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CITY OF FAIRBANKS
DISTRICT HEATING DEVELOPMENT PLAN

SUMMARY REPORT

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TABLE OF CONTENTS

List of Tables

List of Figures

	<u>Page</u>
1. Introduction	1
2. Conclusions and Recommendations	3
2.1 Conclusions.....	3
2.2 Recommendations.....	4
3. District Heat Development Plan.....	6
3.1 General.....	6
3.2 Selection of Service Area.....	7
3.3 Selection of Heat Supply.....	8
3.4 Distribution and Customer Hook-up.....	10
3.5 Expansion Plan.....	10
3.6 System Reliability.....	14
3.7 Economics.....	15
3.8 Socio/Environmental Effects.....	18
4. Factors Affecting District Heat System Development.....	21
4.1 Susitna Hydroelectric Development.....	21
4.2 Anchorage-Fairbanks Railbelt Electrical Intertie.....	22
4.3 Oil and Natural Gas Prices.....	22
4.4 Availability and Price of Coal.....	23
4.5 Alternative Fuels.....	24
4.6 MUS Plant Expansion.....	25

LIST OF TABLES

Table No.

- 1 - MUS Electrical Peak Demand Projection
- 2 - Projections of Thermal Load Growth
- 3 - Capital Cost Estimates District Heating System
- 4 - Summary - District Heating Economics
- 5 - Environmental Effects of Coal-Fired District Heating

LIST OF FIGURES

Figure No.

1. Lower Temperature Thermal Load Distribution 1978 - Normalized
2. Monthly Heating Demand
3. Daily Heat Demand Profile City of Fairbanks - Estimated
4. Cogeneration Vs. Conventional Power Generation
5. Development Plan - Electrical Growth and Generation Capacity Expansion
6. Development Plan - 1981 Configuration
7. Development Plan - 1985 Configuration
8. Development Plan - 1988 Configuration
9. Development Plan - 1990 Configuration
10. Development Plan - 1992 Configuration
11. Development Plan - 1995 Configuration
12. Development Plan - 1997 Configuration
13. Development Plan - 2000 Configuration
14. Development Plan - District Heat System Demand Capability and Growth
15. Comparison of Oil Furnace and District Heating Costs
16. District Heating Cost With State Financing of Investment
17. Comparison of Heating Costs with Fuel Price Escalation
18. Oxides of Sulfur-Emissions Comparison
19. Oxides of Nitrogen-Emissions Comparison
20. Particulates-Emissions Comparison

CITY OF FAIRBANKS
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SUMMARY REPORT

1 - INTRODUCTION

This report examines the technical and economic feasibility of developing a large scale district heating system in Fairbanks, Alaska. District heating is a method of generating and transporting heat from a central plant to a large number of consumers. Historically most U.S. cities have distributed heat as steam to downtown buildings (as in Fairbanks). Over the last 30 years, Scandinavian countries, notably Sweden and Denmark, have distributed heat as hot water instead of steam. Considerable advantages of using hot water over steam for district heating have been experienced.

District heating is applicable mainly to cold climate cities. Considerable effort has been expended by the U.S. government in developing plans for modernization of district heating systems in major northern communities, such as Minneapolis/St. Paul. The annual need for space heating on a degree day basis in Fairbanks is 75 percent greater than Minneapolis/St. Paul and it is therefore reasonable to suppose that a hot water district heating system in Fairbanks will be even more attractive than in the northern cities of the lower 48.

Approximately 60,000 people live in Greater Fairbanks with about 26,000 residing within the city limits. The majority of residential structures in the City of Fairbanks are heated with oil, with a small proportion using electricity, wood, or coal as the primary heat energy source. In the commercial sector, oil is also the primary heating source.

The city operates a district heating system in the downtown area, serving approximately 140 customers with steam at 10 psig. The steam is produced from a coal-fired boiler-extraction steam turbine cogeneration plant located near the city center.

The following sections of this summary report address the proposed plan for expanding the existing district heat facilities to accommodate hot water generation and distribution to Fairbanks consumers in a logical manner, recognizing the impacts of alternative energy sources and environmental constraints on district heating design.

2 - CONCLUSIONS AND RECOMMENDATIONS

2.1 - Conclusions

A modern district heating system which would serve the near and long term needs of the city can be installed and operated as an integral part of the existing MUS electric power generation facility. The system could provide heat at a cost below the cost of heat generated by point-of-use oil and electric heat systems, and may also lower the cost of electricity provided to MUS customers.

The district heating system would involve progressive development of the existing combined heat and power generation and distribution system, with coal continuing to be the source of energy. As the district heating system is expanded, the efficiency of heat and power generation will improve and costs should decrease on a real dollar basis.

Several factors which will influence the design and construction schedule of the complete district heating system should, however, be addressed before much of the system expansion takes place.

Factors affecting district heating system development:

- o Anchorage-Fairbanks electrical intertie - potential for considerable base load electric power by 1985.
- o Susitna hydroelectric development - potential for large amounts of low cost electric power by 1993.
- o Oil and natural gas availability and the potential for cost competitive supplies from gas and oil pipelines, and implications of the Fuel Use Act on cogeneration of electric power and heat.
- o Coal availability and price - Healy coal appears to be a long term satisfactory energy source.

- o MUS plant expansion problems - space limitations.
- o Environmental impacts - increased coal use will increase some stack emissions and ash disposal requirements.

These factors should not affect the decision to go ahead with the first stage of district heating system expansion. However, the energy supply scenario is changing rapidly, and it is therefore prudent to build a pause into the district heating system development plan to (1) allow assessment of the first stage pilot system and (2) consider the impact the above factors may have on district heating system feasibility when additional information becomes available.

2.2 - Recommendations

The City of Fairbanks should proceed with the development of a hot water district heating system in a planned, logical manner, allowing for full consideration of the economic and other factors at work within the state. The recommended plan of action follows.

- A. Construct the pilot hot water district heating system. This pilot system will allow confirmation of:
 - o Capital costs, operating expenses, and reliability
 - o Compatibility with existing residential heating systems
 - o Availability and durability of hardware
 - o Applicability and acceptance of Scandinavian piping system design.
- B. Commence the permit application process for expansion of the MUS power plant.

Make applications based on:

- o 158,000 lb/hr boiler, and
- o 286,000 lb/hr boiler to test the New Source Performance Standards exemption for large cogenerating boilers and turbines.

- C. Concentrate initial expansion of the district heating system in that area of the city presently served by the steam system. During this period, the pilot development can be monitored and lessons learned which can be implemented in subsequent extensions. This period will also allow the various factors affecting district heating system economics to be resolved prior to major investment in new plant.
- D. Incorporate the space requirements for major district heating system piping into the city's downtown utility redevelopment plan.
- E. Begin preliminary investigations into an expansion or relocation of the heat and power plant which could continue to service the district heating system. Additional requirements for cooling, coal and ash handling, and equipment space will require considerable modifications at the existing MUS site and may well be impossible to incorporate without a complete move to a new location.
- F. Continually update the economics of coal-fired district heat compared to:
 - o Oil and natural gas prices from State-owned supplies
 - o Electricity availability and prices associated with:
 - the Anchorage-Fairbanks intertie
 - the Susitna project.
 - o Other alternative energy sources such as refuse burning or biomass.

3 - DISTRICT HEAT DEVELOPMENT PLAN

3.1 - General

The key elements required for successful implementation of district heating are:

- (a) A need for heating during a substantial portion of the year
- (b) A high density service area
- (c) A reliable heat source operating on low cost fuel in close proximity to the service area
- (d) Existing buildings which are suited for hot water or steam heating, or areas where new building construction is projected for the near future.

An assessment of the conditions in Fairbanks indicates that each of the above criteria is satisfied. The downtown section of the city, comprised of both commercial/municipal buildings and residential structures, is higher in population density than many existing northern European district heating areas.

These elements have been combined with available information regarding heating loads in the city and growth projections to develop a district heating plan which will:

- Lower heating costs to the end user when compared to equivalent oil heat costs.
- Reduce dependence on oil as an energy source.

- Improve MUS electric generation plant performance.
- Reduce winter ice fog caused by turbine condenser cooling.
- Increase local employment in construction trades.

3.2 - Selection of Service Areas

The benefits of district heating are greatest in areas of high heat load density (Btu/sq ft/year), since large amounts of energy can be delivered in such areas with a minimum amount of distribution system investment. The highest heat load areas were therefore sought out as candidates for district heat development.

Figures 1 through 3 present the characteristics of the thermal load as it now exists in the City. Most of the data used to develop these figures was collected in 1978 and 1979, but little change in population or thermal energy use has occurred recently. Figure 1 shows that the greatest thermal load density is located in the downtown business/commercial sector, and in a north/south area extending south from the Chena River. In addition, several large individual loads (schools, hospital, large buildings) are located in areas adjacent to the downtown sector.

Thermal loads presented in Figure 1 are presently met primarily (80 percent) using oil. The district steam heat system provides 10 percent of the thermal demand, with coal, electricity, wood and other fuels providing the remaining 10 percent.

Tables 1 and 2 present an estimate of growth in thermal load in the target areas and growth in electrical peak demand expected at the MUS generation plant. Electrical generation requirements are important in that the district heat will be most economic if produced by a cogeneration process which produces heat and electricity at the same time.

The figures were used to establish a logical district heating system expansion plan which matches electric generation requirements with thermal load growth, progresses from most dense to least dense areas, and gives due consideration for equipment replacement schedules and practical construction sequences.

3.3 - Selection of Heat Supply

District heating, to be successful, should be more economic than dispersed, point-of-use heat generation methods. Centralized heat generators operating with comparably priced fuels at comparable fuel conversion efficiencies will not provide sufficient incentive to implement district heating.

Operation of any centralized heat source and heat distribution system will be more costly than the cost of point-of-use heat systems, primarily because plant operators are paid and residents are not, and because central systems must tolerate distribution losses. Also, the capital investment of a district heat system will be higher than equivalent point-of-use systems which are mass-produced. The district heat system must therefore produce heat at a much lower fuel cost than present point-of-use systems.

The most economic means of producing heat energy for the Fairbanks district heat system is via coal-fired boilers and turbines which produce both electric power and heat simultaneously. This combined production of heat and electric power, also called cogeneration, is presently used to generate heat for the City steam district heat system and a small portion of the City's electrical power. An expanded district heating system would allow almost all of the City's electrical power to be produced by cogenerating turbines, reducing the amount of energy wasted through the electricity production process.

Figure 4 illustrates, in simple fashion, how cogeneration improves the overall efficiency of space heat and electric power production. Cogenerating turbines produce electricity somewhat less efficiently than straight condensing turbines (such as Chena 5). But they make available large

amounts of heat energy at a temperature suitable for space heating. The use of this heat raises the power generation and space heating total efficiency at a typical load from 43 percent to 60 percent. Prudent operation of the cogeneration system can raise the total efficiency to as high as 75 percent.

The proposed district heating system is designed around expansion of the MUS power plant and the use of coal as the heat source. Positive features of this strategy are:

- o Heat Density. The MUS plant is ideally located to serve the highest density heating districts.
- o Economic Heat Source. Coal represents the most economic fuel for producing low cost district heat, and cogeneration of electricity and heat is an energy efficient process.
- o Central Plant. The operation of a coal-fired plant should be located at a centralized facility where handling systems for coal and ash and control of environmental contaminants can be performed in the most cost effective manner.
- o Cogeneration. Tying district heat production to the electric generation process allows both electric power production and district heat to be produced at least cost, since capital expenditures and plant operation processes (fuel handling, environmental control, etc.) are shared by both electricity and heat sales.

Other facilities and locations were evaluated as heat sources for a district heating system, including Ft. Wainwright, the University of Alaska at Fairbanks, school and hospital boiler plants, and new sites at the southern end of the city limits. The major existing power plants are much farther from the city's high density thermal loads than the MUS plant and do not have the potential to provide the thermal power demanded by a comprehensive district heating development program. However, if the existing MUS plant site is untenable for environmental reasons, siting of a new plant should also consider supplementary fuel supplies such as refuse and the large sources of wood and peat available in the area.

3.4 - Distribution and Customer Hook-up

District heat will be distributed as pressurized hot water, with a temperature which varies from 200°F, up to approximately 240°F maximum. The piping system will incorporate steel pipes which are insulated and jacketed to prevent moisture from entering the insulation. As presently configured and priced, the distribution system will be developed as a direct burial system running approximately 5 feet below grade. If the city decides to construct a comprehensive utilidor system for the downtown area, the district heat distribution piping could be included in this system also.

The recommended system of customer hook-up is via heat exchangers and secondary heating loops in each facility. This system has several advantages over a direct circulating system:

- (1) It allows the district heat system to be integrated into the existing residential structures without major modifications to the present home heating systems which are predominately hot water baseboard.
- (2) It prevents high temperature district heat water from traveling throughout the structure.
- (3) Heat exchangers allow existing commercial structures to leave presently compatible hot water heating systems in place as backup. The city can then effectively shed load without difficulty in case of a partial shortfall in heat generation capability or localized interruptions in the heat delivery system.

3.5 - Expansion Plan

The district heat system will be expanded in steps, beginning with the areas of highest thermal density and gradually working out toward the farther points of the City.

Initial service area expansion will be aimed at replacing the downtown steam heating system with a hot water district heat system. This approach has the following advantages:

- o It should reduce the operating expense associated with servicing the existing district heat area.
- o It represents the largest concentration of heat users, so that the greatest amount of hot water heat load can be brought on line in the least time and operating costs will therefore be spread over large heat loads.
- o If future events curtail the expansion of the electric generating capacity at the MUS plant, then the city will not be faced with servicing two distinct load types, steam and hot water, with greatly reduced capacity.

The power plant expansion plan is illustrated in Figure 5. This Figure shows the addition of three (3) new coal-fired boilers and two (2) single extraction/condensing steam turbine generators. A waste heat recovery boiler is also added to the Chena 6 gas turbine as a backup source of energy for the district heat system along with the existing Chena 4 waste heat boiler. Additional back-up heat sources will be installed out in the distribution system and will include new heat-only boilers and existing facility boilers.

