



Final Report

Regional System Technical Evaluation

Prepared for:

**SOLID WASTE MANAGEMENT
COORDINATING BOARD**

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March 13, 2000

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EXECUTIVE SUMMARY

On behalf of the Solid Waste Management Coordinating Board, The Barlow Group completed a technical evaluation of future waste combustion options. The evaluation included the three RDF combustion facilities, two RDF processing facilities and the mass burn facility that make up the existing "regional system". The study also evaluated other options for expansion, both within the existing system, as well as beyond. The results of the overall evaluation are presented below in summary form. Details of the overall study, including conclusions and recommendations are presented in the report.

Existing System

The existing waste processing system was determined to be primarily constrained by RDF combustion capacity. Improvements to the existing RDF combustion facilities could result in the availability of additional MSW processing capacity in excess of historical levels. This additional combustion capacity of approximately 85,000 tons of RDF can be realized without the addition of RDF processing lines at the Elk River or Newport RDF processing facilities. Assuming a yield of 85% RDF from each ton of MSW processed, this translates into another 100,000 tons of MSW being processed.

With improvements, total maximum system combustion capacity is projected to be as follows:

Facility	Max. RDF Capacity	Max. MSW Processed
GRE	320,000	376,471
Red Wing	225,000	264,705
Wilmarth	225,000	264,705
Totals	770,000	905,881

In order to realize this maximum throughput capacity, the following improvements are recommended:

1. Permanent modifications at the Newport processing facility to remove long, stringy material which reduces combustion system availability at both Red Wing and Wilmarth combustion facilities. This improvement will likely consist of new screening equipment prior to RDF load out for transport to the combustion facilities, or better screening / shredding at the primary shredder.
2. Additional crews and operating hours at both the Elk River and Newport processing facilities in order to increase overall throughput.
3. Technical improvements at the Elk River, Red Wing and Wilmarth combustion facilities to eliminate downtime associated with removal of agglomerated aluminum in the combustion grate assemblies. Much of this work has already taken place at Elk River and improvements have been realized.
4. Replacement of existing waste contracts with new contracts that better allow for utilization of total projected MSW throughput capacity. It is anticipated that new contracts can provide far greater flexibility to the participating counties at a lower overall cost than is presently paid by the counties.

The study also included identification of issues, which may constrain the additional capacity identified above, as well as improve overall economics associated with MSW combustion. These issues are presented in greater detail in the report.

Existing RDF Processing System

Total maximum annual throughput capacity from the processors could be 1,000,000 tons/yr of MSW. With improvements, the maximum MSW required for the combustion capacity projected is 905,881 tons/yr, assuming an 85% yield at the processors. Therefore, a surplus capacity of 94,119 tons/yr of MSW from the processors could be available over the projected maximum requirement for the combustion facilities. This equates to a potential RDF surplus of 80,000 tons/yr from the processors, assuming an RDF yield of 85%.

Existing Mass Burn Capacity

The only mass burn facility in the system is the Hennepin Energy Resource Company (HERC). The plant is permitted to burn up to 365,000 tons per day of MSW and currently runs at approximately 1220 tons per day. The plant is capable of burning at the permitted limit of 365,000 with a combined capacity/availability of only 82.5%. The plant normally runs at a much higher capacity and therefore must reduce production near the end of the year so that the permit limit is not exceeded. Based upon industry averages for newer mass burn facilities, such as HERC, the facility should be able to realize an overall availability near 92%, which would result in a increase of 42,030 tons per year in overall throughput if the permit limit were higher.

Other RDF Options

Several additional RDF combustion options were identified and evaluated as a part of the overall study. Realization of this additional combustion capacity may require additional processing lines at one or both of the existing processing facilities. Other RDF combustion options evaluated were as follows:

1. RDF co-firing at existing coal fired and biomass facilities
2. Utilization of the RDF combustion capacity at the Western Lakes Superior Sanitation District facility located in Duluth, MN, which is now idle.
3. Densified RDF for co-firing at other combustion facilities.

RDF Co-firing

Seven facilities were identified as having potential capacity for RDF co-firing. Sixty-five other coal and biomass facilities were also identified, but removed from consideration due to technical limitations. Total potential capacity, potential constraints and cost projections were identified and presented in the report. While technically feasible, this option may be considered cost prohibitive. Additional study is recommended with respect to this option, if projected costs are not considered prohibitive.

WLSSD

Approximately 44,000 tons per year of equivalent MSW combustion capacity is potentially available at this facility, assuming an RDF yield of 85 percent. Not unlike RDF co-firing, this additional throughput capacity may be considered cost prohibitive. Further evaluation is also recommended for this option, if projected costs are not considered prohibitive.

Densified RDF

The technical and economic feasibility, as well as overall merits of densified RDF (pelletizing) was addressed. This option was considered as a possibility for enhanced RDF co-firing. This option was found to be economically cost prohibitive.

Conclusions

1. The existing RDF processing system has been determined to be “burn limited” meaning more RDF can be produced at the two processors than can be utilized at the three combustors. If all recommended improvements are implemented at the combustion facilities, an additional 85,000 tons of RDF can be burned annually.
2. HERC is capable of processing an additional 42,030 tons of MSW if the existing permit cap is modified.
3. The economic viability of RDF co-firing at local coal fired plants as identified herein is questionable, in light of other combustion alternatives. In addition, implementation may be very difficult due to environmental issues, negative perceptions and perceived overall risk.
4. WLSSD offers a technically viable alternative for additional RDF combustion capacity, but the costs are likely prohibitive.

Recommendations

1. Implementation of the following modifications at the RDF combustion and processing facilities are recommended:
 - Reduction in undergrate combustion air temperatures and improvements to fuel bed distribution at the combustion facilities in order to minimize downtime for grate cleaning is recommended.
 - Installation of eddy current separators at either the processing or combustion facilities is recommended in order to further minimize aluminum agglomeration in the combustion grate assemblies, as well as improve recycling rates.
 - Installation of additional screening equipment, or improvements to the primary shredder at the Ramsey/Washington processing facility is recommended in order to minimize the amount of long stringy material present in the RDF fuel stream being delivered to the Wilmarth and Red Wing combustion facilities. Consideration should also be given to diverting certain commercial loads containing this type of material to the HERC facility, in exchange for equivalent MSW not containing long stringy or other objectionable material. Mass burn type facilities can more easily combust this type of material due to the lack of fuel conveying equipment where long and stringy material may accumulate.
 - Installation of a bulky waste shredder at the ERRRF processing facility should be considered in order to reduce the quantity of TLO’s, assuming contract incentives can be negotiated to minimize TLO’s.
2. The technical feasibility and economics of the following options should be considered:
 - Construction of new mass burn facilities
 - Newly constructed mass burn facilities have historically been more economical when compared to newly constructed RDF type facilities. Lower costs are the result of:
 - Processing costs are eliminated
 - Energy revenues maximized because no combustible residue is landfilled.
 - Landfill abatement is increased by approximately 5%.
 - Transportation costs may also be reduced.

In addition, RDF processing facilities are not presently removing recyclable materials, with the exception of ferrous material, which can be removed from the ash residue at mass burn facilities.

- Conversion of existing RDF facilities to mass burn type facilities
 - Conversion of existing stoker type coal fired facilities to mass burn facilities
 - Installation of additional RDF combustion / boiler trains at the existing RDF combustion facilities
3. Contract negotiations with the vendor to simplify and extend the contracts and expand capacity should be considered. Contract term should be extended for 10 years beyond the existing term. Since debt service will be eliminated for the new 10 year extension, and given that throughput capacities should be higher than what has been historically achieved, the disposal costs for the contract extension period should be considerably lower than presently charged. The negotiated costs should then be compared against all other disposal cost options available, including those identified above to determine the best economic option for disposal capacity. Recommended contract structure should be as outlined in Section VI herein.

I. SCOPE OF WORK

A. General

Under contract by the Solid Waste Management Coordinating Board (“SWMCB”), The Barlow Group, Inc. was commissioned to complete a technical evaluation of the processing and waste-to-energy facilities that comprise the “regional system” that serves the members of the SWMCB as further specified herein. In addition, pursuant to an addendum dated, January 5, 2000, The Barlow Group’s scope of work was expanded to include the recently closed RDF processing and combustion system owned and operated by the Western Lake Superior Sanitary District in Duluth and additional coal fired and bio-mass facilities that could potentially provide supplemental RDF combustion capacity on a “co-fired” basis. This report summarizes the results of the technical evaluation, including conclusions and recommendations.

B. Evaluation of the “Regional System”

The Barlow Group evaluated the following facilities, which comprise the “regional system”:

- 1) The RDF combustion facility of Great River Energy (GRE) (formerly United Power Association) in Elk River;
- 2) The mass burn Hennepin Energy Resource Company (HERC) operated by Ogden;
- 3) The RDF processing facility in Elk River operated by NRG commonly known as the Elk River Resource Recovery Facility (ERRRF);
- 4) The RDF processing facility in Newport owned and operated by NRG serving Ramsey and Washington counties;
- 5) The RDF combustion facility in Red Wing operated by NSP, and
- 6) The RDF combustion facility in Wilmarth operated by NSP.

As a part of the evaluation, The Barlow Group completed the following tasks for each facility:

- 1) Reviewed facility specifications and design capacity on an as-needed basis,
- 2) Reviewed historical performance data, and operating records regarding processing capacity and availability on an as-need basis,
- 3) Reviewed the primary reasons for unscheduled downtime and other restrictions in processing and combustion capacity,
- 4) Identified maximum processing capacity and technical recommendations, if any, to increase current processing levels at the combustors;
- 5) Assessed the remaining useful lives of the facilities, and
- 6) Compared and contrasted all of this information with national standards or experience.
- 7) Listed of all components of the regional system that would require further study with the goal of further minimizing costs;

The evaluations included interviews with plant managers and key maintenance and operating personnel, site visits and review of plant operations. Assistance with each participating county as well as that of Richardson, Richter and Associates, Inc. was utilized as needed to obtain information and other data necessary to complete the work.

