0	126.9
	3	24.8	-154.9588	204.	92.	599.05	6.00	1.0	151.6
5	14	29.7	-58.6770	204.	88.	72.27	12.00	1.0	580.2
6	9	54.9	-35.4457	204.	91.	190.66	4.00	1.0	54.9
	10	211.2	-147.7744	204.	88.	383.97	8.00	1.0	266.1
	11	29.7	-50.8560	204.	88.	157.93	8.00	1.0	295.8
	12	33.7	-51.8382	204.	91.	192.64	8.00	1.0	329.6
	13	14.7	-84.6739	204.	92.	38.73	12.00	1.0	344.3
7	7	66.4	-49.3433	204.	97.	200.19	6.00	1.0	159.6
	8	46.6	-60.5455	204.	91.	94.56	8.00	1.0	206.2
8	6	12.5	-25.5431	203.	92.	120.32	2.50	1.0	12.5
9	4	18.6	-28.9586	203.	92.	284.82	2.50	1.0	18.6
	5	62.1	-57.9272	204.	91.	71.11	6.00	1.0	80.8

HEAT EXCHANGER DESIGN AND COST (IF HEAT EXCHANGER OPTION = 1)

WK FLD INLET TEMP (DG F)	WK FLD OUTLET TEMP (DG F)	HEAT TRANSFR AREA	INSIDE TUPE DIA	OUTSIDE TUPE DIA	CAPITAL COST (\$X1000)	OPERATING COST (\$X1000)
-----	-----	----	---	---	-----	-----
95.00	204.54	62366.50	.10000	.11040	1047.98	20.96

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

TOTAL CAPITAL COSTS AND MATERIAL REQUIREMENTS BASED ON ESCALATED COSTS FOR MIDPOINT OF FIRST YEAR OF CONSTRUCTION

PIPE SIZE (IN)	PIPE (LIN,FT)	PIPE COST \$X1000	NUMBER OF FITNGS	FITNGS COST \$X1000	NUMBER OF VALVES	VALVE COST \$X1000	INSUL COST \$X1000	CASING COST \$X1000	NUMBER OF EXP LOOPS	EXP LOOP COST \$X1000	TRENCH COST \$X1000	LIN,FT. COST (\$/FT)
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1.0	1867012	1326.0	54880	6380.5	27440.	2457.8	3443.0	21953.9	6223	3910.6	9682.0	26.33
1.5	76089	109.8	728	104.7	364.	52.2	160.5	996.6	253	447.2	439.5	30.37
2.0	2913	6.8	24	3.9	12.	2.2	6.9	47.9	9	20.9	21.3	37.70
2.5	53348	163.5	444	59.1	222.	45.0	125.1	827.3	177	379.7	367.6	36.88
3.0	15974	65.7	124	16.4	62.	34.7	41.2	297.9	53	142.9	133.7	45.85
4.0	19631	122.3	120	18.6	60.	42.7	55.4	414.8	65	217.3	188.2	53.96
6.0	48201	505.6	80	16.5	40.	41.5	150.4	1145.7	160	681.8	528.2	63.68
8.0	27774	455.8	16	5.5	8.	17.5	102.8	835.3	92	543.5	391.6	84.69
12.0	10138	319.7	8	6.0	4.	18.1	51.2	366.1	33	355.2	200.8	129.91
14.0	4224	167.4	4	2.1	2.	7.7	22.8	155.3	14	169.1	85.9	144.47
16.0	9187	420.4	4	4.1	2.	17.5	51.6	355.6	30	425.5	201.2	160.65
	-----	-----		-----		-----	-----	-----		-----	-----	-----
TOTALS	2134494	3662.9		6617.4		2736.9	4210.8	27396.4		7293.8	12239.9	30.06

COST OF 9004. METERS IS \$1979. (THOUSAND)
COST OF PUMPS WITH 1660. HORSEPOWER CAPACITY IS \$ 355. (THOUSAND)

CAPITAL COST ACCOUNTS (\$X1000)

PIPING SYSTEM

PIPE	3662.89
INSULATION	4210.82
CASING	27396.42
FITTINGS	6617.35
EXPANSION LOOP	7293.80
TRENCH	12239.94
VALVES	2736.95
METERS	1978.64
PUMPS	354.63
TOTAL PIPING SYSTEM	66491.43

METERING CONTROL	836.54
BUILDING AND LAND USE	836.54
BUILDING RETROFIT	17066.06
STORAGE	.00
HEAT PUMP	.00
HEAT EXCHANGER	1047.88
HX BOOSTER PUMP	96.47
ABSORPTION CHILLER(S)	.00
ENGINEERING AND ADMINISTRATION	10038.48

TOTAL CAPITAL COSTS 96413.39

OPERATING EXPENSE ACCOUNTS (\$X1000.)

OPERATING EXPENSES	136.58
MAINTENANCE	100.02
PUMP OPERATION	171.20
METER READERS	85.35
HEAT PUMP OPERATION	.00
SUPPLY SHORTFALL SUPPLEMENTAL HEAT(CHILL)	.00
EXTREME TEMP. SUPPLEMENTAL HEAT(CHILL)	252.89
CHILLER(S) OPERATION	.00
HEAT EXCHANGER OPERATION	20.96
HX PUMP OPERATION (ELECTR)	43.14

TOTAL OPERATING EXPENSES 810.14

DISTRIBUTION SYSTEM DESCRIPTION

DIST NO	TOTAL PEAK HEAT DEMAND (MBTU/HR)	UNIT TEMP DROP (F)	UNIT FLOW RATE (LH/HR)	TOTAL PEAK FLUID DEMAND (KLB/HR)	ANNUAL HEAT DEMAND (TBTU)	DISTR SYSTEM COSTS (\$M)
01	12.943	99.3	6149.	133.	.04	1.782
02	32.311	99.3	405.	324.	.09	4.730
03	8.913	99.3	405.	89.	.02	3.421
04	6.685	99.3	405.	67.	.02	1.839
05	22.283	99.3	405.	224.	.06	5.920
06	4.457	99.3	405.	45.	.01	1.310
07	24.226	99.3	6149.	239.	.07	3.037
08	16.712	99.3	405.	168.	.05	4.483
09	19.720	99.3	505.	198.	.05	5.204
10	75.763	99.3	405.	760.	.21	19.443
11	10.618	99.3	505.	107.	.03	3.075
12	12.135	99.3	505.	121.	.03	3.389
13	5.275	99.3	405.	53.	.01	1.944
14	10.618	99.3	505.	107.	.03	3.218
15	34.130	99.3	505.	342.	.09	8.947
16	7.797	99.3	405.	78.	.02	1.757
17	8.131	99.3	6149.	80.	.02	1.252
18	12.726	99.3	545.	128.	.03	4.687
TOTALS	325.442	.0	0.	3263.	.88	81.557

DISTANCE STORAGE AQUIFER TO CITY CENTER(MI)	6.0
SOURCE FLUID TEMPERATURE (F)	223.5
RETURN FLUID TEMPERATURE (F)	90.8
DISTRIBUTION SYSTEM HEAT LOSS (MBTU/HR)	-4.820
SUPPLEMENTAL HEAT REQUIREMENTS DEGREE DAYS	159.
PERCENT OF TOTAL DESIGN DEMAND	3.1
PEAK SUPPLEMENTAL HEAT REQUIREMENTS (MBTU/HR)	27.283
TOTAL SUPPLEMENTAL HEAT REQUIREMENTS (MBTU/HR)	27226.6

LOAD FACTOR	.31
TOTAL DISTRICT AREA (SQMI)	3.2
COLDEST DAY TEMPERATURE (F)	-10.0
DESIGN TEMPERATURE (F)	-5.0
ANNUAL DEGREE DAYS	5267.
DEGREE DAYS AT DESIGN TEMPERATURE	5109.

METRIC EQUIVALENTS

DIST NO	TOTAL PEAK HEAT DEMAND (MCAL/HR)	UNIT TEMP DROP (C)	UNIT FLOW RATE (KG/HR)	TOTAL PEAK FLUID DEMAND (KG/HR*1000)	ANNUAL HEAT DEMAND (GJAL)	DISTR SYSTEM COSTS (\$M)
01	3261.386	55.2	2789.	60.	9.18	1.782
02	8141.945	55.2	184.	147.	22.05	4.730
03	2246.054	55.2	184.	40.	6.08	3.321
04	1684.540	55.2	184.	30.	4.56	1.839
05	5615.134	55.2	184.	101.	15.21	5.920
06	1123.027	55.2	184.	20.	3.04	1.310
07	6104.646	55.2	2789.	108.	17.18	3.037
08	4211.351	55.2	184.	76.	11.41	4.483
09	4969.129	55.2	229.	90.	13.19	5.204
10	19091.457	55.2	184.	345.	51.71	19.443
11	2675.685	55.2	229.	48.	7.10	3.075
12	3057.926	55.2	229.	55.	8.12	3.389
13	1329.179	55.2	184.	24.	3.60	1.944
14	2675.685	55.2	229.	48.	7.10	3.218
15	8600.416	55.2	229.	155.	22.92	8.947
16	1964.873	55.2	184.	35.	5.32	1.757
17	2048.820	55.2	2789.	36.	5.77	1.252
18	3206.898	55.2	270.	58.	8.40	4.687
TOTALS	82008.151	.0	0.	1480.	221.85	83.557

DISTANCE STORAGE AQUIFER TO CITY CENTER(KM)	9.6
SOURCE FLUID TEMPERATURE (C)	106.4
RETURN FLUID TEMPERATURE (C)	32.7
DISTRIBUTION SYSTEM HEAT LOSS (MCAL/HR)	-2222.503
SUPPLEMENTAL HEAT REQUIREMENTS DEGREE DAYS (C)	88.
PERCENT OF TOTAL DESIGN DEMAND	3.1
PEAK SUPPLEMENTAL HEAT REQUIREMENTS (GJAL/HR)	.007
TOTAL SUPPLEMENTAL HEAT REQUIREMENTS (GJAL/HR)	6.9

LOAD FACTOR	.31
TOTAL DISTRICT AREA (SQKM)	8.2
COLDEST DAY TEMPERATURE (C)	-23.3
DESIGN TEMPERATURE (C)	-20.6
ANNUAL DEGREE DAYS (C)	2926.
DEGREE DAYS AT DESIGN TEMPERATURE	2838.

L E G 3 ... TRANSMISSION TO SUPPLY AQUIFER ... ENTERING AND EXIT CONDITIONS AND CAPITAL COSTS

 ABOVE GROUND PIPING ... AVERAGE SEASONAL AIR TEMPERATURE (F) = 35.0

NODE I	J	ITR	STEAM FRACT	FLOW RATE (LB/SEC)	VELOCITY (FT/SEC)	HEAT LOSS (BTU/SEC-FT)	TEMP (F)	PRES(Psia)	SATURATION PRES(Psia)	ENTHALPY (BTU/LB)	PIPE SCHD	INTER DIAM(IN)	EXTER DIAM(IN)	INSUL THK(IN)
1	1	1	.0000	916.	6.572	.026	117.500	132.228	1.579	85.805	10.	20.340	22	2.000
1	1	2	.0000	916.	6.571	.017	116.898	132.228	1.552	85.205	10.	20.341	22	2.000
1	1	3	.0000	916.	6.571	.017	116.898	132.228	1.552	85.205	10.	20.341	22	2.000

PIPING SYSTEM EQUIPMENT

CAPITAL COST (\$)

PIPE	1897974.
INSULATION	1475513.
CASING	786833.
SITE	2042719.
TRANSMISSION SURFACE PUMPS	49715.
TOTAL PIPING SYSTEM	6252685.
ENGINEERING AND DESIGN (12 PCT)	750322.
TOTAL CAPITAL COST	7003007.

