Town of Avon, Colorado
Work Session for Tuesday, January 22, 2008
Meeting Begins at 11:45 AM

Avon Municipal Building, 400 Benchmark Road

Presiding Officials

Mayor	**Ron Wolfe**
Mayor Pro Tem	**Brian Sipes**
Councilors	**Richard Carroll, Dave Dantas, Kristi Ferraro Amy Phillips, Tamra Nottingham Underwood**

Town Staff

Town Attorney: John Dunn **Town Manager: Larry Brooks** **Town Clerk: Patty McKenny**

All Work Session Meetings are open to the public except Executive Sessions
Comments from the public are welcome; Please tell the Mayor you would like to speak under No. 2 below
Estimated times are shown for informational purposes only, subject to change without notice
Please view Avon's website, **http://www.avon.org,** for meeting agendas and meeting materials
Agendas are posted at Avon Municipal building and Recreation center, Alpine Bank, and Avon Library
The Avon Town Council meets on the second and fourth Tuesdays of every month

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11:45 PM – 1:40 PM 1. **Tour of Lionshead Redevelopment Project – The Arrabelle at Vail Square** (Avon Town Council and Planning & Zoning Commission invited to tour; Bus Departs at noon; lunch will be served from 11:45 AM until noon)

1:40 PM – 1:45 PM 2. **Inquiry of the Public for Comment and Approval of Agenda**

1:45 PM – 2:15 PM 3. **Site Tour Follow up Discussion** (Town Council, Planning & Zoning members and staff)

2:15 PM – 3:00 PM 4. **Town Center West Snowmelt Feasibility Report** (Planning & Zoning Commission has been invited to attend, Justin Hildreth, Town Engineer) Discussion on different snow removal scenarios and associated costs and impacts on Town Center West redevelopment plan.

3:00 PM – 3:15 PM 5. **Council Committee and Staff Updates**
   a. Update on Housing Action Team Meeting and Stratton Flats (Ron Wolfe, Mayor)
   b. Update on Eagle County Open Space Advisory Committee Meeting (Ron Wolfe, Mayor)
   c. Update on Issuance of RFP for design services on Public Works Sites (Jenny Strehler, Public Works Director) / verbal report

3:15 PM – 4:45 PM 6. **Executive Session** pursuant to CRS 24-6-402 (4)(b) conference with Town Attorney for the purposed of receiving legal advice on specific legal questions regarding pending issues related to the Village at Avon and municipal services invoice and relocation of E. Benchmark Road right-of-way

4:45 PM 7. **Adjournment**

Memo

To: Honorable Mayor and Town Council
Thru: Larry Brooks, Town Manager
From: Justin Hildreth, P.E., Town Engineer JS for JMH
Jeffrey Schneider, P.E., Project Engineer
Date: January 16, 2008
Re: Town Center West Snowmelt Feasibility Report

Summary:
This memorandum is to provide Town Council with an introduction to the Town Center West Snowmelt Feasibility Report, prepared by Beaudin-Ganze Consulting Engineers and Design Workshop, with input from Town Engineering, Community Development, and Public Works staff. The report, attached as Exhibit A, analyzes and quantifies the financial and environmental impacts of various snowmelt system configurations and scenarios. Results of the Snowmelt Feasibility Report indicate that snowmelt systems have far higher costs (both capital and operational) and environmental impact (in the form of carbon dioxide [CO_2] emissions) than traditional snow removal techniques. However, snowmelt systems provide an ice and snow-free walking surface for visitors, a key consideration in the pedestrian-oriented Town Center West District containing vibrant streetscapes with retail and restaurants below residential uses. Staff recommends implementation of snowmelt systems in a revised scenario, consisting of twelve feet on either side of the Main Street vehicular area and selected crossing locations. Design Workshop and Beaudin-Ganze will present a PowerPoint presentation discussing the key points and conclusions of the Snowmelt Feasibility Report.

Previous Town Council Action:
Snowmelt has been previously contemplated by Town Council and Planning and Zoning during design and construction of Avon Station. The project was approved by Planning and Zoning with the entirety of the hardscape surfaces containing snowmelt, fed from a boiler that was to be located in a vault beneath the transit shelter. After the construction bid was received in excess of the project budget, staff proposed a revision to the snowmelt configuration and allowed snowmelt infrastructure to be installed only beneath primary pedestrian areas and bus turning locations. Staff presented the revised configuration to Planning and Zoning, and the Commission's approval provided that a temporary boiler system would also be implemented. When a change order for a temporary boiler system was presented to council, along with the economic and environmental implications, council rejected the change order and Avon Station was constructed without a mechanical system, though Avon Station contains snowmelt tubing, mains, stub-outs for future connection to a master boiler system.

Discussion:
The Town Center West Snowmelt Feasibility Report presented herein arose out of the snowmelt discussions during Avon Station design and construction. Staff felt that rather than approach each public infrastructure project in the Town Center West district independently, master planning the district-wide snowmelt configuration would be a helpful design and estimating tool as well as enable staff to proceed with mechanical system design for each project without additional snowmelt design debate or review.

Snowmelt is being considered for the Town Center West District primarily due to safety concerns resulting from high pedestrian traffic, the difficulty of snow removal and storage, the "experience" it can provide (e.g. Vail and Beaver Creek), and the noise and disruption caused by traditional snow removal. The report explores three heating source options: natural gas fired boiler plant (Option A), centralized heat pump system using lake water heat exchange (Option B), and a centralized heat pump system using ground loop heat exchange (Option C). Options B and C are not recommended due to very high electricity usage required to run the pump systems, as well as higher capital costs. In addition, Option B would have possible water rights and aquatic ecological implications, and Option C would require severe disruption to Nottingham Park, the only feasible location for installation of the ground loop heat exchange infrastructure. One potential advantage to Options B and C are the possibility of renewable electric energy in the future, whereas natural gas fired boilers are not a renewable energy source.

Four snowmelt scenarios were studied along with the three heat source options. Scenario 1 includes all hardscape surfaces in the Town Center West district, Scenario 2 includes all of Main Street and primary pedestrian zones on the Main Street periphery, and Scenario 3 includes only Main Street Pedestrian Zones as well as primary pedestrian areas near Lake Street and on Lettuce Shed Lane.

The report concludes that traditional snow removal carries far smaller environmental impacts than snowmelting options. Using Option A (natural gas fired boiler system) as a baseline, the estimated annual CO_2 per year emissions for all scenarios is summarized below:

	Snowmelted Area (sq. ft.)	**Snowmelt CO_2 Contribution (tons/year)**	**Traditional Snow Removal CO_2 Contribution (tons/year)**	**Total annual CO_2 emissions (tons/year)**
Scenario 1	154,600	2,085	0	2,085
Scenario 2	141,200	1,904	22	1,926
Scenario 3	97,200	1,311	65	1376
Scenario 4	0	0	104	104

The heat pump option becomes more environmentally attractive if renewable energy sources are utilized. However, as alternative fuel technologies improve and become more widespread, the gap between snow removal and snow melting could remain the same or even widen.

In order to reach the best compromise between safety and level of guest service, capital and operational costs, and environmental impact, Staff recommends a modified Scenario 3. The modified Scenario 3 includes a twelve-foot wide snowmelted area on the northern and southern extents of the Main Street right of way (adjacent to storefronts, etc.), with provisions for snowmelted crossings and other selected areas. Also included in the modified Scenario 3 is the approximately 16,000 square feet of hardscape constructed at Avon Station already containing snowmelt infrastructure, and the remaining approximately 9,000 square feet of Lettuce Shed Lane to be constructed, for a total snowmelted area of 57,000 square feet. For the modified Scenario 3, it is interpolated that CO_2 emissions from snowmelting equal 769 tons of CO_2 per year, and the CO_2 emissions from snow removal equal 66 tons per year, for a total snow removal/snowmelt CO_2 impact of 835 tons of CO_2 per year.