The two steam turbines have been selected to provide steam at an extraction pressure of 25 psig. This pressure is somewhat higher than the minimum extraction pressure which could theoretically be used to provide district heat. But having the extra margin in operating temperature will provide quicker response to changes in district heat system demand, since more Btu's can be extracted per pound of steam delivered.

Boiler sizes were selected to accommodate MUS plant needs and to conform with environmental regulations as they presently exist. Such an approach results in the following boiler installation schedule:

- 1985 Install Boiler No. 6.
 Input Rating: 250 million Btu/hr
 Output Steam: 850 psig/900°F, 158,000 lbs/hr.*
- 1988 Install Boiler No. 7.
 Input Rating: 250 million Btu/hr
 Output Steam: 850 psig/900°F, 158,000 lbs/hr
- 1993 Install Boiler No.8.
 Input Rating: 450 million Btu/hr
 Output Steam: 850 psig/900°F, 286,000 lbs/hr.

The initial boiler installation will serve as a replacement for Chena 1, 2 and 3 boilers, which have reached the end of their useful life and will be phased out after 1985. Boilers No. 6 and No. 7 are sized for compliance within the New Source Performance Standards exemption limit on coal-fired boiler emissions, and meet MUS operating strategy of multiple boiler operation for improved availability.

Boiler No. 8 is presently sized at 286,000 pounds per hour, representing the amount of steam generation capacity required to cover MUS's heat and power needs up until the year 2000. The size of this boiler could vary up or down depending on several factors including actual growth of the district heat system, revisions to environmental regulations, and changes in electric power demands.

The three boiler additions provide all of the capacity necessary to deliver both electricity and heat to the expanding load centers in the time frame required.

*MUS is presently executing the permit process for both 158,000 lbs/hr and 250,000 lbs/hr boilers. If the larger boiler size is approved as meeting State Environmental requirements, then it should be installed.

As presently positioned, future expansion of the MUS electric generation plant is constricted by the water treatment plant (on the west side), the Chena River (on the north side), and other MUS buildings (on the south and east sides). Inclusion of the three new boilers and two new turbines may be possible by westward expansion to the water treatment building, and by removal of Chena 1, 2, and 3 boilers and turbines. However, if pollution control devices (baghouses or scrubbers) are mandated by the environmental review process, location of the necessary equipment within present site restrictions will not be practical without major changes to the water treatment or maintenance buildings. Environmental concerns are further developed in Section 4 of this report.

As an adjunct to the power plant, a heat conversion station will also be located at the site, either adjacent to or across First Avenue from the generation plant. This station will contain the heat exchangers and pumps necessary to provide the district heating through cooling and condensation of the steam extracted from the turbine generator units.

By first converting the steam system to hot water, the city is effectively postponing the expansion of the power plant heat production system by four years. During this period, actions on the intertie, Susitna Hydro and fuels pricing should be taken which may impact district heating development either positively or negatively, and their effect on future expansion plans for the district heating system must be carefully considered.

This approach will further allow the district heat system in the downtown sector to be installed during the 1984 - 1990 time frame, when a major redevelopment of downtown utilities is being planned.

Figures 6 through 13 illustrate the sequence of heat distribution system expansion. The highest density, close-in thermal demands are connected in early years, with expansion southward first and northward later as the development proceeds. Actual routings of main headers could vary somewhat as a function of City utility redevelopment plans.

Figure 14 illustrates both the expansion of the district heat distribution and the associated connected load. Because the distribution system must be sized to handle the load growth projected for the area over the period of 1980 - 2000, connected load lags behind the distribution system's capability to deliver heat until the late 1990's.

3.6 - System Reliability

The planning of district heating system generation and distribution equipment should include an adequate amount of duplication and alternatives as a means of maintaining high system reliability. The development plan has given consideration to reliability by providing dual trunk line access to the smaller feed lines. In addition, the coal-fired boilers acting as the primary source of district heat energy are backed up in the following manner:

- o The existing Chena 4 waste heat boiler will continue to provide standby heat energy for the district heat system.
- o A waste heat boiler operating off of Chena 6 gas turbine will provide 110 million Btu/hr of thermal energy when operating at full load, which it will do when providing electrical power as a backup for the coal-fired steam turbine generator system.
- o In keeping with the philosophy of the area to have fully redundant systems, MUS may in the future select a second gas turbine to act as a backup to the Chena 7 and 8 boilers and steam turbines. If the new gas turbine is purchased, it should be equipped with a heat recovery boiler providing approximately 100 million Btu/hr of heat.
- o A backup "heat-only" station would be located in the city at the opposite end of the district heat system from the MUS plant. This oil-

fired station would be used to pick up approximately one-fourth of the city's district heat load if required in an emergency.

- o The major loads in the city which have heating systems in place would be asked to maintain these systems in place and operable. The district heating system could then shed these loads as necessary to maintain service to remaining customers without having to provide excessive back-up equipment.
- o The MUS plant would stockpile approximately 15 operating day's coal supply to allow operation during disruptions in mining or rail delivery.

3.7 - Economics

Since the costs of district heating are the major obstacle to its implementation, a detailed evaluation of costs of ownership and operation must be performed early in the development process. The evaluation performed in this Phase I study is directed towards identifying the costs to the City of Fairbanks of ownership and operation of the proposed system. The results of the evaluation also indicate the sensitivity of system costs to potential variations in cost factors, such as the escalation of fuel prices, and the amount of plant activity chargeable to electric power consumers.

The approach taken in this work has been to identify annual minimum revenue requirements associated with the 20 year district heat system development plan. These can then be compared to existing operating costs of dispersed oil-fired heating systems to determine the dollar value or cost of converting to a district heat system. Additional, non-monetary factors, such as land use and air emissions, have also been examined.

The minimum revenue requirements approach is particularly well suited to the evaluation of a municipally owned utility. Publicly owned utilities are, by design, more concerned with service at minimum cost than with maintaining an allowable rate of return subject to the need to break even each

year to avoid additional tax revenue requirements. The special situation of Fairbanks, involving potential funding of system construction from State oil revenues, further underscores the use of a break even type cost evaluation, as removal of capital cost eliminates any rate of return concerns.

A "real" or "present dollar" approach has been used to avoid introducing additional indeterminate variables and allow greater clarity in presentation of costs. The base case analysis implies escalation of oil and coal at the prevailing inflation rate. A sensitivity case to indicate the effects of escalation rates above inflation is also shown.

Operating costs have been developed based on evaluation of present operating records for the Chena plant in combination with historical costs of European district heating technology and operating characteristics of existing and planned equipment. Specifically, quantities and costs have been estimated for:

- fuel
- boiler operation and maintenance
- turbine-generator operation and maintenance
- district heating system operation and maintenance
- electric power.

Capital cost estimates were prepared for the planned district heating system additions on a present dollar basis. Construction financing costs at a real cost of money of 3 percent were included where appropriate. A summary of the capital cost estimate is shown in Table 3. The figures presented include allowances for contingencies, engineering and construction management.

The capital requirement of 146.7 million dollars includes a considerable amount of avoided cost which the MUS plant would incur even if district heating system development were not pursued. Boilers No. 6 and No. 7, expanded coal handling facilities, and a new condensing steam turbine would have to be added to meet future MUS electric load growth irrespective of

district heating. This equipment represents about 40 percent of the total district heat system cost, and does not provide any usable space heat in return.

Annual costs of capital, depreciation and insurance were estimated as a continuous percentage of cumulative new investment and included in the revenue requirements evaluation. The intermittent installations of equipment associated with the district heating system development plan result in variable annual revenue requirements and cost per unit of heat delivered as shown in Figures 15 and 16 and Table 4. Average costs are also shown in the figures to indicate relative magnitude of system costs compared to existing oil-fired building heating systems.

A portion of the annual costs are tied to fixed expenses, so that a significant variable is the percentage of district heating market penetration (complete or partial hookup of all potential subscribers). This is directly related to heat sales and thereby has an inversely proportional relationship on required charges per unit of heat delivered. However, some inflation protection is also built into the system when a large portion of annual costs are tied to capital cost. If no capital cost expenses are burdened on the annual revenues, service costs may be substantially lower than oil use, as shown by comparison of Figures 15 and 16.

A second variable is the value of electricity produced by the district heat turbines. The evaluation has credited electricity production by the extraction steam turbines at 2¢ per kilowatt hour up through 1985. In 1986, when a major portion of the MUS's electricity is provided by the extraction turbines, the credit for electricity rises to 3¢ per kilowatt hour. The 2¢ figure represents only the fuel cost associated with the incremental generation of a small amount of power, whereas the 3¢ figure includes fuel costs and operating and maintenance charges which would normally be associated with the operation of a large generation system such as Chena 5 boiler and turbine-generator.

The results shown in Table 4, utilizing the above electric values, indicate that district heat could be provided to customers over the next twenty years at an average rate of \$7.89 per million Btu's. This rate would decrease to \$5.75 per million Btu's if electricity is charged at 4¢ per kilowatt hour, and would rise to \$10.05 per million Btu's if the heating plant electricity was credited at 2¢ per kilowatt hour.

The net tariff for district heat is therefore sensitive to electricity credit, and the correct division of plant charges between electricity and heat production is therefore of prime importance to district heating system development. A thorough evaluation of present and projected operating costs and charges for both electric power and heat should therefore be conducted before a large commitment to district heating is made.

3.8 - Socio/Environmental Effects

The replacement of numerous dispersed heating systems operating on oil with a centralized coal-fired heat source will affect land use, air quality, waste disposal, employment, business activity, and requirements for city services. Some of these effects can be quantitatively evaluated, while others can only be discussed in a general manner.

Fuels substitution and improved cycle efficiency will produce the most significant environmental impact. The cogeneration process, which generates both electricity and district heat, requires less total combustion of fossil fuel than separate heat and electric power production processes. The total fuel mix also changes, from a combination of coal and heating oil to an exclusive use of coal.

The effect of these changes on air emissions is presented in Table 6. Because very little additional coal is required to produce district heat (over that which would be required to produce equivalent electric power using Chena 5), emission levels for oxides of sulfur should decrease considerably when coal-fired district heating replaces oil-fired furnaces.

Oxides of nitrogen will increase slightly, and particulate levels resulting from the added coal combustion will exceed those now produced by oil-fired furnaces, even though high efficiency mechanical dust collectors are included on the coal boilers.

Figures 18, 19, and 20 compare expected total emissions from the cogeneration/district heating system with emissions which would be produced from separate electric generation and space heating processes producing equivalent electricity and heat. The period prior to 1986 is not presented, as only small amounts of district heat and power are produced during that time. These figures illustrate that the district heating development plan does not result in significant changes to emission levels beyond what would be experienced with normal power generation plant expansion.

The figures also highlight the increase in downtown emissions levels which could result from expanded MUS electric power production and normal expansion in space heating requirements.

Expansion of the MUS plant will require a permitting and review process, during which impacts on air quality will be assessed by governing agencies. Compliance with New Source Performance Standards and Prevention of Significant Degradation laws may require the MUS to install sulfur scrubbers or particulate removal baghouses to reduce air emission levels. However, the demonstrable net reduction in oxides of sulfur may result in ready acceptance of plant expansion for district heating.

Fugitive emissions from coal and ash handling systems will also increase as a direct function of the increase in coal use by the MUS plant. The level of these emissions has not been quantified, but these could be significant in the area immediately adjacent to the plant.

Development of cogenerating turbines to serve a large district heating load will reduce the level of warm water discharged into the Chena river from power plant condensers. During the winter months, warm water discharge contributes to fogging in the city; a contribution that will grow larger if

condensing steam turbines are called on to meet the projected MUS electrical load growth over the next 20 years.

Implementation of a district heat system will reduce employment and business in the supply of oil for heating and maintenance of oil furnace systems. However, expansion of the MUS plant and installation of system piping will necessitate increases in plant staff and service personnel. Plant construction activities will also generate work, increase needs for community services, and stimulate the local economy over the 20 year construction period. Construction will also cause moderate disruption of selected city streets and will slightly increase needs for school and hospital services.

Coal mining, and oil production and refining, are capital intensive operations which will not reflect significant changes in employment as a result of the shift from oil to coal. Additionally, the added coal consumption associated with cogeneration and district heating, over and above conventional electricity production methods, represents only about 20 percent of the total coal consumed by the MUS and as such does not create significant additional labor opportunities.

4 - FACTORS AFFECTING DISTRICT HEAT SYSTEM DEVELOPMENT

4.1 - Susitna Hydroelectric Development

The development of the hydroelectric capability of the Susitna River has been under study for about 20 years. The most comprehensive of these studies is now underway and Phase I is due to be completed in June 1982. If the most optimistic schedule of development is followed, without unanticipated delays due to intervenors, up to 400 megawatts of electric power could be on line by 1992 and another 800 megawatts could be available by 2005. This electric power would become available to the Fairbanks area through the proposed Railbelt intertie.

Although its actual costs are a function of the method which is chosen to fund the project, Susitna electric power should be less expensive than coal-fired power generation. The MUS generating plant may then be reduced to peaking and back-up status, providing electric energy to the Fairbanks area only when supplies from Susitna are unavailable. Susitna electric power will probably also be cost competitive with direct fired fossil fuels as a means of space heating residences and commercial structures, and might be low enough to compete with district heating when the combined effects of Susitna on the price of cogenerated electricity and heat are considered.

The relative costs of these options are very difficult to predict at this time, and monitoring of the Susitna power cost forecasts should continue during the district heating pilot leg test period.

4.2 - Anchorage-Fairbanks Railbelt Electrical Intertie

Plans are underway to complete an electrical transmission intertie between Anchorage and Fairbanks by 1985. The intertie will make between 35 and 50 megawatts of electric power available to the Fairbanks area; power which will be produced by spare, natural gas-fired generating capacity. The MUS may receive a share of the available power, which would reduce their need for future base load generation capacity. The MUS plant would then be used to provide primarily peak load generation and reserve margin for the inter-tied system.

The price of energy that could be delivered from the intertie in 1985 will be influenced by power supply agreements, line operating costs and government regulation. Such information is not available at this time but planning of the MUS plant development should not be finalized until firm energy prices for the proposed intertie are available.

4.3 - Oil and Natural Gas Prices

The Trans-Alaska oil pipeline is routed to the east of Fairbanks, with a spur feeding a 25,000 barrel per day refinery at North Pole. Oil refined here is presently sold for home heating at approximately \$1.08/gallon - a price similar to that being charged in the lower 48 states.