TRANSMISSION MAINTENANCE (%)	350150.
TRANSMISSION CAP. REPL. RATE	.0150
TRANSMISSION SURFACE PUMP KILOWATTS	317.31
NUMBER OF TRANSMISSION LEG PUMPS	1
TRANSMISSION LEG PRESSURE DROP (PSI)	85.44

N O D E 4 . . . S U P P L Y A Q U I F E R - E N T E R I N G C O N D I T I O N S

ABOVE GROUND PIPING . . . AVERAGE SEASONAL AIR TEMPERATURE (F) * 35.0

NODE I	J	ITR	STEAM FRACT	FLOW RATE (LB/SEC)	VELOCITY (FT/SEC)	HEAT LOSS (BTU/SEC-FT)	TEMP (F)	PRES(PSIA)	SATURATION PRES(PSIA)	ENTHALPY (BTU/LB)	PIPE SCHD	INTER DIAM(IN)	EXTER DIAM(IN)	INSUL THK(IN)
1	2	1	.0000	239.	5.714	.017	116.898	132.228	1.552	85.205	10.	11.140	12	2.000
1	2	2	.0000	239.	5.714	.010	116.898	132.228	1.552	85.205	10.	11.140	12	2.000
1	3	1	.0000	199.	5.635	.010	116.898	132.228	1.552	85.205	10.	10.240	12	2.000
1	3	2	.0000	199.	5.635	.010	116.840	132.228	1.550	85.146	10.	10.240	12	2.000
1	4	1	.0000	159.	5.540	.010	116.840	132.228	1.550	85.146	10.	9.238	10	2.000
1	4	2	.0000	159.	5.540	.009	116.777	132.228	1.547	85.084	10.	9.238	10	2.000
1	5	1	.0000	119.	5.419	.009	116.777	132.228	1.547	85.084	10.	8.089	10	2.000
1	5	2	.0000	119.	5.419	.009	116.693	132.228	1.543	85.000	10.	8.089	10	2.000
1	6	1	.0000	80.	5.252	.009	116.693	132.228	1.543	85.000	10.	6.709	8	2.000
1	6	2	.0000	80.	5.252	.007	116.588	132.228	1.539	84.896	10.	6.709	8	2.000
1	7	1	.0000	40.	4.975	.007	116.588	132.228	1.539	84.896	10.	4.874	6	2.000
1	7	2	.0000	40.	4.975	.006	116.420	132.228	1.531	84.728	10.	4.874	6	2.000
2	1	1	.0000	677.	6.179	.006	116.898	132.228	1.552	85.205	10.	18.032	20	2.000
2	1	2	.0000	677.	6.179	.016	116.872	132.228	1.551	85.178	10.	18.032	20	2.000
2	2	1	.0000	199.	5.635	.016	116.872	132.228	1.551	85.178	10.	10.240	12	2.000
2	2	2	.0000	199.	5.635	.010	116.871	132.228	1.551	85.178	10.	10.240	12	2.000
2	3	1	.0000	159.	5.540	.010	116.871	132.228	1.551	85.178	10.	9.237	10	2.000
2	3	2	.0000	159.	5.540	.009	116.808	132.228	1.548	85.115	10.	9.237	10	2.000
2	4	1	.0000	119.	5.419	.009	116.808	132.228	1.548	85.115	10.	8.089	10	2.000
2	4	2	.0000	119.	5.419	.009	116.725	132.228	1.545	85.032	10.	8.089	10	2.000
2	5	1	.0000	80.	5.252	.009	116.725	132.228	1.545	85.032	10.	6.709	8	2.000
2	5	2	.0000	80.	5.252	.007	116.620	132.228	1.540	84.927	10.	6.709	8	2.000
2	6	1	.0000	40.	4.975	.007	116.620	132.228	1.540	84.927	10.	4.874	6	2.000
2	6	2	.0000	40.	4.975	.006	116.452	132.228	1.533	84.759	10.	4.874	6	2.000

3	1	1	.0000	478.	6.020	.006	116.872	132.228	1.551	85.178	10.	15.348	16	2.000
3	1	2	.0000	478.	6.020	.013	116.841	132.228	1.550	85.147	10.	15.348	16	2.000
3	2	1	.0000	159.	5.540	.013	116.841	132.228	1.550	85.147	10.	9.238	10	2.000
3	2	2	.0000	159.	5.540	.009	116.840	132.228	1.550	85.147	10.	9.238	10	2.000
3	3	1	.0000	119.	5.419	.009	116.840	132.228	1.550	85.147	10.	8.089	10	2.000
3	3	2	.0000	119.	5.419	.009	116.757	132.228	1.546	85.064	10.	8.089	10	2.000
3	4	1	.0000	80.	5.252	.009	116.757	132.228	1.546	85.064	10.	6.709	8	2.000
3	4	2	.0000	80.	5.252	.007	116.652	132.228	1.541	84.959	10.	6.709	8	2.000
3	5	1	.0000	40.	4.975	.007	116.652	132.228	1.541	84.959	10.	4.874	6	2.000
3	5	2	.0000	40.	4.975	.006	116.484	132.228	1.534	84.791	10.	4.874	6	2.000
4	1	1	.0000	319.	5.840	.006	116.841	132.228	1.550	85.147	10.	12.724	14	2.000
4	1	2	.0000	319.	5.840	.012	116.799	132.228	1.548	85.106	10.	12.724	14	2.000
4	2	1	.0000	119.	5.419	.012	116.799	132.228	1.548	85.106	10.	8.089	10	2.000
4	2	2	.0000	119.	5.419	.009	116.799	132.228	1.548	85.106	10.	8.089	10	2.000
4	3	1	.0000	80.	5.252	.009	116.799	132.228	1.548	85.106	10.	6.709	8	2.000
4	3	2	.0000	80.	5.252	.007	116.694	132.228	1.543	85.001	10.	6.709	8	2.000
4	4	1	.0000	40.	4.975	.007	116.694	132.228	1.543	85.001	10.	4.874	6	2.000
4	4	2	.0000	40.	4.975	.006	116.525	132.228	1.536	84.833	10.	4.874	6	2.000
5	1	1	.0000	199.	5.635	.006	116.799	132.228	1.548	85.106	10.	10.240	12	2.000
5	1	2	.0000	199.	5.635	.010	116.741	132.228	1.545	85.048	10.	10.240	12	2.000
5	2	1	.0000	80.	5.252	.010	116.741	132.228	1.545	85.048	10.	6.709	8	2.000
5	2	2	.0000	80.	5.252	.007	116.741	132.228	1.545	85.048	10.	6.709	8	2.000
5	3	1	.0000	40.	4.976	.007	116.741	132.228	1.545	85.048	10.	4.874	6	2.000
5	3	2	.0000	40.	4.976	.006	116.572	132.228	1.538	84.879	10.	4.874	6	2.000
6	1	1	.0000	119.	5.419	.006	116.741	132.228	1.545	85.048	10.	8.089	10	2.000
6	1	2	.0000	119.	5.419	.009	116.657	132.228	1.542	84.965	10.	8.089	10	2.000
6	2	1	.0000	80.	5.252	.009	116.657	132.228	1.542	84.965	10.	6.709	8	2.000
6	2	2	.0000	80.	5.252	.007	116.657	132.228	1.542	84.964	10.	6.709	8	2.000
6	3	1	.0000	40.	4.975	.007	116.657	132.228	1.542	84.964	10.	4.874	6	2.000
6	3	2	.0000	40.	4.975	.006	116.489	132.228	1.534	84.796	10.	4.874	6	2.000
7	1	1	.0000	40.	4.975	.006	116.657	132.228	1.542	84.965	10.	4.874	6	2.000
7	1	2	.0000	40.	4.975	.006	116.489	132.228	1.534	84.797	10.	4.874	6	2.000
7	2	1	.0000	40.	4.975	.006	116.489	132.228	1.534	84.797	10.	4.874	6	2.000
7	2	2	.0000	40.	4.975	.006	116.489	132.228	1.534	84.796	10.	4.874	6	2.000

N O D E 4 . . . S U P P L Y A Q U I F E R - W E L L F I E L D D E S C R I P T I O N

AQUIFER INPUT DATA

MAXIMUM FLOW RATE/WELL (LB/HR)	1.500000+005	DISTANCE STORAGE AQUIFER TO CITY (M)	9.600000+003
RATIO INJECTION/PRODUCT. WELL FLOW RATE (LB/HR)	1.000000+000	DISTANCE CITY TO SUPPLY AQUIFER (M)	9.600000+003
FRACTION EXCESS PRODUCING WELLS	.000000	ENVIRONMENTAL TEMPERATURE DURING STORAGE (F)	7.000000+001
FRACTION NONPRODUCING WELLS	.000000	ENVIRONMENTAL TEMPERATURE DURING USAGE (F)	3.500000+001
WELL SPACING (ACRES)	2.500000+001	DEPTH OF WELLS (M)	4.000000+002
AVERAGE WELL LIFE (YRS)	3.000000+001	DRILLING COST PER PRODUCING WELL	1.000000+005
AQUIFER EFFICIENCY (FRACTION)	8.500000+001		
AQUIFER FLUID RECOVERY FACTOR (FRACTION)	1.121240+000		

CALCULATIONS AT AQUIFER WELLS

NUMBER OF WELLS	23	EFFECTIVE WELL SPACING (ACRES)	2.500000+001
OUTLET WELLHEAD TEMPERATURE (F)	1.017524+002	PIPE LENGTH BETWEEN WELL NODES (M)	3.417931+002
OUTLET WELLHEAD PRESSURE (PSIA)	1.000464+000	OUTLET WELLHEAD STEAM FRACTION	.000000
OUTLET WELLHEAD ENTHALPY (BTU/LB)	6.974813+001	WELLHEAD PRESSURIZATION FACTOR (PRFACT)	2.639459+000
OUTLET WELLHEAD PRESSURE AT SATURATION (PSIA)	1.000464+000	INLET ACTUAL FLOW RATE/WELL (LB/HR)	1.433772+005
OUTLET ACTUAL FLOW RATE/WELL (LB/HR)	1.495198+005	TOTAL PEAK HEAT(CHILL) INTO AQUIFER (BTU/HR)	2.802241+008
TOTAL PEAK HEAT(CHILL) OUT OF AQUIFER (BTU/HR)	2.398607+008	TOTAL PEAK FLOW RATE INTO AQUIFER (LB/HR)	3.297675+006
TOTAL PEAK FLOW RATE OUT OF AQUIFER (LB/HR)	3.438956+006	TEMPERATURE OF SURROUNDING AQUIFER WATER (F)	5.500000+001
PEAK FLOW TO FLUID SOURCE (LB/HR)	3.438956+006		

N O D E 4 . . . S U P P L Y A Q U I F E R - E X I T C O N D I T I O N S

ABOVE GROUND PIPING . . . AVERAGE SEASONAL AIR TEMPERATURE (F) = 70.0

NODE I	J	ITR	MIX	STEAM FRACT	FLOW RATE (LB/SEC)	VELOCITY (FT/SEC)	HEAT LOSS (BTU/SEC-FT)	TEMP (F)	PRES(PSIA)	SATURATION PRES(PSIA)	ENTHALPY (BTU/LB)	PIPE SCHD	INTER DIAM(IN)	EXTER DIAM(IN)	INSUL THK(IN)
7	2	1		.0000	42.	5.172	.000	101.752	50.164	1.000	69.748	10.	4.874	6	2.000
7	2	2		.0000	42.	5.172	.002	101.623	50.164	.997	69.748	10.	4.874	6	2.000
7	1	1		.0000	42.	5.172	.000	101.623	50.164	.997	69.748	10.	4.874	6	2.000
7	1	2		.0000	42.	5.172	.002	101.562	50.164	.995	69.688	10.	4.874	6	2.000
6	3	1		.0000	42.	5.172	.000	101.752	50.164	1.000	69.748	10.	4.874	6	2.000
6	3	2		.0000	42.	5.172	.002	101.562	50.164	.995	69.687	10.	4.874	6	2.000
6	2	1	M	.0000	83.	5.459	.000	101.592	50.164	.996	69.718	10.	6.709	8	2.000
6	2	2	M	.0000	83.	5.459	.003	101.592	50.164	.996	69.718	10.	6.709	8	2.000
6	1	1	M	.0000	125.	5.633	.000	101.582	50.164	.995	69.708	10.	8.089	10	2.000
6	1	2	M	.0000	125.	5.633	.003	101.552	50.164	.994	69.678	10.	8.089	10	2.000
5	3	1		.0000	42.	5.172	.000	101.752	50.164	1.000	69.748	10.	4.874	6	2.000
5	3	2		.0000	42.	5.172	.002	101.562	50.164	.995	69.687	10.	4.874	6	2.000
5	2	1	M	.0000	83.	5.459	.000	101.592	50.164	.996	69.718	10.	6.709	8	2.000
5	2	2	M	.0000	83.	5.459	.003	101.592	50.164	.996	69.718	10.	6.709	8	2.000
5	1	1	M	.0000	208.	5.858	.000	101.568	50.164	.995	69.694	10.	10.240	12	2.000
5	1	2	M	.0000	208.	5.858	.004	101.548	50.164	.994	69.673	10.	10.240	12	2.000
4	4	1		.0000	42.	5.172	.000	101.752	50.164	1.000	69.748	10.	4.874	6	2.000
4	4	2		.0000	42.	5.172	.002	101.562	50.164	.995	69.687	10.	4.874	6	2.000
4	3	1	M	.0000	83.	5.459	.000	101.592	50.164	.996	69.718	10.	6.709	8	2.000
4	3	2	M	.0000	83.	5.459	.003	101.555	50.164	.995	69.680	10.	6.709	8	2.000
4	2	1	M	.0000	125.	5.633	.000	101.577	50.164	.995	69.703	10.	8.089	10	2.000
4	2	2	M	.0000	125.	5.633	.003	101.577	50.164	.995	69.703	10.	8.089	10	2.000
4	1	1	M	.0000	332.	6.070	.000	101.559	50.164	.995	69.684	10.	12.724	14	2.000
4	1	2	M	.0000	332.	6.070	.004	101.544	50.164	.994	69.670	10.	12.724	14	2.000