Financial Implications:
Due to the likely elimination of Ground Source Heat Pumps (Heat Plant Options B and C), below is a summary of the Capital and first-year operating costs of Scenarios 1-4, as well as the recommended modified Scenario 3.

	Capital Cost	O&M Cost (Year 1)	Capital Cost per Square Foot	O&M Cost per Square Foot
Scenario 1	$4,485,000	$650,000	$29.00	$4.20
Scenario 2	$4,125,000	$635,000	$26.70	$4.10
Scenario 3	$2,992,000	$589,000	$19.40	$3.80
Scenario 4	$242,000	$418,000	$1.60	$2.70
Mod. Scenario 3* (recommended)	$1,825,300	$513,500	$11.80	$3.30

* Note: Modified Scenario 3 assumes $100,000 in new snow removal capital equipment. Snowmelt capital costs, snowmelt O&M costs, and snow removal O&M costs interpolated from report data.

The financial implications of snowmelt indicate that, in general, the larger the area selected to snowmelt, the higher the capital and operational costs. All of the capital costs shown above can be contained within the planned Avon Urban Renewal Authority (AURA) bond funding amount, based on preliminary cost estimates contained herein. However, as construction costs continue to escalate, large scale snowmelt system installations may be implemented at the cost of other items such as streetscape materials, landscape features, etc., in order to fit within the AURA budget.

Recommendations:
Implement a revised Snowmelt Scenario 3, using a central natural gas fired boiler plant to be located in the future parking structure, with the snowmelted areas revised to include twelve-foot wide paths on the northern and southern extents of the Main Street Right of Way (adjacent to future storefronts), terminating on the eastern side of Lake Street. Also included in the modified Scenario 3 are Avon Station and Lettuce Shed Lane.

Town Manager Comments:
As is often the case, the best answer isn't black or white – but some shade of gray.

Attachments:

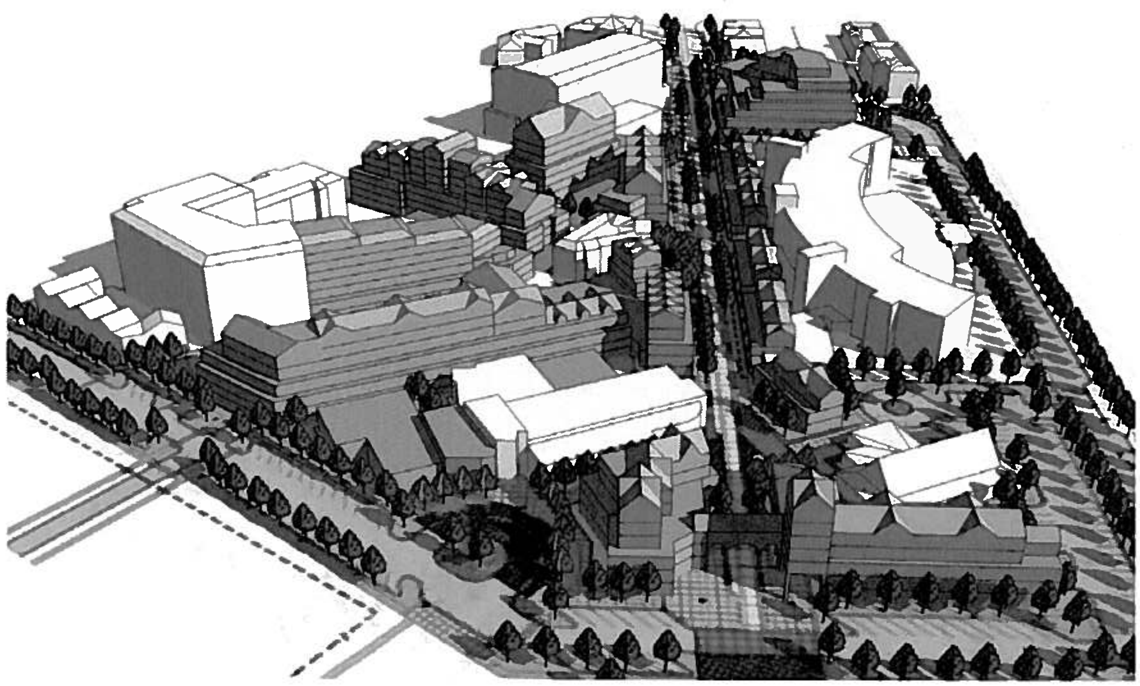
Exhibit A – Avon West Town Center District Snowmelt Feasibility Study

Exhibit A

SNOWMELT FEASIBILITY STUDY

Avon West Town Center District

Avon, Colorado



January 22, 2007

By: Beaudin Ganze Consulting Engineers, Inc.

Prepared for the Town of Avon

I Introduction

The objective of this report is to study the feasibility of incorporating a snowmelt system into the Avon West Town Center (AWTC) District to melt snow from pedestrian ways and/or vehicle ways in lieu of traditional snow removal. A snowmelt system, relatively common in snow country, is being considered for incorporation into the AWTC streetscape for three basic reasons: 1) the potential for high pedestrian traffic, 2) difficulty of snow removal and storage, and 3) concern for public safety.

Consideration for a snowmelt system begins with the need for snow removal without the use of a snowplow or shovels. The system's heart is a heat source, traditionally a natural gas-fired boiler that heats a mixture of water and antifreeze. The heating water from the plant flows through a series of small diameter pipes embedded beneath the area to be melted and warms the finished walking surface melting the snow. The cooled heating water returns to the plant to be heated and pumped back into the underground piping system. If the desired melt area is a sidewalk, for instance, a network of flexible pipes are laid within the form and encased when the concrete is poured. A similar affect can be accomplished with pipes in a bed of sand under pavers instead of concrete. Each type of construction has benefits and disadvantages described in more detail below.

Numerous snowmelt plant options have been considered for use in this application including centralized natural gas-fired boilers, heat pumps utilizing two different heat exchange mediums, decentralized boiler plants, and electric resistance cables. After consideration of the various heating plant alternatives, three viable options have been selected for further review and are included in this report. Option A is a centralized natural gas boiler plant, Option B is a centralized heat pump system with lake water heat exchange, and Option C is a centralized heat pump system with ground loop heat exchange. Each of the three system options identified has noteworthy economic, environmental and user impacts. Our pertinent findings on these primary considerations and other notable considerations follow in the body of the report. As an energy conservation measure, a solar hot water assist system has been considered to supplement the base heating plant.

The extent of the hardscape area to be melted ranges from all of the West District streets and sidewalks (approx. 154,600 square feet) to no snowmelt. For the purposes of this report, four basic area scenarios were considered: Scenario 1 would include Main Street (pedestrian and vehicular areas) and all adjacent pedestrian zones; Scenario 2 would include Main Street (pedestrian and vehicular areas) and primary pedestrian zones; Scenario 3 would include Main Street pedestrian zones and primary pedestrian zones; Scenario 4 is the manual snow removal option – no snowmelt. Each scenario is explained further in Section III. Refer to Figures B-1, B-2, & B-3, Appendix B for graphic representation of the areas. All scenarios are based on the master plan approved for the Avon West Town Center Investment Plan, which includes a 'woonerf' style of street design for Main Street. Although numerous other snowmelt areas could have been considered, it was decided to offer these four scenarios for the purpose of this study.

Information within this report is based on experience, engineering judgment, engineering research and concept charrettes and program brainstorm sessions with Town of Avon (TOA) staff and Design Workshop. Opinions of probable cost contained within this report are based on pre-schematic design concepts and were derived using multiple assumptions, experience with similar systems, and input from qualified local contractors. Actual costs should be determined by qualified contractors, utility providers, and maintenance staff based on completed design.