C. Evaluation of WLSSD

The intent of the evaluation of the Western Lake Superior Sanitation District RDF combustion facility was to assess the potential additional combustion capacity available for the SWMCB region. This facility's RDF operations for the District were discontinued in 1999. The evaluation addressed the following:

1. Status of the RDF combustion facility,
2. The RDF combustion capacity, if any, that could be made available to the SWMCB region,
3. Upgrades necessary to realize any identified capacity,
4. Disposal costs associated with transport and combustion at this facility.
5. Ash disposal issues or concerns, and
6. Any potential permitting issues which may need to be addressed.

D. Co-firing

The Barlow Group was asked to provide a general review and analysis of co-firing RDF at existing coal fired and bio-mass combustion facilities. This review was to address the following:

1. General design constraints,
2. Permitting issues and constraints.
3. Typical retrofit scope of work and costs to allow co-firing,
4. Materials handling problems including the technical feasibility and costs associated with producing RDF pellets,
5. Ash disposal issues or concerns, and
6. A generic cost model indicating predicted disposal costs with various transport distances

II. APPROACH TO WORK

A. General

The primary emphasis of this study was to evaluate the six individual facilities independently to determine their general condition and useful lives, current practical operating capacities, and what limitations restrict the capacities of each of the facilities. Following the assessment of the current state of each facility, the study evaluated potential modifications that would increase those capacities. Subsequently, the six facilities were assessed as a “system” with the focus of the analysis shifting towards maximizing efficiency within the system as a whole.

B. Facility Evaluations

Each facility was evaluated individually in order to determine the following:

- 1) Compliance with original design capacity.
- 2) How the design capacity can be realized or increased given the existing equipment.
- 3) Opportunities for increasing capacity at the facility assuming new equipment or other modifications.
- 4) Technical limitations on MSW receiving and RDF processing capacity.
- 5) The remaining useful life of the facility.

C. System Evaluation

The six facilities were then evaluated as a “system” with regards to the following:

1. Opportunities to manage the current system more efficiently to increase overall capacity.
2. Identification of other processing and combustion resources that may be available to the region to increase capacity.
3. Listing of all components of the regional system that would require further study to integrate into a system approach with the goal of further minimizing costs.
4. Identification of externalities that could impact the Regional County Solid Waste Master Plan's (1998-2017) goals.
 - a) Subtitle D landfill regulation review
 - b) Ash reuse and disposal
 - c) Electric power generated from renewable fuels
 - d) Contract renewals
 - e) Regional landfill capacity

III. DATA COLLECTION

A. Facility Surveys

In order to accurately assess each facility, it was important to compile information that could only be provided by the plant superintendents and facility operating personnel. While some of this information can be ascertained during a site visit, much of the data requires a considerable period of time to collect and organize. Facility surveys were developed and sent to each of the facilities prior to the site visits. Information requested included historical facility throughput, outage rates (forced and un-forced), permit limits, energy production and limitations associated with attaining design and permitted capacity.

Obtaining this information prior to the site visits allowed optimal use of time when visiting the facilities. The areas of primary concern were identified prior to the visit allowing the majority of time spent addressing the most pertinent issues. Additional information was gathered via follow-up phone calls and faxes. This process gave The Barlow Group team members a basic understanding of each facility, the problems that are being faced and the potential changes that should be investigated during the site visit phase of the study.

B. Facility site visits

In order to assess the physical condition of the facilities, four members of The Barlow Group visited each facility. The site visits focused on the following objectives:

- Determining the overall condition of the facilities, including projected remaining useful life;
- Identification of any system improvements that would result in additional capacity; and
- Interviews with facility management

1. Overall facility condition

The primary focus of the site inspections was to assess the general facility condition, evaluate plant operations and assess the overall maintenance levels maintained at each of the six facilities. In most cases, plant tours were allowed and equipment and systems were visually inspected. In all cases, the combustion facilities were operating which prohibited the inspections of internals of the furnace, boiler and air pollutions control equipment. External inspections do, however, provide a general indication of plant maintenance proficiency and general plant procedural care. Additionally, personnel interviews and review of maintenance records adequately provide the balance of the information required to assess the plant condition from an overall standpoint. The inspections also focused on key aspects and facility conditions, which would affect the useful life of the facility. The conditions observed for each facility are detailed in Sections IV and V of this report.

2. Identification of facility improvements

As a part of the site inspections and management interviews, determinations of what improvements, if any, could be made to increase capacity and availability were developed. Improvements were addressed from two perspectives.

- a) First, what problems currently exist that hinder the facility from achieving its design capacity and/or a reasonable capacity as compared with industry standards. This includes degraded or poorly sized equipment, inadequate maintenance or poor operations procedures. For the RDF combustors, fuel quality is addressed because “non-spec” fuel can be a major contributor to the reduction of both capacity and availability.
- b) Secondly, what plant improvements can be made by modifying/expanding the system or upgrading the equipment for increased performance. These changes typically require a much greater capital investment than the prior scenario but could result in an overall benefit that warrants the expenditures.

3. Management Interviews

At each of the six facilities, detailed discussions took place with key plant personnel. Face to face meetings helped to develop a relationship that was conducive to the open exchange of ideas and information. Without exception, these individuals were cooperative in answering questions and accompanied us on facility tours in most cases. Information obtained during these discussions is included throughout this report. There is great value in the information provided by the people responsible for the day to day operation of these facilities. The problems that limit capacity and availability are typically unique to each facility. Operating personnel can quickly convey the problems encountered, their assessment of the underlying causes and what steps have been taken to resolve them in the past.

C. Facility Design Review

A summary level review of the overall facility design was completed. This review did not include a detailed evaluation of original equipment specifications relative to overall plant design due to a lack of available information. The design of the facilities was assessed from the information available in order to assess potential plant improvements and the possible scenarios for plant expansion.

IV. ANALYSIS OF PROCESSORS

A. General

Two general types of facilities were analyzed; processors and combustion facilities. Processors are facilities that convert municipal solid waste (MSW) into refuse derived fuel (RDF). Combustion facilities utilize RDF or MSW as fuel and recover the energy in the form of steam and/or electricity. The processors are as follows:

1. Processors
 - a) NRG RDF Facility in Elk River
 - b) NRG RDF Facility in Newport

2. Definitions

Throughout this report, the terms “capacity” and “availability” are used frequently. Capacity illustrates how close the facility is to operating at its design throughput while it is in operation. Availability means what percentage of the year the plant is in actual operation. They are determined as follows:

$$\text{a) Capacity} = \frac{\text{annual msw processed}}{\text{msw design rate} \times \text{hours operated}}$$

$$\text{b) Availability} = \frac{\text{annual hours operated}}{8760 \text{ hrs per year}}$$

Availability is reduced by both planned outages for routine maintenance and by forced outages due to equipment failure or functional cleanings. Availability is typically evaluated on an overall plant basis, in lieu of each combustion train.

B. RDF Facility in Elk River

1. Plant Condition

The Elk River Resource Recovery Facility (ERRRF) is located in the city of Elk River in Sherburne County. The facility is also referred to as NSP- Elk River. The facility processes MSW from five counties and produces RDF which is burned primarily at the adjacent GRE combustion facility and at the Wilmarth combustion facility. NSP has a service agreement that expires in 2009. NRG is NSP’s operator. The Barlow Group personnel have visited the site on numerous occasions over the past several years. A process flow diagram for this facility is included in Appendix A.

The existing system is in relatively good condition. Equipment is well maintained, operations run smoothly and the facility seems to be soundly managed. The plant runs 24 hours per day and 7 days per week, with the exception of a few major holidays.

2. Retrofit Work to Increase Annual Throughput

a) Existing Facility

The most notable equipment modification that could be made to improve plant capacity would be associated with the two infeed conveyors at the tipping floor. Both conveyors need to be revamped or replaced in order to improve system throughput. The design capacity of the conveyors is undersized and they should be either faster or wider to accommodate an increase in waste flow. These two conveyors are the means for transferring MSW from the tipping floor to the processing plant. Therefore, the plant capacity is only as great as the capacity of these conveyors. To re-work or replace these conveyors would be an expensive undertaking but would allow the overall plant capacity to increase to a level near the design capacity (50 tons per hour per line). The permitted capacity is 62% of design capacity and the facility cannot presently operate at its full permitted capacity (1,500 tons per day).

b) Bulky Waste Shredder Addition

ERRRF currently has no means for handling oversized bulky waste. This waste is consequently rejected as “non-processible”. Bulky waste may include mattresses and furniture etc. Mattresses, for example, tend to bridge the entrance to the flail mill and the springs wrap around the disc screen shafts extending down time for cleaning. Additionally, the difficulty in removing wire and springs from the disc screens leads to an increased level in employee injuries. The addition of a shredder similar to the one employed at the Newport facility would allow for more waste to be processed at ERRRF instead of going to the landfill, while reducing work related injuries.

c) Expansion Potential

The ERRRF facility currently consists of two processing lines designed to process approximately 50 tons per hour. The permitted capacity is 1500 TPD. The plant layout can accommodate an additional processing line although the operating permit would have to be modified as the throughput would then exceed 1500 tons/day or 547,500 tons per year. The costs for adding a third line would include not only processing equipment, but also would likely entail expansion of the facility in a number of areas. The primary areas for expansion would likely include the tipping floor, building enclosure and site roadways.

3. Capacity

- a) Permit - The ERRRF processing facility is permitted to process up to 1500 tons per day of municipal solid waste. There does not appear to be an annual limit stated in the permit. The assumed annual capacity is therefore 547,500 tons per year on a 365 days per year basis. Five counties have waste disposal contracts for ERRRF. The guaranteed waste processing capacity for these counties is shown below in Table 1.

Table 1 – ERRRF Waste Contracts

County	Guarantee Capacity (tons/week)
Anoka	3,000
Hennepin	4,800
Sherburne	500
*Tri-County	900
TOTAL	9,200

*Tri-County represents Benton, Stearns and western Sherburne counties.

Therefore, 13.3% of the permitted capacity is contracted to non-members of the SWMCB group. Only recently has this designated capacity been utilized fully by those counties.

