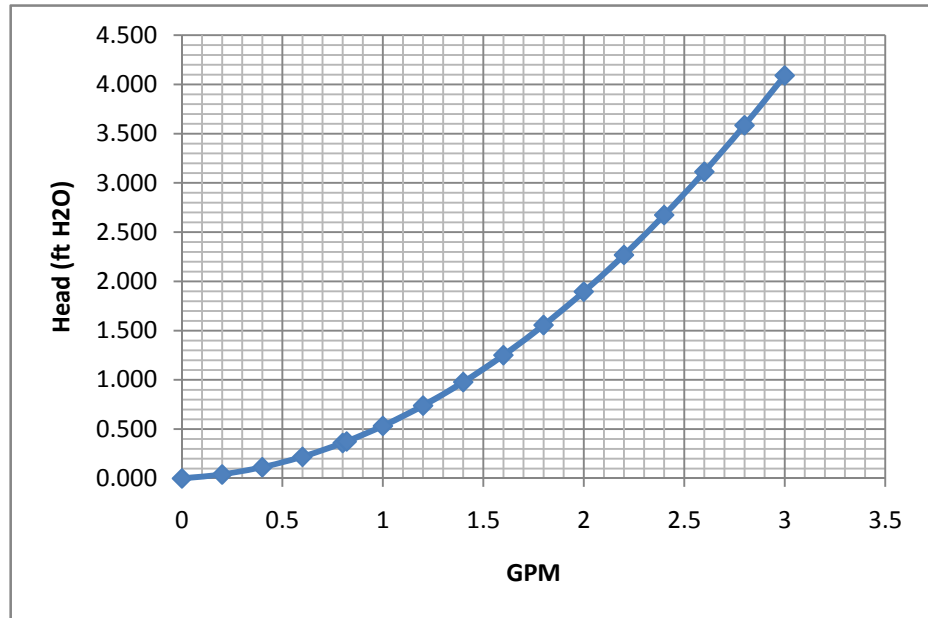


## CALCULATION APPENDIX

### A. COOLING PANEL HEAD

Radiant panel pressure drop	
GPM	Head
0	0.000
0.2	0.040
0.4	0.113
0.6	0.220
0.8	0.360
<b>0.82</b>	<b>0.376</b>
1	0.533
1.2	0.739
1.4	0.978
1.6	1.251
1.8	1.557
2	1.896
2.2	2.268
2.4	2.674
2.6	3.113
2.8	3.584
3	4.090



### B. DIFFUSER AND FTU CALCULATIONS

FTU'S	Current SF	FTU's	SF/FTU	Total SF	Total FTU	Cost/FTU	Total Cost	Savings
<b>Original</b>	31160	33	944	46215	49	\$1,071.63	\$52,449.79	
<b>Redesign</b>	31160	33	944	46215	49	\$150.00	\$7,341.60	<b>\$45,108.19</b>

DIFFUSER	Current SF	Count	SF/FTU	Total SF	Total FTU	Cost/FTU	Total Cost	Savings
<b>Original</b>	15580	44	354	46215	131	\$45.00	\$5,873.28	
<b>Redesign</b>	15580	44	354	46215	131	\$58.00	\$7,570.01	<b>(\$1,696.73)</b>