II System Options

A. Option A – centralized natural gas boiler plant. Boilers transfer heat from the combustion of natural gas to the heating water within the boiler heat exchanger. Refer to Figure A-1, Appendix A for schematic. This is the most common system for large scale snowmelt systems due in large part to its use of conventional equipment and its relative cost effectiveness compared to other systems.

B. Option B – centralized heat pump system utilizing lake water as the 'heat' source. The general premise of a heat pump is to extract heat from a 'source' and reject that heat to the snowmelted area. Lake source water would be pumped from Nottingham Lake to the location of the heating plant (refer to Section V., A. & Figure B-4, Appendix B for proposed plant location). The water would flow through the heat pump, which would transfer the heat energy from the lake water to a snowmelt antifreeze mixture. The lake water would return to the lake at a lower temperature after passing through the heat pump. Utilizing this type of heat exchange would essentially result in no net loss of water from the lake; however, water use rights and the potential for impact to aquatic life would likely result in a time consuming, expensive legal process. The primary benefit of this type of system is a reduced environmental impact as compared to Option A. Although a detailed study of the temperature effects on the lake would need to be performed, initial estimates indicate this is a feasible option. However, research did not turn up a single large scale snowmelt application in North America.

C. Option C – centralized heat pump system with a ground loop heat exchanger, as shown in Figure A-2, Appendix A. This system would operate similar to the lake water system except this system would utilize vertical pipe loops in the ground as the 'heat' source. A drawback to a ground loop for a system of this size is the magnitude of the loop field; roughly twice the size of the snowmelt area is anticipated to satisfy the heating requirement of the system and the potential of creating a permafrost layer within the surrounding ground mass. The ground heat exchanger would be in Nottingham Park, covering up to four times the area of the current soccer field. Following excavation, the boreholes could be covered with sod and the area returned to normal use.

D. A solar hot water system could be used to increase the efficiencies of each heating plant. This type of system can be used in addition to the options described above, with slight modifications for each. Since solar panels are not effective at night or during snowy weather, there would be no reduction to the base heating plant capacity; however a solar system could provide benefits during sunny cold weather to assist with ice clearing and reduce energy consumption in idling mode. Solar pre-heat panels would be mounted on building rooftops or along the south side of Benchmark Road, and can be expanded as the system grows or capital becomes available. All mechanical equipment, less the panels, piping and valves would be housed within the mechanical space and the heat transfer liquid piped to the locations of the panels.

E. Other system options considered were decentralized boiler plants and electric resistance cables. Decentralized boiler plants were deemed undesirable because of the need for additional space to house the additional equipment and increased frequency of maintenance for multiple locations. Electric resistance cables were deemed undesirable due to high operating costs.

III Snowmelt Area Scenarios

Each of the following three scenarios for area of snowmelt can be combined with any of the three heating plants described above. Cost analysis for each system type with regards to each scenario is provided in Section IV., A.

A. Scenario 1 incorporates snowmelt in all pedestrian ways and vehicle ways within the AWTC redevelopment (refer to Figure B-1, Appendix B,). This would encompass roughly 154,600 square feet of snowmelt area including Main Street, Civic Plaza, the Pedestrian Corridor, Park Plaza, Library Plaza, Restaurant Plaza, Gateway to Main Street, Lettuce Shed Lane and Plaza, and Avon Station.

B. Scenario 2 incorporates snowmelt in all primary pedestrian zones and Main Street (refer to Figure B-2, Appendix B). This scenario includes roughly 141,200 square feet of snowmelt. Included in this scenario are Main Street, Civic Plaza, Park Plaza, Library Plaza, Restaurant Plaza, Gateway to Main Street, Lettuce Shed Lane and Plaza, and Avon Station. Traditional snow removal would be utilized for the balance of the AWTC area.

C. Scenario 3 incorporates snowmelt solely in pedestrian zones (refer to Figure B-3, Appendix B). This scenario also focuses on those areas that will receive minimal to no sun on the shortest day of the year, December 22. Vehicle right-of-ways are not included in this scenario. The approximate area of this scenario is approximately 97,200 square feet. Areas included are Civic Plaza, Park Plaza, Library Plaza, Restaurant Plaza, Lettuce Shed Lane and Plaza, and Avon Station. Traditional snow removal would be utilized for the balance of the AWTC area.

D. Scenario 4 includes no snowmelt. Traditional snow removal would be utilized for all areas of AWTC.

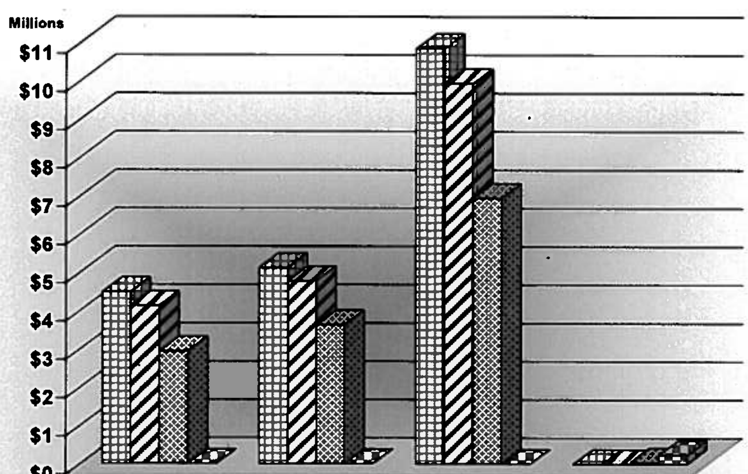
E. A sun-shade analysis prepared by Design Workshop illustrates the areas of the proposed Main Street that will receive minimal or no sun on the shortest day of the year. Appendix C graphically shows these areas, which are the highest priority to be melted, and therefore are included within each scenario.

IV Primary Considerations

There are a multitude of factors to review when considering installation of a snowmelt system. The most significant have been chosen as the basis of this study. The three primary considerations are the economic impacts, environmental impacts, and impacts to users. Other notable considerations are described in lesser detail in Section V.

A. Economic Impacts

1. The capital cost of a snowmelt system is significant, regardless of which system type is utilized. As shown in Figure 1, the capital cost of a natural gas boiler plant is less than that of heat pumps, regardless of the heat exchange medium used by the heat pumps.

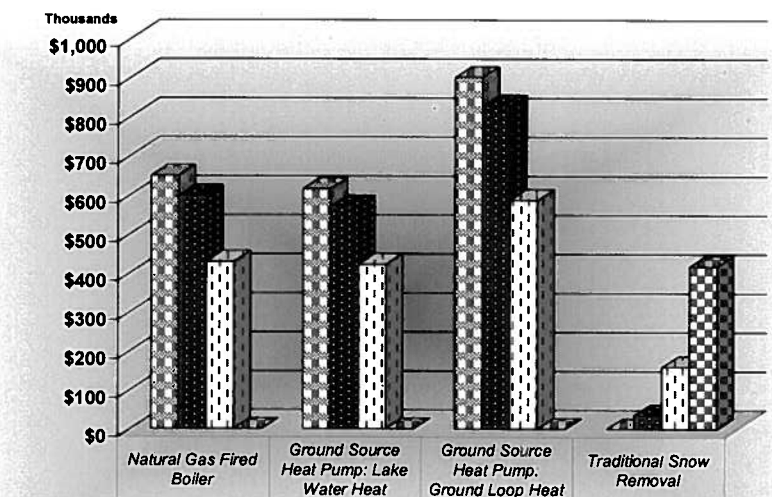


	Natural Gas Fired Boiler	Ground Source Heat Pump: Lake Water Heat	Ground Source Heat Pump: Ground Loop Heat	Traditional Snow Removal
Scenario 1	$4,485,000	$5,121,000	$10,844,000	$0
Scenario 2	$4,125,000	$4,772,000	$9,933,000	$0
Scenario 3	$2,942,000	$3,628,000	$6,941,000	$50,000
Scenario 4	$0	$0	$0	$242,000

Figure 1: Estimated Capital Cost

Economic factors for all the heating plant options will be proportional to the snowmelt area and include heating equipment (boilers or HPs), pumps, tubing & valves, trenching & excavation, insulation, wire mesh to anchor the tubing, heat exchangers, and controls for proper and efficient operation. These factors are included in each system's economic analysis. As the graph indicates, the cost of the system is directly related to the area of snowmelt. (Refer for Appendix B for areas and Appendix D for opinions of probable cost.)

