New Jersey Association of Energy Engineers

Energy Futures Forum

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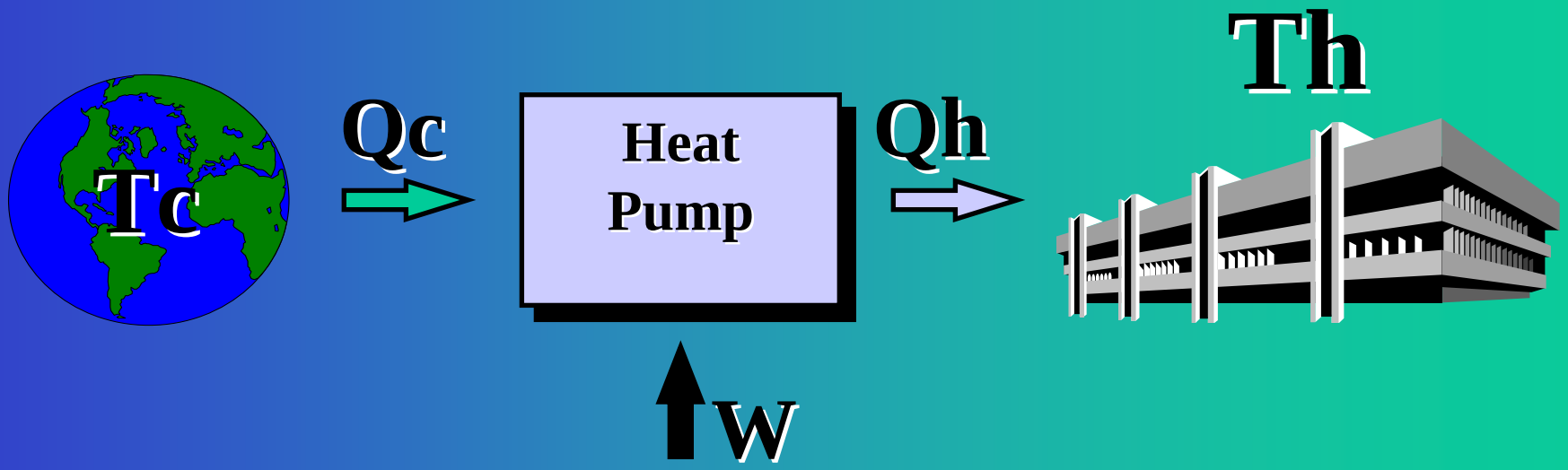
Richard Stockton College of New Jersey

Fundamentals of Heat Pumps

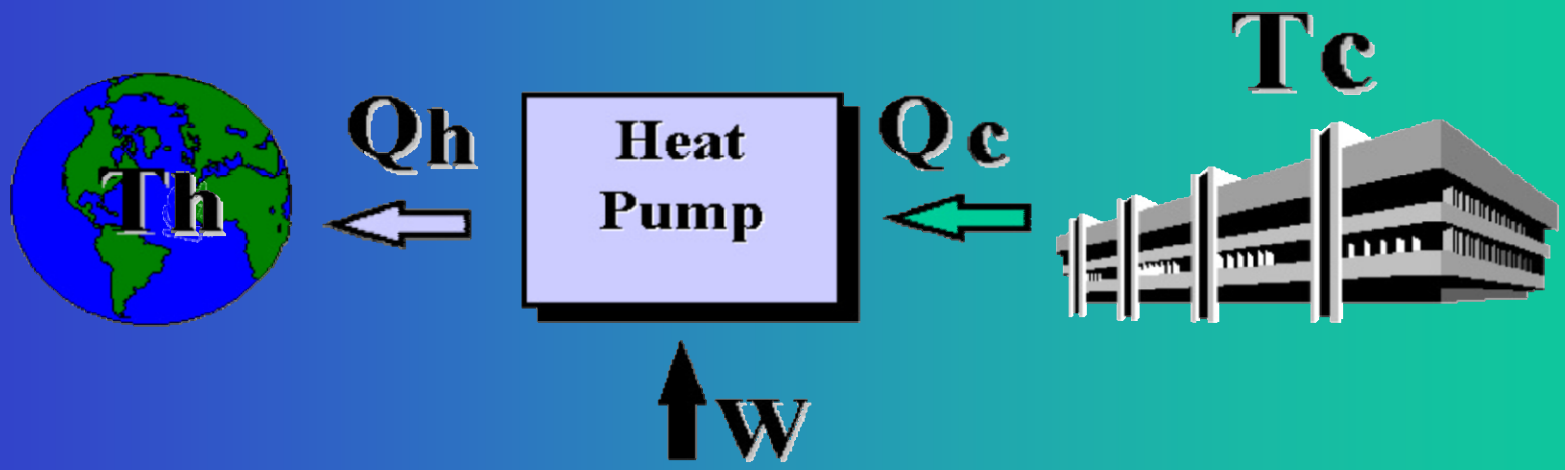
Schematic of Energy Flow (Heating)



- Efficiency:
  - Coefficient of Performance = Q_H /W,

Fundamentals of Heat Pumps

Schematic of Energy Flow (Cooling)



- Efficiency:
  - Coefficient of Performance = Q_c /W
  - Energy Efficiency Rating = 3.4 x COP

Why use GeoExchange Technology ?

- Building Owner's Interest
  - reduction in operating and maintenance costs;
- Tenant's Interest
  - improved indoor environment
  - safety (no combustion);
- Societal Interest
  - more efficient use of energy;
  - emissions reduction;
  - "Green" Technology.