APPENDIX A

ORIGINAL ANNUAL ENERGY USE

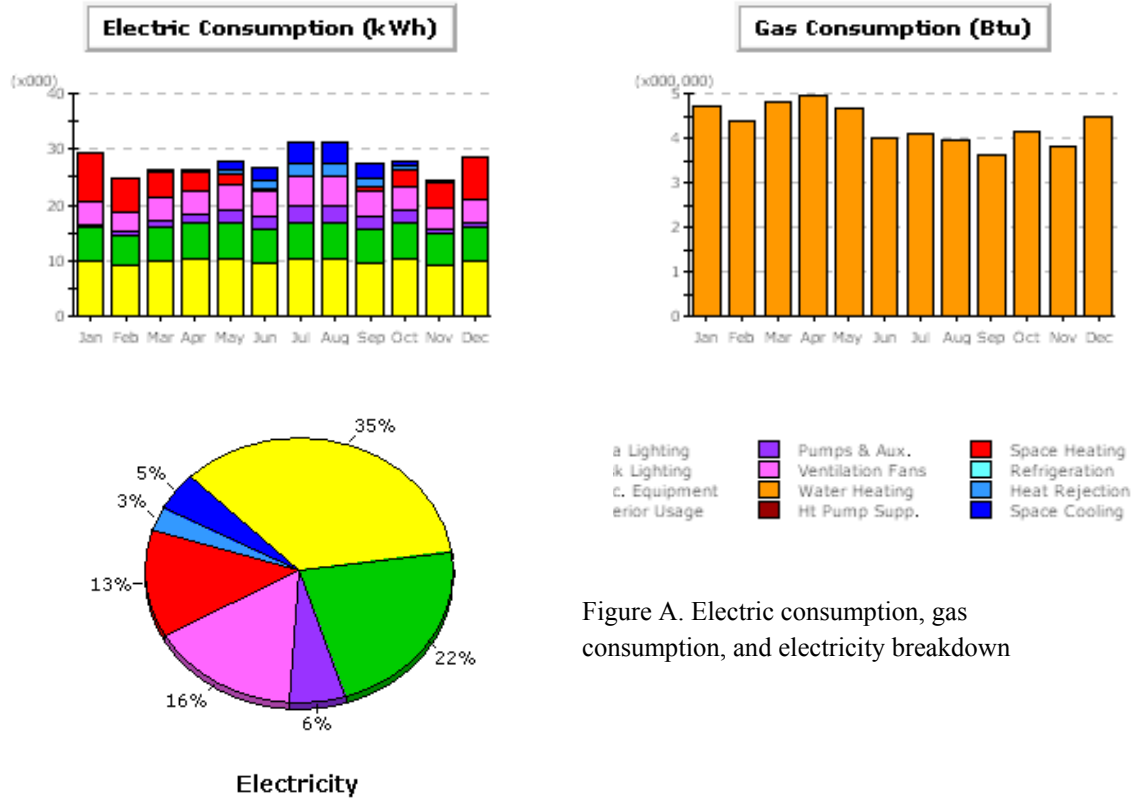


Figure A. Electric consumption, gas consumption, and electricity breakdown

Table A Electric and gas consumption

Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.02	0.05	0.23	0.23	1.33	2.26	3.90	3.73	2.58	0.69	0.11	0.09	15.21
Heat Reject.	0.01	0.03	0.16	0.16	0.92	1.40	2.16	2.19	1.71	0.68	0.08	0.09	9.60
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	8.66	5.88	4.65	3.60	1.76	0.57	0.19	0.18	0.73	3.06	4.88	7.64	41.79
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	4.03	3.64	4.04	4.24	4.57	4.43	5.33	5.24	4.40	4.28	3.64	4.02	51.86
Pumps & Aux.	0.29	0.47	1.10	1.29	2.22	2.50	2.85	2.87	2.57	2.03	0.94	0.68	19.82
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	6.24	5.65	6.24	6.48	6.50	5.96	6.51	6.50	5.96	6.51	5.69	6.24	74.47
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	9.94	9.00	9.95	10.38	10.40	9.48	10.40	10.40	9.48	10.40	9.02	9.94	118.78
<b>Total</b>	<b>29.19</b>	<b>24.72</b>	<b>26.36</b>	<b>26.38</b>	<b>27.69</b>	<b>26.60</b>	<b>31.33</b>	<b>31.11</b>	<b>27.42</b>	<b>27.65</b>	<b>24.37</b>	<b>28.72</b>	<b>331.54</b>

Gas Consumption (Btu x000,000) =(Therms x10)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	4.70	4.37	4.83	4.93	4.65	3.99	4.11	3.96	3.63	4.12	3.82	4.46	51.59
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total</b>	<b>4.70</b>	<b>4.37</b>	<b>4.83</b>	<b>4.93</b>	<b>4.65</b>	<b>3.99</b>	<b>4.11</b>	<b>3.96</b>	<b>3.63</b>	<b>4.12</b>	<b>3.82</b>	<b>4.46</b>	<b>51.59</b>

## APPENDIX B

## DUCTWORK SIZING AND COSTS

### ORIGINAL

DUCTWORK				ELBOWS			CONNECTORS			TEES		
Size	Length (ft)	Cost/ft	Price	Count	Cost ea.	Price	Count	Cost ea.	Price	Count	Cost ea.	Price
36	15	\$29.50	\$442.50							1	\$160.00	\$160.00
26	48	\$14.00	\$672.00				2	\$14.00	\$28.00			
22	96.5	\$11.50	\$1,109.75	7	\$115.00	\$805.00	2	\$11.90	\$23.80			
20	49.5	\$10.50	\$519.75	4	\$74.00	\$296.00	2	\$10.90	\$21.80			
18	22	\$9.50	\$209.00	1	\$55.50	\$55.50	1	\$10.05	\$10.05	1	\$78.00	\$78.00
16	18.5	\$6.95	\$128.58	2	\$42.50	\$85.00	2	\$9.00	\$18.00			
12	134	\$5.20	\$696.80	9	\$14.35	\$129.15	2	\$6.90	\$13.80	3	\$21.00	\$63.00
10	513	\$4.30	\$2,205.90	38	\$10.85	\$412.30				6	\$16.45	\$98.70
8	131	\$2.66	\$348.46	18	\$7.60	\$136.80				1	\$11.55	\$11.55
<b>\$6,332.74</b>				<b>\$1,919.75</b>			<b>\$115.45</b>			<b>\$411.25</b>		
										TOTAL	\$8,779.19	
											per SF	<b>\$0.56</b>
										BUILDING TOTAL	<b>\$26,041.72</b>	