2. Ongoing operation and maintenance cost of a snowmelt system is another important factor; Figure 2 shows the estimated operating costs per square foot per year of operation of the system. The largest cost for operating equipment is fuel. Due to the escalating price of electricity, natural gas, labor and materials, annual operational costs will continue to increase. In this analysis, data has been assimilated over a period of time to estimate future pricing trends. Mechanical equipment must be maintained and serviced on a regular basis. On the other hand, personnel must be hired to shovel snow and operate the plow vehicles.



	Natural Gas Fired Boiler	Ground Source Heat Pump: Lake Water Heat	Ground Source Heat Pump: Ground Loop Heat	Traditional Snow Removal
Scenario 1	$650,000	$616,000	$902,000	$0
Scenario 2	$599,000	$571,000	$829,000	$36,000
Scenario 3	$429,000	$422,000	$587,000	$160,000
Scenario 4	$0	$0	$0	$418,000

Figure 2: Estimated Yearly Snowmelt/Snow Removal Operations and Maintenance - 2008 Dollars

3. Life-cycle cost of each heating plant option is an important factor to consider. Assuming a 5% increase per year for 20 years of the capital and annual operating costs, the heat pump and boiler life-cycle costs are nearly identical, even though the total initial cost for the heat pump option is substantially larger (refer to Appendix D). Since heat pumps operate more cost-efficiently, they become more cost-effective over the long term than a boiler plant; 20 years is the cost intersection between the systems.

4. With respect to economic impacts, a natural gas boiler plant is the most cost-effective solution in the short term, but a heat pump system with lake water heat exchange is likely to be slightly more cost-effective over the life of the system.

B. Environmental Impacts

1. The second major consideration is the impact to the environment. Each option burns fossil fuel: natural gas, coal (at the utility power plant), or diesel. Upstream, or off-site, emissions were weighted equal to tailpipe, or on-site emissions when evaluating an option for environmental impact. Alternative energy production methods have been included in this report for the sake of reducing the carbon footprint of a snowmelt heating plant.

2. Natural gas burns relatively cleanly when consumed in a boiler as opposed to diesel in the vehicles that would be utilized for snow removal. However, a much greater quantity of natural gas would be required to melt snow than diesel to remove snow. As a result, a natural gas boiler system would produce approximately three times the amount of environmentally harmful byproducts (CO, CO_2, NO_X, etc.). Greenhouse gases emitted by diesel engines are relatively small when compared to snowmelt heating plant emissions, due to the reduced amount of time in operation.

3. A heat pump system would consume a substantial amount of electricity. Coal-fired power plants are one of the largest polluters in our country, because of their relative inefficiency and significant number. As shown in Figure 3, the majority of electricity produced in the US is from a 'dirty' power source, which directly relates to the carbon footprint of a system that uses electricity in its normal operations.

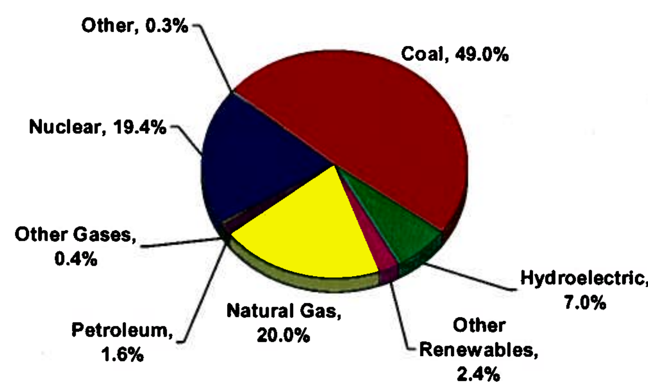
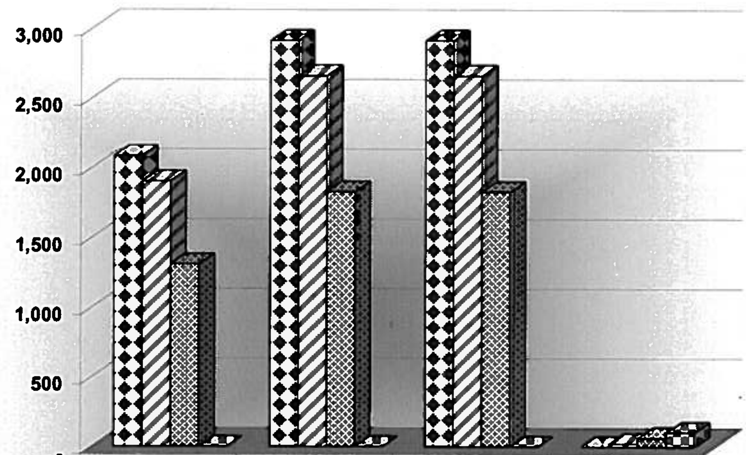


Figure 3: Coal-fired power plants generate nearly half of all electricity consumed in the US.

4. Carbon dioxide emissions from each heating plant will be a significant factor in the selection process. Figure 4 illustrates the amount of CO_2 produced by each heating plant relative to the square footage of each scenario. Electricity generation accounts for the largest amount of pollutants, the primary source of energy for the heat pumps which will produce upwards of 2900 tons of CO_2 annually. Natural gas boilers aren't far behind, emitting almost 2100 tons annually with snow removal being much less impactive, producing only 104 tons of CO_2 each year. Heat pumps become a better environmental option if the electricity is produced

by a renewable source, such as wind power. A similar benefit is achieved if alternative fuels are used in snow removal vehicles, such as biodiesel or E85.



	Natural Gas Fired Boiler	Ground Source Heat Pump: Lake Water Heat	Ground Source Heat Pump: Ground Loop Heat	Traditional Snow Removal
Scenario 1	2,085	2,912	2,912	-
Scenario 2	1,904	2,660	2,660	22
Scenario 3	1,311	1,831	1,831	65
Scenario 4	-	-	-	104

Figure 4: Tons of CO_2 Produced per Year

5. With respect to environmental impacts, snow removal is the least impactive. A natural gas boiler plant will be less impactive than other snowmelt options, unless the electricity to operate heat pumps is generated by renewables.

C. Impacts to Users

In an economy driven primarily by tourism, it is important to look at the perceived reaction of visitors when considering a snowmelt system. However, user safety will also be a large concern when determining whether to install a snowmelt system or continue with snow removal.

1. From a safety perspective, mechanical snowmelt provides a safer, more consistent walking surface for people equipped with all types of footwear, from ski boots to high heels. This also reduces the interface between pedestrians and snow removal equipment. Similarly, businesses often take delivery of their products/merchandise early in the morning which may frequently coincide with the snow removal process.

2. Snow removal vehicles are equipped with back-up alarms: the noise from this safety feature is a frequent complaint to the town as well as the noise created by plows on pavement. Such concerns would be significantly

reduced for the West Town Center with a snowmelt system; mechanical noise produced by the system would occur within the enclosed mechanical space.

3. Is snow on the ground an important factor for the character of a ski town? Vail and Beaver Creek dealt with this issue when incorporating snowmelt into their respective streetscapes. Both municipalities concluded that personal safety, accessibility, and noise concerns outweigh the cost of such a system. With a snowmelted streetscape, TOA has more flexibility in terms of aesthetics: benches, planters, sculptures, etc. can be left in place year-round without risk of damage from snow removal equipment.