- b) Design – The system was originally designed to process 100 tons per hour of msw with both lines in operation. For the sake of calculating capacity and availability ratios, the maximum possible MSW throughput is therefore 876,000 tons per year. It should be noted that the facility cannot achieve an annual throughput near this magnitude, due to maintenance downtime and in-plant equipment deficiencies, such as the in-feed conveyor.
- c) Historical – Data was obtained illustrating the processing statistics for ERRRF for the last three years. The data does not indicate whether or not the facility had the capacity to process more waste during those years, or if they were transferring waste because they were not capable of processing the full amount delivered. There are many complex contractual factors involved in the decisions made by this facility. Table 2 illustrates the amount of waste delivered and the amount processed. The difference is due to the following:
 - Waste transferred
 - Tires and appliances
 - Non-processible waste
 - Moisture loss

The table below illustrates the processing statistics at ERRRF from 1995 through 1999.

Table 2 – ERRRF Processing History

Year	MSW Received	MSW Processed	RDF Produced	RDF to Red Wing	RDF to Wilmarth	RDF to GRE
1997	459,878	422,014	350,099	1,752	47,701	300,646
1998	457,141	417,038	348,898	292	46,572	302,034
1999	443,665	391,845	331,778	750	51,199	279,829
Average	453,561	410,299	343,592	931	48,490	294,170

Average Non-processible & moisture loss %:	9.5%
Average RDF Yield:	83.7% (as defined in the contract)
RDF Production %	75.8% (RDF as a % of MSW received)

d) Future – The plant superintendent at the Elk River Resource Recovery Facility has stated that the facility could maximize its capacity by three primary methods:

1. Revamp the infeed conveyors as discussed previously in this Section.
2. Hire additional personnel to help cover the lines during break periods, vacations, etc. Additional workers typically result in greater efficiency.
3. Incorporate an oversized bulky waste shredder thereby decreasing the percentage of waste that is rejected as “non-processible”.

It should be noted, that when the opportunity for contract restructuring presents itself, a simplified approach to processing calculations can result in an increase in overall throughput capacity while reducing associated processing expenses and landfill requirements. This concept is discussed in further detail in Section X of this report.

4. Availability – The plant operates 7 days per week, 24 hours per day except for major holidays. There were no specific percentages provided by the vendor for ERRRF’s availability. Like most processors, they have considerable downtime due to extensive cleaning requirements and overall equipment maintenance. Certain items in the waste stream result in increased cleaning downtime. Some of the constituents of the waste stream that increase downtime for cleaning are as follows:

- a) Magnetic recording tape
- b) Plastic stringers
- c) Carpet
- d) Cable spools
- e) Large quantities of cardboard
- f) Large plastic and paper rolls

RDF Quality – Average heating value is 5,500 to 6,000 btu/lb. Ash quantities average 18% of RDF burned. The combustion facilities that utilize RDF from ERRRF are typically pleased with the overall quality of the fuel with regards to material handling and combustion characteristics.

5. The tipping floor capacity is approximately 3000 tons of MSW.

6. Equipment

The RDF facility in Elk River, MN consists primarily of the following equipment:

- a) Tipping floor
- b) Grapple cranes
- c) Infeed apron conveyors
- d) Transfer apron conveyors
- e) Flail mills
- f) Magnetic separators
- g) Primary disc screens
- h) Air knife classifiers
- i) Clean-up air knife classifiers
- j) Secondary shredders
- k) Numerous conveyors
- l) RDF and residue compactors

The equipment in the facility is well maintained and no inappropriate operations or maintenance procedures were noted.

7. Outage Summary

Flail mills and conveyors are the most frequent causes for forced outages. Typical outages only last twenty-four to ninety-six hours. Other equipment work includes belt and roller replacement, knife changeout for hammermills, bearing replacement, motor repair/replacement and chute repairs.

8. Remaining Useful Facility Life – The Elk River Resource Recovery Facility began accepting waste for processing in 1989. In estimating the useful life of a facility, the most important factors to consider are as follows:

- a) Was the initial capital investment adequate to provide a quality facility?
- b) Have adequate funds been available to maintain the facility and prevent accelerated degradation?
- c) Are startup, operations and shutdown procedures adequate?
- d) Are sufficient funds available to repair or replace major equipment or systems?

A plant can operate almost indefinitely if enough funds are available to repair and replace equipment. Therefore, when estimating the remaining useful life of a facility, some assumptions are made and the plant is compared to similar facilities in the same size range to arrive at a reasonable estimate for plant life.

In the case of the Elk River Resource Recovery Facility, overall operations and maintenance have been adequate and no excessive system degradation was observed. A facility of this size and type should be able to operate for 25 to 30 years before requiring disproportionate funding to continue operation. Given that the plant is currently 11 years

old, an additional 10 years of useful life from beyond the existing contract term should be easily attained with continued proper maintenance.

C. Ramsey/Washington County Resource Recovery Facility

1. Plant Condition

The Ramsey/Washington County Resource Recovery Facility is owned and operated by NRG Energy, Inc. and located in Newport, MN, in Washington County. NRG has a service agreement with Ramsey and Washington counties that expires in July, 2007.

The facility was toured and a cursory inspection was performed. The condition of the facility and the equipment seemed to be acceptable and no unusual operations or procedures were noted. Management articulated a reliable plan for maintenance and forecasting needs.

Plant operations consist of two 10-hour processing shifts Monday through Friday. Additionally, there is one 10-hour shift on Saturday and one 10-hour shift on Sunday. A second 10-hour shift is added on Sunday if needed. Recently, the second Sunday shift has been implemented about three out of every four weeks. The shift workers consist of six teams. Each team consists of two mechanics, one electrician and two to four helpers. Each shift consists of two teams simultaneously with a maximum of twelve workers on any shift at one time.

The average heating value of the RDF produced at this facility is approximately 5600 btu/lb. The RDF product contains a relatively high percentage of plastics including banding, plastic rolls and magnetic tape.

2. Retrofit Work to Increase Annual Throughput

a) Existing Facility

The secondary shredders at this facility appear to be undersized at 800 horsepower. The secondary shredders at the Elk River facility are more adequately sized at 1200 horsepower. Upgrading the shredder horsepower by 50% would reduce the functional downtime required to clean and maintain these vital pieces of equipment thereby increasing plant availability. However feasibility of an upgrade is questionable, and outright replacement would be the likely cost effective correction.

Since the time of our site visit to this facility, some modifications have been made to the system. Screens have been added to the shredders that recycles oversized material back through the shredder resulting in a more uniform product. Preliminary efforts have been successful and positive feedback concerning the quality of the fuel has been noted. Additionally, an eddy current separator has been purchased for the separation of aluminum from the waste stream although the equipment has not been installed at the time this report was issued.

b) Expansion Potential

The Newport facility currently consists of two processing lines designed to process approximately 50 tons per hour. The plant layout can accommodate an additional processing line although the operating permit would have to be modified as the throughput would then exceed the permitted capacity of 500,000 tons per year. The costs for adding a third line would include not only processing equipment, but also would likely entail expansion of the facility in a number of areas. The primary areas for expansion would likely include the tipping floor, building enclosure and site roadways.

3. Capacity

- a) Permit – The facility is currently permitted to receive up to 500,000 tons per year of waste.
- b) Design – The system was originally designed to process 100 tons per hour of MSW with both lines in operation.
- c) Historical – Table 3 illustrates the quantities of waste delivered and processed at Newport as well as the RDF distribution from 1990 to 1998.

Table 3 – Newport Processing Summary

Year	MSW Received	MSW Processed	RDF Produced	RDF to Red Wing	RDF to Wilmarth	RDF to GRE
1997	409,852	404,391	340,507	193,572	146,425	510
1998	444,532	434,654	352,025	206,417	145,608	0
1999	429,331	419,484	328,505	186,946	141,859	0
Average	427,905	419,510	340,346	195,645	144,630	170

Average Non-processible and moisture loss %: **2.0%**

Average RDF Yield: **81.1%** (as defined by contract)

RDF Production % **79.5%** (RDF as a % of MSW received)

- d) Future – There are no apparent modifications to the existing system that would dramatically increase the facility capacity without substantial capital expenditures. The most practical means to increase capacity would be to hire additional plant personnel. If the facility were to add an additional shift on Saturday and Sunday, an increase in capacity of 15% could be achieved.

In 1998, 434,654 tons of waste was processed. An increase of 15% would yield an annual processing capacity of about 500,000 tons which is the plant’s permitted capacity.

It should be noted, that when the opportunity for contract restructuring presents itself, a simplified approach to processing calculations can result in an increase in

overall throughput capacity while reducing associated processing expenses and landfill requirements. This concept is discussed in further detail in section X of this report.

4. Availability – This plant does not currently operate 7 days per week, 24 hours per day as does ERRRF. Therefore, the off-shift time is used to a great extent for cleaning and mechanical and electrical repair work. This facility has no planned outages but does experience forced outages as equipment and systems fail during normal shift work. No data was available regarding the number or duration of the forced outages.

Like most processors, this facility has considerable downtime due to excessive cleaning and equipment maintenance. The Newport facility appears to receive a relatively high percentage of troublesome waste, which affects both the plant availability and the RDF quality.

5. The tipping floor capacity is approximately 6000 tons of MSW.
6. Equipment – A processing diagram for the plant system is included in Appendix B. The RDF facility in Newport, MN consists primarily of the following equipment:
 - a) Tipping floor
 - b) Grapple cranes
 - c) In-feed apron conveyors
 - d) Transfer apron conveyors
 - e) Flail mills
 - f) Magnetic separator
 - g) Primary disc screens
 - h) Secondary disc screens
 - i) Air knife classifiers
 - j) Clean-up air knife classifiers
 - k) Secondary shredders (2 @ 800 HP each)
 - l) Oversized bulky waste shredder
 - m) Numerous conveyors
 - n) RDF and residue compactors

The equipment at Newport is almost identical to ERRRF with a few exceptions. The secondary shredders are 800 horsepower as compared to 1200 horsepower at ERRRF. The higher power shredder results in less functional downtime but has substantially higher capital and operating costs. In addition, Newport has an oversized bulky waste (OBW) shredder that Elk River does not.