3	5	1		.0000	42.	5.172	.000	101.752	50.164	1.000	69.748	10.	4.874	6	2.000
3	5	2		.0000	42.	5.172	.002	101.562	50.164	.995	69.687	10.	4.874	6	2.000
3	4	1	M	.0000	83.	5.459	.000	101.592	50.164	.996	69.718	10.	6.709	8	2.000
3	4	2	M	.0000	83.	5.459	.003	101.555	50.164	.995	69.680	10.	6.709	8	2.000
3	3	1	M	.0000	125.	5.633	.000	101.577	50.164	.995	69.703	10.	8.089	10	2.000
3	3	2	M	.0000	125.	5.633	.003	101.548	50.164	.994	69.673	10.	8.089	10	2.000
3	2	1	M	.0000	166.	5.759	.000	101.566	50.164	.995	69.692	10.	9.238	10	2.000
3	2	2	M	.0000	166.	5.759	.003	101.566	50.164	.995	69.692	10.	9.238	10	2.000
3	1	1	M	.0000	498.	6.258	.000	101.551	50.164	.994	69.677	10.	15.348	16	2.000
3	1	2	M	.0000	498.	6.258	.005	101.540	50.164	.994	69.666	10.	15.348	16	2.000
2	6	1		.0000	42.	5.172	.000	101.752	50.164	1.000	69.748	10.	4.874	6	2.000
2	6	2		.0000	42.	5.172	.002	101.562	50.164	.995	69.687	10.	4.874	6	2.000
2	5	1	M	.0000	83.	5.459	.000	101.592	50.164	.996	69.718	10.	6.709	8	2.000
2	5	2	M	.0000	83.	5.459	.003	101.555	50.164	.995	69.680	10.	6.709	8	2.000
2	4	1	M	.0000	125.	5.633	.000	101.577	50.164	.995	69.703	10.	8.089	10	2.000
2	4	2	M	.0000	125.	5.633	.003	101.548	50.164	.994	69.673	10.	8.089	10	2.000
2	3	1	M	.0000	166.	5.759	.000	101.566	50.164	.995	69.692	10.	9.237	10	2.000
2	3	2	M	.0000	166.	5.759	.003	101.544	50.164	.994	69.670	10.	9.237	10	2.000
2	2	1	M	.0000	208.	5.858	.000	101.560	50.164	.995	69.685	10.	10.240	12	2.000
2	2	2	M	.0000	208.	5.858	.004	101.560	50.164	.995	69.685	10.	10.240	12	2.000
2	1	1	M	.0000	706.	6.423	.000	101.546	50.164	.994	69.672	10.	18.032	20	2.000
2	1	2	M	.0000	706.	6.423	.006	101.537	50.164	.994	69.662	10.	18.032	20	2.000
1	7	1		.0000	42.	5.172	.000	101.752	50.164	1.000	69.748	10.	4.874	6	2.000
1	7	2		.0000	42.	5.172	.002	101.562	50.164	.995	69.687	10.	4.874	6	2.000
1	6	1	M	.0000	83.	5.459	.000	101.592	50.164	.996	69.718	10.	6.709	8	2.000
1	6	2	M	.0000	83.	5.459	.003	101.555	50.164	.995	69.680	10.	6.709	8	2.000
1	5	1	M	.0000	125.	5.633	.000	101.577	50.164	.995	69.703	10.	8.089	10	2.000
1	5	2	M	.0000	125.	5.633	.003	101.548	50.164	.994	69.673	10.	8.089	10	2.000

1	4	1	M	.0000	166.	5.759	.000	101.566	50.164	.995	69.692	10.	9.238	10	2.000
1	4	2	M	.0000	166.	5.759	.003	101.544	50.164	.994	69.670	10.	9.238	10	2.000
1	3	1	M	.0000	208.	5.858	.000	101.560	50.164	.995	69.685	10.	10.240	12	2.000
1	3	2	M	.0000	208.	5.858	.004	101.539	50.164	.994	69.665	10.	10.240	12	2.000
1	2	1	M	.0000	249.	5.939	.000	101.553	50.164	.995	69.679	10.	11.140	12	2.000
1	2	2	M	.0000	249.	5.939	.004	101.553	50.164	.995	69.679	10.	11.140	12	2.000

TRANSMISSION SYSTEM AND AQUIFER WELL PRESSURE DROPS FOR DOWNHOLE PUMPS

MINIMUM TRANS PRESSURE DROP (PSI)	1.529333-002
MAXIMUM TRANS PRESSURE DROP (PSI)	3.517698+001
MEDIAN TRANS PRESSURE DROP (PSI)	3.517698+001
WELL DEPTH (FT)	1.312333+003
WELL DIAMETER (FT)	7.291667-001
ELEVATION PRESSURE DROP (PSI)	5.647936+002
WELL REYNOLDS NUMBER	1.617589+005
WELL FRICTION FACTOR	2.348016-002
WELL FRICTION PRESSURE DROP (PSI)	7.279791-001
WELL FLOW RATE (LBM/SEC)	4.153328+001
WELL FLUID VELOCITY (FT/SEC)	1.604889+000
WELL VELOCITY PRESSURE DROP (PSI)	1.718175-002
TOTAL WELL PRESSURE DROP (PSI)	5.655388+002
TOTAL TRANS AND WELL PRESSURE DROP (PSI)	6.007158+002

PUMP CAPITAL COST AND ENERGY REQUIREMENT ... DOWNHOLE PUMP

FLUID FLOW RATE (LBM/HR)	1.495198+005
PRESSURE DROP RESTORED (PSI)	6.007158+002
PUMP HEAD (FT OF H ₂ O)	1.395801+003
PUMP EFFICIENCY (FRACT)	6.500000-001
INLET FLUID TEMPERATURE (F)	1.017524+002
PUMP CAPITAL COST (\$)	5.636704+004
NON-ELECTRIC OPERATING COST (\$)	.000000
ENERGY CONSUMPTION (KWS)	1.208327+002

N O D E 4 . . . S U P P L Y A Q U I F E R - C A P I T A L C O S T S

PIPING SYSTEM EQUIPMENT	CAPITAL COST (\$)
PIPE	488694.
INSULATION	624638.
CASING	183808.
SITE	1028832.
WELLHEAD VALVES	238916.
INSTRUMENTATION	47783.
SOLIDS SEPARATORS	234999.
STORAGE AND DELIVERY SURFACE PUMPS	0.
DELIVERY DOWNHOLE PUMPS	1296442.
TOTAL PIPING SYSTEM	4144111.
ENGINEERING AND DESIGN (12 PCT)	497293.
TOTAL CAPITAL COST	4641405.

STORAGE AND DELIVERY MAINTENANCE (\$)

232070.

STORAGE AND DELIVERY CAP. REPL. RATE

.0150

STORAGE AND DELIVERY SURFACE PUMPS KILOWATTS

77.46

DELIVERY DOWNHOLE PUMPS KILOWATTS

2774.15

L E G 4 ... TRANSMISSION TO ENERGY SOURCE ... ENTERING AND EXIT CONDITIONS AND CAPITAL COSTS

 ABOVE GROUND PIPING ... AVERAGE SEASONAL AIR TEMPERATURE (F) = 70.0

NODE I	J	ITR	MIX	STEAM FRACT	FLOW RATE (LB/SEC)	VELOCITY (FT/SEC)	HEAT LOSS (BTU/SEC-FT)	TEMP (F)	PRES(Psia)	SATURATION PRES(Psia)	ENTHALPY (BTU/LB)	PIPE SCHD	INTR DIAM(IN)	EXTR DIAM(IN)	INSUL THK(IN)
1	1	1	M	.0000	955.	6.474	.000	101.541	97.942	.994	69.667	10.	20.889	22	2.000
1	1	2		.0000	955.	6.474	.006	101.204	97.942	.984	69.456	10.	20.890	22	2.000
1	1	3		.0000	955.	6.474	.006	101.204	97.942	.984	69.456	10.	20.890	22	2.000

PIPING SYSTEM EQUIPMENT

CAPITAL COST (\$)

PIPE	1897904.
INSULATION	1475513.
CASING	786833.
SITE	2042719.
TRANSMISSION SURFACE PUMPS	49933.
TOTAL PIPING SYSTEM	6252902.
ENGINEERING AND DESIGN (12 PCT)	750348.
TOTAL CAPITAL COST	7003250.

TRANSMISSION MAINTENANCE (\$)

350163.

TRANSMISSION CAP. REPL. RATE

.0150

TRANSMISSION SURFACE PUMP KILOWATTS

320.21

NUMBER OF TRANSMISSION LFG PUMPS

1

TRANSMISSION LEG PRESSURE DROP (PSI)

82.98

01/07/82

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

JAN 1980. DOLLARS ON THIS PAGE

AQUIFER EXPLORATION COSTS

	TOTAL (DOLLARS)	CAPITALIZED (DOLLARS)	EXPENSED (DOLLARS)	FAVORABLE SITES	BEGINNING MONTH/YEAR	ENDING MONTH/YEAR
IDENTIFICATION OF TARGETS						
LITERATURE SEARCH	100.	100.0	.0	1.	JAN/1986	DEC/1986
PRELIMINARY LAND CHECK	250.	250.0	.0	1.	JAN/1986	DEC/1986
PRELIMINARY RECONNAISSANCE						
LITERATURE SEARCH	700.	700.0	.0	1.	JAN/1986	DEC/1986
GEOLOGICAL RECONNAISSANCE	1000.	1000.0	.0	1.	JAN/1986	DEC/1986
DETAILED LAND CHECK	1200.	1200.0	.0	1.	JAN/1986	DEC/1986
DETAILED RECONNAISSANCE						
LEASE COST	22000.	22000.0	.0	1.	JAN/1986	DEC/1986
FIELD GEOLOGY	5000.	5000.0	.0	1.	JAN/1986	DEC/1986
ENVIRONMENTAL IMPACT STATEMENT PREPARATION AND PUBLICATION	250000.	250000.0	.0	1.	JAN/1986	DEC/1986
AQUIFER CHARACTERIZATION						
PUMP TEST	1000.	1000.0	.0	1.	JAN/1987	DEC/1987
INJECTION/TRACER TEST	3000.	3000.0	.0	1.	JAN/1987	DEC/1987
ANISOTROPY TEST	5000.	5000.0	.0	1.	JAN/1987	DEC/1987
GEOPHYSICAL LOG	15000.	15000.0	.0	1.	JAN/1987	DEC/1987
MICROBIOLOGY/GEOCHEMISTRY	10000.	10000.0	.0	1.	JAN/1987	DEC/1987
EXPLORATION DRILLING						
TOTAL COST OF DRILLING	131233.	131233.3	.0	1.	JAN/1987	DEC/1987
TOTAL PREDEVELOPMENT COST	445481.	445483.3	.0	1.00		
FIELD DEVELOPMENT						
PRODUCTION WELL DRILLING	4600000.	4600000.0	.0		JAN/1987	DEC/1988
LEGS 1 & 2, NODE 2, & HEAT EXCHANGER	15725400.	15725400.1	.0		JAN/1988	DEC/1989
LEGS 3 & 4 AND NODE 4	12045654.	12045654.5	.0		JAN/1988	DEC/1989
TOTAL FIELD DEVELOPMENT COST	32371055.					
ANNUAL FIELD OPERATION COSTS						
REPLACEMENT WELL COST	153333.	153333.3	.0		JAN/1990	DEC/2018
PURCHASED THERMAL ENERGY	6123708.	.0	6123707.9		JAN/1990	DEC/2019
WELL ABANDONMENT	1533.	.0	1533.3		JAN/1990	DEC/2019
WELL MAINTENANCE	46000.	.0	46000.0		JAN/1990	DEC/2019
OVERHEAD AND MANAGEMENT	1141810.	.0	1141809.8		JAN/1990	DEC/2019
REPLACEMENT OH PUMP COSTS	0.	.0	.0		JAN/1990	DEC/2019
HEAT EXCHANGER OPERATIONAL COST	25341.	.0	25341.1		JAN/1990	DEC/2019
PUMPING ELECTRICITY COST	442525.	.0	442524.5		JAN/1990	DEC/2019
LEGS 1&2, NODE 2, & HEAT EXCH. MAINT.	786270.	.0	786270.0		JAN/1990	DEC/2019
LEGS 3&4 AND NODE 4 MAINT.	602283.	.0	602282.7		JAN/1990	DEC/2019
TOTAL FIELD OPERATION COST	9322803.	153333.3	9169469.4			