A pipeline carrying natural gas is scheduled to be operational in the mid 1980's. The gas pipeline will parallel the oil pipeline and could, if the State authorities request, include a spur capable of delivering natural gas to the Fairbanks area.

The State of Alaska may decide to make its royalty gas and oil available to the residents of the State at a price considerably lower than the world market price. If this occurs, the cost of direct fired space heating, and

electricity production from gas turbines could become more attractive than the operation of the coal-fired MUS cogeneration plant.

The Federal government's Fuel Use Act prohibits the use of oil and natural gas fuels for base load electric power generation, however, unless it is used in a cogeneration process. So if these fuels do become economically attractive, district heating may be a prerequisite to their use for electric power production.

4.4 - Availability and Price of Coal

Coal consumed in the MUS power plant and other Fairbanks area plants is produced from the Nenana coal field at Healy. The field has an estimated 95 million tons potential of surface stripping coal and underground mining could bring the total resources to above 2 billion tons. The Usibelli Coal Company mines the coal at a present rate of 700,000 tons/year. The coal is trucked 8 miles to Suntrana where it is loaded on gondola cars for transport 111 miles to Fairbanks.

The coal is sub-bituminous, with a price delivered to the MUS plant of about \$1.55 per million Btu. This compares to \$1.46 for coal in the Pacific northwest and California region of the lower 48 states and \$7.20 for fuel oil in Fairbanks. MUS has a long term contract for coal from the Usibelli Coal Company at a rate subject to some limiting factors which result in good long term prices to the City.

Expansion plans for Healy coal propose a doubling of present production levels which would result in a life for the surface mined operation of 65 years (with no further production expansion) and an extended life of 1400 years if underground resources are included.

No other significant coal sources exist local to Fairbanks. It is not expected that large scale electric generation will occur using Healy coal,

as the Beluga coal field appears to be more convenient to major electric loads and about four times as much coal is recoverable there by low cost surface stripping methods.

It would seem from the above information that Healy coal should be available to Fairbanks in the required quantities and at competitive prices for the foreseeable future. It should therefore be a satisfactory source of energy upon which to base the district heating system development.

4.5 - Alternative Fuels

Several alternative fuels are available in the Fairbanks area for generation of heat:

- o Wood and wood products waste
- o Peat
- o Miscellaneous vegetation
- o Combustible solid waste (refuse)

Considerable advances have been made in recent years on the technology of combusting these fuels and converting the available heat to useful purposes. The quantity of refuse produced in greater Fairbanks should make steam production technically feasible. The economic feasibility will depend on plant operating and maintenance costs, the revenues obtained from generated heat, and the price charged for disposal.

A refuse fired heat plant could be constructed near the existing solid refuse disposal facilities. If future expansion of MUS electricity generating capability takes place at a new site, the refuse burning operation could be relocated there also.

4.6 - MUS Plant Expansion

The MUS plant is located near the center of the city's heat and power service territory and convenient to supplies of cooling water. Expansion of the plant to match projected demands will require additional space for new boiler and turbine plant. This new equipment can be accommodated at the existing plant site if bulky emission control systems, such as scrubbers and particulate removal baghouses are not required. Should these emission control components be necessary, relocation of the adjacent maintenance facilities or water plant would be required in order to provide the necessary space.

The existing plant location also cannot easily accommodate expanded coal unloading and storage that will be required in conjunction with plant growth. One, or possibly two new rail sidings would have to be built, and coal storage area would have to be increased appreciably. Space is presently limited on the North side of the Chena River. Plans for a revision to the road system in the railroad industrial park area may restrict an already limited coal unloading area.

There appear to be potential new plant sites near the city from which heat and power could be economically transmitted. However, a new MUS plant site would require considerable additional capital expenditure for site development, structures, equipment and transmission systems. Operating costs would also increase initially due to duplication of staff and other services until the existing site is abandoned.

Information regarding the feasibility of expanding the MUS plant at the present site is important to district heat economics. A permit application should be made soon for installation of new boiler equipment. The application can also be organized to test the State emission regulations with regard to cogeneration systems. This permit application will also give State environmental authorities an opportunity to review MUS plans for thermal discharges into the Chena River. If concern is raised over thermal discharges, future generation additions may have to resort to air cooling

rather than river water cooling. This constraint may even apply to the cogeneration turbines which discharge much less heat through condensers than conventional turbines such as Chena 5.

Ice fogging conditions in Fairbanks are aggravated by warm water discharges from MUS plant steam turbine condensers. If the district heat system load could be increased considerably and extraction steam turbines were used to produce electric power and heat, warm water discharges would be correspondingly reduced. The result would be less ice fog and more efficient fuel use. Alternatively, if a portion of the MUS plant electrical load could be removed, a better heat/electric balance would result. In either case, it is very difficult to quantify the reduction in ice fog production which would result from the development of district heating. All that can be stated with assurance is that less heat would be discharged to the river, and river-generated ice fog will be reduced.

TABLE 1

MUS ELECTRICAL PEAK DEMAND
PROJECTION OF FUTURE GROWTH

<u>Year</u>	<u>Peak Demand</u>
1980	25.2 MW
1983	27.3 MW
1985	30.0 MW
1988	35.2 MW
1990	37.6 MW
1992	41.5 MW
1997	52.0 MW
2000	58.4 MW

Figures based on MUS projections through 1990, and percentage growth rates for the time frame 1990 through 2000 extracted from the report titled "Electric Power Consumption in the Railbelt" prepared by the Institute for Social and Economic Research.

TABLE 1

TABLE 2

PROJECTIONS OF THERMAL LOAD GROWTH
DISTRICT HEATING DEVELOPMENT PLAN
TARGET AREA

<u>Year</u>	<u>Yearly Energy Use Btu x 10⁹</u>	<u>Peak Demand Btu x 10⁶</u>
1980	1369	390
1985	1587	452
1990	1831	524
1995	2132	607
2000	2473	704

NOTES:

- o Target area represented as Sections A, B, C, D, E, of Figure 1.
- o Yearly energy use and peak demand escalated by 3 percent per year, reflecting population and energy density changes in the target area.
- o Peak demand calculated from load duration data (Figures 1 - 3) and yearly energy use above.

TABLE 2

TABLE 3

DISTRICT HEATING SYSTEM
CAPITAL COST ESTIMATE

SUMMARY

<u>Account No.</u>	<u>Item</u>	<u>\$1,000</u>
1.0	Boiler Plant	
1.1	Boilers No. 6 and No. 7	31,715
1.2	Boiler No. 8	25,510
1.3	Chenal 6 WHRB	4,610
1.4	Coal Handling Facilities	2,590
2.0	Turbine-Generator Plant	
	Turbines 7 and 8	20,800
3.0	DH System	
3.1	Heat Station and Exchangers	1,395
3.2	Pumphouse	1,540
3.3	Distribution Piping System	37,335
3.4	Backup Heat Supply	3,750
3.5	User Installations	<u>17,520</u>
		146,765 (1981)

TABLE 3

TABLE 4
(Revised 2/23/81)

SUMMARY - DISTRICT HEATING SYSTEM ECONOMICS

(Millions of 1981 Dollars, No Escalation)

Column	1	2	3	4	5	6	7	8
	Heat Use	Cogenerated Electricity Production	Total System Costs	Electric Value	Heat Revenue Required	District Heat Tariff	Oil Savings	Oil User Savings
Year	Btu x 10 ⁹	kWh x 10 ⁶	\$ x 10 ⁶	\$ x 10 ⁶	\$ x 10 ⁶	\$/10 ⁶ Btu	Gal x 10 ⁶	\$ x 10 ⁶
1982	197	15.0	2.03	.30	1.73	8.78	.268	+ .09
1983	197	15.0	2.19	.30	1.89	9.59	.268	+ .07
1984	197	15.0	2.65	.30	2.35	11.93	.268	+ .02
1985	197	15.0	4.08	.30	3.78	19.19	.268	- .14
1986	197	184.0	9.12	5.52	3.60	18.27	.268	- .12
1987	289	201.5	9.98	6.05	3.93	13.60	1.253	- .08
1988	482	211.7	11.35	6.35	5.00	10.37	3.373	+ .67
1989	495	214.9	12.02	6.45	5.57	11.25	3.516	+ .45
1990	683	218.8	12.69	6.56	6.13	8.98	5.582	+ 1.75
1991	867	224.0	13.62	6.72	6.90	7.96	7.604	+ 3.02
1992	1,029	226.7	15.65	6.80	8.85	8.60	9.384	+ 3.24
1993	1,204	275.4	19.40	8.26	11.14	9.25	11.307	+ 3.30
1994	1,239	289.3	19.63	8.68	10.95	8.84	11.692	+ 3.81
1995	1,432	303.9	20.95	9.12	11.83	8.62	13.813	+ 4.75
1996	1,625	316.6	21.39	9.50	11.89	7.32	15.933	+ 7.18
1997	1,896	329.2	22.42	9.88	12.54	6.61	18.912	+ 9.62
1998	2,076	343.1	23.13	10.29	12.84	6.18	20.890	+11.36
1999	2,142	357.7	23.78	10.73	13.05	6.09	21.615	+11.92
2000	2,203	369.7	24.10	11.09	13.01	5.91	22.285	+12.61

Average district heat tariff = \$ 7.89/10⁶ Btu delivered.
Equivalent oil-fired furnace cost = \$12.82/10⁶ Btu delivered.

NOTES TO TABLE 4

- Column 1. Heat use is based on a typical year (taken to be 1978), with 100 percent hookup of areas served by the district heat system.
- Column 2. Electrical production is based on 95 percent availability of turbines between 1986 and 1993 to generate power and heat whenever heat is required. Production from Chena 4, 5 or 6 turbine generators is not included.
- Column 3. Total annual costs to own and operate district heating system, excluding administrative costs (billing, accounting, customer relations). Includes additional costs of cogenerating electric power for sale through electric system.
- Column 4. Electricity value based on estimated in-plant cost of generating electric power using a condensing turbine generator. 2¢/kWh through 1985, 3¢/kWh after 1985.
- Column 5. District heat system revenue required to break even. (Annual costs of column 3 less credits of column 4.)
- Column 6. Column 5 divided by column 1.
- Column 7. Oil savings accrued by switching from point-of-use oil furnaces operating at 63 percent efficiency to district heat. No. 2 oil at 130,000 Btu/gal (LHV).
- Column 8. Total dollars saved by oil users converted to district heat at annual tariff rate of column 6.

TABLE 5
(Revised 2/23/81)

ENVIRONMENTAL EFFECTS OF DISTRICT HEATING DEVELOPMENT

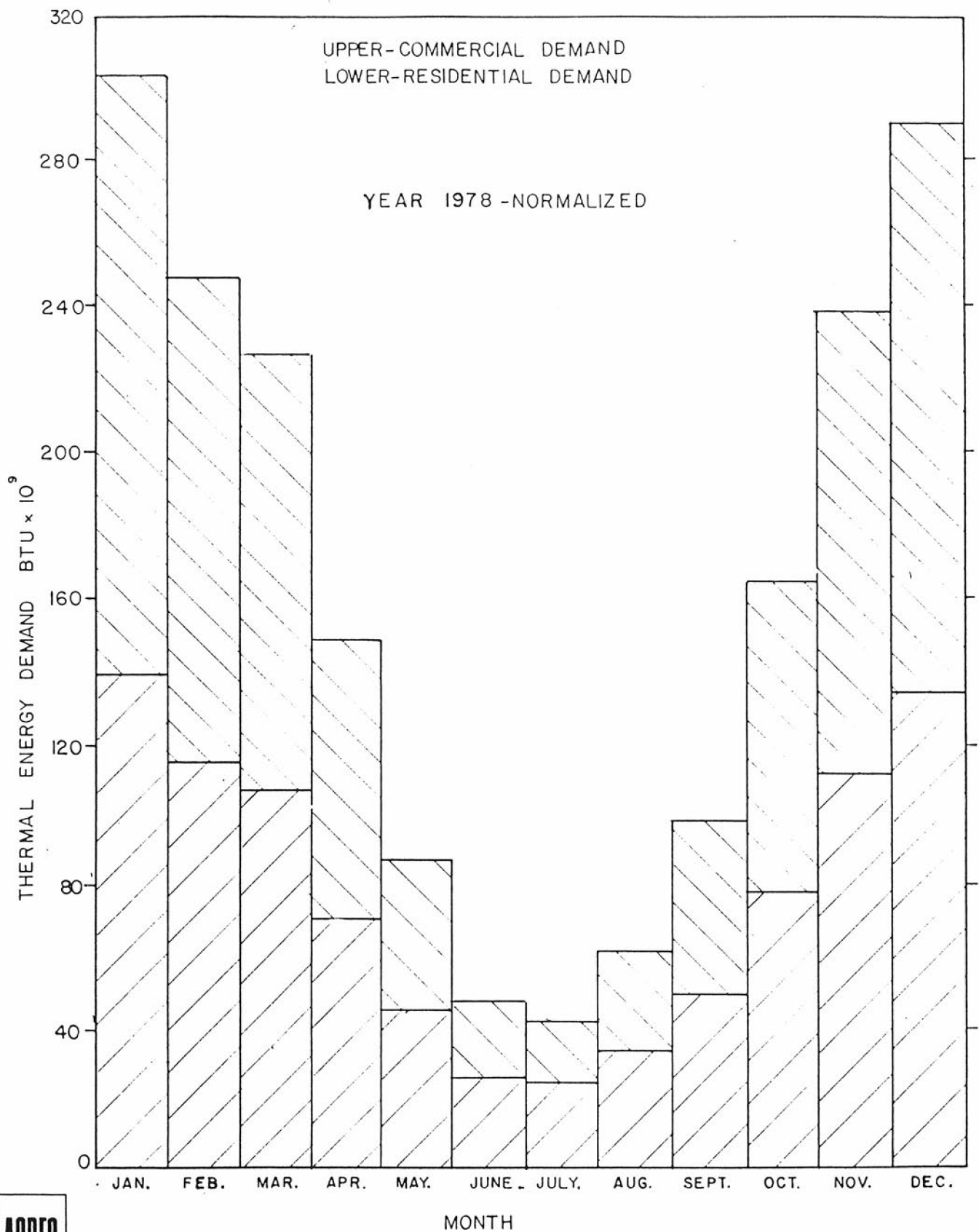
Column	1	2	3	4	5	6
	Total Coal Used, Heat and Power Tons	Coal Required for District Heating Tons	Oil Saved Gallons	District Heat Emissions Impact		
Year				SO _x Tons	NO _x Tons	Particulates Tons
1981	27,000	+ 1,500	268,400	- 2.17	1.65	2.23
1982	27,000	+ 1,500	268,400	- 2.17	1.65	2.23
1983	27,000	+ 1,500	268,400	- 2.17	1.65	2.23
1984	27,000	+ 1,500	268,400	- 2.17	1.65	2.23
1985	27,000	+ 1,500	268,400	- 2.17	+ 1.65	+ 2.23
1986	171,000	- 3,900	268,400	- 11.92	-12.99	- 7.03
1987	177,000	-13,400	1,253,100	- 46.98	-47.59	-24.55
1988	198,000	- 1,400	3,373,800	- 63.90	-34.15	- 6.22
1989	199,000	- 3,200	3,516,200	- 69.74	-40.32	- 9.89
1990	209,000	+ 3,300	5,582,300	- 95.58	-41.30	- 1.32
1991	224,000	+13,800	7,604,600	-113.42	-31.04	+14.56
1992	231,000	+18,400	9,384,600	-137.50	-34.60	+19.83
1993	305,000	+49,300	11,307,700	-116.70	+31.83	+49.28
1994	315,000	+47,000	11,692,300	-127.85	+22.14	+45.84
1995	345,000	+64,100	13,813,100	-135.57	+49.39	+65.18
1996	353,000	+60,900	15,933,800	-179.92	+21.64	+58.41
1997	375,000	+71,700	18,912,300	-214.60	+24.10	+68.69
1998	392,000	+76,400	20,890,000	-242.10	+19.03	+72.16
1999	412,000	+83,500	21,615,400	-242.47	+31.75	+80.38
2000	421,000	+81,900	22,285,400	-257.55	+21.38	+77.49

(-) values indicate decrease in net emissions.