7. Outage Summary
 - a) Explosions in the flail mills are the most frequent cause for forced outages. Typical outages only last two to three hours.
 - b) This facility has no scheduled outages. All maintenance and repair is done as needed during the non-operating periods available on a daily basis.

8. Remaining Useful Facility Life – The Ramsey/Washington County Resource Recovery Facility began accepting waste for processing in 1987. As with the Elk River Resource Recovery Facility, the plant was compared to similar facilities in the same size range to arrive at a reasonable estimate for plant life. In the case of the Newport plant, overall operations and maintenance have been adequate and no excessive system degradation was observed. Given that the plant is currently 13 years old, an additional 10 years of useful life from beyond the existing contract term should be easily attained with continued proper maintenance.

V. ANALYSIS OF COMBUSTION FACILITIES

A. General

Combustion facilities burn the MSW and RDF to produce steam and/or electricity. All of the facilities assessed utilize RDF with the exception of HERC which burns MSW without pre-processing. The combustion facilities are as follows:

1. Great River Energy (formerly United Power Association) in Elk River
2. Hennepin Energy Resource Company in Minneapolis, Minnesota
3. Red Wing Facility in Red Wing, Minnesota
4. Wilmarth Facility in Mankato, Minnesota

B. Great River Energy - Elk River

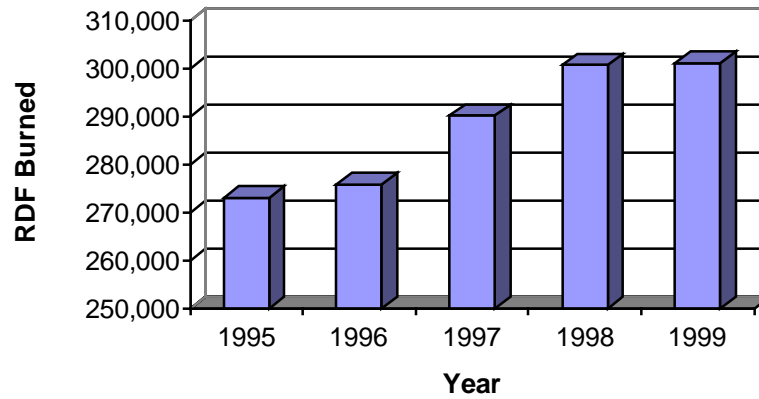
1. Plant Condition

The combustion facility located in Elk River burns RDF generated by the Elk River Resource Recovery Facility. The facility was originally a coal fired baseload electric utility station, until converted to RDF combustion in 1988. The RDF combustion facility consists of three (3) combustion furnace/boiler trains that discharge flue gas into two (2) dry scrubbers. One of the combustor/boiler trains is rated at twice the capacity of the other two units. A diagram of the facility site is included in Appendix C.

2. Capacity

- a) Permit – The plant is permitted to burn up to 1050 tons per day of RDF or 383,250 tons on an annualized basis.
- b) Design – Realistic design capacity appears to be close to the permitted daily throughput. A fuel feed system retrofit in 1997 and 1998 increased overall capacity by approximately 10%. The primary limitation with any higher firing rate is the increased wear with boiler tubes. Discussions with plant personnel indicate that the units are typically operating at the maximum design limit when sufficient fuel is available.
- c) Historical – Figure 1 below shows the increase in burn capacity achieved over the past 5 years. The plant capacity has increased significantly over the past three years, with much of the increase attributable to the recent fuel feed system retrofit. However, the additional throughput has not been realized due to poor plant availability during this time period. As indicated, the limiting plant component from a capacity standpoint is the boilers. Increased firing rates will result in far greater tube failure rates, increased downtime and additional maintenance expense. Since the plant is addressing the problem with all known means, as will be discussed further, it is doubtful that the capacity can be increased beyond its present limit.

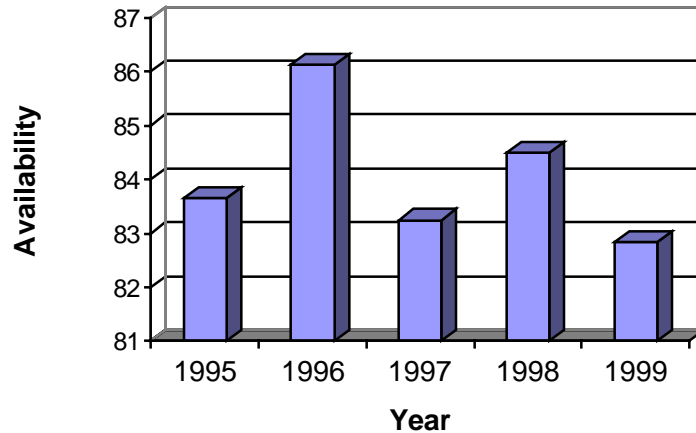
Figure 1 – GRE Burn Capacity



- d) Availability – This percentage is calculated by the number of hours on line divided by the number of hours in a year.

Figure 2 - GRE Availability

As indicated, overall plant availability has been below the industry standard of approximately 87% for this type of facility. Downtime for the past 3 years has been higher in part due to retrofit work and a major generator overhaul due to a lightning strike.



- e) Future – As previously noted, the plant capacity is limited by boiler tube failure rates, which are likely to increase at a far higher rate, if capacity is increased beyond present levels. Inconel overlays of waterwall and superheater tubes minimize tube failures. However, tube failure continues to

be a significant outage factor. Elk River appears to have experienced a lower failure rate than comparable facilities in the industry. The facility is presently in the process of superheater replacement work. The Elk River replacement cycle has been on a 5 to 10 year basis. By comparison, other facilities in the industry replace superheater tubes as frequent as every year.

Therefore, the primary opportunity for additional throughput at Elk River is by improving plant availability. Historical availability records are not a good indicator, due to the presence of major outage items in recent years for items such as the fuel feed system retrofit work and a generator overhaul. However, other routine outage work has been evaluated and the potential for improvement was identified. Each unit has historically scheduled to be off-line for approximately 3 days every six weeks for grate cleanings and ID fan rotor repair (unit 3 only). A dust collector was recently installed ahead of the unit 3 ID fan and appears to have substantially improved the life expectancy of the rotor. Therefore, if the frequency and/or duration of grate cleanings can be improved, overall plant throughput can be increased. Recent downtime appears to have improved regarding grate cleanings.

Grate cleaning is necessitated by the accumulation of aluminum in and under the grate assemblies. This results from molten aluminum dripping in the grate where it cools and solidifies. Two changes to the operation should significantly improve this situation. First, combustion air preheat at this facility is excessive, which increases the temperature under the grate by as much as 400 °F. Reducing this temperature should reduce the amount of molten aluminum present. A test with one of the units to reduce the combustion air temperature by bypassing the air preheater is presently in progress. Initial results suggest improvement. Second, maintaining a stable, consistent bed depth is known in the industry to minimize the amount of aluminum accumulation. With a proper fuel bed, molten aluminum cools and solidifies within the fuel bed before it reaches the grate assembly. Therefore, additional work in this area is recommended. An overall plant availability of approximately 87% should be attainable with these improvements, which would be within normal industry expectations for this type of facility.

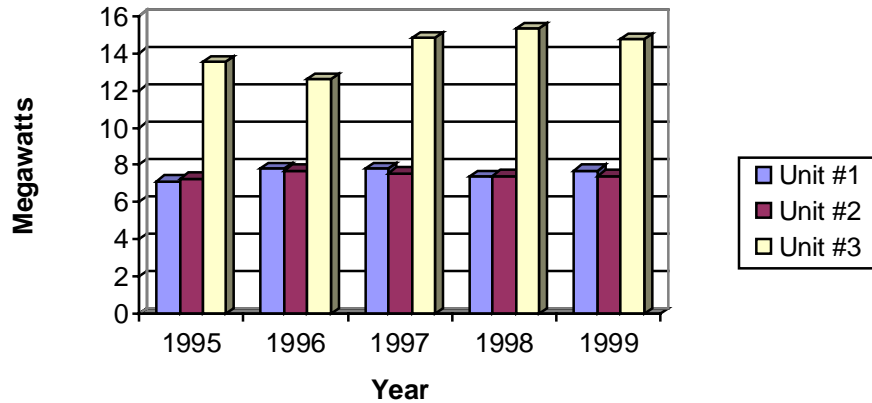
Reaching an 87% availability will result in annual RDF combustion of 315,500 tons . This represents an approximate 5% increase over 1998 and assumes sufficient waste is available.

3. Retrofit Work – When assessing potential retrofit work for combustion facilities, the incorporation of additional combustion trains was not considered as part of the scope of this evaluation. Retrofit work was considered that could be implemented while keeping the facility within its current permit requirements.

Other retrofit work that has been recently completed, is in process, or as recommended was identified previously. The primary recommendations are lowering the combustion air temperature and improving the fuel bed depth consistency.

4. Electricity Produced – The boilers generate steam that produce approximately 35,000 kilowatts of power from the facility’s steam turbine generators. Figure 2 below shows the average electric power production for the three turbines when in operation. The net generation was 612 kwh/ton of RDF in 1998.

Figure 3 – GRE Average MW Output



5. Remaining Useful Facility Life – As indicated previously, the facility has considerable age, even though it began operation as an RDF facility in 1989 after a substantial retrofit. It has since undergone numerous modifications. However, the plant has continued to upgrade critical equipment and systems necessary to maintain emissions compliance and reliable operations. For example, the plant control system was recently replaced with a state-of-the-art system, which should have a useful life of approximately 15 years. Assuming that overall plant maintenance practices continue in such a way as to maintain plant reliability, it is reasonable to assume that the plant could be operated efficiently for an additional 10 years beyond the present contract term.