### REDESIGN

DUCTWORK				ELBOWS			CONNECTORS			TEES		
Size	Length (ft)	Cost/ft	Price	Count	Cost ea.	Price	Count	Cost ea.	Price	Count	Cost ea.	Price
18	15	\$9.50	\$142.50							1	\$78.00	\$78.00
14	48	\$6.05	\$290.40				2	\$8.00	\$16.00			
12	110	\$5.20	\$572.00	9	\$14.35	\$129.15	2	\$6.90	\$13.80			
10	12	\$4.30	\$51.60	1	\$10.85	\$10.85	1	\$5.70	\$5.70			
9	24	\$3.50	\$84.00	2	\$9.00	\$18.00	1	\$4.20	\$4.20			
8	86	\$2.66	\$228.76	6	\$7.60	\$45.60				2	\$11.55	\$23.10
7	175	\$2.40	\$420.00	12	\$6.55	\$78.60				1	\$10.20	\$10.20
6	219	\$2.02	\$442.38	20	\$6.20	\$124.00	1	\$2.81	\$2.81	1	\$8.85	\$8.85
5	139	\$1.77	\$246.03	10	\$5.40	\$54.00	1	\$2.61	\$2.61	1	\$8.20	\$8.20
4	199.5	\$1.39	\$277.31	19	\$4.71	\$89.49				6	\$6.15	\$36.90
<b>\$2,754.98</b>				<b>\$549.69</b>			<b>\$45.12</b>			<b>\$165.25</b>		
										TOTAL	\$3,515.04	
											per SF	<b>\$0.23</b>
										BUILDING TOTAL	<b>\$10,426.66</b>	

# APPENDIX C

# PIPE SIZING AND COSTS

Table C.1. Original Piping Costs, Hot Water ONLY

PIPE				ELBOWS			TEES		
Size	Length (ft)	Cost/ft	Price	Count	Cost ea.	Price	Count	Cost ea.	Price
2	125	\$25.00	\$3,125.00	2	\$29.00	\$58.00	5	\$44.50	\$222.50
1.5	31	\$16.10	\$499.10	3	\$16.10	\$48.30	0	\$31.50	\$0.00
1.25	70	\$12.50	\$875.00	1	\$10.25	\$10.25	5	\$29.50	\$147.50
1	59	\$9.05	\$533.95	1	\$6.80	\$6.80	4	\$15.75	\$63.00
0.75	165	\$6.00	\$990.00	11	\$2.76	\$30.36	1	\$7.00	\$7.00
0.5	34	\$3.83	\$130.22	3	\$1.23	\$3.69	0	\$10.85	\$0.00
<b>\$6,153.27</b>				<b>\$157.40</b>			<b>\$440.00</b>		
								TOTAL	\$6,750.67
								with Return	\$13,501.34
								per SF	<b>\$0.87</b>
								BUILDING TOTAL	<b>\$40,049.06</b>

Table C.2. Redesign Piping Costs, Hot Water ONLY

PIPE				ELBOWS			TEES		
Size	Length (ft)	Cost/ft	Price	Count	Cost ea.	Price	Count	Cost ea.	Price
2	125	\$25.00	\$3,125.00	2	\$29.00	\$58.00	5	\$44.50	\$222.50
1.5	31	\$16.10	\$499.10	3	\$16.10	\$48.30	0	\$31.50	\$0.00
1.25	70	\$12.50	\$875.00	1	\$10.25	\$10.25	5	\$29.50	\$147.50
1 <sup>1</sup>	59	\$1.26	74.34	1	\$1.26	\$1.26	4	\$1.26	\$5.04
0.75 <sup>1</sup>	165	\$0.76	125.4	11	\$0.76	\$8.36	1	\$0.76	\$0.76
0.5 <sup>1</sup>	34	\$0.62	21.08	3	\$0.62	\$1.86	0	\$0.62	\$0.00
<b>\$4,719.92</b>				<b>\$128.03</b>			<b>\$375.80</b>		
								TOTAL	\$5,223.75
								with Return	\$10,447.50
								per SF	<b>\$0.67</b>
								BUILDING TOTAL	<b>\$30,990.45</b>