V Other Notable Considerations

A. Heating Plant Location

The heating plant would ideally be located relatively close to the snowmelt zones. The mechanical space to house the heating plant would likely be located within the West Town Center Parking Garage to be built between the Recreation Center and the Sheraton Hotel, on the north side of Main Street (refer to Figure B-4, Appendix B for approximate location). Construction of this building is scheduled to begin in 2010. Since construction of many streetscape areas are anticipated to be complete prior to completion of this central heating plant building, provisions could be made for a temporary heating plant or manual snow removal provided in the interim. Another option considered is to construct the mechanical room before the rest of the parking structure; a stand-alone facility to house all the mechanical equipment required for operation of the system, which will be incorporated into the parking garage when construction commences. This would allow for the heating plant to be purchased and/or assembled incrementally as construction allows.

B. Private Property

Private property boundaries are another factor to consider. In the case of Main Street, these property boundaries are set; however, some structures are scheduled for construction after this system is installed. If individual property owners are interested in continuing the snowmelt to the door of their respective buildings, then an agreement must be reached between owner and TOA to allow for expansion of the system onto private property. This agreement should address topics such as time frame for construction, rights of operation of the system, area of private property to be melted, and cost incurred to owners for service of snowmelt by TOA. Vail was successful in implementing such agreements with many private parties when installing a snowmelt system within their streetscape.

C. Utilities

Utilities buried beneath Main Street will require service at some point in the future. Access to these utilities should not require complete removal of the snowmelt system; therefore, the type of construction should allow for maintenance access to buried utilities. Tubing set in a sand bed with pavers above (for pedestrian areas only) will be easier to temporarily dismantle for access to buried utilities than tubing embedded in concrete. Since Main Street is a new development, it may be possible to relocate these utilities from under the snowmelt area prior to construction.

VI Conclusion

Traditional snow removal is cost effective and has relatively little impact to the environment. However, if a snowmelt system is desired, a natural gas boiler system appears the most appropriate choice overall.