01/07/82

DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL SUPPLY SYSTEM OPERATION COSTS, \$ MILLIONS

		O AND M COSTS	PUMPING ELECTRIC COSTS	PURCHASED THERMAL ENERGY	GENERAL MANAGEMENT	REPLACEMENT WELLS	TOTAL SYSTEM OPERATION
YEAR							
1	1986	.000000	.000000	.000000	.000000	.000000	.000000
2	1987	.000000	.000000	.000000	.000000	.000000	.000000
3	1988	.000000	.000000	.000000	.000000	.000000	.000000
4	1989	.000000	.000000	.000000	.000000	.000000	.000000
5	1990	2.694566	.900465	11.290835	2.105258	.282715	17.273838
6	1991	2.856239	.963498	11.968285	2.231574	.299677	18.319273
7	1992	3.027614	1.030943	12.686382	2.365468	.317658	19.428065
8	1993	3.209271	1.103109	13.447565	2.507396	.336718	20.604058
9	1994	3.401827	1.180326	14.254419	2.657840	.356921	21.851333
10	1995	3.605936	1.262949	15.109684	2.817310	.378336	23.174216
11	1996	3.822293	1.351356	16.116265	2.986349	.401036	24.577298
12	1997	4.051630	1.445951	16.977241	3.165530	.425098	26.065450
13	1998	4.294728	1.547167	17.995875	3.355462	.450604	27.648836
14	1999	4.552412	1.655469	19.075628	3.556749	.477640	29.317938
15	2000	4.825556	1.771352	20.220165	3.770197	.506299	31.093569
16	2001	5.115090	1.895346	21.433375	3.996409	.536677	32.974897
17	2002	5.421995	2.028020	22.719378	4.236193	.568877	34.974464
18	2003	5.747315	2.169982	24.082541	4.490365	.603010	37.093212
19	2004	6.092154	2.321881	25.527493	4.759787	.639190	39.340504
20	2005	6.457683	2.484412	27.059143	5.045374	.677542	41.724154
21	2006	6.845144	2.658321	28.682691	5.348096	.718194	44.252447
22	2007	7.255853	2.844404	30.403653	5.668982	.761286	46.934177
23	2008	7.691204	3.043512	32.227872	6.009121	.806963	49.778672
24	2009	8.152676	3.256558	34.161544	6.369668	.855381	52.795827
25	2010	8.641837	3.484517	36.211237	6.751848	.906704	55.996142
26	2011	9.160347	3.728433	38.363911	7.156959	.961106	59.390756
27	2012	9.709968	3.989423	40.686946	7.586377	1.018772	62.991486
28	2013	10.292566	4.268683	43.128162	8.041559	1.079899	66.810869
29	2014	10.910120	4.567491	45.715852	8.524053	1.144693	70.862208
30	2015	11.564727	4.887215	48.458803	9.035496	1.213374	75.159615
31	2016	12.258610	5.229320	51.366331	9.577626	1.286177	79.718064
32	2017	12.994127	5.595372	54.448311	10.152283	1.363347	84.553441
33	2018	13.773775	5.987048	57.715210	10.761420	1.445148	89.682602
34	2019	14.600201	6.406142	61.178123	11.407105	.000000	93.591571

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL SUPPLY SYSTEM CASH FLOW, \$ MILLIONS

YEAR	LOAD FACTOR	PRE- DEVELOP.	FIELD DEVELOPMENT	TOTAL SYSTEM OPERATION	PROPERTY TAXES AND INSURANCE	INTERIM (A) CAPITAL REPLACEMENT	TOTAL	TAX CREDIT
1 1986	.0000	.409292	.000000	.000000	.000491	.000000	.409784	.000000
2 1987	.0000	.255795	.3560589	.000000	.005071	.000000	3.421454	.000000
3 1988	.0000	.000000	26.559917	.000000	.036943	.000000	26.596859	.000000
4 1989	.0000	.000000	24.152834	.000000	.065926	.000000	24.218760	.000000
5 1990	.3086	.000000	.000000	17.273838	.069882	1.161602	18.505322	.000000
6 1991	.3086	.000000	.000000	18.319273	.074075	1.231298	19.624646	.000000
7 1992	.3086	.000000	.000000	19.428065	.078519	1.335176	20.841769	.000000
8 1993	.3086	.000000	.000000	20.604058	.083230	1.383487	22.070775	.000000
9 1994	.3086	.000000	.000000	21.851133	.088224	1.466496	23.406053	.000000
10 1995	.3086	.000000	.000000	23.174216	.093517	1.554486	24.822219	.000000
11 1996	.3086	.000000	.000000	24.577298	.099128	1.647755	26.324182	.000000
12 1997	.3086	.000000	.000000	26.065450	.105076	1.746620	27.917146	.000000
13 1998	.3086	.000000	.000000	27.643836	.111381	1.851417	29.606634	.000000
14 1999	.3086	.000000	.000000	29.317938	.118064	1.962502	31.398504	.000000
15 2000	.3086	.000000	.000000	31.093569	.125147	2.080252	33.298969	.000000
16 2001	.3086	.000000	.000000	32.976897	.132656	2.205068	35.314621	.000000
17 2002	.3086	.000000	.000000	34.974464	.140616	2.337372	37.452451	.000000
18 2003	.3086	.000000	.000000	37.093212	.149053	2.477614	39.719879	.000000
19 2004	.3086	.000000	.000000	39.340504	.157996	2.626271	42.124771	.000000
20 2005	.3086	.000000	.000000	41.724154	.167476	2.783847	44.675476	.000000
21 2006	.3086	.000000	.000000	44.252447	.177524	2.950876	47.380849	.000000
22 2007	.3086	.000000	.000000	46.934177	.188175	3.127931	50.250283	.000000
23 2008	.3086	.000000	.000000	49.778872	.199466	3.315606	53.293744	.000000
24 2009	.3086	.000000	.000000	52.795827	.211434	3.514543	56.521804	.000000
25 2010	.3086	.000000	.000000	55.996142	.224120	3.725415	59.945678	.000000
26 2011	.3086	.000000	.000000	59.390756	.237567	3.948940	63.577263	.000000
27 2012	.3086	.000000	.000000	62.991486	.251821	4.185877	67.429184	.000000
28 2013	.3086	.000000	.000000	66.810869	.266931	4.437029	71.514829	.000000
29 2014	.3086	.000000	.000000	70.862208	.282946	4.703251	75.848405	.000000
30 2015	.3086	.000000	.000000	75.159615	.299923	4.985446	80.444985	.000000
31 2016	.3086	.000000	.000000	79.718064	.317919	5.284573	85.320556	.000000
32 2017	.3086	.000000	.000000	84.553441	.336944	5.601647	90.492082	.000000
33 2018	.3086	.000000	.000000	89.682602	.357213	5.937746	95.977561	.000000
34 2019	.3086	.000000	.000000	95.591571	.378646	.000000	93.970217	.000000

(A) INTERIM CAPITAL REPLACEMENT DOES NOT INCLUDE CAPITALIZED PART OF REPLACEMENT WELL COST WHICH IS INCLUDED UNDER SYSTEM OPERATION

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL SUPPLY SYSTEM DEDUCTIBLE EXPENSES, \$ MILLIONS

YEAR	10.000 PCT PRESENT WORTH FACTOR	FIELD OPERATING EXPENSES	BOND INTEREST	WELL DEPRECIATION	AMORTIZ. AND DEPRECIATION	TOTAL DEDUCTIBLE OPER. EXP.	STATE INCOME TAXES
1 1986	.95346	.00049	.00000	.00000	.00000	.00049	.00000
2 1987	.86678	.00507	.04098	.00000	.00000	.04605	.00000
3 1988	.78799	.03694	.42722	.00000	.00000	.46416	.00000
4 1989	.71635	.06593	3.12963	.00000	.00000	3.19556	.00000
5 1990	.65123	17.06101	5.86447	.24449	3.15140	26.32137	.00000
6 1991	.59203	18.09367	5.29868	.25424	3.22884	26.87544	.00000
7 1992	.53820	19.18493	5.10347	.26495	3.31093	27.86828	.00000
8 1993	.48928	20.35057	4.90817	.27671	3.39794	28.93339	.00000
9 1994	.44480	21.58264	4.71272	.28966	3.49018	30.07520	.00000
10 1995	.40436	22.88940	4.51708	.30394	3.58794	31.29836	.00000
11 1996	.36760	24.27539	4.32118	.31970	3.69157	32.60784	.00000
12 1997	.33418	25.74543	4.12493	.33714	3.80142	34.00492	.00000
13 1998	.30380	27.30461	3.92824	.35646	3.91787	35.50718	.00000
14 1999	.27618	28.95836	3.73101	.37792	4.04129	37.10859	.00000
15 2000	.25108	30.71242	3.53311	.40180	4.17213	38.81945	.00000
16 2001	.22825	32.77288	3.33437	.42845	4.31081	40.64650	.00000
17 2002	.20750	34.54620	3.13462	.45826	4.45782	42.59690	.00000
18 2003	.18864	36.63925	2.93363	.49173	4.61364	44.67825	.00000
19 2004	.17149	38.85931	2.73116	.52941	4.77881	46.89870	.00000
20 2005	.15590	41.21409	2.52688	.57203	4.94666	49.25966	.00000
21 2006	.14173	43.71178	2.33335	.62042	5.12607	51.77162	.00000
22 2007	.12884	46.36107	2.14361	.67567	5.31997	54.46132	.00000
23 2008	.11713	49.17117	1.95587	.73911	5.52962	57.33577	.00000
24 2009	.10648	52.15188	1.76775	.81247	5.75581	60.32791	.00000
25 2010	.09680	55.31356	1.57612	.89801	5.99750	63.43518	.00000
26 2011	.08800	58.66722	1.37678	.99875	6.25580	66.69855	.00000
27 2012	.08000	62.22453	1.16413	1.11889	6.53157	70.02912	.00000
28 2013	.07273	65.99790	0.93055	1.26443	6.80311	73.49598	.00000
29 2014	.06612	70.00046	0.68549	1.44441	7.09119	77.22954	.00000
30 2015	.06011	74.24616	0.43392	1.67335	7.39900	81.15244	.00000
31 2016	.05464	78.74981	0.27357	1.97669	7.73668	85.26675	.00000
32 2017	.04967	83.52709	0.08930	2.40542	8.10120	89.52301	.00000
33 2018	.04516	88.59467	0.24014	3.08709	8.50620	94.42810	.00000
34 2019	.04105	93.97022	2.10010	4.53224	9.04877	100.65133	.00000
TOTALS=				28.15386	133.14376		