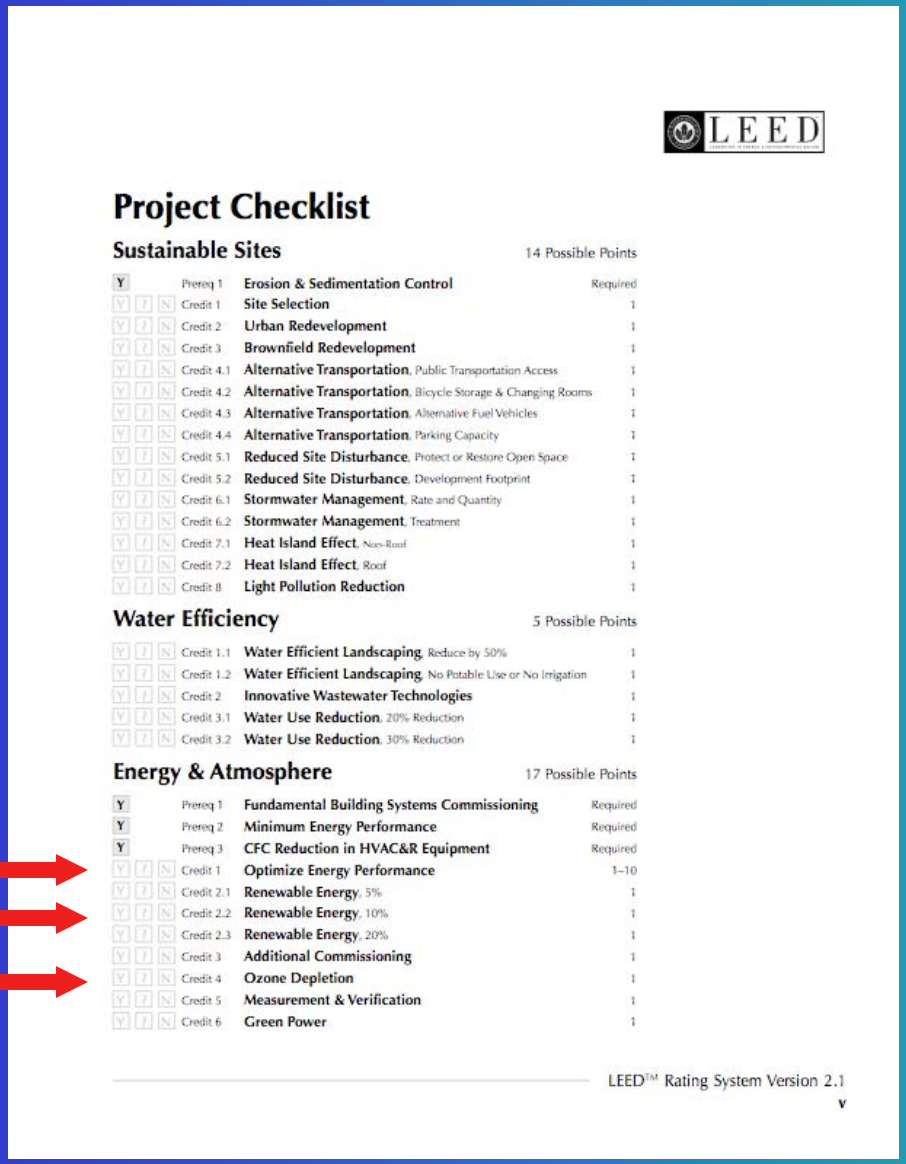
Sample output of AXCESS model
(for classroom building)

	Typical System		Geothermal System	
	Gas (Therms)	Electric (kWh)	Medium Efficiency Electric (kWh)	High Efficiency Electric (kWh)
Jan	2,730	60,937	78,095	75,815
Feb	1,389	65,765	76,457	75,310
Mar	815	76,615	83,263	82,382
Apr	478	70,855	72,724	71,759
May	202	74,663	66,495	63,893
Jun	0	91,109	78,582	73,283
Jul	0	122,579	107,517	98,906
Aug	0	106,210	91,538	84,147
Sep	165	107,257	95,120	89,540
Oct	331	88,754	85,017	83,025
Nov	740	75,522	80,186	79,321
Dec	2,020	62,408	75,335	73,662
Total	8,870	1,002,674	990,329	951,043

Comparison of typical systems with medium and high efficiency GHP's

Project type	Size (ft^2)	Cooling Capacity (tons)	CO_2 reduction	CO_2 reduction (kg/kW_c)
1 - Commercial office	5,600	25	19% - 34%	156-255
2 - Commercial office	160,000	500	41% - 46%	177-201
3a - College cluster housing (10 month occupancy)	23,000	30	38% - 45%	75-91
3b - College cluster housing (12 month occupancy)	23,000	30	43% - 50%	167-198
4 - College classrooms	20,000	75	19% - 26%	63-87
5 - College classrooms	80,000	300	18% - 26%	51-73
6 - College classrooms	25,000	100	17% - 31%	85-159
7 - Middle school (ages 11-13)	140,000	350	29% - 42%	136-192
8 - Elderly care facility	560,000	180	28%-34%	120-144
9 - Single family residence	2,000	5.5	48%	220

LEED Rating



LEED

Project Checklist

Sustainable Sites — 14 Possible Points

Y	Prereq 1	Erosion & Sedimentation Control	Required
Y ? N	Credit 1	Site Selection	1
Y ? N	Credit 2	Urban Redevelopment	1
Y ? N	Credit 3	Brownfield Redevelopment	1
Y ? N	Credit 4.1	Alternative Transportation, Public Transportation Access	1
Y ? N	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
Y ? N	Credit 4.3	Alternative Transportation, Alternative Fuel Vehicles	1
Y ? N	Credit 4.4	Alternative Transportation, Parking Capacity	1
Y ? N	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
Y ? N	Credit 5.2	Reduced Site Disturbance, Development Footprint	1
Y ? N	Credit 6.1	Stormwater Management, Rate and Quantity	1
Y ? N	Credit 6.2	Stormwater Management, Treatment	1
Y ? N	Credit 7.1	Heat Island Effect, Non-Roof	1
Y ? N	Credit 7.2	Heat Island Effect, Roof	1
Y ? N	Credit 8	Light Pollution Reduction	1

Water Efficiency — 5 Possible Points

Y ? N	Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1
Y ? N	Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	1
Y ? N	Credit 2	Innovative Wastewater Technologies	1
Y ? N	Credit 3.1	Water Use Reduction, 20% Reduction	1
Y ? N	Credit 3.2	Water Use Reduction, 30% Reduction	1

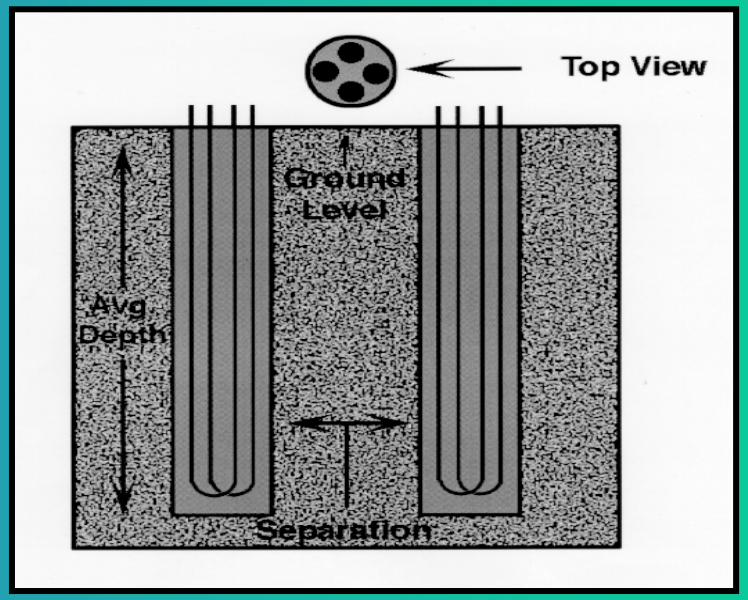
Energy & Atmosphere — 17 Possible Points

Y	Prereq 1	Fundamental Building Systems Commissioning	Required
Y	Prereq 2	Minimum Energy Performance	Required
Y	Prereq 3	CFC Reduction in HVAC&R Equipment	Required
Y ? N	Credit 1	Optimize Energy Performance	1–10
Y ? N	Credit 2.1	Renewable Energy, 5%	1
Y ? N	Credit 2.2	Renewable Energy, 10%	1
Y ? N	Credit 2.3	Renewable Energy, 20%	1
Y ? N	Credit 3	Additional Commissioning	1
Y ? N	Credit 4	Ozone Depletion	1
Y ? N	Credit 5	Measurement & Verification	1
Y ? N	Credit 6	Green Power	1