Table C.3. Redesign Piping Costs, Chilled Water ONLY

PIPE				ELBOWS			TEES		
Size	Length (ft)	Cost/ft	Price	Count	Cost ea.	Price	Count	Cost ea.	Price
3.5 <sup>2</sup>	88	\$17.45	\$1,535.60	2	\$200.00	\$400.00	4	\$245.00	\$980.00
3 <sup>2</sup>	31	\$15.55	\$482.05	0	\$78.00	\$0.00	1	\$133.00	\$133.00
2.5	32	\$38.00	\$1,216.00	3	\$58.50	\$175.50	0	\$119.00	\$0.00
2	64	\$25.00	\$1,600.00	2	\$25.00	\$50.00	4	\$44.50	\$178.00
1.5	14	\$16.10	\$225.40	1	\$16.10	\$16.10	0	\$31.50	\$0.00
1.25	88	\$12.50	\$1,100.00	4	\$12.50	\$50.00	3	\$29.50	\$88.50
1 <sup>1</sup>	122	\$1.26	\$153.72	9	\$1.26	\$11.34	0	\$15.75	\$0.00
0.75 <sup>1</sup>	27	\$0.76	\$20.52	2	\$0.76	\$1.52	0	\$7.00	\$0.00
0.5 <sup>1</sup>	18	\$0.62	\$11.16	1	\$0.62	\$0.62	1	\$10.85	\$10.85
<b>\$6,344.45</b>				<b>\$705.08</b>			<b>\$1,390.35</b>		
								TOTAL	\$8,439.88
								With Return	\$16,879.76
								per SF	<b>\$1.08</b>
								BUILDING TOTAL	<b>\$50,070.48</b>

<sup>1</sup>PEX Piping

<sup>2</sup>Steel Pipe

# APPENDIX D

# PORTLAND DESIGN CONDITIONS

2005 ASHRAE Handbook - Fundamentals (IP)

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## Design conditions for PORTLAND, OR, USA

### Station Information

Station name	WMO#	Lat	Long	Elev	StdP	Hours +/- UTC	Time zone code	Period
<i>1a</i>	<i>1b</i>	<i>1c</i>	<i>1d</i>	<i>1e</i>	<i>1f</i>	<i>1g</i>	<i>1h</i>	<i>1i</i>
<b>PORTLAND</b>	<b>726980</b>	<b>45.58N</b>	<b>122.58W</b>	<b>39</b>	<b>14.675</b>	<b>-8.00</b>	<b>NAP</b>	<b>7201</b>

### Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.5% DB	
	99.5%	99%	99.5%		99%		0.4%		1%		MCWS	PCWD	6a	6b
	3a	3b	DP	HR	DP	HR	MCDB	WS	MCDB	WS				
<i>2</i>	<i>3a</i>	<i>3b</i>	<i>4a</i>	<i>4b</i>	<i>4c</i>	<i>4d</i>	<i>4e</i>	<i>4f</i>	<i>5a</i>	<i>5b</i>	<i>5c</i>	<i>5d</i>	<i>6a</i>	<i>6b</i>
<b>1</b>	<b>21.9</b>	<b>27.0</b>	<b>7.1</b>	<b>7.9</b>	<b>24.7</b>	<b>14.0</b>	<b>11.2</b>	<b>31.2</b>	<b>31.1</b>	<b>32.5</b>	<b>28.1</b>	<b>35.6</b>	<b>13.3</b>	<b>120</b>

### Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%		MCWS	PCWD
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB		
<i>7</i>	<i>8</i>	<i>9a</i>	<i>9b</i>	<i>9c</i>	<i>9d</i>	<i>9e</i>	<i>9f</i>	<i>10a</i>	<i>10b</i>	<i>10c</i>	<i>10d</i>	<i>10e</i>	<i>10f</i>	<i>11a</i>	<i>11b</i>
<b>8</b>	<b>21.5</b>	<b>90.8</b>	<b>67.5</b>	<b>86.6</b>	<b>66.2</b>	<b>83.1</b>	<b>65.0</b>	<b>69.2</b>	<b>87.2</b>	<b>84.2</b>	<b>65.9</b>	<b>80.7</b>	<b>10.8</b>	<b>310</b>	

Dehumidification DP/MCDB and HR						Enthalpy/MCDB								
0.4%		1%		2%		0.4%		1%		2%				
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB
<i>12a</i>	<i>12b</i>	<i>12c</i>	<i>12d</i>	<i>12e</i>	<i>12f</i>	<i>12g</i>	<i>12h</i>	<i>12i</i>	<i>13a</i>	<i>13b</i>	<i>13c</i>	<i>13d</i>	<i>13e</i>	<i>13f</i>
<b>62.5</b>	<b>84.7</b>	<b>75.0</b>	<b>61.1</b>	<b>80.5</b>	<b>73.0</b>	<b>59.7</b>	<b>76.7</b>	<b>71.2</b>	<b>25.5</b>	<b>87.7</b>	<b>24.1</b>	<b>84.0</b>	<b>22.8</b>	<b>80.7</b>

### Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB									
1%	2.5%	5%		Mean	Standard deviation	n=5 years		n=10 years		n=20 years		n=50 years					
<i>14a</i>	<i>14b</i>	<i>14c</i>	<i>15</i>	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min		
<b>24.2</b>	<b>20.0</b>	<b>17.9</b>	<b>77.2</b>	<b>98.8</b>	<b>19.2</b>	<b>3.9</b>	<b>5.8</b>	<b>101.6</b>	<b>15.0</b>	<b>103.9</b>	<b>11.6</b>	<b>106.1</b>	<b>8.4</b>	<b>108.9</b>	<b>4.2</b>		

### Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
<i>18a</i>	<i>18b</i>	<i>18c</i>	<i>18d</i>	<i>18e</i>	<i>18f</i>	<i>18g</i>	<i>18h</i>	<i>18i</i>	<i>18j</i>	<i>18k</i>	<i>18l</i>	
0.4%	<b>58.4</b>	<b>54.1</b>	<b>62.3</b>	<b>52.4</b>	<b>68.9</b>	<b>53.9</b>	<b>77.5</b>	<b>60.8</b>	<b>87.0</b>	<b>65.6</b>	<b>91.3</b>	<b>67.7</b>
1%	<b>56.3</b>	<b>52.0</b>	<b>60.1</b>	<b>52.2</b>	<b>66.6</b>	<b>53.3</b>	<b>74.7</b>	<b>59.0</b>	<b>84.0</b>	<b>64.5</b>	<b>87.3</b>	<b>66.1</b>
2%	<b>54.6</b>	<b>50.4</b>	<b>58.2</b>	<b>51.6</b>	<b>64.3</b>	<b>52.5</b>	<b>71.8</b>	<b>57.4</b>	<b>80.6</b>	<b>62.7</b>	<b>84.7</b>	<b>65.2</b>

%	Jul		Aug		Sep		Oct		Nov		Dec	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
<i>18m</i>	<i>18n</i>	<i>18o</i>	<i>18p</i>	<i>18q</i>	<i>18r</i>	<i>18s</i>	<i>18t</i>	<i>18u</i>	<i>18v</i>	<i>18w</i>	<i>18x</i>	
0.4%	<b>96.8</b>	<b>69.9</b>	<b>97.5</b>	<b>69.4</b>	<b>91.6</b>	<b>65.1</b>	<b>80.2</b>	<b>60.1</b>	<b>63.6</b>	<b>56.5</b>	<b>58.7</b>	<b>54.8</b>
1%	<b>93.4</b>	<b>69.3</b>	<b>93.5</b>	<b>68.6</b>	<b>89.1</b>	<b>65.0</b>	<b>76.3</b>	<b>59.1</b>	<b>61.4</b>	<b>55.7</b>	<b>56.5</b>	<b>53.0</b>
2%	<b>90.2</b>	<b>68.4</b>	<b>90.3</b>	<b>67.7</b>	<b>86.4</b>	<b>64.2</b>	<b>73.3</b>	<b>58.1</b>	<b>59.7</b>	<b>54.3</b>	<b>54.8</b>	<b>51.9</b>

### Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
<i>19a</i>	<i>19b</i>	<i>19c</i>	<i>19d</i>	<i>19e</i>	<i>19f</i>	<i>19g</i>	<i>19h</i>	<i>19i</i>	<i>19j</i>	<i>19k</i>	<i>19l</i>	
0.4%	<b>54.7</b>	<b>57.6</b>	<b>56.2</b>	<b>59.2</b>	<b>56.5</b>	<b>64.7</b>	<b>62.8</b>	<b>74.1</b>	<b>67.7</b>	<b>85.4</b>	<b>69.1</b>	<b>87.5</b>
1%	<b>52.7</b>	<b>55.4</b>	<b>54.7</b>	<b>58.2</b>	<b>55.2</b>	<b>63.0</b>	<b>60.4</b>	<b>71.5</b>	<b>65.5</b>	<b>79.7</b>	<b>67.7</b>	<b>85.0</b>
2%	<b>51.1</b>	<b>54.0</b>	<b>52.9</b>	<b>56.5</b>	<b>54.1</b>	<b>61.1</b>	<b>58.9</b>	<b>69.4</b>	<b>64.0</b>	<b>77.4</b>	<b>66.3</b>	<b>82.4</b>