C. HERC

1. Plant Condition

The Hennepin Energy Resource Company (HERC) is a mass burn facility operated by Ogden Energy Group (formerly Ogden Projects) in 1989. It is located in downtown Minneapolis. The facility receives 365,000 tons annually from Hennepin County via a contract that expires in the year 2019. The RDF combustion facility consists of two (2) combustion furnace/boiler trains that discharge flue gas into two (2) dry scrubbers and fabric filters. A process flow diagram and a site layout diagram are included in Appendix D.

2. Capacity

- a) Permit – The facility is operating with an annual limit of 365,000 tons per year as set by Minnesota State Statute and permit limits.

- b) Design – The HERC facility consists of two units, each with a design capacity of 606 tons per day, for a total of 1212 tons per day of RDF. Assuming an overall plant availability of 92%, the plant could theoretically process approximately 407,000 tons per year of RDF.
 - c) Historical – Plant personnel indicated that they currently run approximately 1220 tons per day. Near the end of the year, production is reduced so the permit limit is not exceeded. The result is that the facility easily reaches the 365,000 tons per year limit on a consistent basis.
 - d) Future – The future depends almost entirely on the ability to modify the state statute that limits this facility to a production level far less than its capability.
 - e) Availability – Combustion at the permitted limit of 365,000 yields a combined capacity/availability of 82.5%. The plant has about 25 to 30 days annually for planned outages. In years where a turbine overhaul is performed, planned outage days average between 40 and 45. Major maintenance items included in planned outage work include boiler cleaning and repair, grate repair and general maintenance. Based upon industry averages for newer mass burn facilities, such as HERC, the facility should be able to realize an overall availability near 92%, which would result in a substantial increase in overall throughput. No other opportunities for improvement were noted, with the exception of converting the facility to RDF combustion, which will be discussed elsewhere herein.
3. Retrofit Work – No potential retrofit work was identified for this facility.
 4. Design Energy Production – 33,700 kilowatts (net)
 5. Actual Energy Production – 227,742 megawatt-hours (in 1998 net)
 6. Boiler Design Steam Flow – Steam flow – 380,000 lbs per hour
 7. Fuel Storage Capacity – 8,400 tons
 8. Heating value of the MSW-5,200 btu/lb
 9. Net energy generation –596 kwh/ton (1999)
 10. Ash as a % of MSW – 25.1% (1997-9)

Remaining Useful Facility Life – The tour of the HERC facility that was performed was restricted to minimal areas of the plant due to restrictions imposed by the facility operator. Typically, facilities owned and operated by Ogden are well maintained and operated with high standards. The plant appeared to be well maintained. The plant began commercial operation in October, 1989. Given that the plant is currently 11 years old, with a contract term of 25 years, the remaining term of the contract should be easily attained with continued proper maintenance.

D. Red Wing

1. Plant Condition

The Red Wing waste to energy facility is located in Red Wing, MN. The facility was originally a coal fired baseload electric utility station, until converted to RDF combustion in 1986. The facility began operation as an RDF combustion facility in 1987. The facility receives approximately 200,000 tons of RDF annually from the Newport processing facility. The plant burns RDF in two furnaces utilizing Detroit Stoker grates with heat recovery from two Foster Wheeler boilers operating at 650 psi and 750 °F.

Tube corrosion and failure has been an ongoing problem at the facility. Plant personnel have replaced tubes in the upper rear wall in both boilers. Additionally, extensive inconel overlaying on boiler tubes is a continual process. At one point, a vent valve on the deaerator inadvertently closed resulting in little deaeration of the boiler feedwater. The result was fairly extensive internal O₂ corrosion of the boiler tubes.

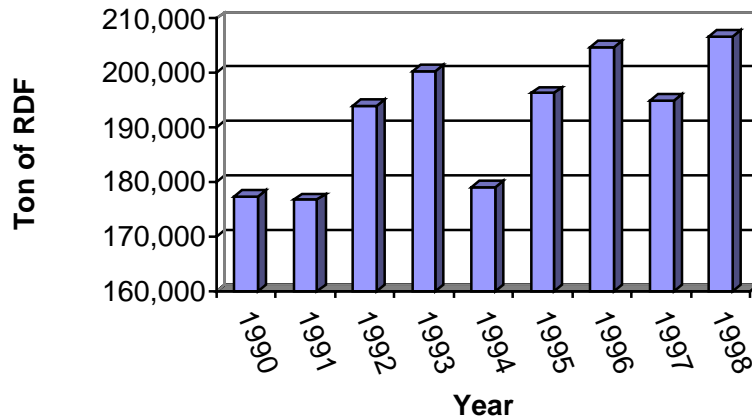
In addition, large quantities of stringy material such as magnetic tape and plastic banding creates major material handling problems. This material forms into large stringy masses at the scalping conveyor by rolling back down the incline and “balling up”. These masses, commonly referred to as “rag monsters” also form at other points in the material handling system. This material tends to wrap around conveyor shafts causing downtime and does not feed into the furnaces without great difficulty. Fuel feed chute and bin plugging can take as much as 24 hours to clear.

The Red Wing facility also experiences considerable downtime due to the accumulation of aluminum material within the grate.

2. Capacity

- a) Permit – The permit at Red Wing is based on a maximum steam flow of 106,000 pounds per hour per unit.
- b) Design – Each of the two units in the facility is designed to burn 360 tons per day of RDF for a total of 720 tons per day, which is equivalent to 106,000 pounds per hour steam flow, depending upon fuel heating value and other plant conditions.
- c) Historical – Figure 4 below illustrates the burn capacity at Red Wing since 1990.

Figure 4 – Red Wing RDF Burn History



Interviews with plant personnel indicated that operation at the design / permitted steaming rate induces a tube corrosion rate, resulting in increased facility downtime. Therefore, the primary capacity limit at the Red Wing facility is the boilers, like the Elk River Facility. This is a common issue in the industry. Given that the plant maintenance staff appears to be addressing the problem in a normal fashion with inconel overlay and occasional tube replacement, it is doubtful that the capacity can be increased.

- d) Availability – The plant availability in 1999 was reported to be 85%. The forced outage rate for Red Wing was reported to be 4.3%.
- e) Future – The opportunities for additional throughput at the Red Wing facility will be through increased availability. Improvements in fuel quality, elimination of “rag monsters” and reductions in grate cleanings should provide a significant increase in overall availability. Improvements in fuel bed control and possibly under-grate combustion air temperatures are also needed to reduce outage rates resulting from grate cleanings.

According to plant personnel, a 90% availability should be attainable. If this availability is achieved by eliminating rag monsters and excessive grate cleanings, combustion capacity of this facility could increase to between 215,000 and 225,000 tons per year.

- 3. Retrofit Work – The following items were identified as potential retrofit work on the existing system that would result in additional availability and increased throughput:

- a) Improve fuel delivery and distribution to maintain a more even bed depth is recommended.
 - b) Also, installation of equipment to screen stringy material from the waste stream at the Newport processing facility should improve the fuel quality by eliminating material prone to form “rag monsters”. A rotating type screen, designed to entrap stringy material, while allowing acceptable fuel to pass and having an easy ability to clean agglomerated material is needed.
4. Boiler Design Steam Conditions
- a) Steam flow – 106,000 lbs per hour
 - b) Steam pressure – 650 psig
 - c) Steam temperature – 700 °F
5. Outage Summary
- a) The most frequent maintenance item is the boiler. Each of the two units has one scheduled 3 week outage per year and approximately two 1 week outages per year.
6. Fuel Storage Capacity – 1000 tons
7. Ash Disposal – averages 18% of the RDF combusted.
8. Energy generation – 624 kwh/ton (1998)
9. Remaining Useful Facility Life – The Red Wing facility began operation in 1987. The plant is presently completing the installation of new air pollution control equipment in place of the electrostatic precipitators. The new equipment includes fabric filters, sorbent injection system, fans, ductwork and continuous emissions monitoring system. Assuming that overall plant maintenance practices continue in such a way as to maintain plant reliability, it is reasonable to assume that the plant could be operated efficiently for an additional 15 to 20 years.

E. Wilmarth

1. Plant Condition

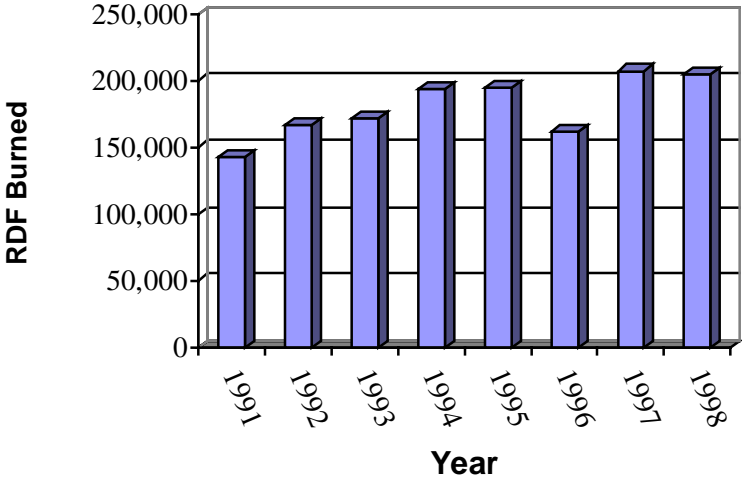
The RDF burned at this facility is approximately 65% Ramsey/Washington RDF, 30% ERRRF, and 5% local. Plant availability is often limited by fuel quality. The facility operates better when utilizing RDF from Elk River, primarily because the RDF from Newport contains a higher percentage of plastics, banding, magnetic tape, etc. These “streamers” tend to wrap around equipment shafts resulting in temporary shutdowns for cleaning. Newport waste has a high chlorine content at times. This causes HCl emissions to rise substantially. Plant personnel would like to incorporate a ferrous removal system also to reduce some of the ferrous metals entering the combustion chamber. This would improve fuel feeding and ash handling. The removal of aluminum from the fuel stream would greatly reduce grate cleaning frequency. Aluminum removal would have to be accomplished with an eddy current separator at the processing plant.