Optimize Energy Performance			
New Bldgs	Old Bldgs	Points	Project Points
15%	5%	1	------
20%	10%	2	------
25%	15%	3	------
30%	20%	4	4
35%	25%	5	------
40%	30%	6	------
45%	35%	7	------
50%	40%	8	------
55%	45%	9	------
60%	50%	10	------
Renewable Energy			
5%	------	1	1
10%	------	1	1
20%	------	1	1
Ozone Protection			
No HCFC's		1	1
Project Total			8

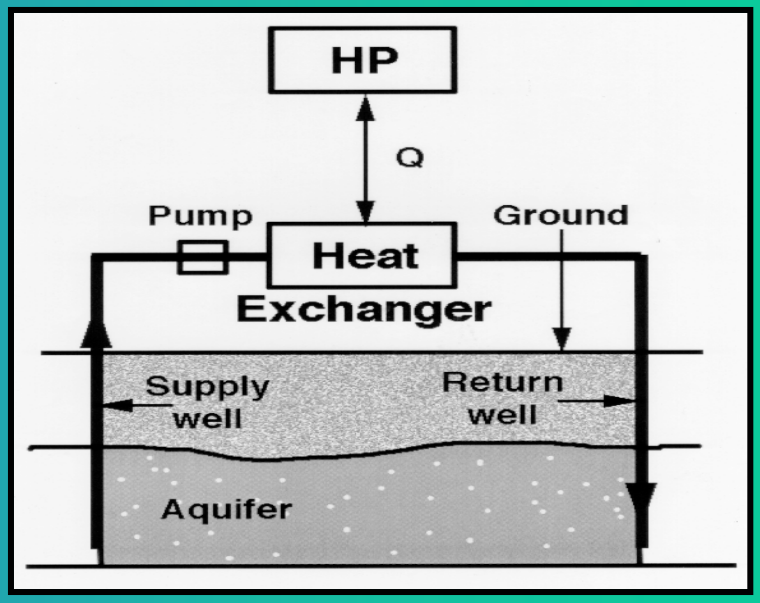
Closed Vertical Loop

- Guidelines:
  - 100 to 150 ft/ton;
  - 15’ x 15’ spacing
  - HDPE Piping

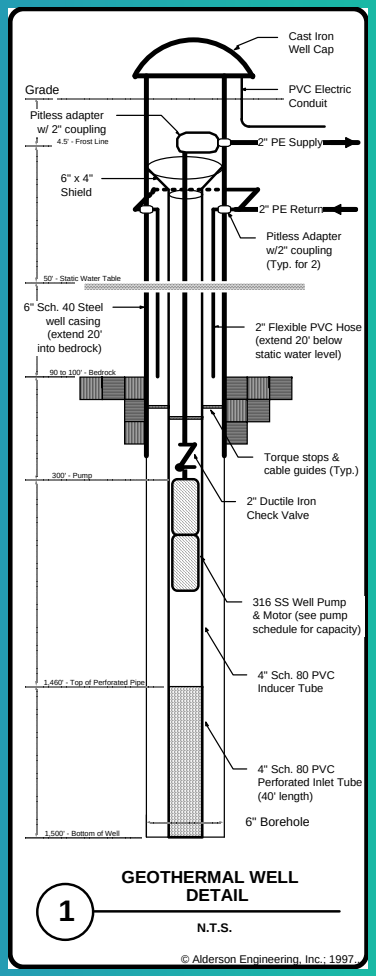


Open Vertical Loop
(Ground Discharge)

- Open Loop Variations:
  - pump-and-dump
  - use of surface water as a source
  - plate-and-frame heat exchanger

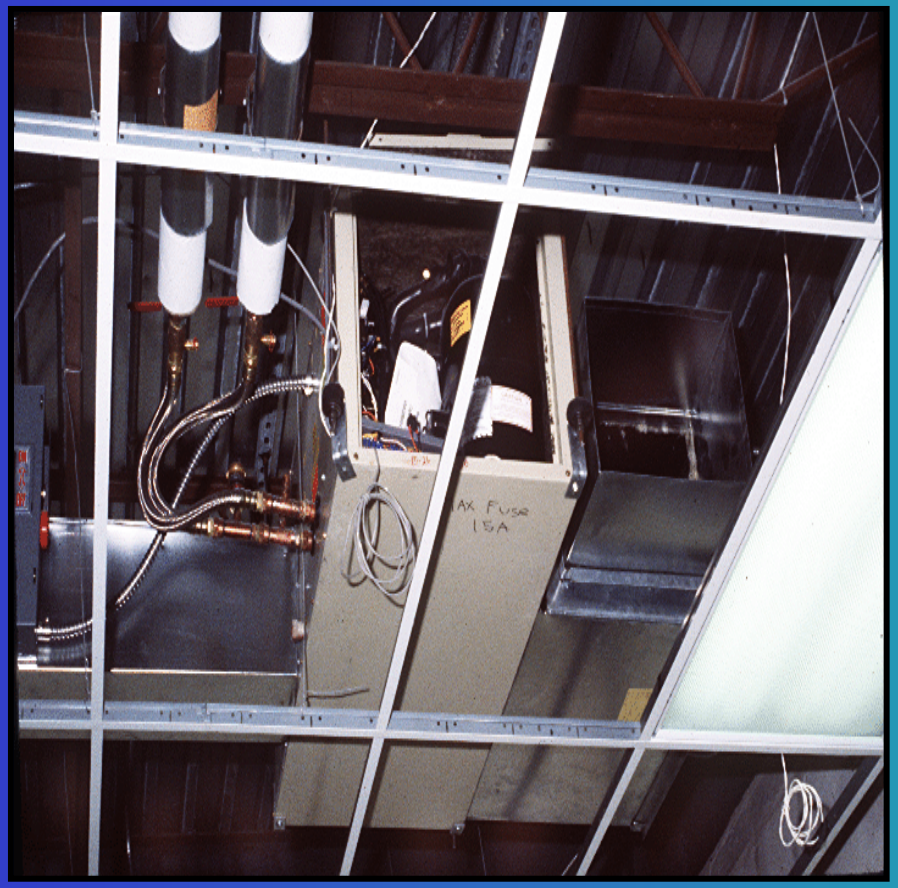


Standing Column Well



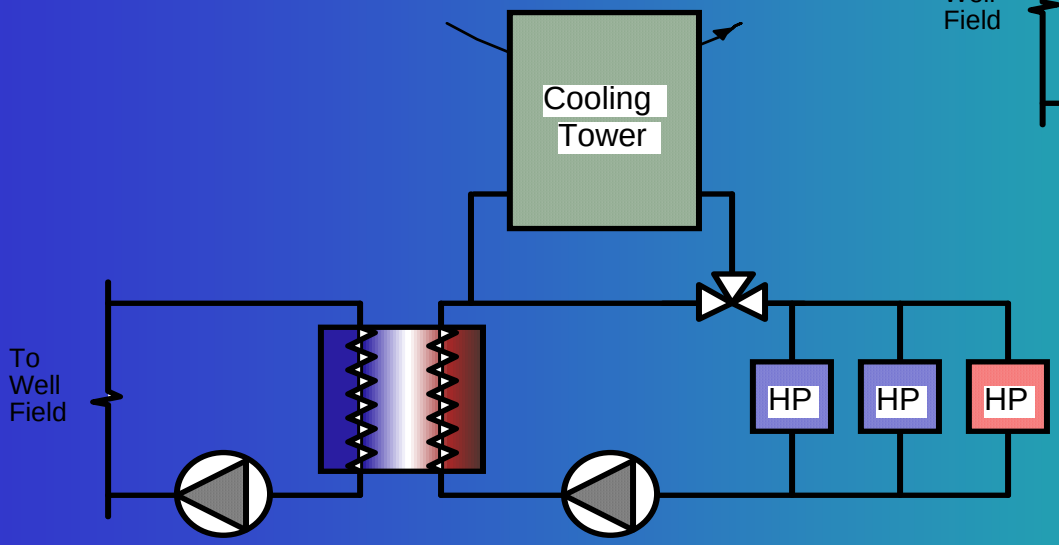
- Guidelines:
  - Concentric pipe-in-pipe (4” / 6”);
  - Approx. 50 - 100 ft/ton;
  - Check water quality.