NOTES TO TABLE 5

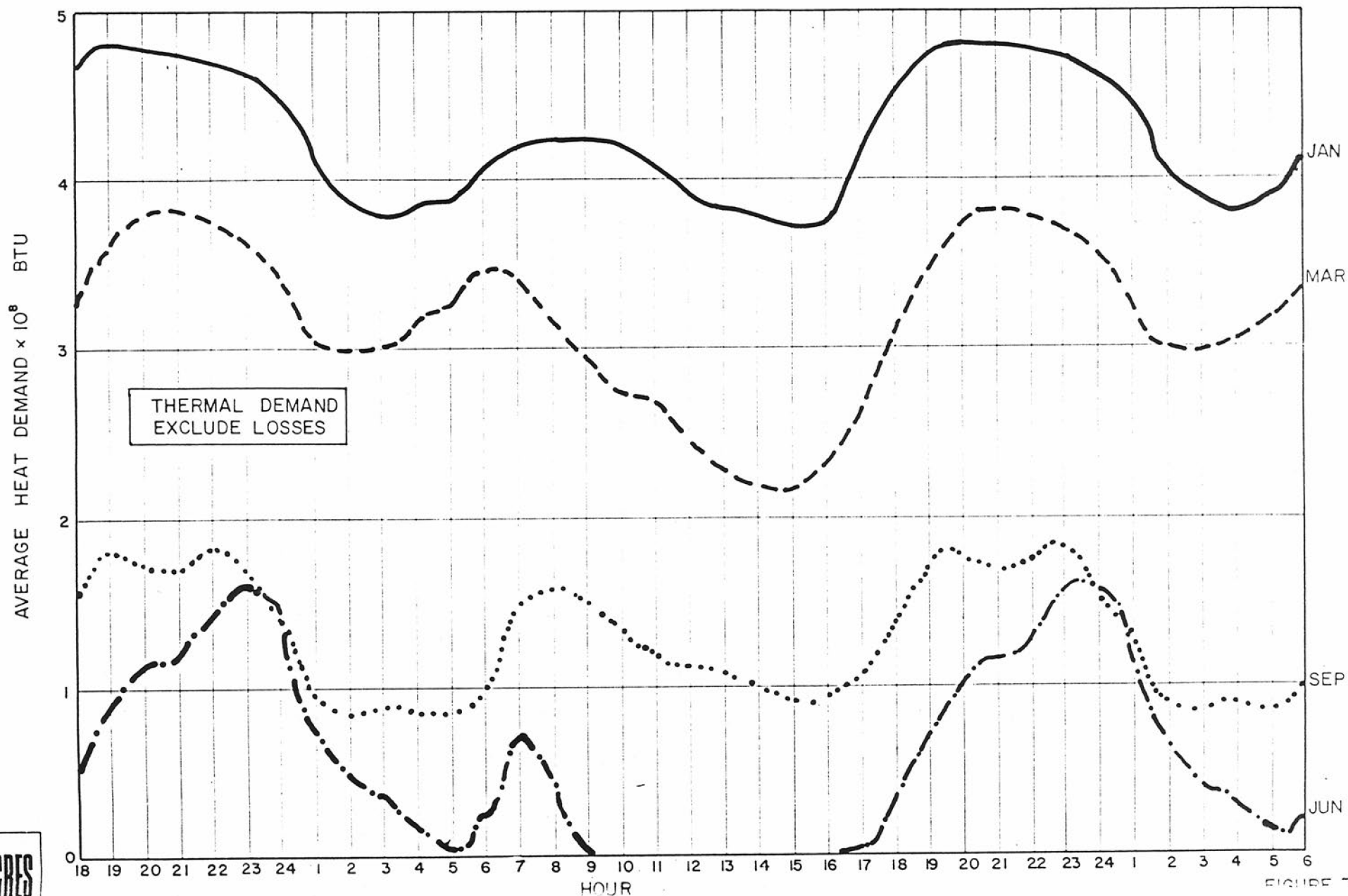
- Column 1. Coal used to provide heat and generate electric power using district heat cogeneration turbines only. Coal required to provide steam exclusively for electric power production (in Chena 5 turbine) is not included.
- Column 2. Coal required if all electric power was produced at the 14,500 Btu/kWh heat rate of Chena 5 turbine at average load.
- Column 4. Based on sulfur content of Nenana Poker Flat #6 coal, vs .25 percent sulfur content of home heating oil.
- Column 5. NO_x emissions for coal boilers based on measurements taken by MUS plant staff on Chena 5 boiler. Oil furnace NO_x levels based on EPA data.
- Column 6. Particulates emissions based on State standards for coal-fired boilers, and EPA data for oil furnace operation.

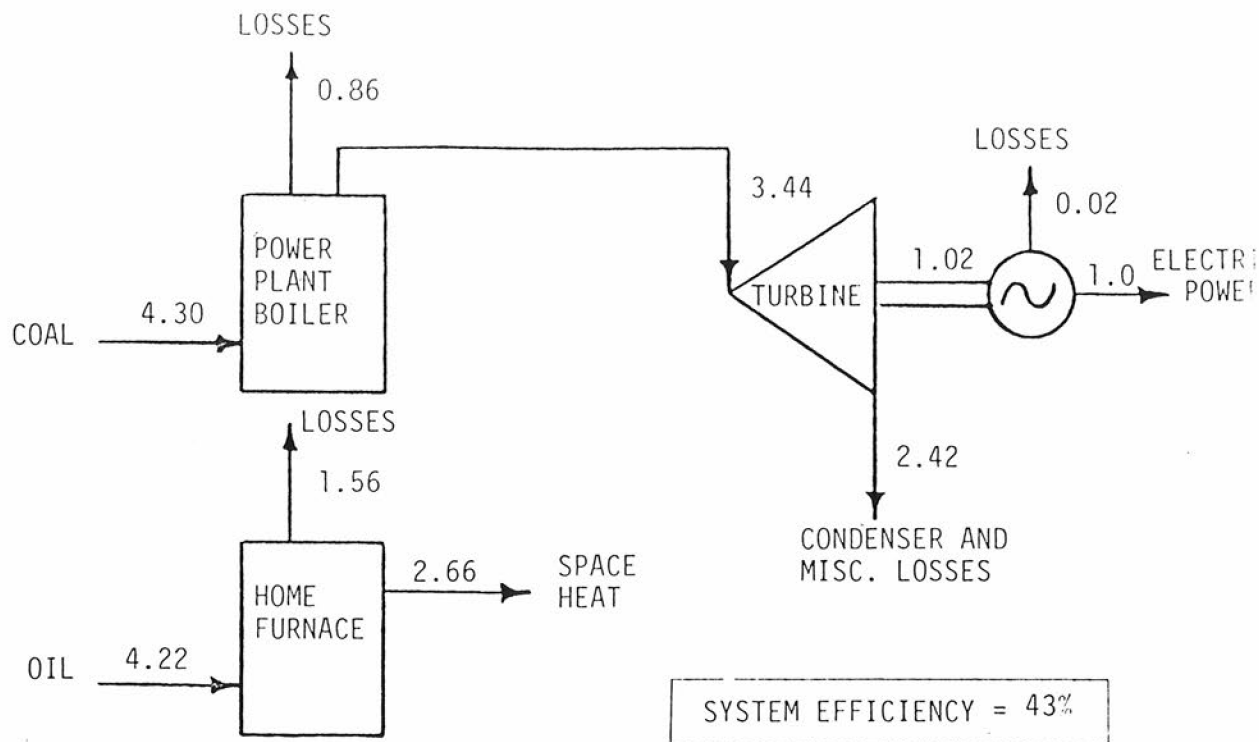
CITY OF FAIRBANKS MONTHLY HEATING DEMAND



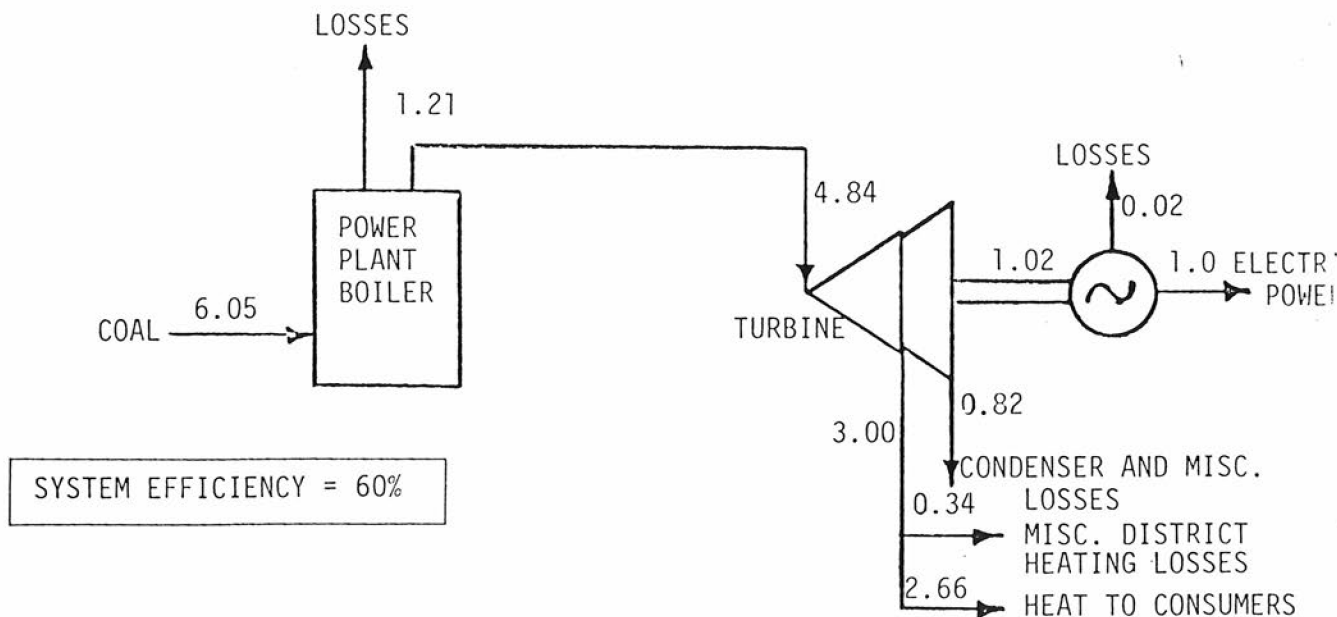
DAILY THERMAL DEMAND PROFILE FOR SELECTED MONTHS