The plant air pollution control consist of a fabric filter and a dual flow dry scrubber. Dry lime injection is utilized for acid gas reduction. The boilers were manufactured by B & W and the furnace is a Detroit Stoker grate design. Boilers currently operate at 625 psi and 700 °F. The turbine has a 12 megawatt nameplate but runs about 11 megawatts at the design boiler steam output. The turbine could operate as high as 14 megawatts with higher steam pressure and temperature but the boiler tubes degrade at an exponentially higher rate. Currently, superheater tubes are needing replacement every 10 years. Between replacements, frequent tube repair is needed using inconel overlays. The plant has implemented a cycled replacement schedule for the boiler waterwall tubes as well. Outages are scheduled three times per year in order to thoroughly clean the grates. The two units share a common ash system but this arrangement has not historically been problematic.

2. Capacity

- a) Permit – The units at Wilmarth are limited by permit 180 million btu’s per hour per unit.
- b) Design – The furnaces are designed to accommodate 720 tons per day of RDF. The boilers are designed for a steam flow of 106,000 pounds per hour each.
- c) Historical – Figure 5 below illustrates the burn capacity at Wilmarth from 1991 through 1998.

Figure 5 – Wilmarth RDF Burn History



- d) Availability – Plant availability averages approximately 85% per year. The forced outage rate for 1999 was reported to be 2.2%.
- e) Future – An availability of 90% is achievable if the fuel quality could be improved by the reduction of rag monsters and aluminum. If so, the new

combustion capacity of this facility would increase to between 215,000 and 225,000 tons per year.

3. Retrofit Work

Retrofit recommendations are the same for Wilmarth as Red Wing:

- a) Improve fuel delivery and distribution to maintain a more even bed depth is recommended.
- b) Also, installation of equipment to screen stringy material from the waste stream at the Newport processing facility should improve the fuel quality by eliminating material prone to form “rag monsters”. A rotating type screen, designed to entrap stringy material, while allowing acceptable fuel to pass and having an easy ability to clean agglomerated material is needed.

4. Boiler Design Steam Conditions

- a) Steam flow – 106,000 lbs per hour
- b) Steam pressure – 650 psig
- c) Steam temperature – 700 °F

5. Outage Summary

- a) The most frequent maintenance item is the boiler. Each of the two units has one scheduled 3 week outage per year and approximately two 1 week outages per year.

6. Fuel Storage Capacity – 1000 tons

7. Ash Disposal – averages 18% of the RDF combusted.

8. Energy generation – 655 kwh/ton (1998)

9. Remaining Useful Facility Life – Assuming that overall plant maintenance practices continue in such a way as to maintain plant reliability, it is reasonable to assume that the plant could be operated efficiently for an additional 15 to 20 years.

VI. SYSTEM CAPACITY CONSTRAINTS

A. General

The work completed hereunder also identified several constraints, which may limit or restrict utilization of the additional Processing Capacity that has been identified. These constraints are in addition to other site specific constraints identified previously. Other constraints that may limit overall system capacity have been summarized within the following categories

1. Contract
2. Ash Disposal
3. Permit

B. Contract

In order to fully utilize the processing capacity contained within the existing system, existing contracts between the vendors and the counties will likely require revisions or replacement. A “System Approach” to processing will probably be necessary to ensure adequate waste is always available to each processing facility. Fee arrangements, restrictions and other contractual components are restrictive in existing contracts in such a way that will likely be counter productive towards utilization of the total system capacity. For example, during periods of waste shortfalls from one county, it will be advantageous to have another participating county divert waste from the landfill to the appropriate processor to ensure maximum waste capacity is used and no fuel shortfalls occur.

New contract agreements with the vendor should include the following:

1. Standard pricing for each participating county to deliver waste to both Elk River and Newport. Provided capacity is available, counties should not be penalized for waste deliveries provided to ensure total system capacity is utilized. Pricing is recommended on a “fixed monthly fee basis” for normal deliveries within the maximum quantity range. Counties should be allowed to assist each other in ensuring the maximum supply is always provided.
2. Simple fee approach based upon an RDF production of 85% of MSW received . This approach would leave the responsibility for managing non-processibles, oversized and bulky waste and RDF yields with the operator and dramatically reduce the contract administration requirements. TLO’s should only be allowed for one of the following reasons:
 - a) Oversupply by the county(s), in which case the expense will be borne by the responsible county(s).
 - b) Hazardous or infectious waste.
 - c) Long, “stringy” waste generated by specified commercial suppliers. All other oversize or bulky waste will not be cause for TLO. The vendor should be responsible for processing such waste or including the costs for assumed TLO percentages. Fees should be based upon the targeted facility

availabilities and capacities provided herein. The vendor will therefore be incentivized to maintain these minimum levels by avoiding TLO expenses.

3. Each participating county will have a contract maximum supply quantity. No minimum supply will be required, since the fee will be a flat fee. The maximum supply should be based upon the Processing Capacities identified herein.
4. Counties should be responsible to track waste deliveries amongst themselves under participation type agreements in such a way that the vendor is not responsible for this tracking activity. Counties may therefore “trade” capacity or charge themselves as they otherwise agree.

C. Ash Disposal

Ash disposal may also impose considerable limitations with respect to realizing the additional Processing Capacity identified herein. A discussion of the potential limitations identified follows:

1. GRE

Ash from this facility is delivered to the Becker ash monofill. Original design capacity for this monofill was 1,276,000 cubic yards. A recent permit expansion was completed which adds an additional 306,000 cubic yards of capacity. The total capacity is therefore projected at 1,582,000 cubic yards. At present disposal rates, this capacity is projected by the vendor to be sufficient for the remaining contract term which ends in 2009. Space utilization was higher than originally projected until 1998 when improvements to the ash quality were made through improved combustion. The permit expansion was designed to account for the additional space used beyond original projections during the first half of the contract term. It is expected that space utilization will be improved through the remaining contract term.

In order to realize additional Processing Capacity through a period extending beyond the current contract term, additional monofill capacity will be required. The additional capacity must account for the projected increase in Processing Capacity as well as any additional time beyond the original contract term.

2. Wilmarth

Ash from this facility is delivered a dedicated ash monofill. Original design capacity for this monofill was 767,000 cubic yards. A recent permit expansion was completed which adds an additional 833,000 cubic yards of capacity. The total capacity is therefore projected at 1.6 million cubic yards. At present disposal rates, this capacity is projected by the vendor to be sufficient for the remaining contract term which ends in 2009. Approximately 750,000 cubic yards of capacity has been used.

In order to realize additional Processing Capacity through a period extending beyond the current contract term, additional monofill capacity will be required. The additional capacity must account for the projected increase in Processing Capacity as well as any additional time beyond the original contract term. In addition, any permit restrictions which limit county deliveries in a participating manner should be removed.

3. Red Wing

Ash from this facility is delivered to a dedicated ash monofill. A recent permit expansion was completed which brings the total capacity to 1.2 million cubic yards. At present disposal rates, this capacity is projected by the vendor to be sufficient for the remaining contract term, which ends in 2009. Approximately 540,000 cubic yards of capacity has been used.

In order to realize additional Processing Capacity through a period extending beyond the current contract term, additional monofill capacity will be required. The additional capacity must account for the projected increase in Processing Capacity as well as any additional time beyond the original contract term. In addition, any permit restrictions, which limit county deliveries in a participating manner should be removed.

4. HERC

Ash from this facility is presently delivered to a private ash landfill operated by Safety-Kleen corporation. Additional research is necessary to determine how sufficient disposal capacity may be available beyond the current contract term.

5. WLSSD

The district presently owns an ash monofill which was used when the facility was firing RDF. No specific restrictions with respect to waste origin are known, but should be further reviewed.

6. RDF Co-Firing

Ash disposal may be a considerable constraint with respect to RDF co-firing at the coal fired facilities identified herein. Facilities currently land applying ash may be restricted or prevented otherwise from continuing this practice under a co-firing arrangement. If this should occur, landfilling of the ash would be the likely alternative at a much higher disposal cost. Facilities not presently land applying ash would therefore have a greater probability of success for co-firing over those that are land applying ash.

D. Permit

In addition to ash monofill permit restrictions identified above, other present permit conditions associated with combustion facilities will restrict utilization of all Processing Capacity that could be available. Specifically, these restrictions are as follows:

1. HERC

State law and permit restrictions limit MSW throughput at this facility to 365,000 TPY, even though the facility is designed to process about 405,000 tons per year. Removing this restriction to allow full utilization of the plant design capacity is a low cost alternative for additional capacity.

While no other permit restrictions were identified with respect to the additional Processing Capacity identified herein, further evaluation in this area is recommended in order to ensure there are no other constraints that may prevent utilization of the capacity.

VII. OTHER COMBUSTION / PROCESS OPTIONS

All options available to the Counties for MSW processing were identified for further consideration. These options included options beyond the current system. A discussion of each of these potential options follows. A detailed assessment of the potential for RDF co-firing (including densified RDF) at existing coal/biomass facilities was completed. Further review of the other 6 options identified may be warranted to determine the best disposal options from a processing cost standpoint.

A. Co-Firing RDF at Existing Coal-Fired and Biomass Facilities

The potential for co-firing RDF at existing coal and biomass facilities located in the region was evaluated. This review addressed the following:

1. Permitting issues and constraints – Under Minnesota Statute §116.90, existing or new solid fuel fired boilers may utilize refuse-derived fuel in amount up to 30 percent by weight. Subd. 2. of this statute states that “The agency may not require, as a condition of using refuse-derived fuel under this section, any additional monitoring or testing of a solid fuel fired boiler’s air emissions beyond the monitoring or testing required by state or federal law or by the terms of the solid fuel fired boiler’s permit issued by the agency.”
2. Ash disposal issues or concerns – Ash disposal is the restriction of greatest concern. A majority of ash generated from coal and wood combustion at the facilities identified herein is presently land applied. The presence of metals and other contaminants may prohibit continued land application.. All ash may be required to be disposed of in an ash monofill if RDF co-firing is utilized. Further study of this issue will be required if RDF co-firing is pursued.
3. Assessment Methodology – In order to adequately determine the total potential co-firing capacity that could be available, a list of all of the facilities in the state of Minnesota was obtained. Facilities were then omitted from this list if they did not meet all of the following criteria:
 - a) The facilities must be either a stoker, cyclone or fluid bed design. Many of the facilities listed utilize pulverized coal technologies and it is not economically feasible to convert the feed systems of these plants to accommodate RDF, due to extremely fine particle size requirements for fuel fired at pulverized coal fired facilities.
 - b) For coal fired facilities, the fuel throughput of the facilities must be at least 250 tons per day. It is assumed that no more than 30% of the total fuel feed will be RDF due to permitting and regulatory issues.
 - c) Transportation costs must be limited in order to make the co-firing economical. For this assessment, any facility more than 120 miles from a processing facility was not considered.