Horizontal WSHP

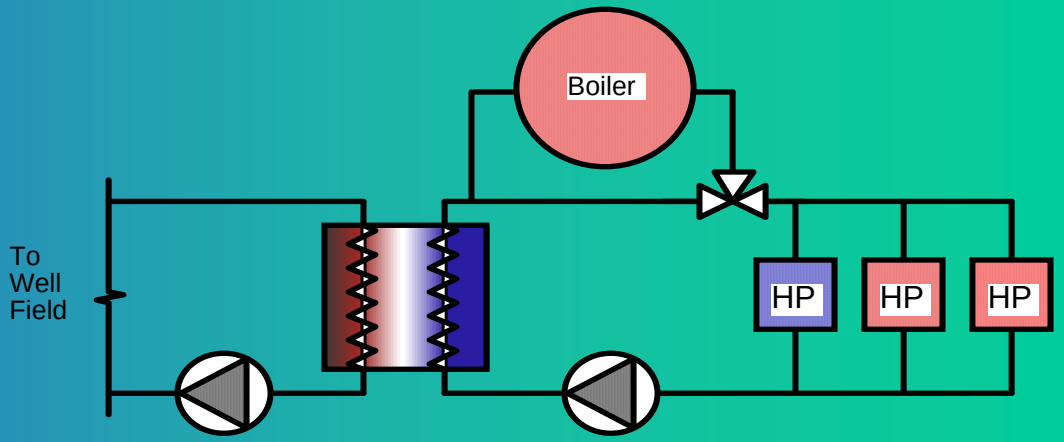


Hybrid Systems

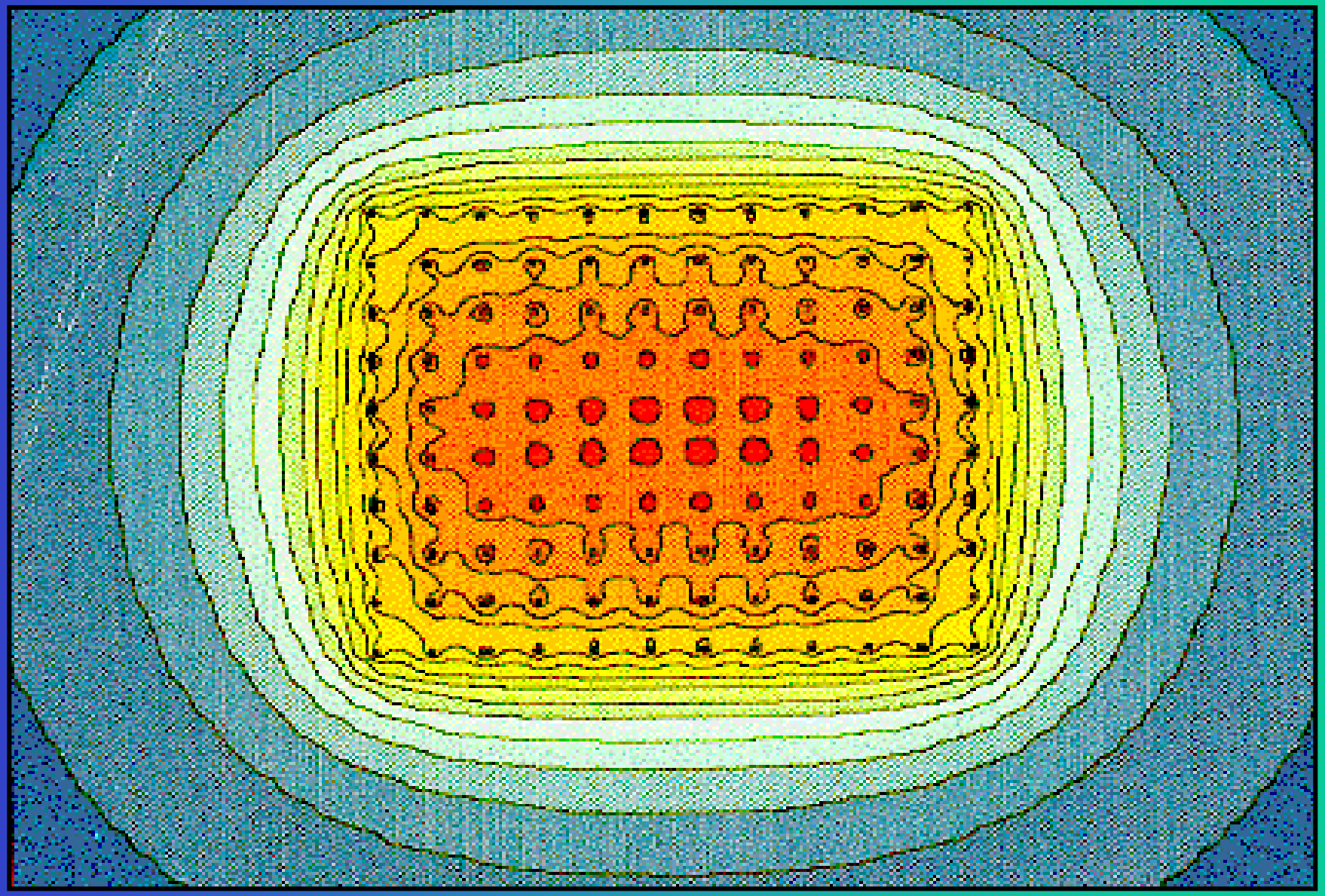
- Hybrid System with Cooling Tower



- Hybrid System with Boiler



BTES Heat Store



Case Study:

Richard Stockton College

- Public four-year comprehensive college in Pomona, NJ with 5600 full-time equivalent students;
- Has third largest single well field;
- gross floor area:
  - 400,000 sq. ft.
- installed heat pump capacity:
  - 1,400 tons (1,620 in 1995)

Richard Stockton College

Borehole Field Data

- Type:
  - vertical, closed-loop w/ central well field
- No. of boreholes:
  - 400
- Borehole depth:
  - 425 ft.
- Total heat exchanger length:
  - 340,000 ft.
- Borehole length/ton:
  - 121 ft/ton
- Circulating fluid:
  - water
- Flow rate through ground loop:
  - 4,000 gpm (max.)