CITY OF FAIRBANKS , ESTIMATED - 1978 DATA





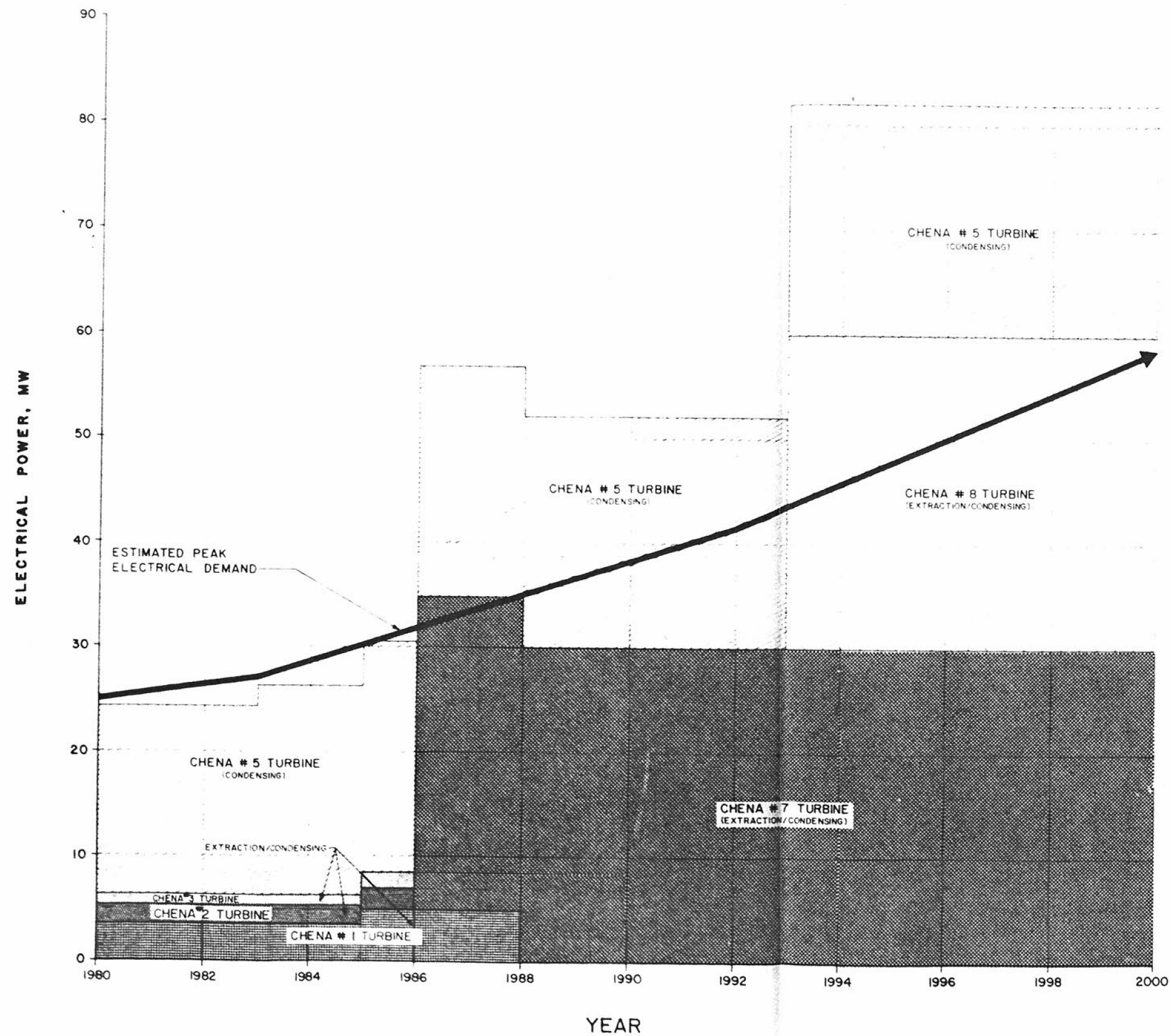
SEPARATE HEAT AND ELECTRICITY PRODUCTION



HEAT AND ELECTRICITY COGENERATION PLANT

COMPARISON OF ENERGY REQUIREMENTS FOR
EXISTING AND COGENERATION SYSTEMS
TYPICAL OFF-DESIGN CONDITION

FIGURE 4



NOTES

1 RESERVE CAPACITY -- OIL FIRED

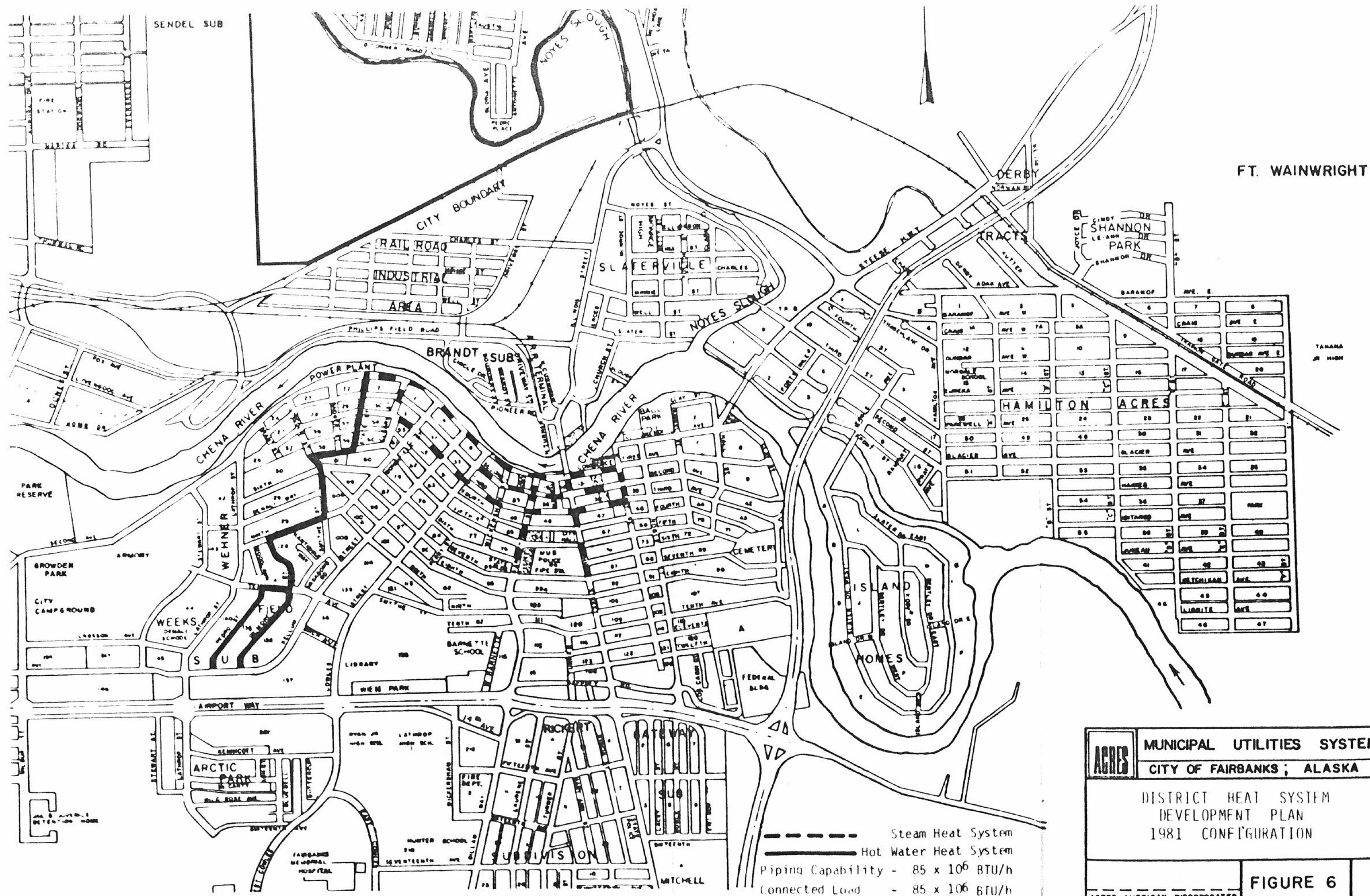
CHENA #6 -- GAS TURBINE -- 29 MW -- PEAK WINTER
-- 23 MW -- PEAK SUMMER

CHENA #4 -- GAS TURBINE -- 65 MW -- PEAK WINTER
-- 52 MW -- PEAK SUMMER

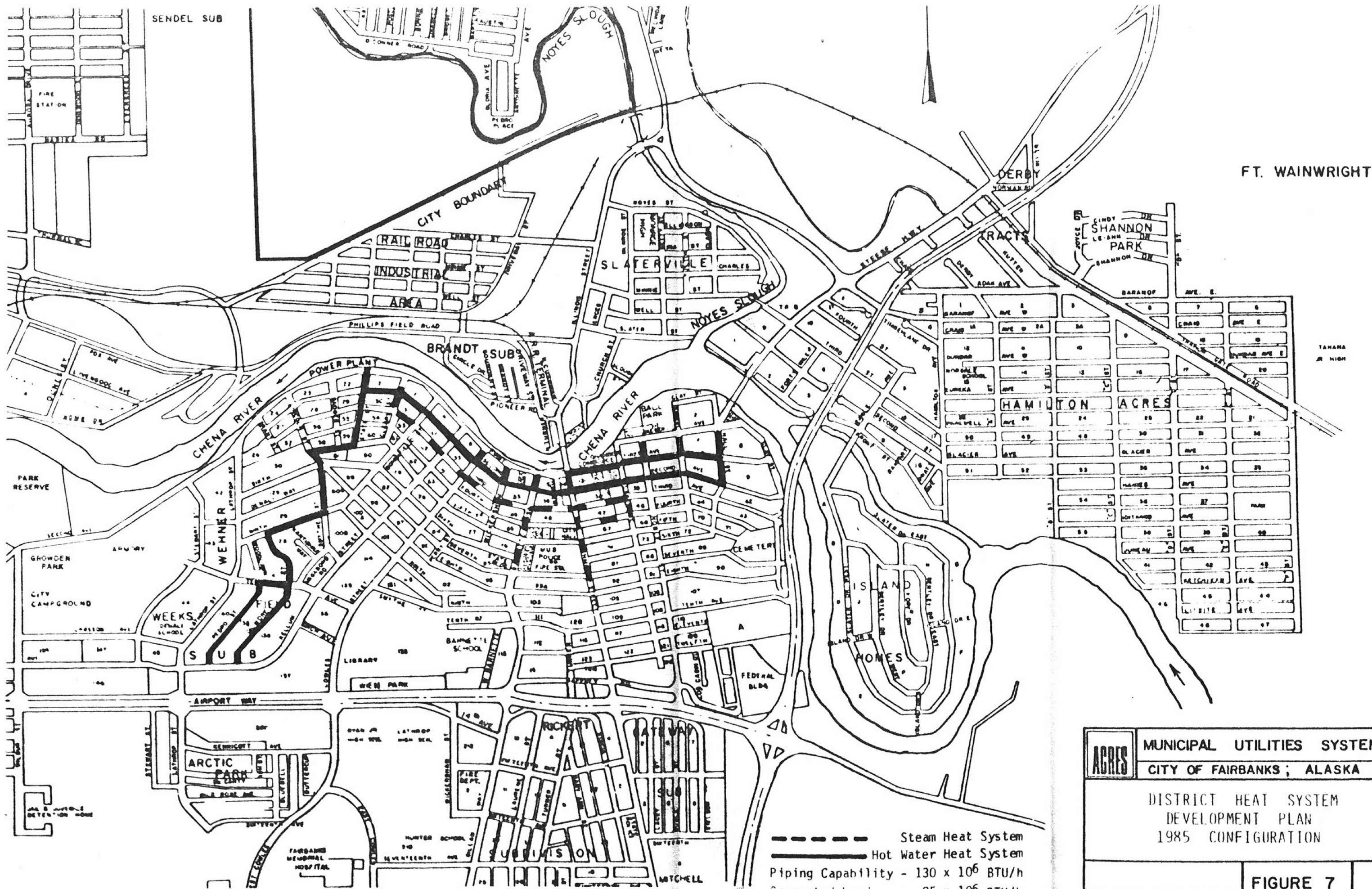
2 RESERVE CAPACITY -- COAL FIRED

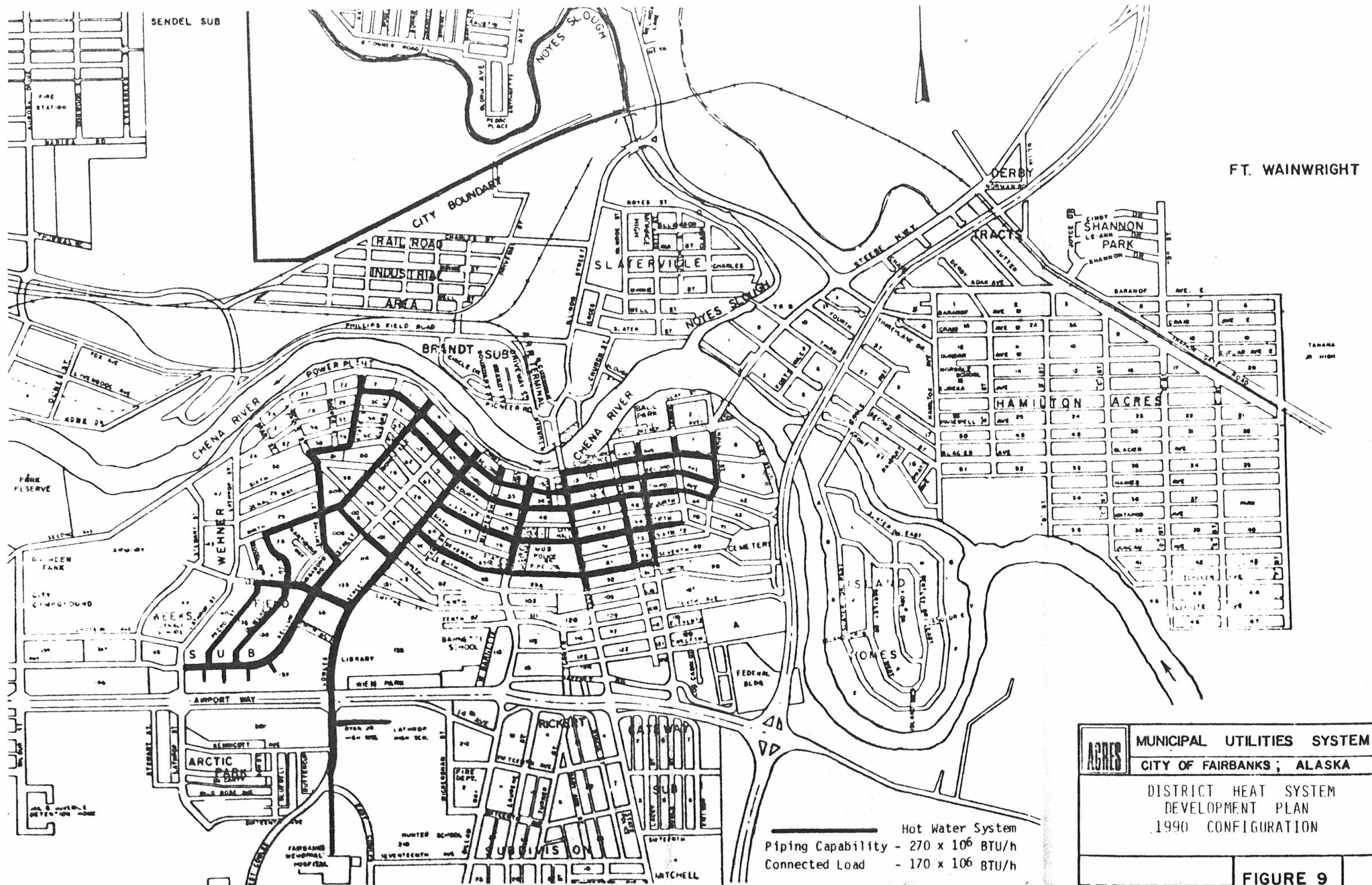
CHENA #2 + CHENA #3 -- STEAM TURBINES -- 3.5 MW PEAK
IN RESERVE 1986-1988