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL SUPPLY SYSTEM INCOME STATEMENT, \$ MILLIONS

YEAR	ENERGY UNITS (T BTU)	TOTAL ENERGY SALES	HY PRODUCT SALES	TOTAL TAX DEDUCTIBLE EXPENSES	TAXABLE INCOME (FEDERAL)	FEDERAL (A) INCOME TAX
1 1986	.00000	.00000	.00000	.00049	-.00049	.00000
2 1987	.00000	.00000	.00000	.04605	-.04605	.00000
3 1988	.00000	.00000	.00000	.46416	-.46416	.00000
4 1989	.00000	.00000	.00000	3.19556	-3.19556	.00000
5 1990	.95770	30.02763	.00000	26.32137	3.70626	.00000
6 1991	.95770	26.87544	.00000	26.87544	.00000	.00000
7 1992	.95770	27.86828	.00000	27.86828	.00000	.00000
8 1993	.95770	28.93339	.00000	28.93339	.00000	.00000
9 1994	.95770	30.07520	.00000	30.07520	.00000	.00000
10 1995	.95770	31.29836	.00000	31.29836	.00000	.00000
11 1996	.95770	32.60784	.00000	32.60784	.00000	.00000
12 1997	.95770	34.00892	.00000	34.00892	.00000	.00000
13 1998	.95770	35.50718	.00000	35.50718	.00000	.00000
14 1999	.95770	37.10859	.00000	37.10859	.00000	.00000
15 2000	.95770	38.81945	.00000	38.81945	.00000	.00000
16 2001	.95770	40.64650	.00000	40.64650	.00000	.00000
17 2002	.95770	42.59690	.00000	42.59690	.00000	.00000
18 2003	.95770	44.67825	.00000	44.67825	.00000	.00000
19 2004	.95770	46.89870	.00000	46.89870	.00000	.00000
20 2005	.95770	48.13766	.00000	48.13766	.00000	.00000
21 2006	.95770	48.91162	.00000	48.91162	.00000	.00000
22 2007	.95770	51.87132	.00000	51.87132	.00000	.00000
23 2008	.95770	55.03077	.00000	55.03077	.00000	.00000
24 2009	.95770	58.40591	.00000	58.40591	.00000	.00000
25 2010	.95770	62.01518	.00000	62.01518	.00000	.00000
26 2011	.95770	65.88055	.00000	65.88055	.00000	.00000
27 2012	.95770	70.02912	.00000	70.02912	.00000	.00000
28 2013	.95770	74.49598	.00000	74.49598	.00000	.00000
29 2014	.95770	79.32954	.00000	79.32954	.00000	.00000
30 2015	.95770	84.60244	.00000	84.60244	.00000	.00000
31 2016	.95770	90.43675	.00000	90.43675	.00000	.00000
32 2017	.95770	97.07301	.00000	97.07301	.00000	.00000
33 2018	.95770	105.11810	.00000	105.11810	.00000	.00000
34 2019	.95770	117.07133	.00000	117.07133	.00000	.00000

(A) THIS COLUMN SHOWS THE FEDERAL INCOME TAXES PRIOR TO THE APPLICATION OF THE INVESTMENT TAX CREDIT

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

PAYOUT OF SUPPLY SYSTEM INVESTMENTS, \$ MILLIONS

YEAR	NET CASH FLOW	OUTSTANDING BONDS	EQUITY CAPITAL NOT RECOVERED	BOND INTEREST	EARNINGS ON UNRECOVERED EQUITY	BONDS REPAID	RECOVERY OF EQUITY
1 1986	-.40978	.00000	.00000	.00000	.00000	-.40978	.00000
2 1987	-3.86243	.40978	.00000	.04098	.00000	-3.86243	.00000
3 1988	-27.02408	4.27222	.00000	.42722	.00000	-27.02408	.00000
4 1989	-27.34839	31.29430	.00000	3.12943	.00000	-27.34839	.00000
5 1990	5.65784	58.64464	.00000	5.86447	.00000	5.65784	.00000
6 1991	1.95211	52.98684	.00000	5.29868	.00000	1.95211	.00000
7 1992	1.95304	51.03473	.00000	5.10347	.00000	1.95304	.00000
8 1993	1.95445	49.08164	.00000	4.90817	.00000	1.95445	.00000
9 1994	1.95642	47.12724	.00000	4.71272	.00000	1.95642	.00000
10 1995	1.95906	45.17082	.00000	4.51708	.00000	1.95906	.00000
11 1996	1.96249	43.21176	.00000	4.32118	.00000	1.96249	.00000
12 1997	1.96684	41.24928	.00000	4.12493	.00000	1.96684	.00000
13 1998	1.97231	39.28243	.00000	3.92824	.00000	1.97231	.00000
14 1999	1.97907	37.31013	.00000	3.73101	.00000	1.97907	.00000
15 2000	1.98738	35.33106	.00000	3.53311	.00000	1.98738	.00000
16 2001	1.99751	33.34368	.00000	3.33437	.00000	1.99751	.00000
17 2002	2.00983	31.34617	.00000	3.13462	.00000	2.00983	.00000
18 2003	2.02474	29.33634	.00000	2.93363	.00000	2.02474	.00000
19 2004	2.04277	27.31160	.00000	2.73116	.00000	2.04277	.00000
20 2005	-1.06470	25.26883	.00000	2.52688	.00000	-1.06470	.00000
21 2006	-1.10258	23.33353	.00000	2.33353	.00000	-1.10258	.00000
22 2007	-1.12257	21.43611	.00000	2.14361	.00000	-1.12257	.00000
23 2008	-1.11884	19.55868	.00000	1.95587	.00000	-1.11884	.00000
24 2009	-1.08364	17.67752	.00000	1.76775	.00000	-1.08364	.00000
25 2010	-1.00661	15.76116	.00000	1.57612	.00000	-1.00661	.00000
26 2011	-.87349	13.77778	.00000	1.37778	.00000	-.87349	.00000
27 2012	-.66419	11.84127	.00000	1.18413	.00000	-.66419	.00000
28 2013	-.34939	9.80546	.00000	0.98055	.00000	-.34939	.00000
29 2014	.11565	7.65485	.00000	0.76549	.00000	.11565	.00000
30 2015	.80353	5.35920	.00000	0.53592	.00000	.80353	.00000
31 2016	1.84263	3.13566	.00000	0.31357	.00000	1.84263	.00000
32 2017	3.49163	0.84304	.00000	0.08430	.00000	3.49163	.00000
33 2018	6.40040	27.40141	.00000	2.74014	.00000	6.40040	.00000
34 2019	21.00101	21.00101	.00000	2.10010	.00000	21.00101	.00000

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

SUPPLY SYSTEM: ANNUAL COST OF ENERGY IN CURRENT DOLLARS

DOLLARS PER MBTU

YEAR	FULL COST RECOVERY	OUT-OF- POCKET COSTS ONLY	ENERGY AND OPERATING COSTS ONLY	ELECTR. AND PURCH. ENERGY COSTS ONLY	PURCHASED ENERGY COSTS ONLY
1 1986	.00	.00	.00	.00	.00
2 1987	.00	.00	.00	.00	.00
3 1988	.00	.00	.00	.00	.00
4 1989	.00	.00	.00	.00	.00
5 1990	31.35	25.45	19.32	12.73	11.79
6 1991	28.06	26.02	20.49	13.50	12.50
7 1992	29.10	27.06	21.73	14.32	13.25
8 1993	30.21	28.17	23.05	15.19	14.04
9 1994	31.40	29.36	24.44	16.12	14.88
10 1995	32.68	30.64	25.92	17.10	15.78
11 1996	34.05	32.00	27.49	18.13	16.72
12 1997	35.51	33.46	29.15	19.24	17.73
13 1998	37.08	35.02	30.91	20.41	18.79
14 1999	38.75	36.68	32.79	21.65	19.92
15 2000	40.53	38.46	34.77	22.96	21.11
16 2001	42.44	40.36	36.87	24.36	22.38
17 2002	44.48	42.38	39.11	25.84	23.72
18 2003	46.65	44.54	41.47	27.41	25.15
19 2004	48.97	46.84	43.99	29.08	26.66
20 2005	48.19	49.29	46.65	30.85	28.25
21 2006	51.07	52.22	49.47	32.73	29.95
22 2007	54.16	55.33	52.47	34.72	31.75
23 2008	57.46	58.63	55.65	36.83	33.65
24 2009	60.99	62.12	59.02	39.07	35.67
25 2010	64.75	65.81	62.59	41.45	37.81
26 2011	68.79	69.70	66.39	43.97	40.08
27 2012	73.12	73.82	70.41	46.65	42.48
28 2013	77.79	78.15	74.67	49.49	45.03
29 2014	82.83	82.71	79.20	52.50	47.74
30 2015	88.34	87.50	84.00	55.70	50.60
31 2016	94.43	92.51	89.09	59.10	53.64
32 2017	101.34	97.72	94.49	62.70	56.85
33 2018	109.76	103.08	100.22	66.52	60.26
34 2019	122.24	100.31	98.12	70.57	63.88

PERCENT DISCOUNT RATE USED TO DERIVE LEVELIZED COST 3.77 %

EQUIVALENT LEVELIZED COST OF ENERGY IN JAN 1990 BASE YEAR DOLLARS 12.51 DOLLARS PER MBTU
(FULL COST RECOVERY BASIS)NOTE-COST OF ENERGY INCLUDES USEABLE HEAT(CHILL) AND HEAT(CHILL) LOSSES IN DISTRIBUTION PIPING NETWORK
I.E. GROSS HEAT(CHILL) DELIVERED TO DISTRIBUTION SYSTEM

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL DISTRIBUTION SYSTEM OPERATING COSTS, \$ MILLIONS

YEAR	O AND M COSTS	PUMPING ELECTRIC COSTS	SUPPLEMENTAL ENERGY COSTS	TOTAL DISTRIBUTION OPERAT. COSTS
1 1987	.000000	.000000	.000000	.000000
2 1988	.000000	.000000	.000000	.000000
3 1989	.000000	.000000	.000000	.000000
4 1990	.408408	.262570	.301200	.972178
5 1991	.432913	.280949	.319272	1.033135
6 1992	.458888	.300616	.338429	1.097932
7 1993	.486421	.321659	.358734	1.166814
8 1994	.515606	.344175	.380259	1.240040
9 1995	.546543	.368267	.403074	1.317884
10 1996	.579335	.394046	.427259	1.400640
11 1997	.614095	.421029	.452894	1.488619
12 1998	.650941	.451143	.480068	1.582152
13 1999	.689997	.482723	.508872	1.681593
14 2000	.731397	.516514	.539404	1.787315
15 2001	.775281	.552670	.571768	1.897719
16 2002	.821798	.591357	.606074	2.019229
17 2003	.871106	.632752	.642439	2.146297
18 2004	.923372	.677045	.680985	2.281402
19 2005	.978774	.724438	.721844	2.425057
20 2006	1.037501	.775148	.765155	2.577804
21 2007	1.099751	.829409	.811064	2.740224
22 2008	1.165736	.887467	.859728	2.912932
23 2009	1.235680	.949590	.911312	3.096582
24 2010	1.309621	1.016061	.965990	3.291873
25 2011	1.388410	1.087186	1.023950	3.499546
26 2012	1.471715	1.163289	1.085387	3.720391
27 2013	1.560018	1.244719	1.150510	3.955247
28 2014	1.653619	1.331849	1.219541	4.205009
29 2015	1.752836	1.425079	1.292713	4.470628
30 2016	1.858006	1.524834	1.370276	4.753116
31 2017	1.969487	1.631573	1.452493	5.053552
32 2018	2.087656	1.745783	1.539642	5.373081
33 2019	2.212915	1.867948	1.632021	5.712923