Cost Comparison with Current Rebate With Credits

Actual Project

HVAC capital cost:

- $1,627,477 (Premium)
- ($135,000) (Parking Lot Credit)
- ($600,000) (Library Addition)
- ($300,000) (A&S Bldg Well Field)
- $592,477 (Net Premium)
- $1,100,000 (rebate)

Annual operating cost:

- $126,047 (Savings)

Simple Payback:

- 4.6 years w/o incentive
- $507,523 w/incentive

W Today's Rebate

HVAC capital cost:

- $1,627,477 (Premium)
- ($135,000) (Parking Lot Credit)
- ($600,000) (Library Addition)
- ($300,000) (A&S Bldg Well Field)
- $592,477 (Net Premium)
- $200,000 (rebate)

Annual operating cost:

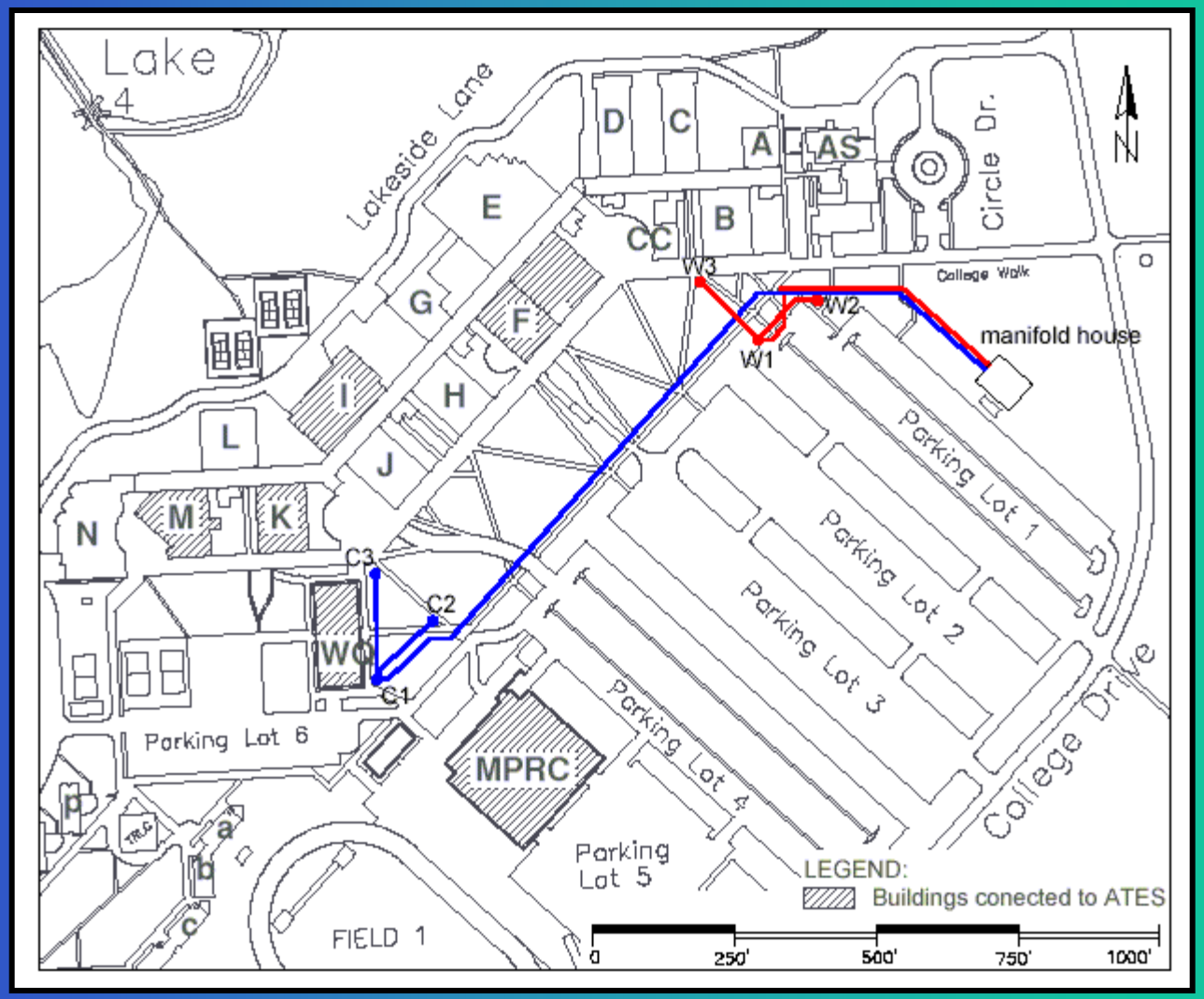
- $126,047 (Savings)

Simple Payback:

- 4.6 years w/o incentive
- 3 years w/incentive

Richard Stockton College - ATES

Site Plan



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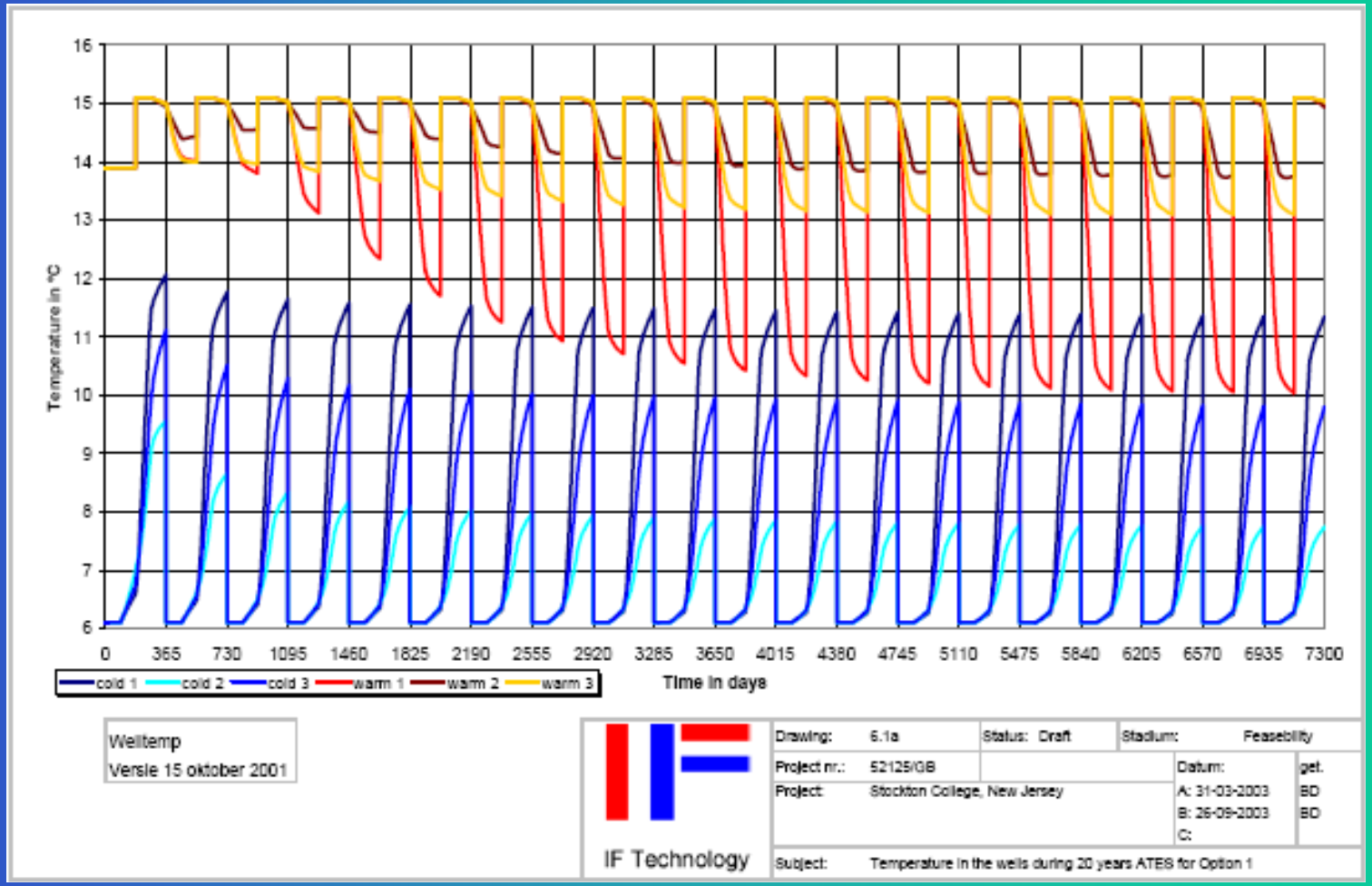
Temperature in 3 cold and 3 warm for 20 Yrs