Appendix A
System Schematics

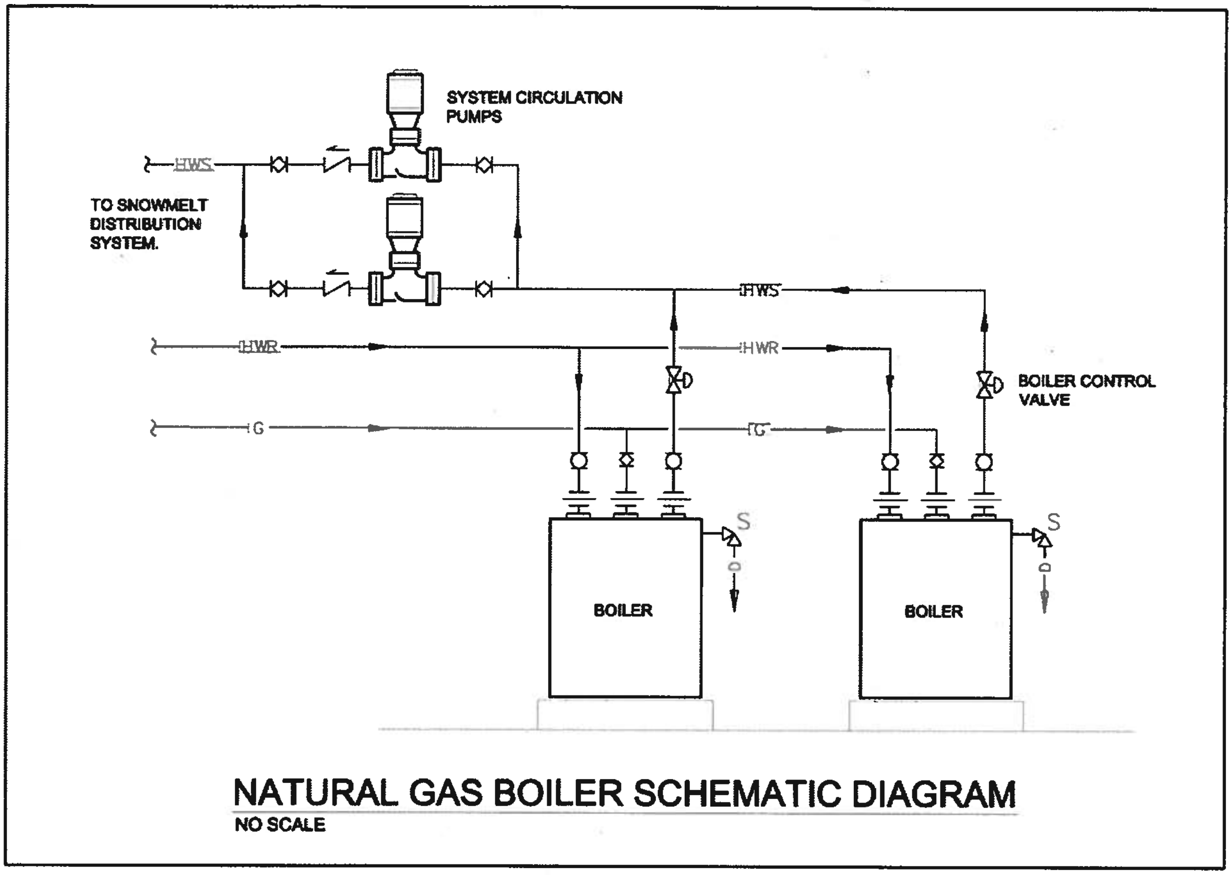


Figure A-1. Note: HWS/HWR = Heating water supply/return, G = Gas

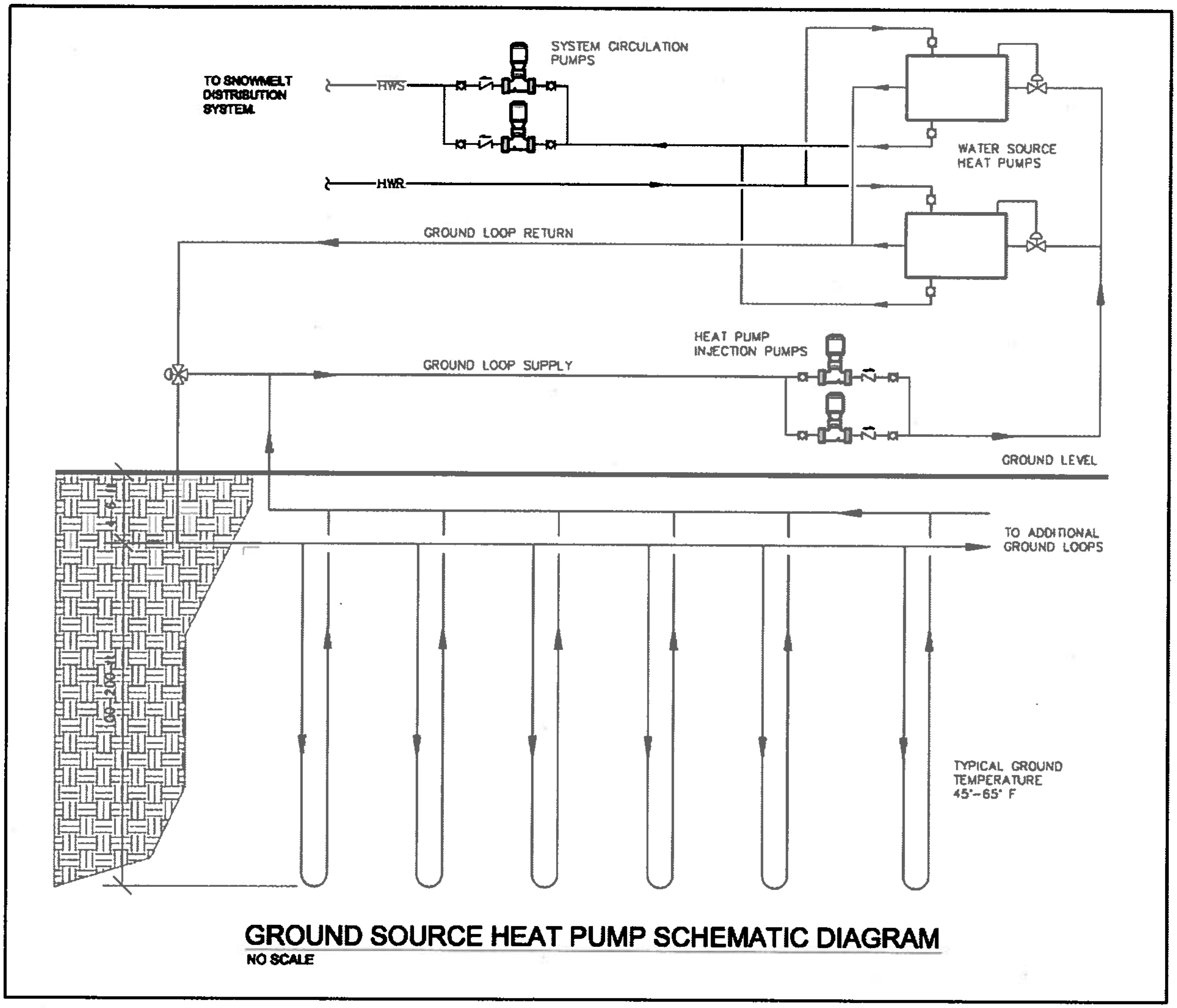


Figure A-2. Note: HWS/HWR = Heating water supply/return

Appendix B

Snowmelt area scenarios

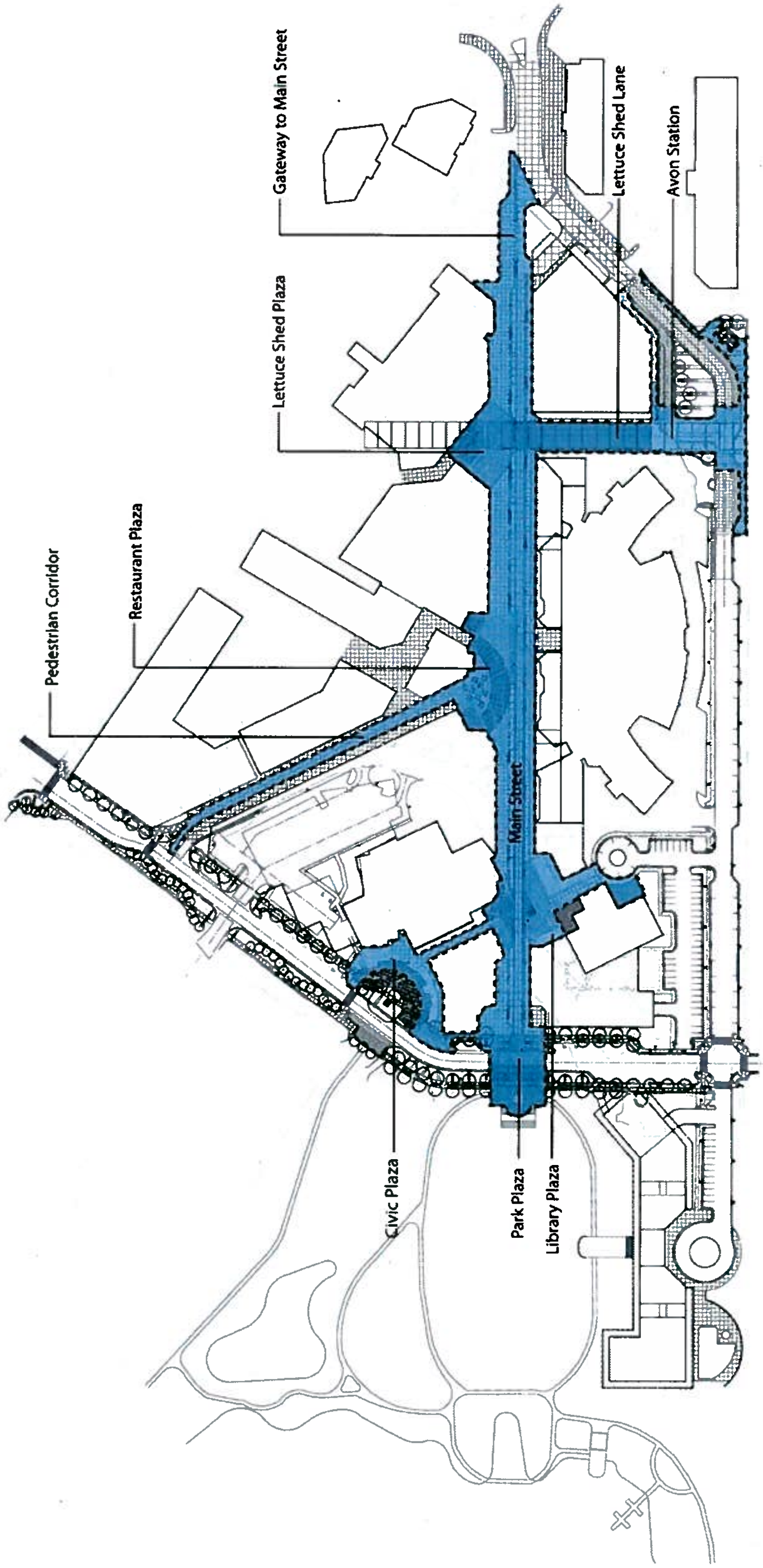


Figure B-1: Snowmelt Scenario 1

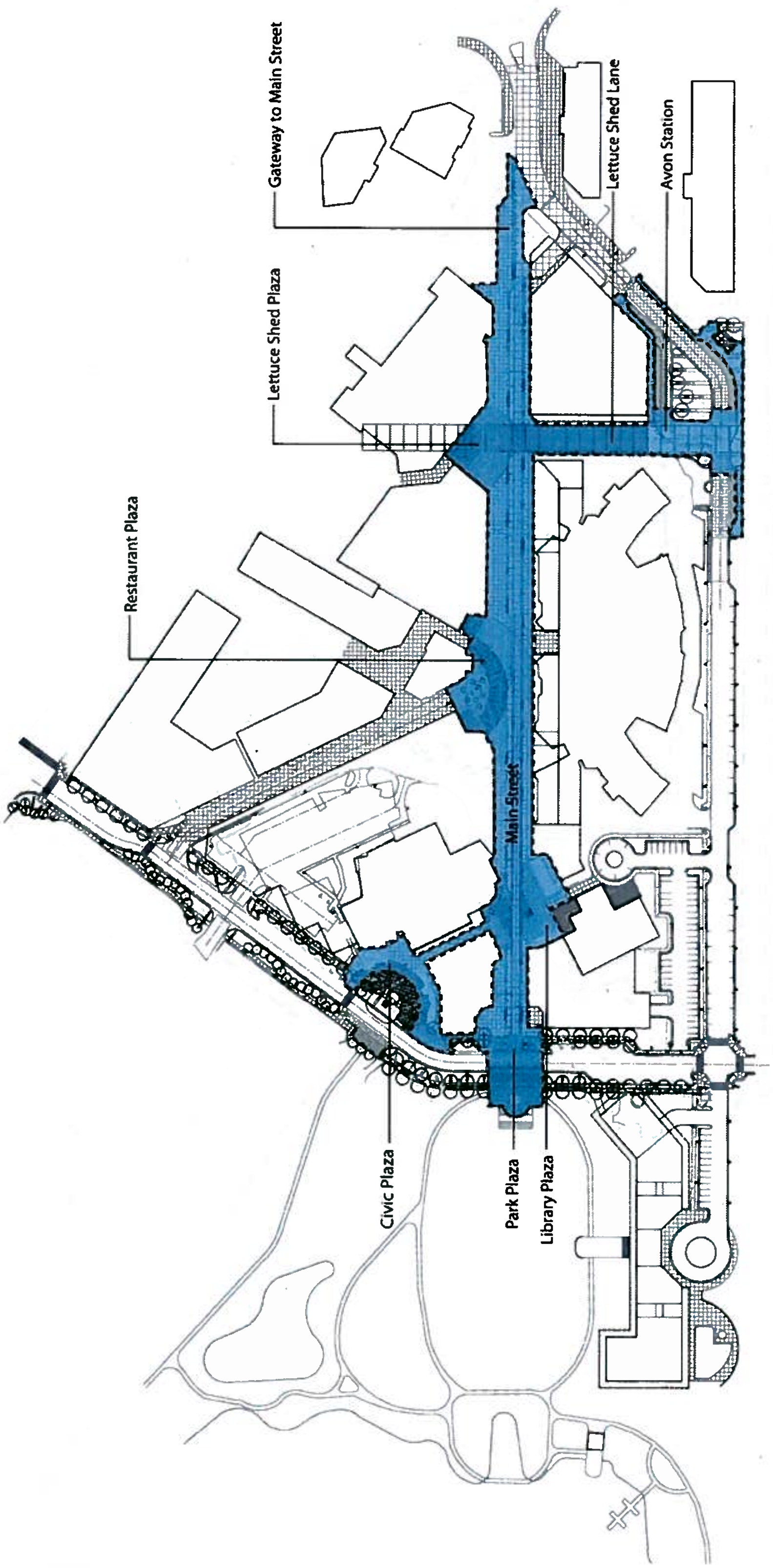


Figure B-2: Snowmelt Scenario 2

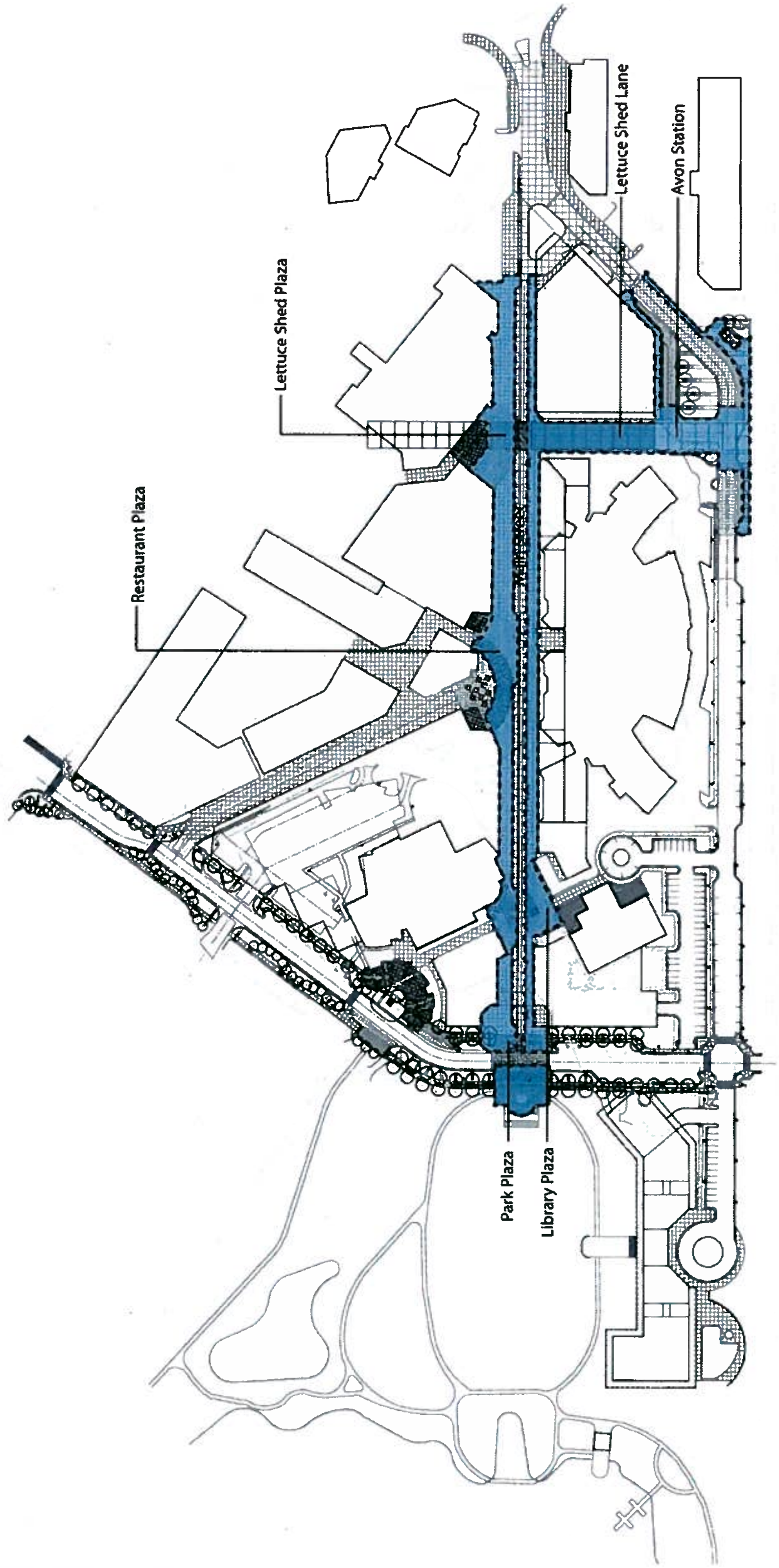


Figure B-3: Snowmelt Scenario 3

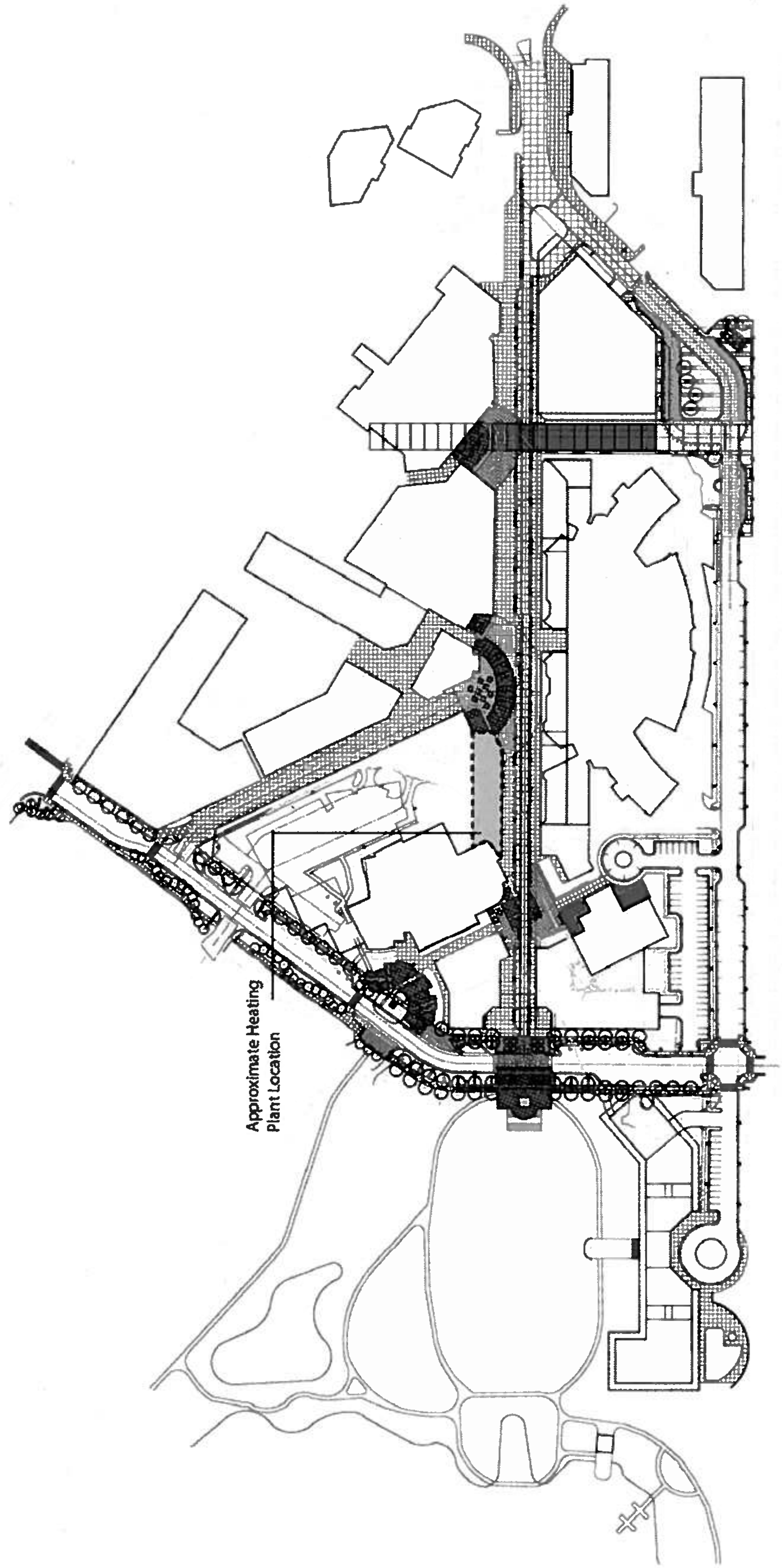


Figure B-4: Approximate Heating Plant Location

Appendix C
Design WorkShop Sun-Shade Analysis