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL CASH FLOW TABLE DISTRIBUTION SYSTEM, \$ MILLIONS

YEAR	LOAD FACTOR	CAPITAL COSTS	SUPPLY SYSTEM ENERGY COSTS	TOTAL DISTR OPERATING COSTS	INTERIM CAPITAL REPLACEMENT	PROPERTY TAXES INSURANCE	TOTAL COSTS	TAX CREDIT
1 1987	.00000	9.12114	.00000	.00000	.00000	.00000	9.12114	.00000
2 1988	.00000	55.48617	.00000	.00000	.00000	.01095	55.49712	.00000
3 1989	.00000	39.26623	.00000	.00000	.00000	.07753	39.34376	.00000
4 1990	.30860	.00000	30.02763	.97218	1.72245	.13780	32.46006	.00000
5 1991	.30860	.00000	26.87544	1.03313	1.82580	.14606	29.88044	.00000
6 1992	.30860	.00000	27.86828	1.09793	1.93534	.15483	31.05638	.00000
7 1993	.30860	.00000	28.93339	1.16681	2.05146	.16412	32.21579	.00000
8 1994	.30860	.00000	30.07520	1.24004	2.17455	.17396	33.66375	.00000
9 1995	.30860	.00000	31.29836	1.31788	2.30502	.18440	35.10567	.00000
10 1996	.30860	.00000	32.60784	1.40064	2.44333	.19547	36.64728	.00000
11 1997	.30860	.00000	34.00892	1.48862	2.58993	.20714	38.29466	.00000
12 1998	.30860	.00000	35.50718	1.58215	2.74532	.21963	40.05428	.00000
13 1999	.30860	.00000	37.10859	1.68159	2.91004	.23280	41.93302	.00000
14 2000	.30860	.00000	38.81945	1.78732	3.08464	.24677	43.93818	.00000
15 2001	.30860	.00000	40.64650	1.89972	3.26972	.26158	46.07752	.00000
16 2002	.30860	.00000	42.59690	2.01923	3.46590	.27727	48.35930	.00000
17 2003	.30860	.00000	44.67825	2.14630	3.67386	.29391	50.79232	.00000
18 2004	.30860	.00000	46.89870	2.28140	3.89429	.31154	53.38593	.00000
19 2005	.30860	.00000	48.13766	2.42506	4.12795	.33024	56.02090	.00000
20 2006	.30860	.00000	49.91162	2.57780	4.37562	.35005	58.74150	.00000
21 2007	.30860	.00000	51.87132	2.74022	4.63816	.37105	61.62076	.00000
22 2008	.30860	.00000	55.03077	2.91293	4.91645	.39332	63.25347	.00000
23 2009	.30860	.00000	58.40591	3.09658	5.21144	.41692	67.13085	.00000
24 2010	.30860	.00000	62.01518	3.29187	5.52413	.44193	71.27311	.00000
25 2011	.30860	.00000	65.88055	3.49955	5.85557	.46845	75.70411	.00000
26 2012	.30860	.00000	70.02912	3.72039	6.20691	.49655	80.45297	.00000
27 2013	.30860	.00000	74.49598	3.95525	6.57932	.52635	85.55690	.00000
28 2014	.30860	.00000	79.32954	4.20501	6.97408	.55793	91.06656	.00000
29 2015	.30860	.00000	84.60244	4.47063	7.39253	.59140	97.05699	.00000
30 2016	.30860	.00000	90.43675	4.75312	7.83608	.62689	103.65283	.00000
31 2017	.30860	.00000	97.07301	5.05355	8.30624	.66450	111.09731	.00000
32 2018	.30860	.00000	105.11810	5.37308	8.80462	.70437	120.00017	.00000
33 2019	.30860	.00000	117.07133	5.71292	.00000	.74663	123.53089	.00000

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL TAX DEDUCTIBLE EXPENSES DISTRIBUTION SYSTEM, \$ MILLIONS

YEAR	10.000 PCT PRESENT WORTH FACTOR	OPERATING EXPENSES	BOND INTEREST	DEPRECIATION	TOTAL DEDUCTIBLE OPERATING EXPENSES	STATE INCOME TAX
1 1987	.95346	.00000	.00000	.00000	.00000	.00000
2 1988	.86678	.01095	.91211	.00000	.92306	.00000
3 1989	.78799	.07753	6.55304	.00000	6.63057	.00000
4 1990	.71635	31.13761	11.14272	6.92490	49.20523	.00000
5 1991	.65123	28.05464	9.86711	7.03973	44.96148	.00000
6 1992	.59203	29.12104	9.34572	7.16145	45.62820	.00000
7 1993	.53820	30.26432	8.82310	7.29048	46.37790	.00000
8 1994	.48928	31.48920	8.29920	7.42724	47.21564	.00000
9 1995	.44480	32.80065	7.77393	7.57221	48.14679	.00000
10 1996	.40436	34.20395	7.24722	7.72588	49.17704	.00000
11 1997	.36760	35.70473	6.71896	7.88877	50.31246	.00000
12 1998	.33418	37.30896	6.18908	8.06143	51.55947	.00000
13 1999	.30380	39.02298	5.65747	8.24445	52.92490	.00000
14 2000	.27618	40.85354	5.12402	8.43845	54.41602	.00000
15 2001	.25108	42.80780	4.58864	8.64410	56.04054	.00000
16 2002	.22825	44.89340	4.05121	8.86208	57.80668	.00000
17 2003	.20750	47.11846	3.51159	9.09314	59.72319	.00000
18 2004	.18864	49.49164	2.96966	9.33806	61.79937	.00000
19 2005	.17149	48.89795	2.42528	2.67278	53.99102	.00000
20 2006	.15590	51.83948	2.57040	2.85280	57.26308	.00000
21 2007	.14173	54.98260	2.72308	3.06767	60.77335	.00000
22 2008	.12884	58.33702	2.88013	3.32516	64.54231	.00000
23 2009	.11713	61.91941	3.03926	3.63534	68.59401	.00000
24 2010	.10648	65.74898	3.19687	4.01152	72.95737	.00000
25 2011	.09680	69.84854	3.34813	4.47164	77.66831	.00000
26 2012	.08800	74.24606	3.48653	5.04070	82.77329	.00000
27 2013	.08000	78.97758	3.60315	5.75474	88.33546	.00000
28 2014	.07273	84.09248	3.68561	6.66827	94.44636	.00000
29 2015	.06612	89.66447	3.71619	7.86908	101.24974	.00000
30 2016	.06011	95.81675	3.68853	9.51157	108.99685	.00000
31 2017	.05464	102.79106	3.50098	11.90562	118.19766	.00000
32 2018	.04967	111.19555	3.14104	15.82768	130.16427	.00000
33 2019	.04516	123.53089	2.43874	24.38737	150.35699	.00000

DEPRECIATION SUM = 230.7143

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL INCOME STATEMENT DISTRIBUTION SYSTEM, \$ MILLIONS

YEAR	HEAT UNITS (1 BTU)	TOTAL HEAT SALES	REVENUE TAXES	TOTAL TAX DEDUCTIBLE EXPENSES	TAXABLE INCOME (FEDERAL)	FEDERAL (A) INCOME TAX
1 1987	.00000	.00000	.00000	.00000	.00000	.00000
2 1988	.00000	.00000	.00000	.92306	-92306	.00000
3 1989	.00000	.00000	.00000	6.63057	-6.63057	.00000
4 1990	.90761	59.12381	2.36495	49.20523	7.55363	.00000
5 1991	.90761	46.83488	1.87340	44.96148	.00000	.00000
6 1992	.90761	47.52938	1.90118	45.62820	.00000	.00000
7 1993	.90761	48.31032	1.93241	46.37790	.00000	.00000
8 1994	.90761	49.18296	1.96732	47.21564	.00000	.00000
9 1995	.90761	50.15291	2.00612	48.14679	.00000	.00000
10 1996	.90761	51.22609	2.04904	49.17704	.00000	.00000
11 1997	.90761	52.40881	2.09635	50.31246	.00000	.00000
12 1998	.90761	53.70778	2.14831	51.55947	.00000	.00000
13 1999	.90761	55.13010	2.20520	52.92490	.00000	.00000
14 2000	.90761	56.68335	2.26733	54.41602	.00000	.00000
15 2001	.90761	58.37556	2.33502	56.04054	.00000	.00000
16 2002	.90761	60.21529	2.40861	57.80668	.00000	.00000
17 2003	.90761	62.21165	2.48847	59.72319	.00000	.00000
18 2004	.90761	64.37434	2.57497	61.79937	.00000	.00000
19 2005	.90761	66.24064	2.24963	53.99172	.00000	.00000
20 2006	.90761	59.64904	2.38596	57.26308	.00000	.00000
21 2007	.90761	63.30557	2.53222	60.77335	.00000	.00000
22 2008	.90761	67.23158	2.64926	64.58231	.00000	.00000
23 2009	.90761	71.45210	2.85808	68.59401	.00000	.00000
24 2010	.90761	75.99726	3.03989	72.95737	.00000	.00000
25 2011	.90761	80.90449	3.23618	77.66831	.00000	.00000
26 2012	.90761	86.22214	3.44889	82.77329	.00000	.00000
27 2013	.90761	92.01611	3.68064	88.33546	.00000	.00000
28 2014	.90761	98.38162	3.93526	94.44636	.00000	.00000
29 2015	.90761	105.46848	4.21874	101.24974	.00000	.00000
30 2016	.90761	113.53839	4.54154	108.99685	.00000	.00000
31 2017	.90761	123.12256	4.92490	118.19766	.00000	.00000
32 2018	.90761	135.58774	5.42351	130.16427	.00000	.00000
33 2019	.90761	156.62147	6.26487	150.35699	.00000	.00000

(A) THIS COLUMN SHOWS THE FEDERAL INCOME TAXES PRIOR TO THE APPLICATION OF THE INVESTMENT TAX CREDIT

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL PAYOUT OF DISTRIBUTION SYSTEM INVESTMENTS, \$ MILLIONS

YEAR	NET CASH FLOW	OUTSTANDING BONUS	EQUITY CAPITAL NOT RECOVERED	BOND INTEREST	EARNINGS ON UNRECOVERED EQUITY	BONDS REPAID	RECOVERY OF EQUITY
1 1987	-9.12114	.00000	.00000	.00000	.00000	-9.12114	.00000
2 1988	-56.40923	9.12114	.00000	.91211	.00000	-56.40923	.00000
3 1989	-45.89680	65.53037	.00000	6.55304	.00000	-45.89680	.00000
4 1990	12.75608	111.42717	.00000	11.14272	.00000	12.75608	.00000
5 1991	5.21394	98.67109	.00000	9.86711	.00000	5.21394	.00000
6 1992	5.22611	93.45715	.00000	9.34572	.00000	5.22611	.00000
7 1993	5.23901	88.23104	.00000	8.82310	.00000	5.23901	.00000
8 1994	5.25269	82.99203	.00000	8.29920	.00000	5.25269	.00000
9 1995	5.26719	77.73934	.00000	7.77393	.00000	5.26719	.00000
10 1996	5.28255	72.47216	.00000	7.24722	.00000	5.28255	.00000
11 1997	5.29884	67.18961	.00000	6.71896	.00000	5.29884	.00000
12 1998	5.31611	61.89077	.00000	6.18908	.00000	5.31611	.00000
13 1999	5.33441	56.57466	.00000	5.65747	.00000	5.33441	.00000
14 2000	5.35381	51.24025	.00000	5.12402	.00000	5.35381	.00000
15 2001	5.37437	45.88644	.00000	4.58464	.00000	5.37437	.00000
16 2002	5.39617	40.51207	.00000	4.05121	.00000	5.39617	.00000
17 2003	5.41928	35.11589	.00000	3.51159	.00000	5.41928	.00000
18 2004	5.44377	29.64662	.00000	2.96466	.00000	5.44377	.00000
19 2005	-1.45517	24.25285	.00000	2.42528	.00000	-1.45517	.00000
20 2006	-1.52282	25.70802	.00000	2.57080	.00000	-1.52282	.00000
21 2007	-1.57049	27.23084	.00000	2.72308	.00000	-1.57049	.00000
22 2008	-1.59129	28.80133	.00000	2.88013	.00000	-1.59129	.00000
23 2009	-1.57609	30.39263	.00000	3.03926	.00000	-1.57609	.00000
24 2010	-1.51261	31.96872	.00000	3.19687	.00000	-1.51261	.00000
25 2011	-1.38393	33.48133	.00000	3.34813	.00000	-1.38393	.00000
26 2012	-1.16621	34.86526	.00000	3.48653	.00000	-1.16621	.00000
27 2013	-.82458	36.03147	.00000	3.60315	.00000	-.82458	.00000
28 2014	-.30581	36.85605	.00000	3.68561	.00000	-.30581	.00000
29 2015	.47656	37.16186	.00000	3.71619	.00000	.47656	.00000
30 2016	1.67550	36.68530	.00000	3.66453	.00000	1.67550	.00000
31 2017	3.59938	35.00981	.00000	3.50098	.00000	3.59938	.00000
32 2018	7.02306	31.41043	.00000	3.14104	.00000	7.02306	.00000
33 2019	24.38737	24.38737	.00000	2.43874	.00000	24.38737	.00000