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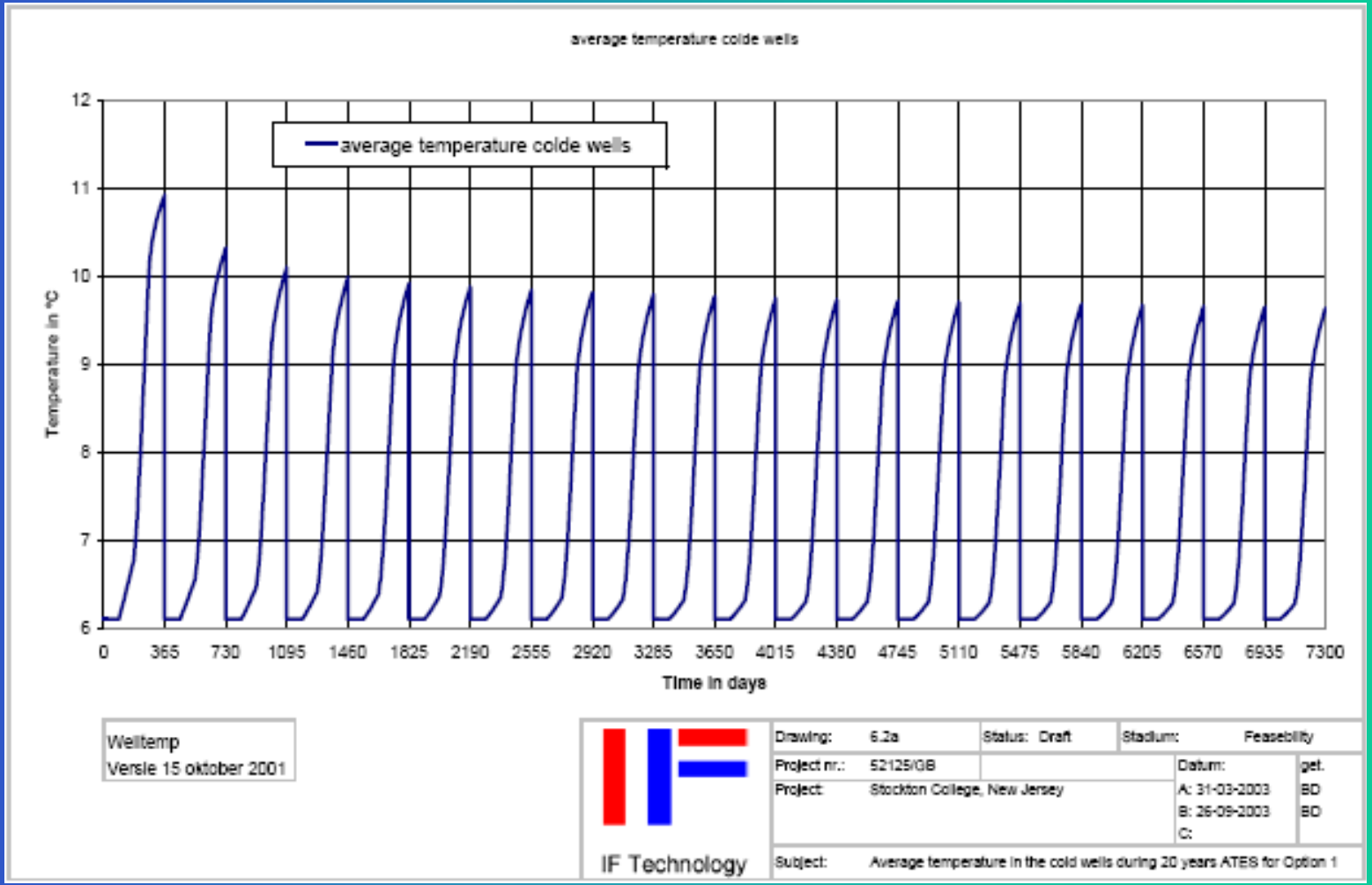
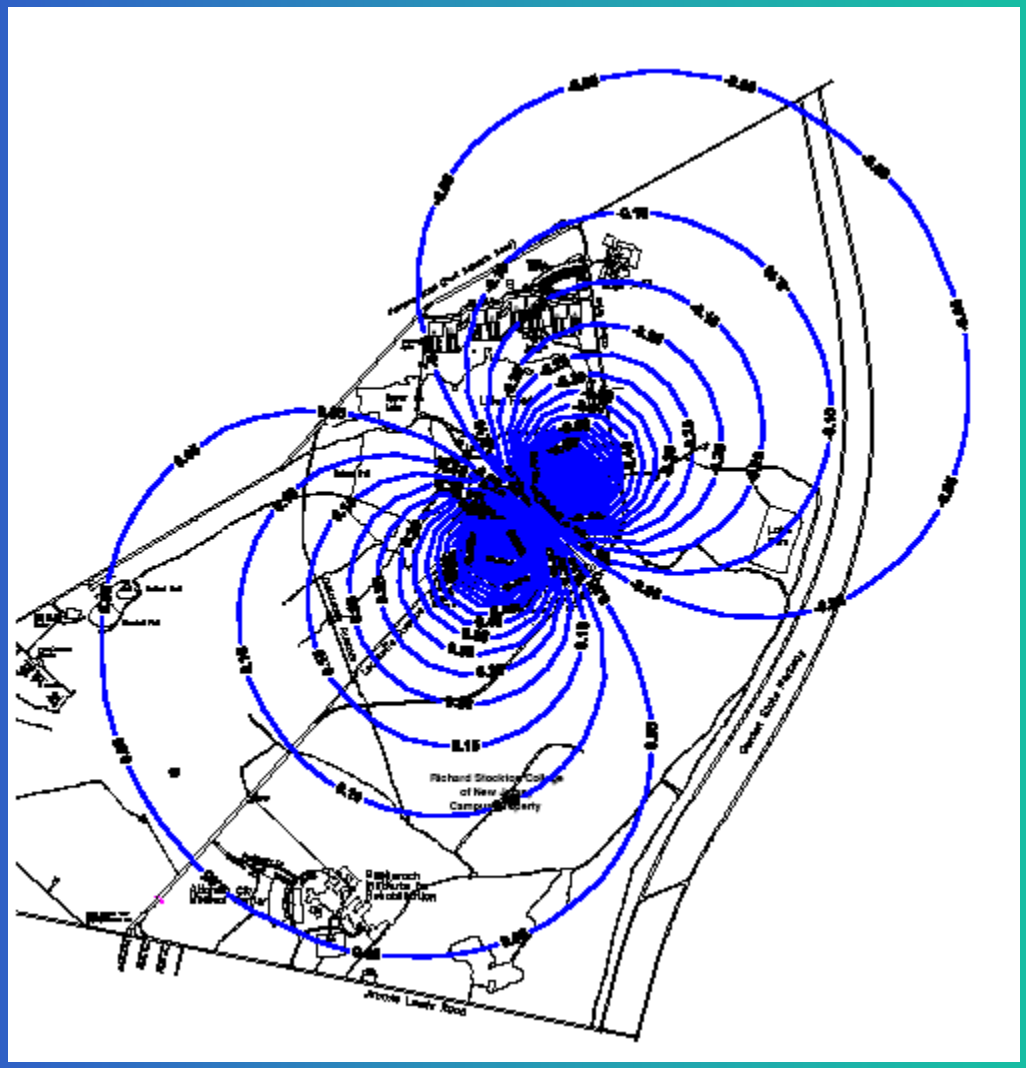
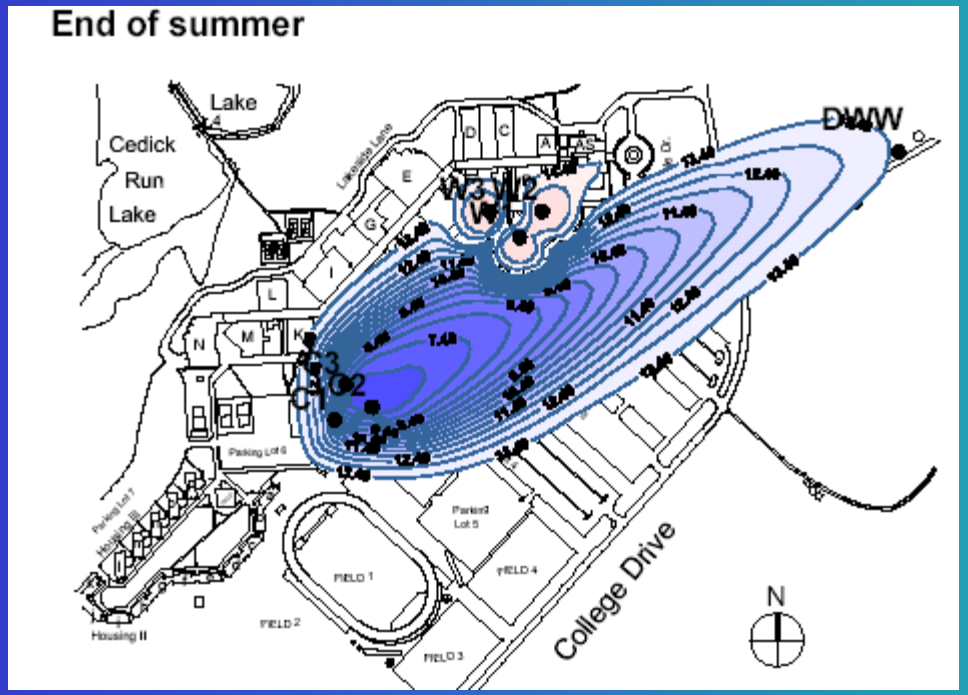
AverageTemperature of 3 cold wells for 20 Yrs