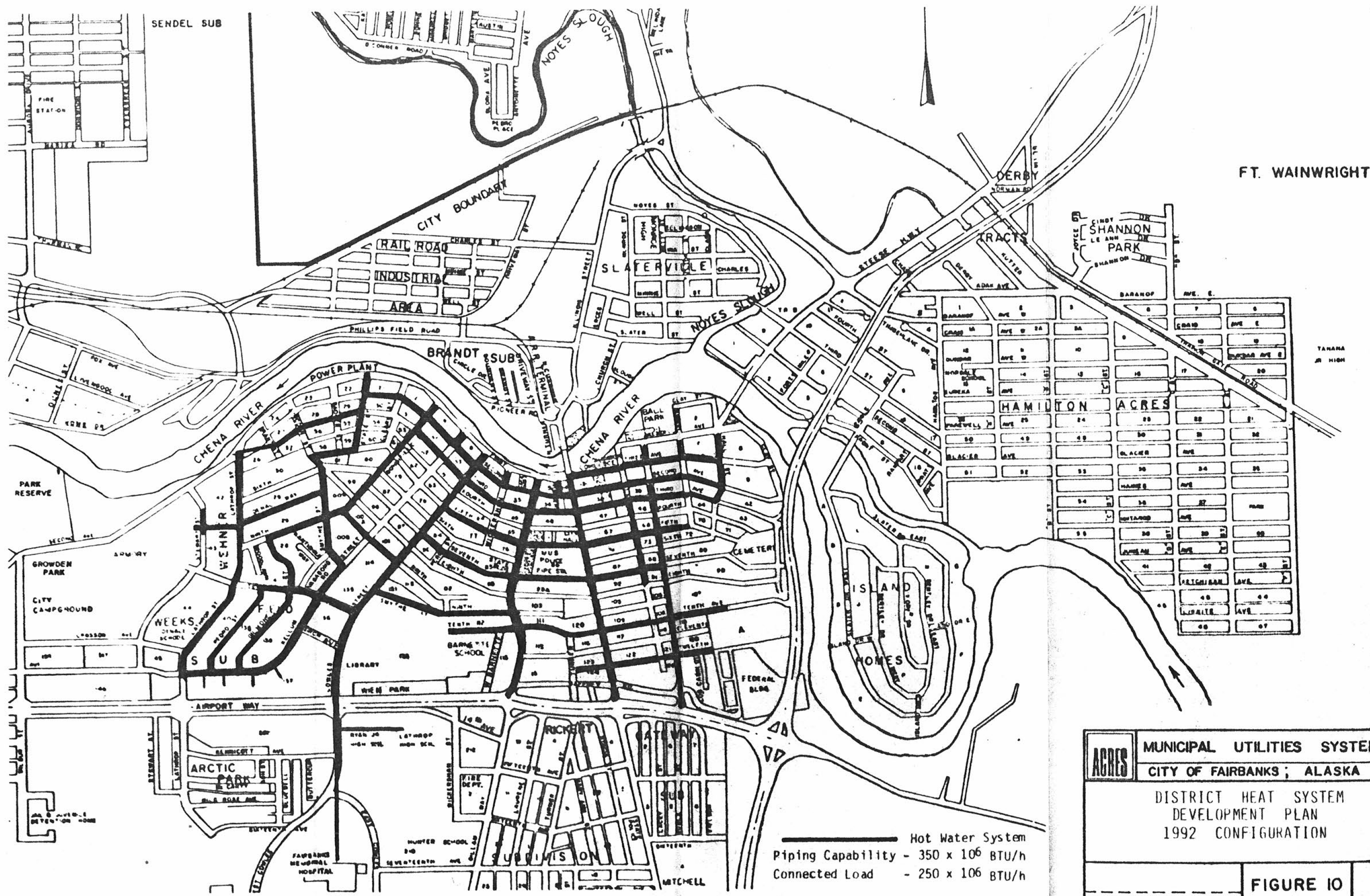
1/15/81	C	REVISED TURBINE CAPABILITIES	N.B.
2/5/81	B	ISSUED FOR APPROVAL	
4/9/81	A	ISSUED FOR INFORMATION	AG/HA
DATE	NO	REVISIONS	BY CHK PROJ APPR (ENR)
MUNICIPAL UTILITIES SYSTEM			
CITY OF FAIRBANKS, ALASKA			
HOT WATER DISTRICT HEATING SYSTEM			
DEVELOPMENT PLAN			
ELECTRICAL LOAD GROWTH AND			
GENERATION CAPACITY EXPANSION			
DATE DECEMBER 30, 1980		SCALE NONE	
DEPARTMENT		DRAWING NO	
ACRES AMERICAN INCORPORATED		FIGURE 5	
PROJECT		SHEET 2 OF 2	
		REV C	



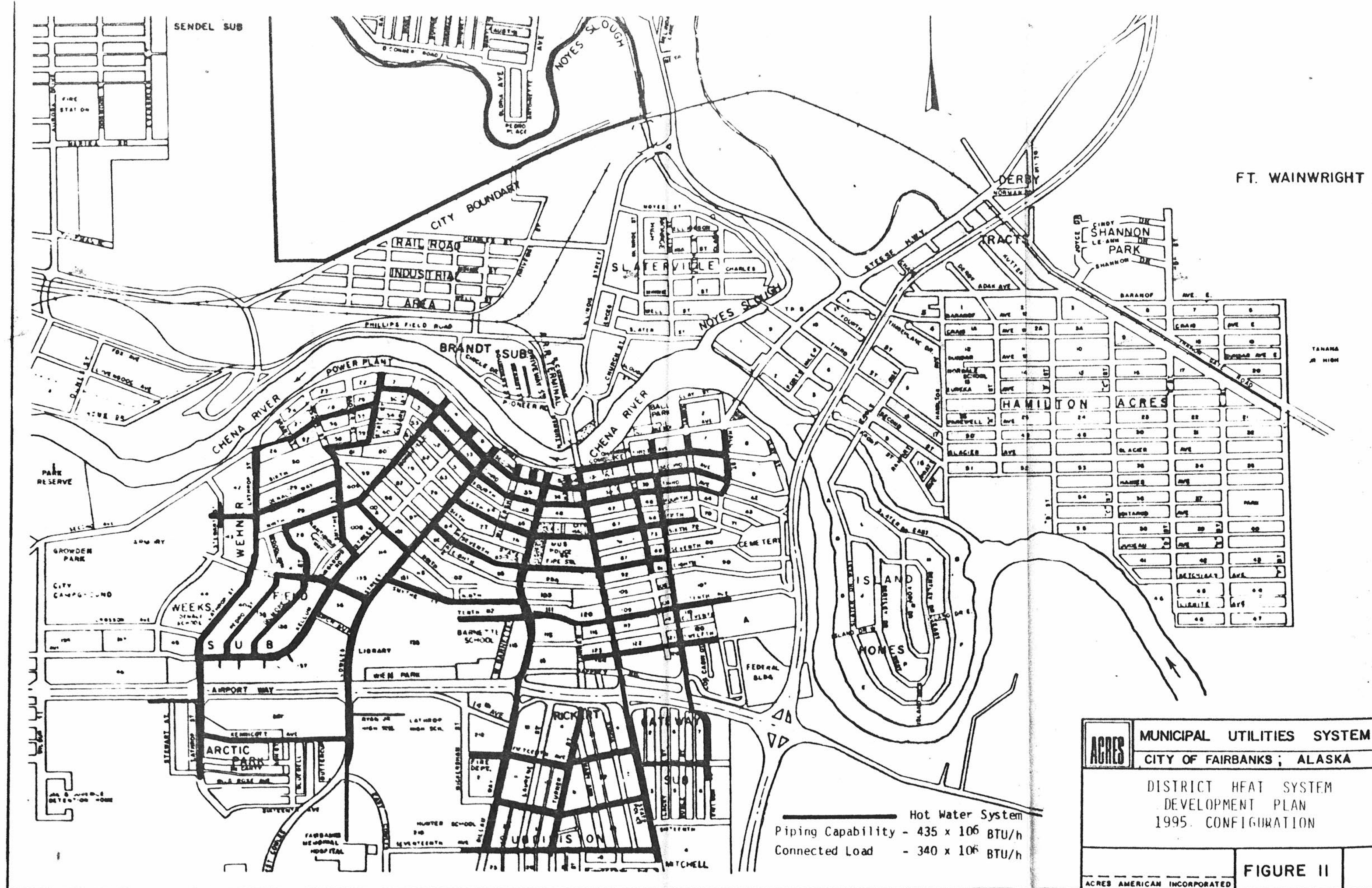
ACRS	MUNICIPAL UTILITIES SYSTEM	
	CITY OF FAIRBANKS ; ALASKA	
	DISTRICT HEAT SYSTEM DEVELOPMENT PLAN 1981 CONFIGURATION	
ACRS AMERICAN INCORPORATED		FIGURE 6