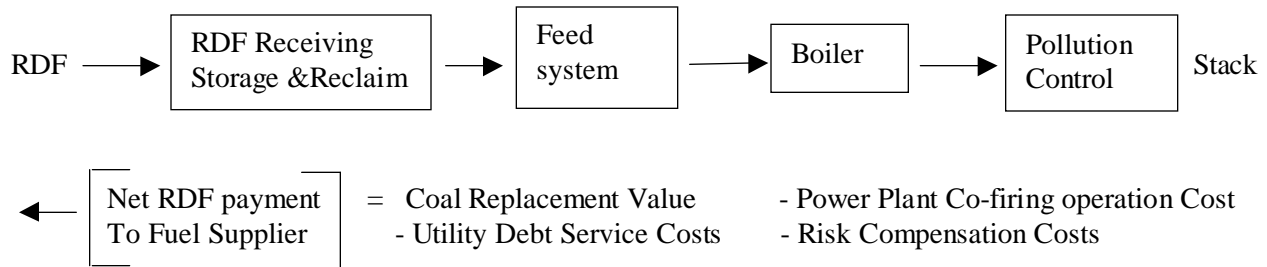
Table 4 summarizes the results of the potential facilities identified as potential RDF co-firing candidates. Included in the table is the total potential capacity, and distance from each of the two processing facilities. Also included are the costs associated with the facility retrofit, additional

operating expenses and transportation to the plant. No fuel value was assumed for the RDF. Costs associated with RDF processing or additional ash disposal costs are not included. Therefore, the total disposal costs for this option may be considerably higher. No biomass facilities were found that met the feasibility criteria.

Table 4 – Coal Plant Co-fire Candidates

<i>Facility</i>	<i>Fuel</i>	<i>Additional RDF Capacity (TPY)</i>	<i>Distance from ERRF (miles)</i>	<i>Distance from Newport (miles)</i>	<i>Miles from Closest Facility</i>	<i>Trans. & Costs (\$/ton)</i>	<i>Cap. & Oper. Costs (\$/ton)</i>	<i>Total Costs (\$/ton)</i>
Facility 1	coal	13,178	99	92	92	\$13.80	\$21.99	\$35.79
Facility 2	coal	13,009	35	20	20	\$3.00	\$21.99	\$24.99
Facility 3	coal	14,276	35	20	20	\$3.00	\$21.99	\$24.99
Facility 4	coal	15,154	35	20	20	\$3.00	\$21.99	\$24.99
Facility 5	coal	23,990	44	10	10	\$1.50	\$21.99	\$23.49
Facility 6	coal	75,391	92	116	92	\$13.80	\$21.99	\$35.79
Facility 7	coal, pet coke	109,644	45	24	24	\$3.60	\$21.99	\$25.59

The following is a graphic representation of RDF combustion flow through the system and what constitutes the RDF costs to the consumer. The costs and risks associated with RDF co-firing are illustrated below.



Power plant Cofiring Operating Cost

- Boiler Efficiency Decrease
- Increased Power Costs
 - RDF Handling
 - ESP
 - Ash Handling
- Increased System Maintenance
 - Labor
 - Materials
- Increased Operating Labor
 - Supervision
 - Plant Engineer
 - Unit Operators

Coal Replacement Value

Cost of Coal Btu's Replaced by RDF

Debt Service Cost

Debt Service of Capital Cost for:

- RDF Receiving, Storage, Reclaim, Flow Metering and Boiler Injection System
- Pollution Control Increase Capacity
- Ash handling Increased Capacity
- ID Fan Increased Capacity
- Ash Disposal Costs

- Startup Crew
- Power Replacement for Load Reduction When Co-firing if Unit Is Limited Due to:
 - Particulate Emissions
 - Steaming Capacity
 - Convection Pass Velocity
 - Fan Capacity
 - Ash handling Capacity

Risk compensation Costs

- Cost of Greater Risk of Unit Downtime
- Cost of Premature Project Termination (Cost of Project Termination Before Investment in Power plant Facilities is Paid Off.)

B. Densified RDF

1. General

Densified RDF (d-RDF) has been attempted as a way of creating a more uniform fuel that is acceptable to utilities and industrial power producers as a substitute or supplement to coal. This process has not been commercially successful and has failed for economic as well as technical problems. To gain a perspective of the issues and economics of producing and selling d-RDF, the following information was compiled from industry reports as well as an extensive study prepared by the *National Renewable Energy Laboratory Data Summary of Municipal Solid Waste Management Alternatives*

2. Co-Firing With Coal

When replacing or co-firing d-RDF with stoker coal, the utility operator must address that on an equivalent input basis, RDF has very different properties from coal:

Table 5 Ratio of RDF Properties Relative to Equivalent Heat Content of Coal

Property	Mult.
Weight of RDF	1.7x
Volume of RDF	2.0x
Ash Content of RDF	4.0x
Volatile Content of RDF	3.0x
Fixed Carbon Content of RDF	1/3x

In order to produce a densified RDF which more closely approximates coal, both the fluff RDF (used to form the d-RDF) and the densification process have to be controlled. The particle size must be sufficiently fine to account for stringy materials and sheet plastics, which would interfere with the production and quality of d-RDF pellets. Further, the non-combustible content of the fluff RDF must be reduced to minimize the ash resulting from d-RDF combustion. An overall ash content of between 10% and 15% is recommended in order to decrease erosion of the pelletizer during production of the d-RDF and slagging of the boiler during combustion of d-RDF.

Moisture control of the fluff RDF is a critical factor in d-RDF production. Moisture content of the fluff RDF should be maintained under 25%. At moisture contents less than 12%, hard, stable pellets are produced because of the increased friction between the die

and the extruded material. However, production rates suffer with this high friction. As moisture content increases, the friction decreases. Resultant pellets have poor surface features, are loosely compacted, and demonstrate lower integrity during handling. To assure the integrity of pellets, materials with low moisture content (binders) need to be added to the fluff. These binders are additives that enhance the resultant pellet integrity. In the mid-1980s, the U.S. Department of Energy sponsored research examining more than 200 types of binders. It was determined that the best additive was calcium hydroxide, or lime. The researchers reported that the calcium hydroxide assisted in the formation of strong, water-resistant pellets.

3. Production Costs

Pellet mill processes have indicated operating throughput levels of 2-4 tons per hour. The following table representing the cost to produce d-RDF is based upon NREL study and has been updated to today's dollars. It assumes a 4 ton per hour capacity for each pellet mill and includes no costs for land and buildings. The cost of d-RDF production is \$16.31 per ton based upon the production of 50,000 tons per year.

**Table 6 - Densification Module Capital and Operating Cost Estimate
(1985 \$ escalated to 2000 \$)**

Capital Costs	(\$)
Four single speed pellet mills includes rollers, in-line feeders, centrifeder, dies, and all motors.	\$397,600
live-bottom feeders (includes all motors and hydraulics)	\$ 50,000
Conveyors (includes both infeed and takeaway conveyors and motors)	\$ 33,800
Fines screen and return (includes motors)	\$ 14,000
Pellet coolers (includes fan and all motors)	\$ 80,000
Motor control center (includes automatic controls)	\$ 50,000
Installation	\$ 93,800
Contingency (30%)	\$215,800
Total Capital Cost	\$935,000
Total Capital Cost in 2000 \$	\$1,600,000
Annual Debt Service (at 6% per year, 20 years)	\$131,600
Capital Cost per ton (50,000 tons per year/two shifts)	\$ 2.63/ton
Operating Costs	
Die and roller replacement	4.00/ ton
Electricity	2.23/ ton
Maintenance and materials	0.50/ ton
Insurance	0.28/ ton
Labor (\$16.80/hr)	0.29/ ton
Contingency (10%)	0.70/ ton
Total Operating Cost	\$ 8.00/ton
Total Operating Cost in 2000 \$	\$13.68 ton
Total Cost Per Ton in 2000 \$	\$16.31/ ton

1. 50,000 tons per year = (2 shifts/day) x (16 tons/h) x (8 h/ shift) x (260 day/y) x (.075)
2. CPI escalator of 1.71 1985 – 2000

C. Western Lakes Superior Sanitation District (WLSSD)

WLSSD constructed and operated an RDF fired waste-to-energy facility located in Duluth, MN. The facility began operation in 1982 and operated until 1998. The facility consisted of two combustor/ boiler trains, each rated for co-firing of 144 TPD of RDF with approximately 7 TPD of wet sewage sludge. Each combustor/boiler train included a fuel feed system, refractory lined fluid bed combustion reactor, heat recovery steam generator, wet type venturi scrubber, fans and auxiliary equipment. Combustors are designed and permitted to co-fire either coal or RDF with sewage sludge. RDF was originally prepared in a nearby processing facility and transported by conveyor to one of the two combustors.

Design and permit restrictions did not allow for normal operation of both units on a simultaneous basis. The facility experienced substantial problems in the early years of operation with the majority of the problems associated with the fluid bed reactors. After numerous modifications, most of the reactor based problems were overcome according to personnel at the facility. However, the boiler design has inherent limitations that require major tube work on an annual basis. The primary issue is related to tube failures resulting from steam impingement from the sootblowers. According to personnel at the site, the boilers have been re-tubed on numerous occasions and are reaching the end of their useful life. Further, the boilers are not designed properly for this application and therefore require replacement.