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DISCOUNTED CASH FLOW ANALYSIS

ATES DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON

ANNUAL COST OF HEAT IN CURRENT DOLLARS

DOLLARS PER MBTU

YEAR	FULL COST RECOVERY	OUT-OF- PUCKET COSTS ONLY	ENERGY AND OPERATING COSTS ONLY	AQUIFER AND SUPL. ENERGY COSTS ONLY	AQUIFER ENERGY COSTS ONLY
1 1987	.00	.00	.00	.00	.00
2 1988	.00	.00	.00	.00	.00
3 1989	.00	.00	.00	.00	.00
4 1990	65.14	51.09	36.21	33.42	33.08
5 1991	51.60	45.86	32.92	29.96	29.61
6 1992	52.37	46.61	34.22	31.08	30.71
7 1993	53.23	47.46	35.61	32.27	31.88
8 1994	54.19	48.40	37.09	33.56	33.14
9 1995	55.26	49.45	38.68	34.93	34.48
10 1996	56.44	50.62	40.38	36.40	35.93
11 1997	57.74	51.91	42.19	37.97	37.47
12 1998	59.17	53.32	44.13	39.65	39.12
13 1999	60.74	54.86	46.20	41.45	40.89
14 2000	62.45	56.55	48.41	43.37	42.77
15 2001	64.32	58.40	50.77	45.41	44.76
16 2002	66.34	60.40	53.28	47.60	46.93
17 2003	68.54	62.57	55.96	49.93	49.23
18 2004	70.93	64.93	58.82	52.42	51.67
19 2005	61.97	63.57	58.42	51.63	50.83
20 2006	65.72	67.40	61.94	54.73	53.89
21 2007	69.75	71.48	65.69	58.05	57.15
22 2008	74.08	75.83	69.69	61.58	60.63
23 2009	78.73	80.46	73.96	65.36	64.35
24 2010	83.73	85.40	78.53	69.39	68.33
25 2011	89.14	90.67	83.41	73.72	72.59
26 2012	95.00	96.28	88.64	78.35	77.16
27 2013	101.38	102.29	94.27	83.35	82.08
28 2014	108.40	108.73	100.34	88.75	87.40
29 2015	116.20	115.68	106.94	94.64	93.21
30 2016	125.10	123.25	114.20	101.15	99.64
31 2017	135.66	131.69	122.41	108.55	106.95
32 2018	149.39	141.65	132.22	117.52	115.82
33 2019	172.57	145.70	136.11	130.79	128.99

PERCENT DISCOUNT RATE USED TO DERIVE LEVELIZED COST 3.77 %

EQUIVALENT LEVELIZED COST OF HEAT IN 1980 BASE YEAR DOLLARS 19.65 DOLLARS PER MBTU
(FULL COST RECOVERY BASIS)

NOTE-COST OF HEAT INCLUDES BOTH THE ANNUAL USEABLE HEAT PURCHASED BY THE USER RELATIVE TO THE
OUTDOOR DESIGN TEMPERATURE AND THE ANNUAL SUPPLEMENTAL HEAT PURCHASED BY THE USER THROUGHOUT THE YEAR FOR
TEMPERATURES BELOW THE OUTDOOR DESIGN TEMPERATURE

CASE NAME: ATE DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON
 OPERATOR: HD HUBER

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TECHNICAL SUMMARY

SOURCE		USER	
-----		----	
TEMPERATURE (F)	325.0	TYPE (POINT/DIST/COMB)	DIST
PEAK FLOW RATE (LB/HR)	3407674.	MODE (COOLING/HEATING/COMB)	HEATING
DAILY AVAILABILITY (HR)	24.0	PEAK DEMAND (MMTU/HR)	325.4
ANNUAL AVAILABILITY (DAYS)	120.0	ANNUAL AVERAGE DEMAND (MMTU/HR)	100.
HX EMPLOYED?	YES	LOAD FACTOR (%)	30.9
HX APPROACH TEMP (F)	17.5	HX EMPLOYED?	YES
HX SURFACE AREA (SQ FT)	139324.	HX INLET APPROACH TEMP (F)	17.5
SUPPLY/DEMAND (%)	99.9	HX OUTLET APPROACH TEMP (F)	17.5
		HX SURFACE AREA (SQ FT)	62367.
		REJECT TEMPERATURE (F)	100.0

SUPPLY AQUIFER		STORAGE AQUIFER		ENVIRONMENTAL	
-----		-----		-----	
NO. OF WELLS	23	NO. OF WELLS	23	DESIGN DEGREE HOURS	5109.
DEPTH (FT)	1312.	DEPTH (FT)	1312.	DESIGN INDOOR TEMPERATURE (F)	65.
DESIGN FLOW RATE (LB/HR)	150000.	DESIGN FLOW RATE (LB/HR)	150000.	DESIGN OUTDOOR TEMPERATURE (F)	-5.
ACTUAL FLOW RATE (LB/HR)	149520.	ACTUAL FLOW RATE (LB/HR)	143437.	AQUIFER TEMPERATURE (F)	55.0
THERMAL EFFICIENCY (%)	85.0	THERMAL EFFICIENCY (%)	60.0	STORAGE TEMPERATURE (F)	70.0
FLUID RECOVERY FACTOR (%)	112.1	FLUID RECOVERY FACTOR (%)	90.0	DELIVERY TEMPERATURE (F)	35.0

FLOW INFORMATION

	PIPING (IN,FT)				INSULATION (IN)		CASING (IN)		FLOW (LB/HR,FT/SEC,DEG F)			
LEG	OD	LENGTH	MATER	SCHED	THICK	MATERIAL	OD	MATERIAL	RATE	VEL	T/IN	T/OUT
1: SOURCE/STORAGE	22.	31496.	CH STEEL	10.	4.0	MIXTURE	30.	ALUMINUM	3438956.	7.2	307.500	306.537
2: STORAGE/LOAD	22.	31496.	CH STEEL	10.	3.5	MIXTURE	29.	ALUMINUM	3249056.	6.9	223.045	222.036
3: LOAD/SUPPLY	22.	31496.	CH STEEL	10.	2.0	CAL SILC	26.	ALUMINUM	3297675.	6.6	117.500	116.898
4: SUPPLY/SOURCE	22.	31496.	CH STEEL	10.	2.0	CAL SILC	26.	ALUMINUM	3438956.	6.5	101.541	101.204
DISTRIBUTION MAIN	16.	4594.	CH STEEL	40.	1.0	CAL SILC	18.	PF STEEL	3262663.	12.2	204.536	204.420

CASE NAME: ATE DISTRICT HEATING TEST CASE FOR RICHLAND, WASHINGTON
 OPERATOR: HD HUBER

PAGE NUMBER: 2
 DATE: 01/07/82

FINANCIAL SUMMARY

ALL VALUES IN JAN 1980, DOLLARS

	SUPPLY	DIST
TYPE (PRIVATE/MUNICIPAL):	MUNI	MUNI
FRACTION BOND FINANCING:	1.00	1.00
FRACTION EQUITY FINANCING:	.00	.00
BOND RATE (%):	10.0	10.0
EQUITY RATE (%):	.0	.0
DISCOUNT RATE (%):	10.0	10.0
ANNUALIZED COST FACTOR (FH):	.17	.17
FEDERAL INCOME TAX RATE (%):	.0	.0
STATE INCOME TAX RATE (%):	.0	.0
STATE REVENUE TAX RATE (%):	.0	4.0
PROPERTY TAX AND INSURANCE (%):	.1	.1

ELECTRICITY (MILLS/KWH):	20.0
THERMAL ENERGY (\$/MBTU):	3.00
COST/WELL (\$):	100000.
ESCALATION RATES:	
CAPITAL EQUIPMENT (%):	6.0
ELECTRICITY (%):	7.0
THERMAL ENERGY (%):	6.0
O&M (%):	6.0
OVERALL INFLATION (%):	6.0

LEVELIZED PRODUCTION COST (\$/MBTU) : 19.65

TOTAL EXPLORATION COST (\$) : 445483.

LEVELIZED COST COMPONENTS

	\$/MBTU	%
ELECTRICITY	.78	3.96
THERMAL ENERGY	6.93	35.26
O&M	3.11	15.84
CAPITAL	8.83	44.93
TOTAL	19.65	100.00

DEPRECIATION SCHEDULE:	SL	SL	BASE YEAR FOR DOLLAR VALUE:	1980.
INVESTMENT TAX CREDIT (%):	.0	.0	PROJECT LIFE (YR):	30.
CAP. REPL. RATE (%/YR):	1.5	1.5	FIRST YEAR OF OPERATION:	1990.

	CAPITAL COST	%
TOTAL EXPLORATION COST	445483.	.47
NODE 1: ENERGY SOURCE	1387472.	1.46
LEG 1: SOURCE/STORAGE PIPELINE	5615387.	5.90
NODE 2: STORAGE WELL FIELD:	5645906.	5.94
LEG 2: STORAGE/USER PIPELINE:	5376635.	5.65
NODE 3: USER HEAT EXCHANGER	739208.	.78
LEG 3: USER/SUPPLY PIPELINE	4523666.	4.76
NODE 4: SUPPLY WELL FIELD:	5298164.	5.57
LEG 4: SUPPLY/SOURCE PIPELINE:	4523824.	4.76
DISTRIBUTION SYSTEM:	50516043.	53.12
END-USE EQUIPMENT:	11024000.	11.59
INITIAL CAPITAL INVESTMENT	95095789.	100.00

#FIN

APPENDIX H

SUPPLY INPUT PARAMETER, DISTRIBUTION INPUT
PARAMETER, AND AQUASTOR SUBROUTINE INDICES

SUPPLY INPUT PARAMETER INDEX
(NAMELIST Group \$RESVOR)

All parameters beginning with the letters I through N are "integer" except KINS and IO, which are declared "real" in the code. The page numbers listed below for each parameter correspond to the first reference to each parameter in the text. Additional information concerning each parameter may be found in subsequent pages.

<u>Parameter</u>	<u>Page No.</u>	<u>Default Value</u>	<u>Description</u>
ACRES	3.8	500. acres	Size of aquifer site leased for exploration
APPHX	3.7	5. ⁰ F	Supply aquifer water temperature approach to energy source water temperature
AVGWL	3.24	30. yrs	Average well life
CASFRC	3.24	1.	Fraction of each well cased
DCPW	3.8	\$150,000.	Drilling cost of one well
DIA	2.13	8.75 in.	Well diameter
DINPUT(4)	3.8	0.42	Fraction of initial investment in bonds
DINPUT(5)	3.8	0.08	Bond interest rate
DINPUT(6)	3.8	0.15	Earning rate on equity after taxes
DINPUT(7)	3.8	0.46	Federal income tax rate
DINPUT(9)	3.65	30. yrs	Depreciable life of aquifer wells
DINPUT(14)	3.65	1990.	Startup year for operation of the supply system
DINPUT(15)	3.8	0.07	State income tax rate
DINPUT(16)	3.66	0.	State gross revenue tax rate
DINPUT(17)	3.8	0.025	Property tax rate
DINPUT(18)	3.66	0.0035	Transmission system interim capital replacement rate
DINPUT(19)	3.66	0.0012	Property insurance rate
DINPUT(26)	3.66	15. yrs	Depreciable life of transmission systems

Parameter	Page No.	Default Value	Description
DINPUT(27)	3.66	0.%	Royalty payment percentage
DINPUT(28)	3.66	0.05	Transmission system maintenance rate
FLORAT	3.7	500,000. lb/hr	Withdrawal well flow rate
FRCEPW	3.24	0.	Fraction excess wells
FTF[NTARG(N)-1] (see page 3.85)			Success ratios indexed by the array NTARG(N), associated with the major decision points in the process of reducing the number of prospective aquifer sites
ICOST	3.76	1	Option to use either current dollar or constant dollar analysis
IDRILL	3.66	0	Option to use drilling model or input directly the cost of drilling a well
IDRPNT	3.88	0	Print switch to print the results from the well drilling model, when employed
IEXPNS	3.66	0	Option to capitalize or expense all aquifer pre-development costs
IPLLOT	3.8	0	Print switch to display printer plots of capital costs estimated for various distribution system components
IPUMP	3.29	2	Option to employ only surface pumps or a combination of surface pumps and downhole pumps in the transmission system
LAGS[ITEX(N,K)] (see page 3.81)			Time array defining the schedule of expenditures and occurrence of supply system pre-development, development, and operational activities
LL6	3.87	1	Print switch for selecting the iteration printout between the supply and distribution systems
LL11, LL12	3.87	1,1	Print switches for selecting the supply and distribution system economic printout
NUMTYP	3.24	1	Number of different rock types encountered in the strata during well drilling