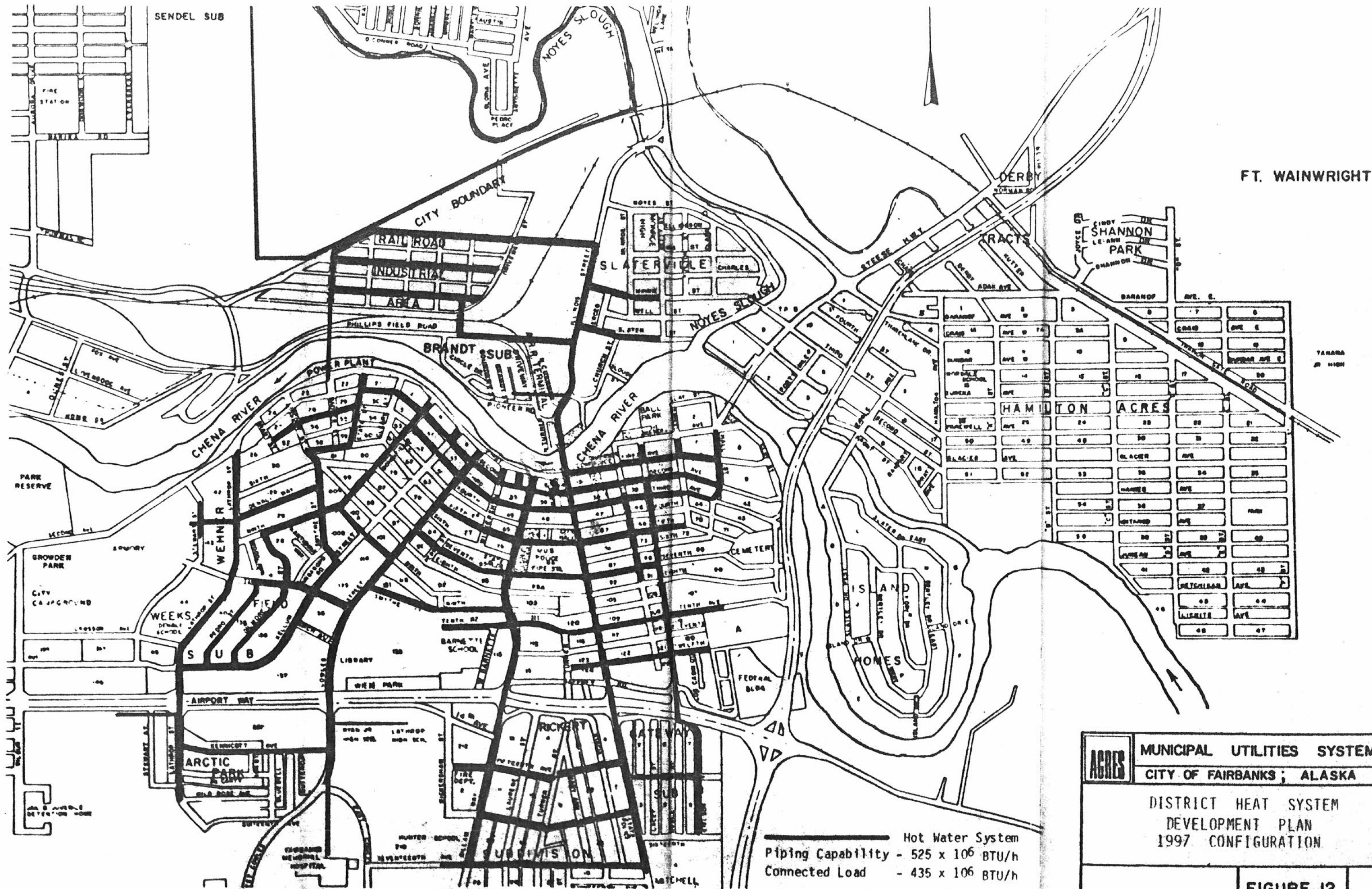






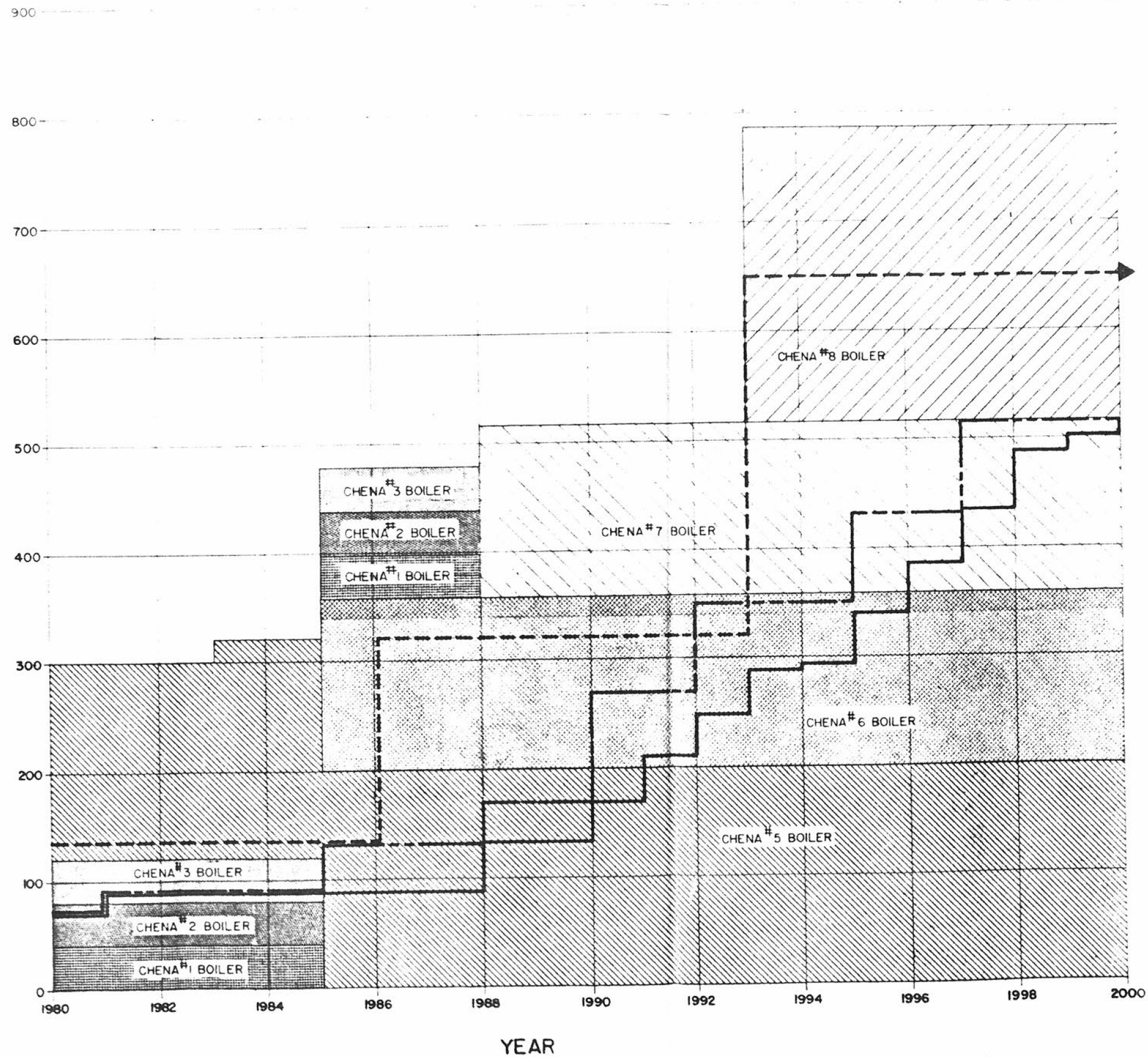
ACRES	MUNICIPAL UTILITIES SYSTEM	
	CITY OF FAIRBANKS ; ALASKA	
	DISTRICT HEAT SYSTEM DEVELOPMENT PLAN 1992 CONFIGURATION	
ACRES AMERICAN INCORPORATED		FIGURE 10





ACRES	MUNICIPAL UTILITIES SYSTEM
	CITY OF FAIRBANKS ; ALASKA
	DISTRICT HEAT SYSTEM DEVELOPMENT PLAN 1997 CONFIGURATION
FIGURE 12	
ACRES AMERICAN INCORPORATED	

——— DISTRIBUTION SYSTEM CAPACITY, BTU $\times 10^6$ /hr
 ——— PROJECTED THERMAL DEMAND, BTU $\times 10^6$ /hr
 - - - EXTRACTION SYSTEM CAPABILITY, BTU $\times 10^6$ /hr

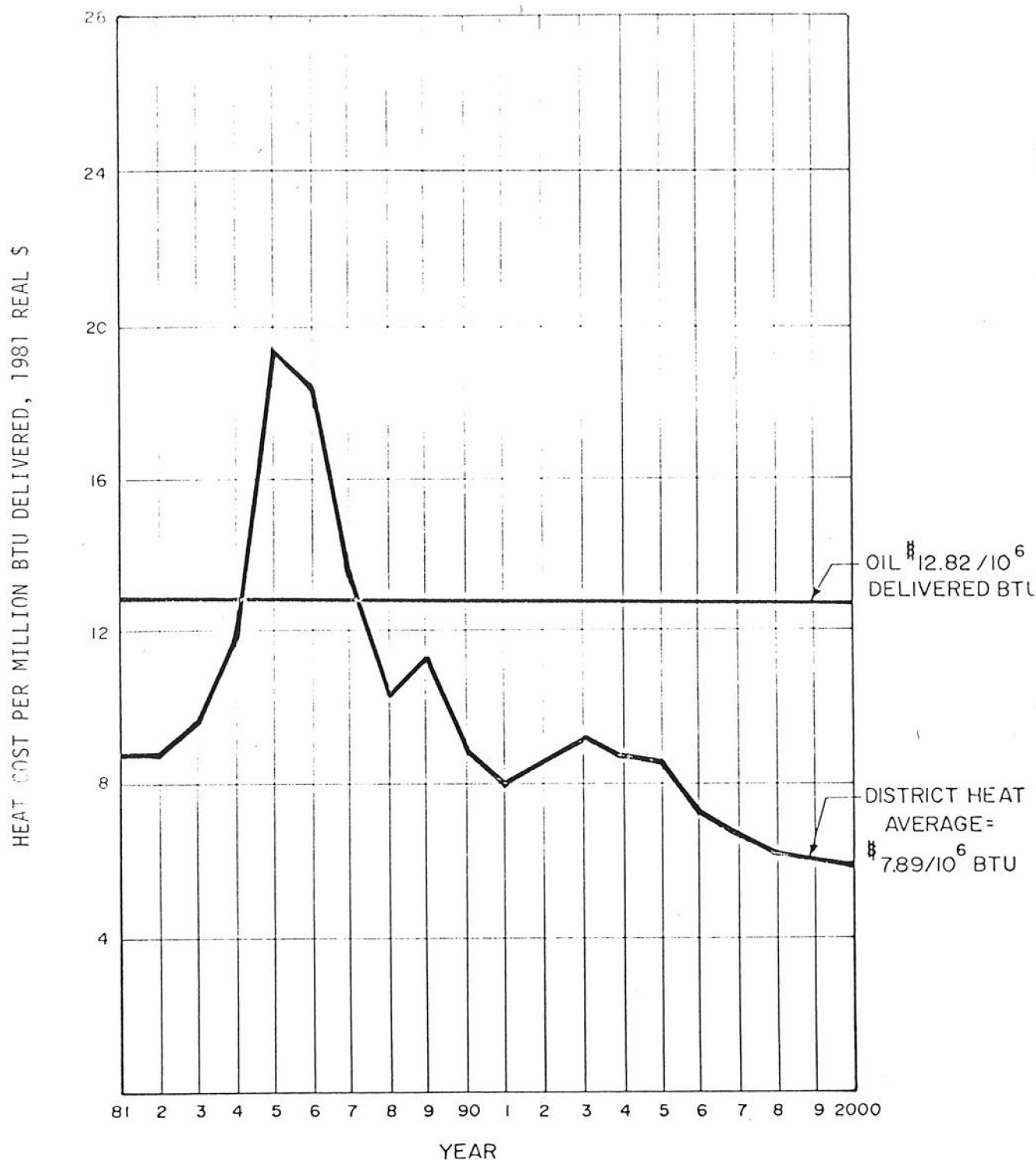


NOTES

RESERVE STEAM CAPACITY

- GT CHENA #4 — WASTE HEAT RECOVERY BOILER
 — 30,000 lbs/hr AT 600 ps, 720°F
 — AVAILABLE 1980
 GT CHENA #5 — WASTE HEAT RECOVERY BOILER
 — 161,900 lbs/hr AT 850 ps, 900°F
 — REQUIRED 1986

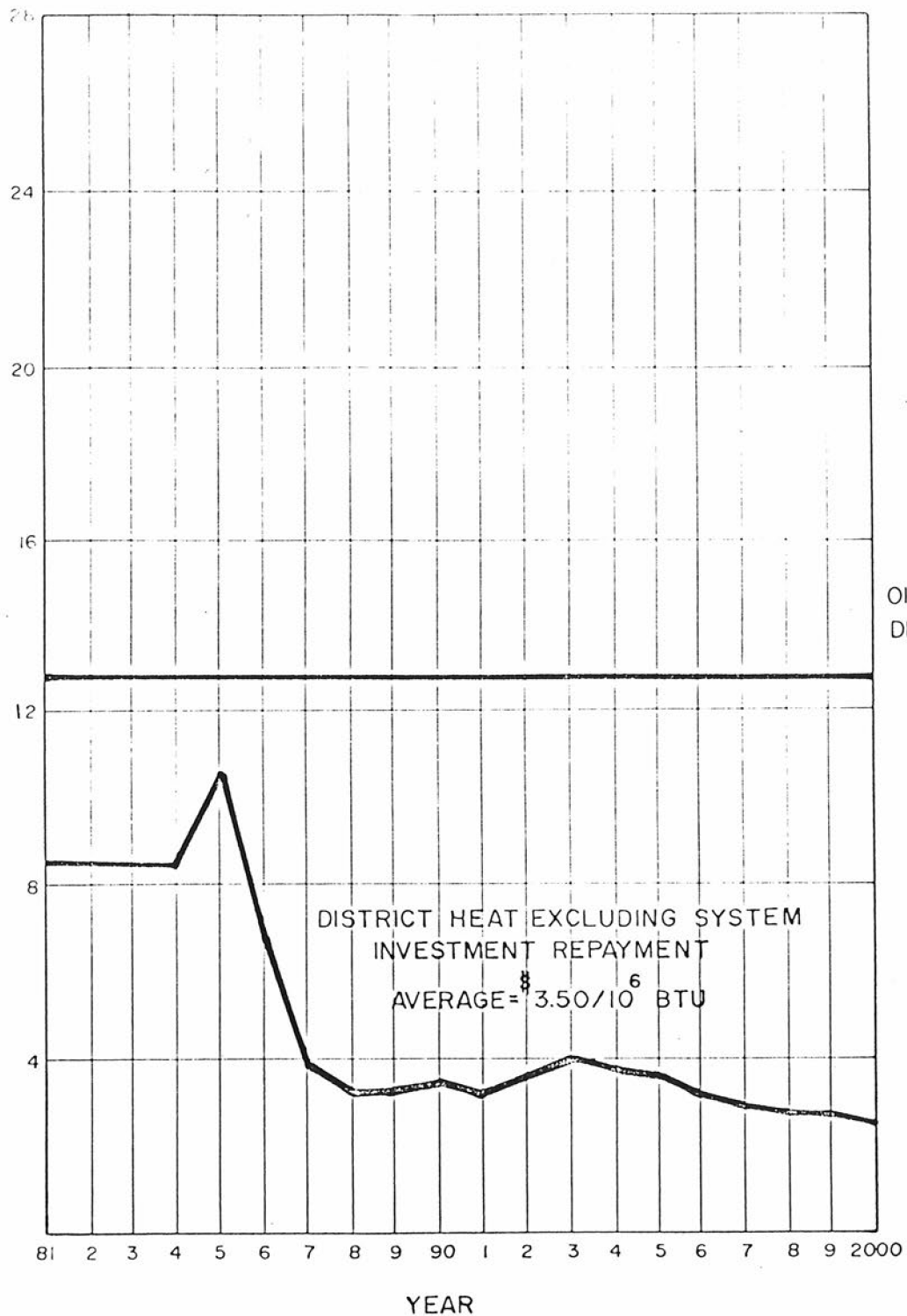
DATE	2/5/80	REVISIONS	1	BY	CHK	APP	15
MUNICIPAL UTILITIES SYSTEM							
CITY OF FAIRBANKS, ALASKA							
HOT WATER DISTRICT HEATING SYSTEM							
DEVELOPMENT PLAN							
DISTRICT HEAT SYSTEM CAPABILITY							
AND DEMAND GROWTH SCHEDULE							
DATE	DECEMBER 30, 1980	SCALE	NONE				
DEPARTMENT			FIGURE	14			
PROJECT			SHEET	OF			



HOME FURNACE EFFICIENCY
ASSUMED TO BE 63%

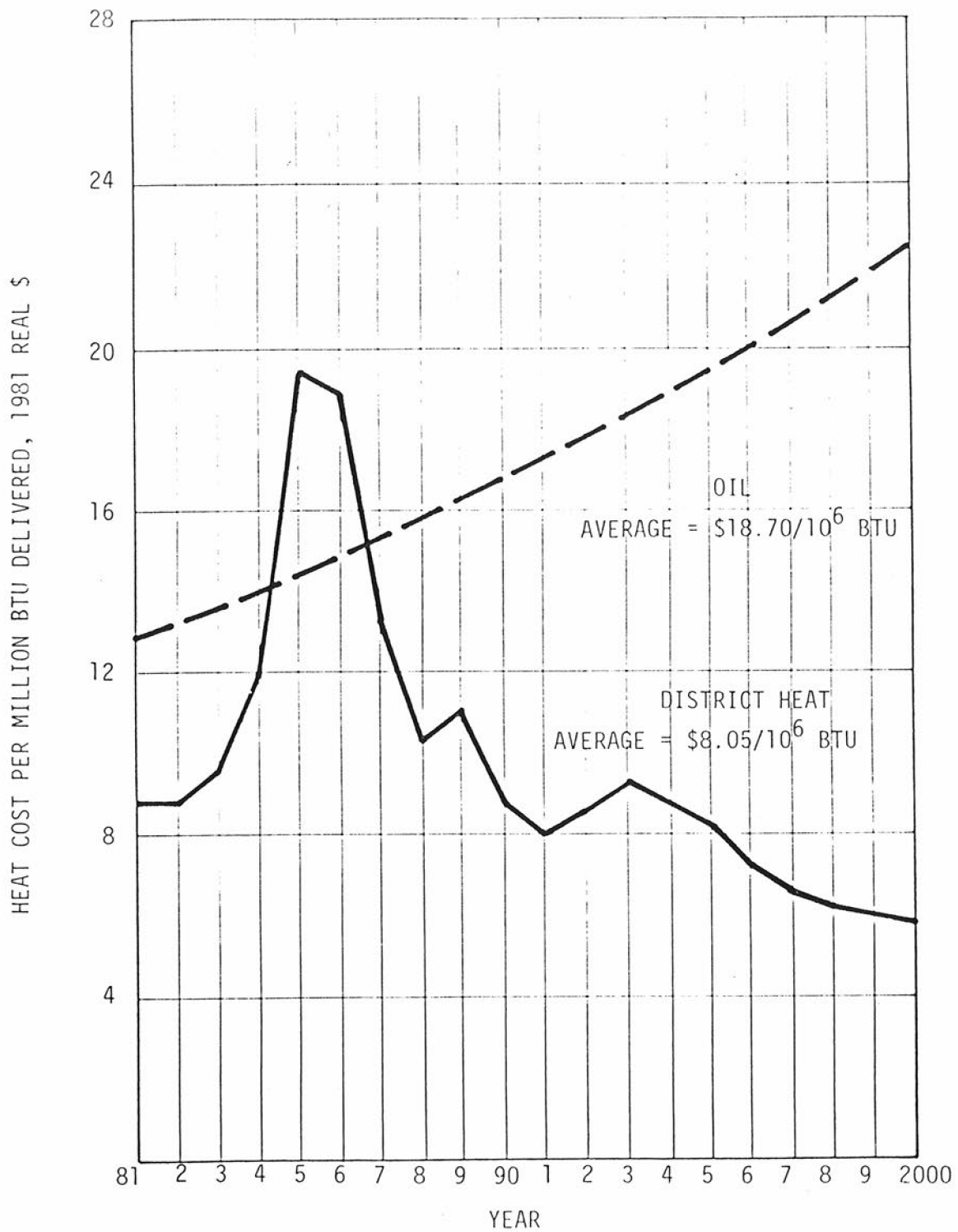
COMPARISON OF OIL FURNACE AND
DISTRICT HEATING COSTS