%	Jul		Aug		Sep		Oct		Nov		Dec	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
<i>19m</i>	<i>19n</i>	<i>19o</i>	<i>19p</i>	<i>19q</i>	<i>19r</i>	<i>19s</i>	<i>19t</i>	<i>19u</i>	<i>19v</i>	<i>19w</i>	<i>19x</i>	
0.4%	<b>72.1</b>	<b>91.1</b>	<b>71.4</b>	<b>91.8</b>	<b>68.4</b>	<b>85.6</b>	<b>63.0</b>	<b>75.6</b>	<b>58.7</b>	<b>62.4</b>	<b>55.3</b>	<b>57.6</b>
1%	<b>70.7</b>	<b>89.5</b>	<b>70.2</b>	<b>89.2</b>	<b>67.3</b>	<b>84.1</b>	<b>61.8</b>	<b>72.3</b>	<b>57.0</b>	<b>60.1</b>	<b>53.6</b>	<b>56.1</b>
2%	<b>69.3</b>	<b>87.4</b>	<b>69.1</b>	<b>87.0</b>	<b>66.3</b>	<b>81.6</b>	<b>60.4</b>	<b>69.1</b>	<b>55.6</b>	<b>58.4</b>	<b>52.1</b>	<b>54.4</b>

### Monthly Mean Daily Temperature Range

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>20a</i>	<i>20b</i>	<i>20c</i>	<i>20d</i>	<i>20e</i>	<i>20f</i>	<i>20g</i>	<i>20h</i>	<i>20i</i>	<i>20j</i>	<i>20k</i>	<i>20l</i>
<b>10.2</b>	<b>13.1</b>	<b>15.6</b>	<b>17.1</b>	<b>18.2</b>	<b>18.9</b>	<b>21.2</b>	<b>21.5</b>	<b>21.3</b>	<b>17.2</b>	<b>11.1</b>	<b>9.4</b>

WMO#	World Meteorological Organization number	Lat	Latitude, °	Long	Longitude, °
Elev	Elevation, ft	StdP	Standard pressure at station elevation, psi		
DB	Dry bulb temperature, °F	DP	Dew point temperature, °F	WB	Wet bulb temperature, °F
WS	Wind speed, mph	Enth	Enthalpy, Btu/lb	HR	Humidity ratio, grains of moisture per lb of dry air
MCDB	Mean coincident dry bulb temperature, °F	MCDP	Mean coincident dew point temperature, °F	MCWB	Mean coincident wet bulb temperature, °F
MCWS	Mean coincident wind speed, mph	PCWD	Prevailing coincident wind direction, °, 0 = North, 90 = East		

**APPENDIX E**

**COOLING PANEL SIZING**

**Radiant Cooling Panel** 

**Cooling Performance**

Room Air Temperature minus MWT °F (°C)	Absorbed Energy per Room Designation* BTUH/Ft. <sup>2</sup> (Watts/m <sup>2</sup> )					
	A	B	C	D	E	F
10 (5.5)	17 (54)	21 (66)	28 (88)	35 (110)	38 (120)	40 (126)
11 (6.1)	19 (60)	23 (73)	30 (95)	37 (117)	40 (126)	42 (132)
12 (6.7)	21 (60)	25 (73)	31 (95)	38 (117)	41 (126)	43 (132)
13 (7.2)	22 (69)	27 (85)	33 (104)	40 (126)	43 (136)	45 (142)
14 (7.8)	24 (76)	28 (88)	35 (110)	42 (132)	45 (142)	47 (148)
15 (8.3)	26 (82)	30 (95)	38 (120)	44 (139)	47 (148)	48 (151)
16 (8.9)	28 (88)	32 (101)	39 (123)	45 (142)	48 (151)	50 (158)
17 (9.4)	30 (95)	34 (107)	41 (129)	47 (148)	50 (158)	52 (164)
18 (10.0)	31 (98)	36 (114)	43 (136)	49 (155)	52 (164)	53 (167)
19 (10.6)	33 (104)	38 (120)	45 (142)	50 (158)	54 (170)	55 (173)
20 (11.1)	35 (110)	40 (126)	46 (145)	52 (164)	55 (173)	57 (180)
21 (11.7)	37 (117)	42 (132)	48 (151)	54 (170)	57 (180)	58 (183)
22 (12.2)	39 (123)	43 (136)	50 (158)	56 (177)	59 (186)	60 (189)
23 (12.8)	40 (126)	45 (142)	52 (164)	58 (183)	61 (192)	62 (196)
24 (13.3)	42 (132)	47 (148)	53 (167)	59 (186)	62 (196)	63 (199)
25 (13.9)	44 (139)	49 (154)	55 (174)	61 (192)	64 (202)	65 (205)
26 (14.4)	46 (145)	51 (161)	56 (177)	63 (199)	66 (208)	67 (211)
27 (15.0)	48 (151)	53 (167)	58 (183)	64 (202)	67 (205)	68 (214)
28 (15.6)	49 (155)	55 (174)	60 (189)	65 (205)	69 (218)	72 (227)