<u>Parameter</u>	<u>Page No.</u>	<u>Default Value</u>	<u>Description</u>
PERCNT(1)	3.67	1.0	Fraction of the well drilling costs considered tangible
PERCNT(2)	3.67	0.0	Fraction of the well drilling costs considered intangible
PIFALL	3.77	6.%	Percent general inflation rate
PIFCAP	3.77	6.%	Percent escalation rate for capital
PIFCSB	3.8	8.%	Percent escalation rate for purchased thermal energy
PIFELR	3.77	7.%	Percent escalation rate for electricity
PIFOM	3.77	6.%	Percent escalation rate for O&M
PIVTCR	3.66	0.0	Percent investment tax credit
PLMANF	3.8	0.0	Distance from the manifold pipe nodes to the first column of well nodes
PLNGTH(1)	3.8	2500.m	Length of transmission leg 1 from the energy source to the storage wellfield
PLNGTH(2)	3.8	2500.m	Length of transmission leg 2 from the storage wellfield to the distribution system inlet
PLNGTH(3)	3.8	2500.m	Length of transmission leg 3 from the distribution system inlet to the supply wellfield
PLNGTH(4)	3.8	2500.m	Length of transmission leg 4 from the supply wellfield to the energy source
PMLIFE	3.29	10. yrs	Downhole pump service life
PRDRAT	3.24	1.0	Ratio of injection to withdrawal well flow rate
PRFLAG	3.89	0.0	Print switch to suppress all but summary data
SAFLOW	2.20	2,191,500,000. lb/yr	Annual water flow rate from the energy source
SDFLOW	3.7	12,000,000. lb/day	Daily water flow rate from the energy source

Parameter	Page No.	Default Value	Description
SHCOST	3.7	0.\$/MBtu	Cost of purchased thermal energy from the energy source
SMFLOW	2.20	500,000. lb/hr	Peak hourly water flow rate from the energy source
SMXFLW	3.7	1.E99 lb/hr	Upper bound on the peak hourly water flow rate from the energy source
SPAQEF	3.8	.8	Aquifer thermal efficiency fraction of the supply wellfield
STAQEF	3.7	.8	Aquifer thermal efficiency fraction of the storage wellfield
STFREC	2.20	.9	Aquifer fluid recovery fraction for the storage wellfield
STRATA(1,N)	3.24	3.	Rock hardness of each strata encountered during well drilling
STRATA(2,N)	2.3	300.m	Well depth of each strata encountered during well drilling
TAQIF	3.8	55. ⁰ F	Discovery (natural) aquifer temperature in both wellfields
TENVR(1)	3.28	70. ⁰ F	Average ambient air temperature during storage of hot water or delivery of cold water
TENVR(2)	3.29	35. ⁰ F	Average ambient air temperature during delivery of hot water or storage of cold water
TRCASE	3.28	-1.0	Option to delete the casing or allow the code to use 0.016 inch aluminum jacket casing to cover all transmission system insulation
TRINSL	3.28	-1.0	Option to directly input or allow the code to calculate the insulation thickness on all transmission system piping
TSRIN	2.22	200. ⁰ F	Inlet water temperature entering the heat exchanger from the energy source

<u>Parameter</u>	<u>Page No.</u>	<u>Default Value</u>	<u>Description</u>
TSROUT	2.22	80. ⁰ F	Outlet water temperature exiting the heat exchanger back to the energy source
UNITO	3.83	see pg 3.83	Cost array defining costs for pre-development, development, and operational activities of the supply system
WELSPC	2.38	1. acre	Aquifer well spacing

DISTRIBUTION INPUT PARAMETER INDEX
(NAMELIST Group \$DISTRB)

All parameters beginning with the letters I through N are "integer" except KINS and IO, which are declared "real" in the code. The page numbers listed below for each parameter correspond to the first reference to each parameter in the text. Additional information concerning each parameter may be found in subsequent pages.

<u>Parameter</u>	<u>Page No.</u>	<u>Default Value</u>	<u>Description</u>
ACDGHR	3.43	19,571. ⁰ F-hrs/yr	Annual cooling degree-days
ADGDAY(1)	3.11	6500. ⁰ F-days	Annual heating degree-days
AGFACT(I)	2.40	depends on pipe dia.	Age factor for increasing the frictional losses in pipes due to deterioration with age
AREA(M)	2.19	1. mile ²	Area of district M
BACKC	3.72	\$13.10/m ³	Backfilling cost for trenching
BEDC	3.72	\$13.10/m ³	Bedding fill cost for trenching
CG	3.56	0.36J/s-m- ⁰ C	Thermal conductivity of the ground
CO	3.56	1.0	Casing material option
COPUMP	3.78	\$.029/kWh	Unit cost of electricity for pumping
CP	3.56	3.56J/s-m- ⁰ C (carbon steel)	Thermal conductivity of the pipe
CQ(N)	3.39	depends on building	Peak cooling demand of a typical building in district type N
CRTF(N)	3.53	depends on building	Cost of retrofitting building heating or cooling systems in district type N
CSBTU	3.64	\$6./Btu	Cost of supplemental heat
CSF(M)	3.51	1.0	Crooked street factor for district M
DDGDAY(1)	2.19	6000. ⁰ F-days	Design heating degree days
DDTR(M)	3.49	1. mile	Length of the main pipe serving district M

<u>Parameter</u>	<u>Page No.</u>	<u>Default Value</u>	<u>Description</u>
DENSE(N)	2.19	depends on building	Building density in district type N
DFLAG	3.88	.TRUE.	Print switch for selecting the distribution system printout
DIAL	3.21	0.1 ft	Heat exchanger tube inside diameter
DIAOL	3.21	0.1104 ft	Heat exchanger tube outside diameter
DINPUT(39)	3.69	0.59	Fraction of investment in bonds
DINPUT(40)	3.69	0.08	Bond interest rate
DINPUT(41)	3.69	0.12	Earning rate on equity after taxes
DINPUT(42)	3.69	0.46	Federal income tax rate
DINPUT(44)	3.69	15. yrs	Depreciable life of distribution system
DINPUT(49)	3.69	1990.	Startup year for operation of the distribution system
DINPUT(50)	3.69	0.07	State income tax rate
DINPUT(51)	3.69	0.04	State gross revenue tax rate
DINPUT(52)	2.64	0.025	Property tax rate
DINPUT(53)	2.64	0.0035	Interim capital replacement rate
DINPUT(54)	2.64	0.0012	Property insurance rate
DINPUT(61)	3.69	30. yrs	Distribution system operating life
DINPUT(63)	3.69	0.05	Distribution system maintenance rate
DIVF(N)	3.53	0.72	Diversity factor for district type N
DNET(M,MM)	3.60	must be input	Defines the districts serviced by each main
DPTH	3.56	0.5 m	Burial depth of the casing
ELDIFF(M)	3.49	0.0 ft	Elevation of district M above the end of the transmission line

<u>Parameter</u>	<u>Page No.</u>	<u>Default Value</u>	<u>Description</u>
ETA	3.27	0.65	Combined motor and pump efficiency for both supply and distribution system pumps
EXCC	3.72	\$26.16/m ³	Excavation cost for trenching
FINC	3.72	\$1.30/m ³	Finish fill cost for trenching
FOULFI	3.21	0.001 hr-ft-F/Btu	Heat exchanger inside fouling factor
FOULFO	3.21	0.001 hr-ft-F/Btu	Heat exchanger outside fouling factor
HDES(2)	3.38	0.0125 lb H ₂ O/lb air	Absolute humidity at the summer outdoor dry-bulb and wet-bulb temperature for cooling
HQ(N)	2.19	depends on building	Peak heating demand of a typical building in district type N
HROD(K)	3.42	depends on interval	Number of hourly temperature observations per year which lie in each temperature interval for cooling
HTEXOP	3.46	0.0	Option for a centralized heat exchanger at the end of the transmission leg from the storage aquifer
HW(N)	3.51	depends on building	Daily sanitary hot water demand for a typical building in district type N
IDTR(M)	3.48	depends on district	District type for the Mth district
IDTYPE	3.48	1	The generic type of district at the simulated site
IO	3.2	1.0	Insulation material option
KINS	3.2	depends on insulation	Thermal conductivity of the insulation
LL2	3.75	1	Depreciation option for supply and distribution systems

<u>Parameter</u>	<u>Page No.</u>	<u>Default Value</u>	<u>Description</u>
MCOOL	3.36	0	Controls option for direct input or internal calculation of CQ and ACDGHR
MODE	3.31	0	Selection of space heating or cooling simulation
NDTR	3.48	1	Number of districts at the simulated site
NRES(D)	3.38	depends on building	Number of residences in a typical building of district type N
NTMINT	3.40	10	Number of outdoor dry-bulb ambient temperature intervals used in hourly calculations of cooling energy requirements
NYC	2.63	3	Number of years to construct the distribution system
PF	3.58	must be input	Annual load factor for point demand load
PIVTCF	2.65	0.0	Percent investment tax credit for the distribution system
PMO	3.56	1.0	Pipe material option
PO	3.55	1.0	Pipe option for designing the configuration of the conduit bundle
POPHSE(D)	3.53	depends on building	Number of residents in a typical building of district type N
PRINDX	3.73	1980.	January 1 of base year used by AQUASTOR for calculating capital and O&M costs of the supply and distribution systems
RESRFC	3.72	\$8.40/m ²	Resurfacing cost for trenching
TA	3.56	1. inch	Annular air space between the insulation and the casing
TAOD(K)	3.40	depends on interval	Midpoints of the outdoor dry-bulb temperature intervals for cooling
TDES(1)	2.19	-5. ⁰ F	Winter design outdoor dry-bulb

Parameter	Page No.	Default Value	Description
TDES(2)	3.38	99. ⁰ F	Summer design outdoor dry-bulb temperature
TG	3.57	50. ⁰ F	Average year-round ground temperature
TINDES(1)	3.33	65. ⁰ F	Indoor design temperature for heating
TINDES(2)	3.37	78. ⁰ F	Indoor design temperature for cooling
TMIN	3.32	-15. ⁰ F	Minimum winter outdoor temperature for heating
TRDF	3.72	1.0	Trenching difficulty factor
TREJ(N)	2.49	100. ⁰ F	Temperature of the return water at the outlet of the building heating system in district type N
TREJC(N)	3.53	55. ⁰ F	Temperature of the return water at the outlet of the building cooling system in district type N
TWATC	2.47	50. ⁰ F	Cold water temperature in the sanitary hot water tank
TWATH	2.47	140. ⁰ F	Hot water temperature from the sanitary hot water tank
TWIDTH	3.40	5. ⁰ F	Outdoor temperature interval size grouping annual hourly temperature data for cooling
UAPIN	3.44	5. ⁰ F	Distribution system water temperature approach to storage aquifer water entering the distribution heat exchanger
UAPOUT	3.44	5. ⁰ F	Distribution system water temperature approach to storage aquifer water exiting the distribution heat exchanger
VMBTU	3.57	\$6./MBtu	Value of one million Btus of heat or chill
WIDTH(M)	3.49	1. mile	Width of district M

<u>Parameter</u>	<u>Page No.</u>	<u>Default Value</u>	<u>Description</u>
WLEAK	2.19	0.01	Fraction of water lost by leakage in the transmission and distribution systems
WVELL	3.23	8. ft/s	Heat exchanger tube water velocity
XLNGTH(M)	3.49	1. mile	Length of district M

AQUASTOR SUBROUTINE INDEX

The page numbers listed below for each subroutine correspond to the first reference to each subroutine in the text. Additional information concerning each subroutine may be found in subsequent pages.

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(a) Slash(/) means alternate entry point within subroutine.

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