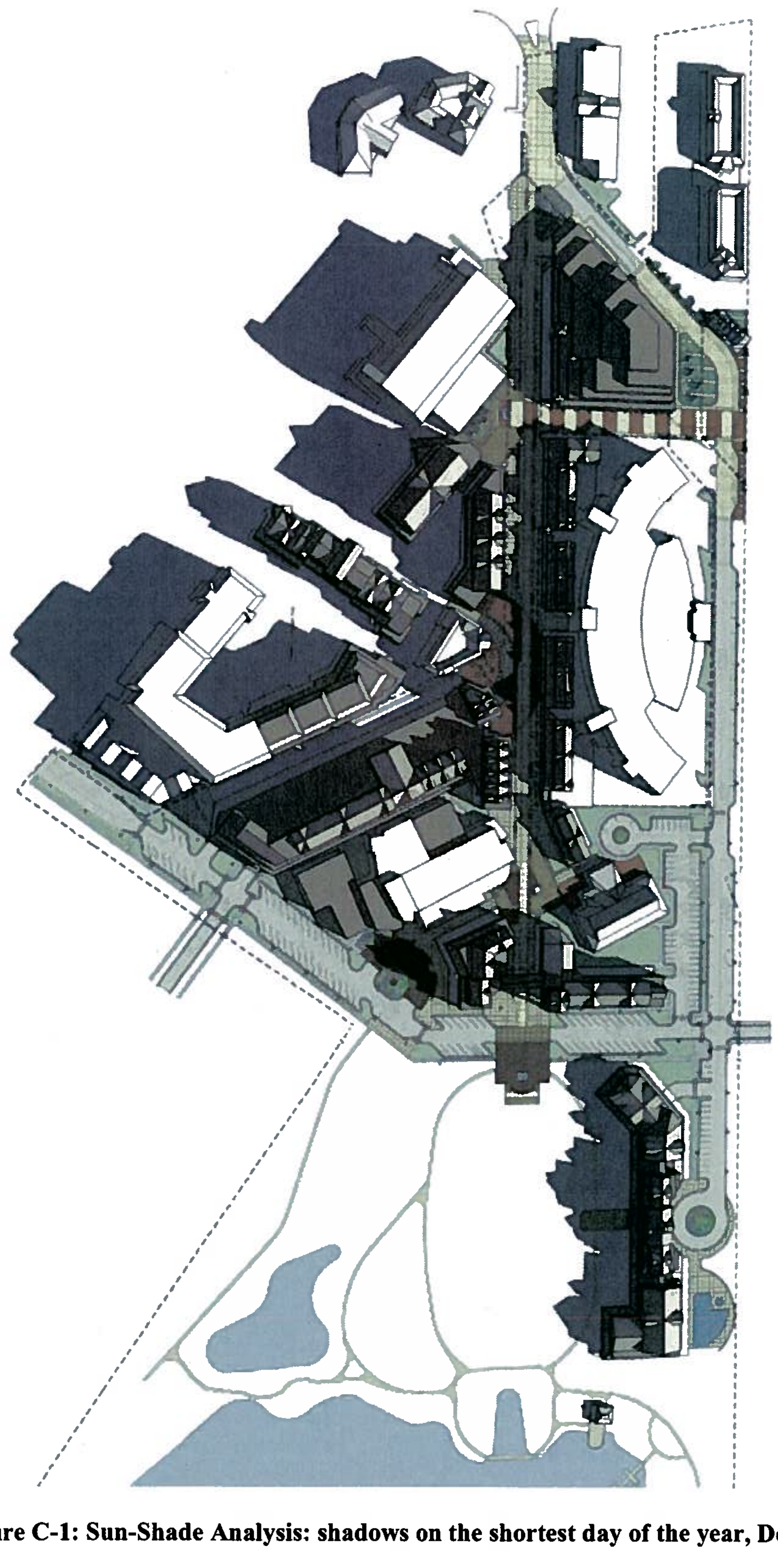


Figure C-1: Sun-Shade Analysis: shadows on the shortest day of the year, December 21st.

Appendix D
Cost analysis (spreadsheet)

Heating Plant	Capital Cost	Capital Cost Per S.F	O&M Total	O&M Total Per S.F.	20 Year Capital & O&M Total	20 Year Capital & O&M Total Per SF
Natural Gas Fired Boiler						
Scenario 1	$4,485,000	$29.00	$650,000	$4.20	$18,020,000	$117
Scenario 2	$4,125,000	$29.20	$599,000	$4.20	$16,585,000	$117
Scenario 3	$2,942,000	$30.30	$429,000	$4.40	$11,873,000	$122
Scenario 4	$0	$0.00	$0	$0.00	$0	$0
Ground Source Heat Pump: Lake Water Heat Exchange						
Scenario 1	$5,121,000	$33.10	$616,000	$4.00	$17,940,000	$116
Scenario 2	$4,772,000	$33.80	$571,000	$4.00	$16,648,000	$118
Scenario 3	$3,628,000	$37.30	$422,000	$4.30	$12,407,000	$128
Scenario 4	$0	$0.00	$0	$0.00	$0	$0
Ground Source Heat Pump: Ground Loop Heat Exchange						
Scenario 1	$10,844,000	$70.10	$902,000	$5.80	$29,619,000	$192
Scenario 2	$9,933,000	$70.30	$829,000	$5.90	$27,179,000	$192
Scenario 3	$6,941,000	$71.40	$587,000	$6.00	$19,166,000	$197
Scenario 4	$0	$0.00	$0	$0.00	$0	$0
Traditional Snow Removal						
Scenario 1	$0	$0.00	$0	$0.00	$0	$0
Scenario 2	$0	$0.00	$36,000	$0.30	$753,000	$5
Scenario 3	$50,000	$0.50	$160,000	$1.60	$3,371,000	$35
Scenario 4	$242,000	$1.60	$418,000	$2.70	$8,944,000	$58