\* Room Designations:

A: Interior Room

B: No Glass, Exterior Wall

C: 25% Clear Glass, Exterior Wall

D: 50% Clear Glass, Exterior Wall

E: 75% Clear Glass, Exterior Wall

F: 100% Clear Glass, Exterior Wall

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**APPENDIX F**

**HEATING PANEL SIZING**

Table assumes 20F ΔT. Redesign uses 40F ΔT. Multiply all values 2x for actual output

**Linear Radiant Panel** 

**LINEAR PANEL IMPERIAL OUTPUTS**

# OF TUBES	1	2	2	2	4	3	4	4	5	6	
NOMINAL PANEL WIDTHS * (INCHES)	6	8	10	12	16	18	20	24	30	36	
<b>M E A N  W A T E R  T E M P E R A T U R E  (°F)</b>	<b>120</b>	54	63	-	78	94	109	-	163	196	224
	<b>125</b>	62	73	-	93	111	128	-	188	226	258
	<b>130</b>	71	85	-	106	129	148	-	213	256	292
	<b>135</b>	79	94	-	121	147	166	-	238	285	327
	<b>140</b>	87	104	125	134	165	186	227	263	315	361
	<b>145</b>	96	114	137	149	185	205	245	288	345	394
	<b>150</b>	104	124	151	162	202	225	264	313	375	428
	<b>155</b>	112	134	163	177	219	246	282	338	406	463
	<b>160</b>	121	145	177	190	238	263	301	363	436	497
	<b>165</b>	129	154	189	205	255	282	320	389	466	531
	<b>170</b>	137	164	203	218	276	302	340	413	495	565
	<b>175</b>	146	175	215	233	292	320	360	438	525	599
	<b>180</b>	154	186	229	246	312	340	380	463	555	633
	<b>185</b>	162	197	241	261	329	359	404	488	586	668
	<b>190</b>	171	207	255	275	348	379	427	513	615	702
	<b>195</b>	179	216	267	289	365	397	452	538	645	736
<b>200</b>	187	226	281	303	384	417	471	563	675	771	
<b>205</b>	195	236	293	317	401	436	490	588	705	805	
<b>210</b>	204	248	307	330	420	456	509	613	735	839	
<b>215</b>	212	258	319	345	439	474	527	638	764	874	

OUTPUTS EXPRESSED IN BTUH/LINEAL FOOT OF PANEL AND ARE BASED ON 70°F ROOM TEMPERATURE. FOR EVERY 1°F DECREASE IN ROOM TEMPERATURE BELOW 70°F, THE OUTPUT INCREASES BY 0.9%. FOR EVERY 1°F INCREASE IN ROOM TEMPERATURE ABOVE 70°F, THE OUTPUT DECREASES BY 0.9%.

ANY PANEL WIDTH CAN BE CONSTRUCTED BY COMBINING 4" AND 6" EXTRUSIONS AND INTERPOLATING THE APPROPRIATE OUTPUTS.

\*REFER TO PAGE L-7 FOR ACTUAL PANEL WIDTHS & FINISHED OPENINGS

Note: Table for ethylene and propylene 50/50 glycol also available upon request.

**APPENDIX G****MECHANICAL EQUIPMENT**

<b>PUMPS</b>	Well Water Supply (P-1, P-2 Alternate)	Chilled Water (P-3, P-4 Alternate)	Condenser Water (P-5, P-6 Alternate)
Location	Well	Mechanical Room	Mechanical Room
GPM	200-300	140	130
Total Head (ft)	128-153	81	90
VFD	Yes	No	No
Motor HP	25	7.5	7.5
Efficiency	ASHRAE Table 10.8	ASHRAE Table 10.8	ASHRAE Table 10.8

<b>EXHAUST FANS</b>	EF-1	EF-2	EF-3	EF-4
Location	Toilet Room	Data Room	Locker Room	Elevator Room
Fan Type	Centrifugal	Centrifugal	Centrifugal	Centrifugal
CFM	1200	400	1080	400
HP	.33	.125	.33	.125
Efficiency	Code minimum	Code minimum	Code minimum	Code minimum