HEAT COST PER MILLION BTU DELIVERED, 1981 REAL \$



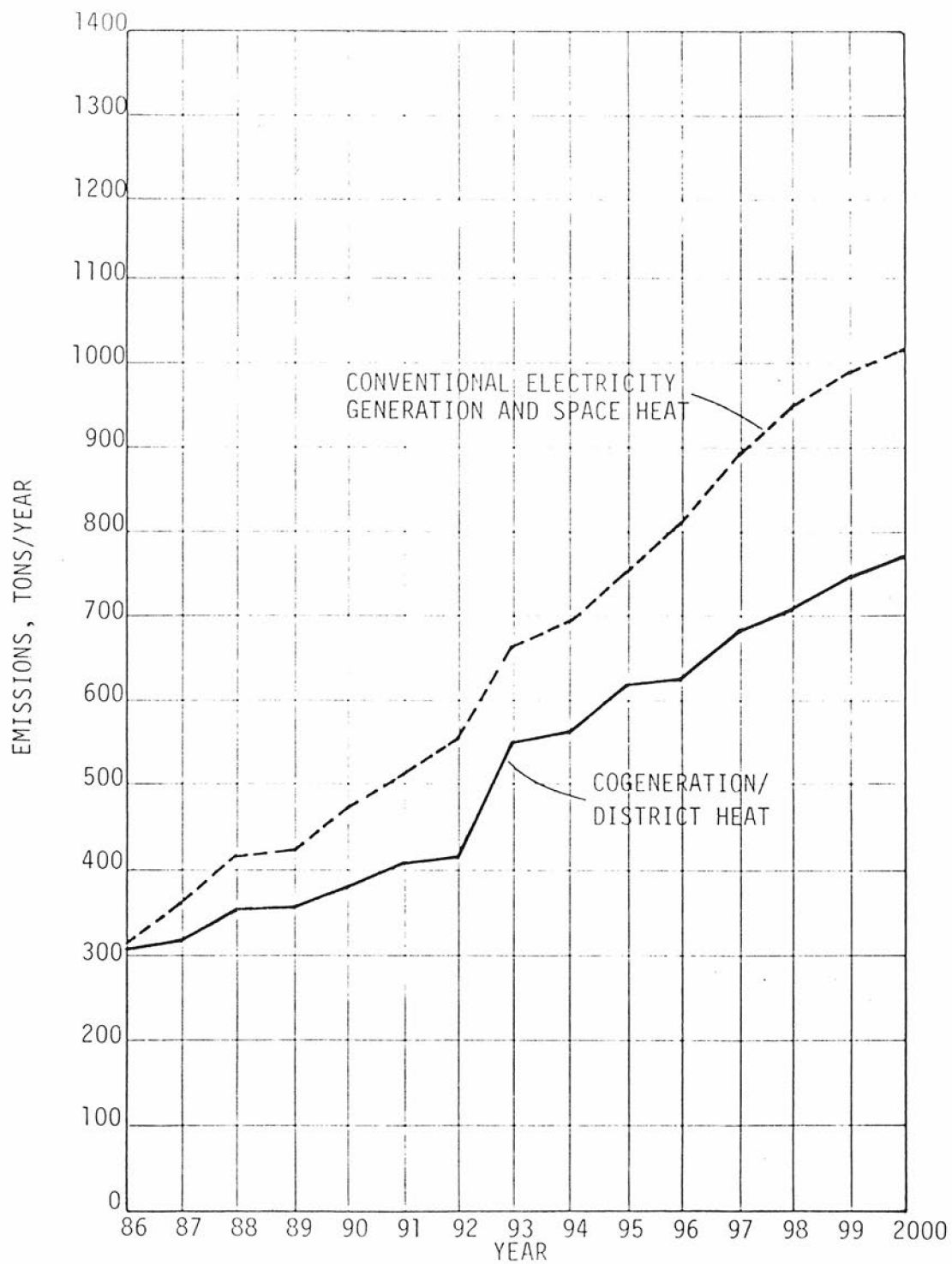
HOME FURNACE EFFICIENCY
ASSUMED TO BE 63%

COMPARISON OF OIL FURNACE AND
DISTRICT HEATING COSTS
WITH STATE FINANCING



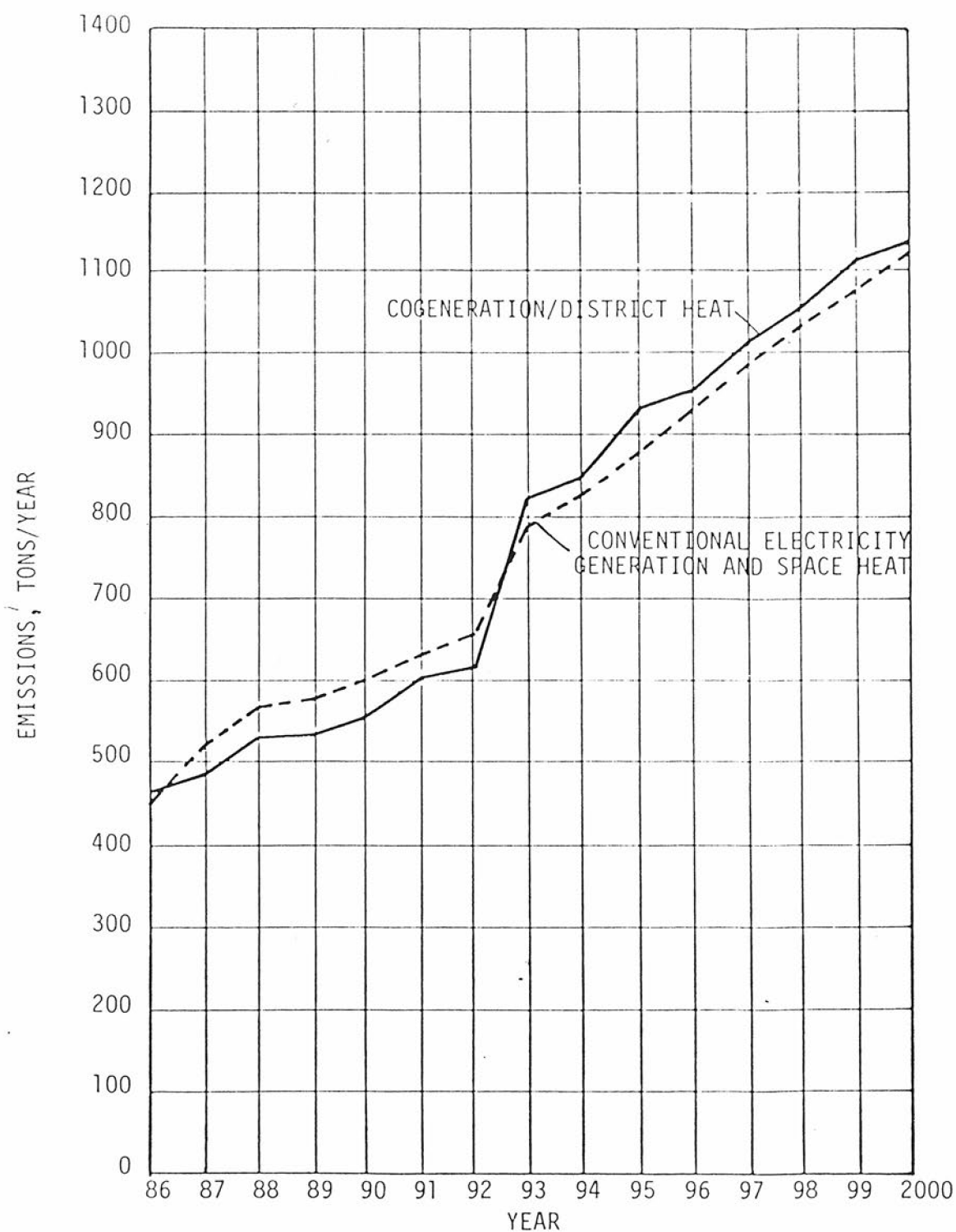
COMPARISON OF OIL FURNACE AND
DISTRICT HEATING COSTS WITH
FUEL PRICE ESCALATION

ESCALATION RATES: OIL - 3%/YR
COAL - 1%/YR



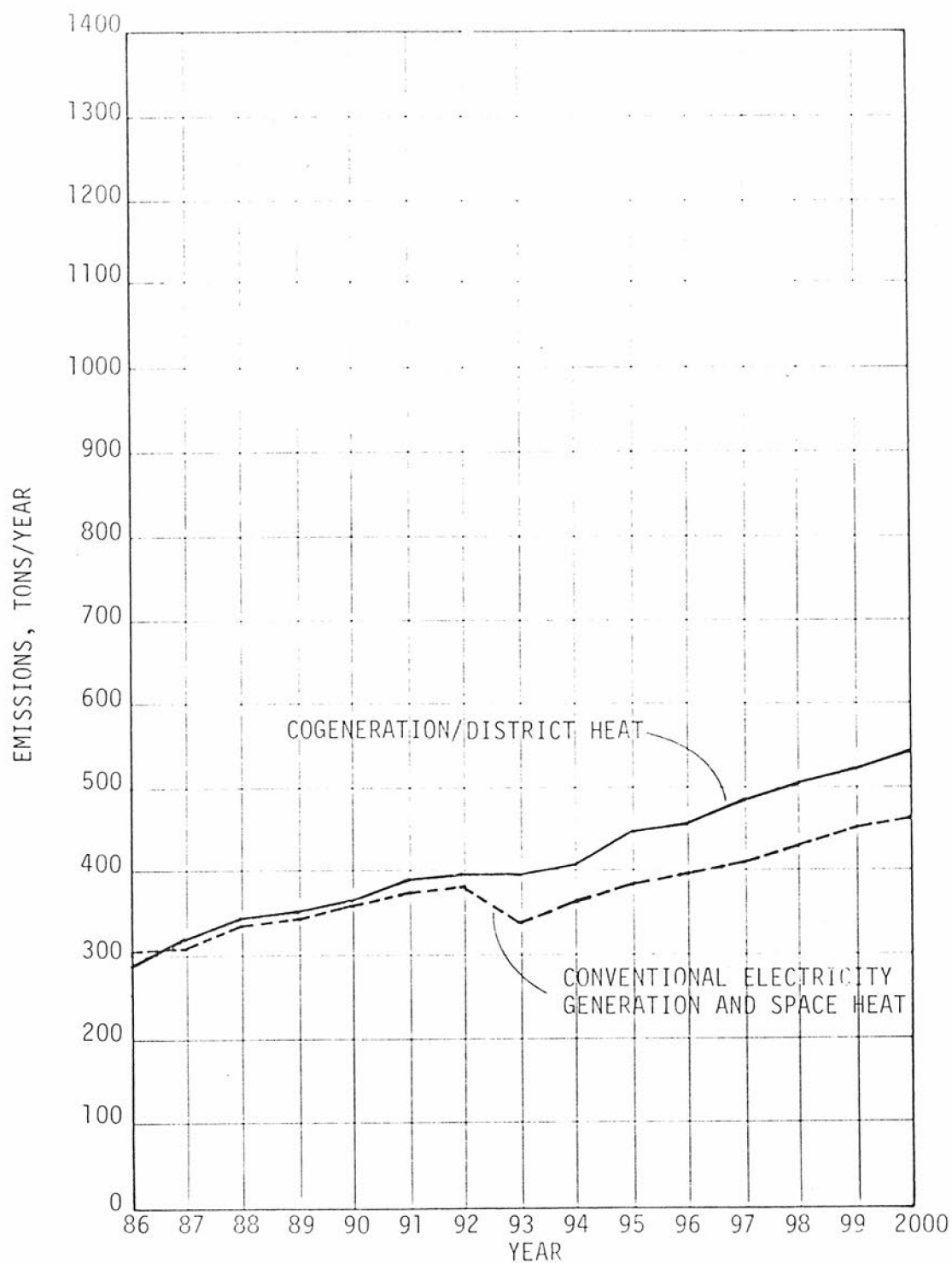
OXIDES OF SULFUR EMISSIONS

COGENERATION/DISTRICT HEATING
VS.
CONVENTIONAL ELECTRICITY AND SPACE HEAT PRODUCTION



OXIDES OF NITROGEN EMISSIONS

COGENERATION/DISTRICT HEATING
VS.
CONVENTIONAL ELECTRICITY AND SPACE HEAT PRODUCTION



PARTICULATE EMISSIONS

COGENERATION/DISTRICT HEATING
VS.
CONVENTIONAL ELECTRICITY AND SPACE HEAT PRODUCTION