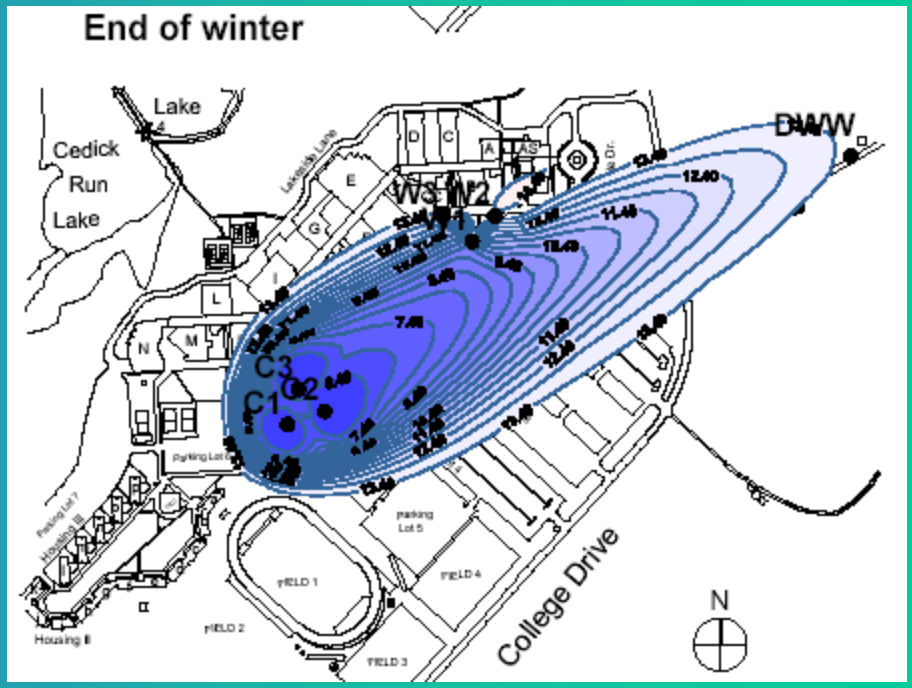


RSC ATES project



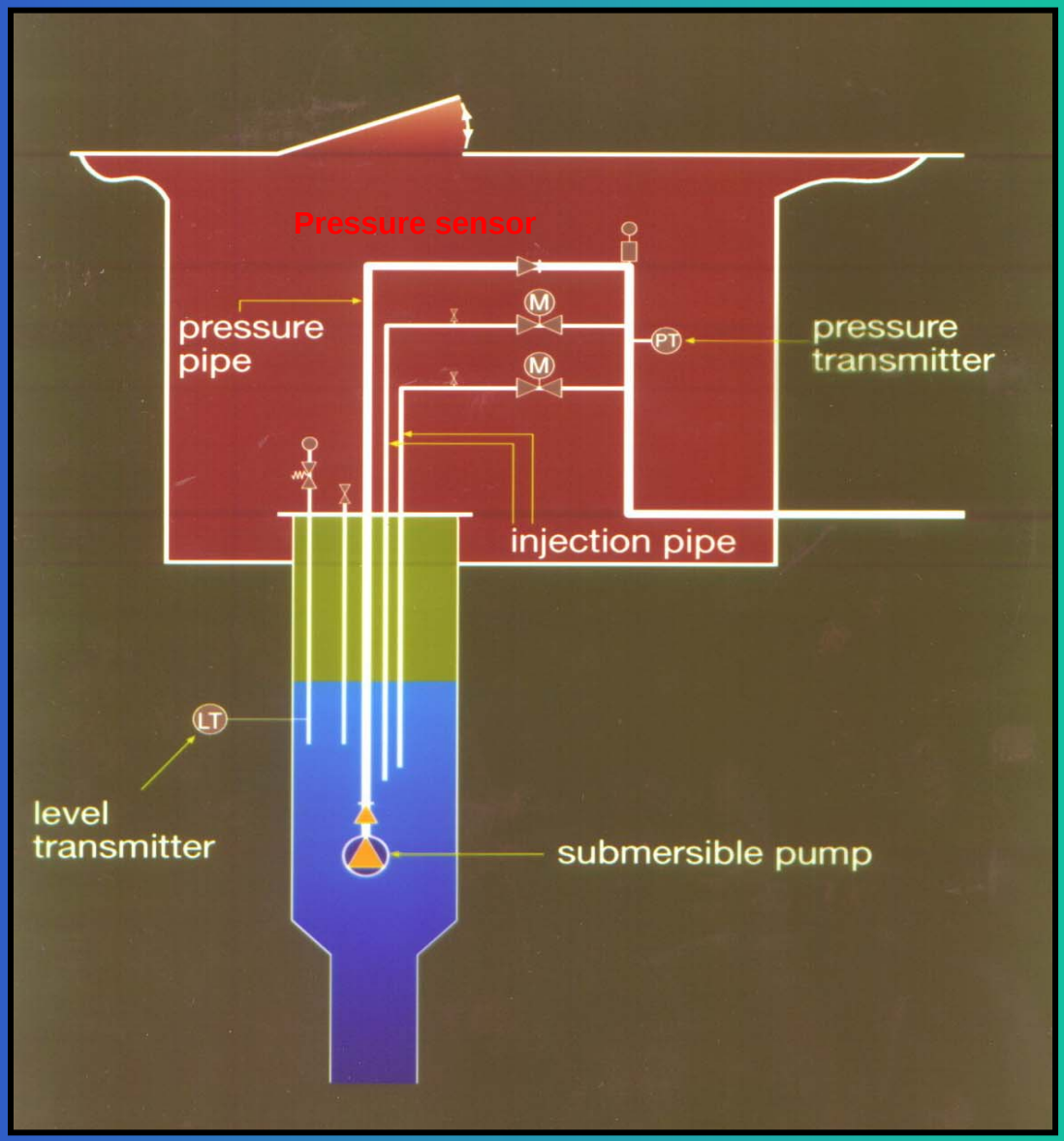
RSC ATES Project
After 20 years of operation



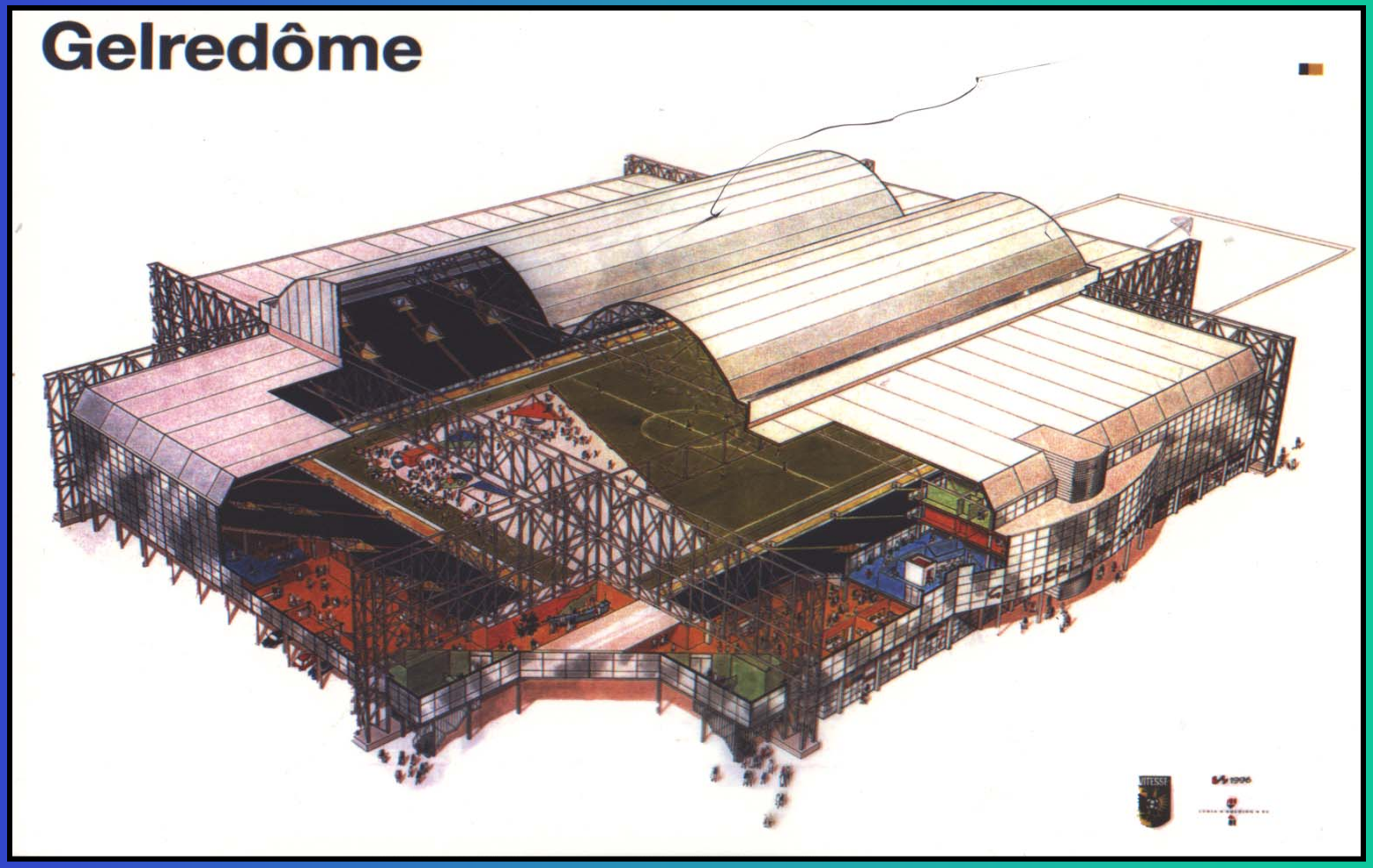


Aquifer Systems

Control and Protection



Gelredome Sports Stadium in Arnhem



Gelredome Project

Cooling capacity of heat pump	**90 tons**
Heating capacity of heat pump	**120 tons**
Heat production by heat pump	5400 million BTU
Cold-energy production by heat pump	4320 million BTU
Cold-energy demand in summer	1728 million BTU
Cooling capacity of cold storage	**800 tons**
Groundwater flow rate in winter	270 gpm
Groundwater flow rate in summer	1000 gpm
Pumped quantity in winter	50 million gallons
Pumped quantity in summer	17 million gallons
Injection temperature in winter	45°F
Injection temperature in summer	58°F

Q&A

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