<b>CHILLER – CH-1</b>		<b>AIR HANDLING UNIT – AHU-1</b>	
Multi-stage, water cooled		Location	Rooftop
Location	Mechanical Room	Supply Fan	Plug, Blow Through
Operating Weight	4100 lbs	Supply CFM	35,800
Compressor	Rotary Scroll	Supply BHP/HP	44.7/50
<b>HEATING</b>		Supply Motor Eff	Premium
kBTUh	1,303	Supply VAV Control	VFD
COP	4.1	Minimum OA	5,500 CFM
Power Input	94.3 kW	Exhaust CFM	35,800
CHW EWT/LWT	52/38	Exhaust BHP/HP	12.75/15
CDW EWT/LWT	100/120	Exhaust Motor Eff	Premium
<b>COOLING</b>		Exhaust VAV Control	VFD
kBTUh	1,722	Cooling MBH	970 Sens/1065 Total
Capacity	123.5 tons	Chilled Water EWT/LWT	44/59.2
EER	21	Cooling Coil EAT/LAT	79DB,62WB/ 52.3
Power Input	70.6 kW	CW GPM	140
CHW EWT/LWT	69.2/48	Heating MBH	1122
CDW EWT/LWT	60/86.8	Heating Coil EWT/LWT	120/100
		Heating Coil EAT/LAT	69/98
		HW GPM	112
		Unit Size	16,000 lbs



## APPENDIX H

## ENERGY SOURCES AND RATES

Electricity is provided to the building by Portland General Electric (PGE). The rate code is “PGE 83S 3P N-TOU Lrg N-Res Elec”. Essentially this means it is large non-residential electric. The following is a general formula for charges:

$$\text{Monthly Charge} = [\$25 + \$.05298 * (\text{kWh usage}) + \$2.27 * (\text{kW demand})] / .8$$

Where 0.8 is the Power Factor adjustment. Average cost comes to about **\$.08/kWh**

Natural Gas is provided by Northwest Natural. The code is “NW Natural-OR 3-Comm Uniform”. The following is a general formula for charges:

$$\text{Monthly Charge} = \$8 + \$1.198 / \text{therm. Average cost comes to about } \mathbf{\$1.23 / \text{therm}}$$

APPENDIX I

SYSTEM COSTS BREAKDOWN



**McK - Oregon HQ  
Building #1  
Permit Pricing**

updated: 08/06/08

Trade	Shell & Core Market Base	Shell & Core Premium	Shell & Core Sub Total	Tenant* Market Base	Tenant* Premium	Tenant* Sub Total	Total Market Base	Total Project
HVAC	\$ 276,013	\$ 581,369	\$ 857,382	\$ 368,829	\$ 168,300	\$ 537,129	\$ 644,842	\$ 1,394,511
Plumbing	\$ 204,713	\$ 26,400	\$ 231,113	\$ 87,517	\$ 13,800	\$ 101,317	\$ 292,230	\$ 332,430
Electrical	\$ 246,000	\$ 154,600	\$ 400,600	\$ 649,988	\$ 116,300	\$ 766,288	\$ 895,988	\$ 1,166,888
Fire Protection	\$ 108,706		\$ 108,706	\$ 28,389		\$ 28,389	\$ 137,095	\$ 137,095
Data			\$ -	\$ 83,382	\$ 69,302	\$ 152,684	\$ 83,382	\$ 152,684
Energy - ITS		\$ 43,390	\$ 43,390	\$ -	\$ -	\$ -	\$ -	\$ 43,390
Energy - Cx			\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Energy - Model			\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Energy - LEED			\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Total</b>	<b>\$ 835,432</b>	<b>\$ 805,759</b>	<b>\$ 1,641,191</b>	<b>\$ 1,218,105</b>	<b>\$ 367,702</b>	<b>\$ 1,585,807</b>	<b>\$ 2,053,537</b>	<b>\$ 3,226,998</b>

\* Based on McK Tenant Buildout Only

Premium Breakdown

General	1) Additional trailer/office set-up for additional office staff	Not in Budget
HVAC - Shell and Core		
	1) Well Drilling/Permits	\$ 180,000
	2) Heat Pump System	\$ 401,369
Plumbing - Shell and Core		
	1) Rain Water Harvesting	\$ 21,000
	2) Overflow Drains	\$ 5,400
HVAC - Tenant		
	1) Hot Water to FPB	\$ 125,000
	2) ITS	\$ 43,300
Plumbing -Tenant		
	1) Rain Water Harvesting	\$ 5,800
	2) Gas Piping	\$ 8,000
Elec Shell and Core		
	1) Well	
	2) Building Communications conduit between B1 and B2	
	3) Power distribution and Electrical room location	
	4) Future underslab conduit provisions	
	5) CCTV and DSL at site trailers	
	6) Upgrades to mechanical equipment	\$ 154,600
Elec Tenant		
	1) Lighting Control Panel coordinated w/ ITS	
	2) Light fixtures and interior controls	
	3) IT infrastructure	
	4) Security and CCTV	\$ 116,300
Data Tenant		
	1) Paging System	\$ 8,942
	2) Audio Visual	\$ 60,360