In 1998, WLSSD made the decision to cease sludge disposal through combustion in favor of a land based application alternative. As a result, combustion of RDF has since ceased. The processing facility, including the fuel delivery system has been dismantled in order to make room for other facilities on the site. Also, one of the two waste heat boilers is being removed to make room for a new gas fired auxiliary boilers.

Despite these changes, it remains possible to utilize the remaining combustor train as a capacity option. The air permit remains valid and the facility management have indicated an initial interest in pursuing the possibility of having outside RDF brought in. The potential to co-fire sludge with the RDF to reduce the land based application quantities may be advantageous. Further, emission summaries from testing performed prior to the shutdown indicate that the unit is capable of compliance with the proposed federal emission guidelines for small waste combustors. However, a number of improvements to the facility would be required in order for the remaining combustor train to be used. These improvements and estimated costs are as follows:

Table 7 – WLSSD Capital Costs for Remaining Combustion Train

Work Item	Cost (\$)
New fuel unloading & delivery system	1,000,000
New waste heat boiler	950,000
Turbine generator and auxiliaries (used)	450,000
Miscellaneous equipment work	350,000
Engineering	140,000
Construction & Construction Management	3,700,000
Miscellaneous project costs including shipping	150,000
Total Retrofit Costs (\$)	6,740,000
* Total Retrofit Costs (\$/ton)	\$19.63

* Uses 6% interest and 10 year debt service.

The new fuel unloading system would include a walking floor based trailer unloading dock, walking floor conveyor, apron conveyor and belt conveyor similar to the systems installed at ERRF, Wilmarth and Red Wing. The new waste heat boiler would be designed for this particular waste heat application. The turbine generator and auxiliaries would be necessary for energy recovery since the total site steam load is well below what would be generated from RDF combustion. It is estimated that gross output would be approximately 3.75 MW, which could be used to offset purchased power by the district, with any excess sold to the local utility. This scenario would maximize energy sales revenues (avoided costs), which would assist with the reduction of tipping fees. However, several concerns related to utilizing this facility for RDF combustion must be addressed. These concerns are as follows:

1. Distance to the facility from the twin cities area (approximately 150 miles from the Elk River RDF facility).
2. Potential for reduced facility availability as a result of having only one combustor/boiler train.
3. Total throughput would be approximately 44,000 TPY, which may not be sufficient to warrant the investment in additional processing capacity at Elk River, which would probably be required in order to ensure sufficient RDF is available.

***Table 8 – WLSSD Cost Summary**

Expense	\$/ton
Capital cost	19.63
* Operating cost	64.09
Ash disposal	5.61
Transportation	21.00
** Energy Credit	-36.00
TOTAL	74.33

* Costs exclude RDF processing

** Cost estimate from WLSSD.

*** Calculated using 6000 btu/lb HHV, 20,000 btu/kw-hr net plant heat rate and power cost rate of \$2.00 capacity charge /energy charge of 0.030/kw-hr.

D. New mass burn facilities

Mass burn combustion processes have been the dominant technology used to date for MSW combustion in the United States. This is primarily due to lower installed and operating costs associated with mass burn when compared to RDF technologies for newly constructed facilities. As indicated in Appendix E, mass burn is typically less expensive than RDF on both a small scale and large scale basis. Therefore, new mass burn facilities should also be considered for additional future capacity. Further evaluation should be conducted with respect to facility sizes and costs, when compared to other capacity options identified, including RDF co-firing.

E. Conversion of Existing RDF Combustion Facilities to Mass Burn

As indicated above, processing costs associated with RDF production are high. Elimination of these costs within the system by conversion of the existing RDF combustion facilities to mass burn type facilities may significantly reduce the total costs for disposal, depending upon costs and feasibility of conversion. The following considerations should be noted regarding this possible option:

1. Evaluation of suitable mass burn combustion technology and feasibility of modifying the existing combustion facilities should be evaluated.
2. Suitable space on each site for mass burn storage capacity should be addressed.
3. Costs associated with conversion of each combustion facility to mass burn should be identified.
4. Transportation cost impacts should be considered. The ERRRF processing facility and GRE combustion facilities are presently located within 2 miles of each other. Therefore, additional transportation costs for this option is negligible. However, the Ramsey Washington processing facility is located a considerable distance from the Wilmarth and Red Wing combustion facilities. Conversion of these two facilities to mass burn would necessitate a much further transportation distance for MSW. The transportation distance for RDF process residue to landfill must also be included in this cost analysis.
5. Impacts associated with combustion unit heat release and total plant energy production must be evaluated. The heating value of MSW is typically lower than RDF, which may reduce the heat release in each combustion unit, depending upon actual heating values and mass burn combustion technology employed.
6. Impacts associated with permit modifications from a RDF type facility to mass burn type facility should be addressed.
7. Potential changes to emission rates should be evaluated.

F. Conversion of Existing Coal / Biomass Facilities to Mass Burn

Conversion of existing stoker type coal fired and biomass fired facilities to mass burn type combustion facilities should be considered. This option would potentially offer much higher throughput capacity at a lower cost. The following considerations should be noted regarding this possible option:

1. Evaluation of suitable mass burn combustion technology and feasibility of modifying the existing combustion facilities should be evaluated.

2. Suitable space on each site for MSW storage capacity should be addressed.
3. Costs associated with conversion of each combustion facility to mass burn should be identified.
4. Transportation cost impacts should be considered.
5. Energy production revenues should be considered.
6. Impacts associated with permit modifications from a coal fired facility to mass burn type facility should be evaluated. Unlike RDF co-firing, this option would require a new facility permit. Also, the facility would be considered a “new source” from a permitting standpoint.

G. Additional combustor/boiler trains at existing RDF combustion facilities

While new RDF combustion facilities are expected to be cost prohibitive, additional combustion capacity at existing sites through new combustor/boiler trains, including air pollution controls may be more cost effective. Additional study of this option is therefore warranted from a disposal cost standpoint. Issues that may impact the economic feasibility of this option will include:

- Availability of additional processing capacity
- Costs of other processing alternatives, such as RDF co-firing and new mass burn facilities
- Ability to permit the expansion project

VIII. POTENTIAL FUTURE COST REDUCTIONS

Only three potential cost reductions were identified outside of the cost reduction options within the present system as it is structured. The first option is related to the current movement towards deregulation of the electric utility industry. In the event this occurs, a percentage of power generation from renewable sources may be mandated at either a state or federal level. Further, waste-to-energy may be included as a renewable power option. In this event, the energy sales rates from waste-to-energy may increase, depending upon current contract rates with utilities. Higher energy sales rates could be used to reduce disposal and processing costs.

In addition, the potential for ash re-utilization may allow for cost reductions in the future. In the event that Minnesota Pollution Control Agency policy changes allow for ash utilization for applications such as road base, disposal costs may be reduced. Another option which could reduce ash residue disposal costs would be the emergence of new ash recycling technologies that are cost effective. While ash utilization is possible, it is not a likely scenario due to public perception issues.

Finally, should the members of the SWMCB elect to re-negotiate the existing contracts, an overall reduction in cost per ton for processing and disposal may be realized. Re-negotiation will be required in order to realize the additional capacity presented herein, as well as improve flexibility with the facilities necessary for the “system approach” to function properly. The basis for lower fees may include realization of lower market rates, a longer period for debt service repayment and additional capacity without substantial increase in project related debt.

It should be noted that there are other factors outside the system, which may impact the costs and capacity of the system from a negative standpoint. These issues have not been expounded upon. One example pertains to a recent decision by the United States EPA to consider boiler tube replacement as a “modification” to the plant, which triggers New Source Review. Lawsuits are presently pending between approximately a dozen utilities and the EPA over this issue. It seems implausible that the courts will uphold the position being held by the EPA. Virtually all power plants, including waste-to-energy plants, perform periodic boiler tube replacement as a part of their overall maintenance program. All of the system combustion facilities presently replace tubes on a periodic basis. However, should the EPA’s position be upheld, then any plant replacing boiler tubes, or performing other major maintenance work could face New Source Review Standards each time the work is performed. Overall implications could include reclassification of facilities as “new sources”, which must meet more stringent regulations. The result would likely mean a higher disposal cost, due to the increased costs associated with compliance.

IX. CONCLUSIONS / RECOMMENDATIONS

A. General

The existing RDF processing system has been determined to be “burn limited” meaning more RDF can be produced at the two processors than can be utilized at the three combustors. If all recommended improvements are implemented at the combustion facilities, an additional 85,000 tons of RDF can be burned annually. HERC is capable of processing an additional 42,030 tons of MSW if the existing permit cap is modified.

The economic viability of RDF co-firing at local coal fired plants as identified herein is questionable, in light of other combustion alternatives. In addition, implementation may be very difficult due to environmental issues, negative perceptions and perceived overall risk. WLSSD offers a technically viable alternative for additional RDF combustion capacity, but the costs are likely prohibitive.

B. Existing System

The existing waste processing system was determined to be primarily constrained by RDF combustion capacity. Improvements to the existing RDF combustion facilities could result in the availability of additional MSW processing capacity in excess of historical levels. This additional combustion capacity of approximately 85,000 tons of RDF can be realized without the addition of RDF processing lines at the Elk River or Newport RDF processing facilities. Assuming a yield of 85% RDF from each ton of MSW processed, this translates into another 100,000 tons of MSW being processed.

With improvements, total maximum system combustion capacity is projected to be as follows:

Table 9 – Existing System - Combustion Capacity (tons/yr)
(Assuming 85% RDF Yield)

Facility	Max. RDF Capacity	Max. MSW Processed
GRE	320,000	376,471
Red Wing	225,000	264,705
Wilmarth	225,000	264,705
Totals	770,000	905,881

In order to realize this maximum throughput capacity, the following improvements are recommended:

1. Permanent modifications at the Newport processing facility to remove long, stringy material which reduces combustion system availability at both Red Wing and Wilmarth combustion facilities. This improvement will likely consist of new screening equipment prior to RDF load out for transport to the combustion facilities, or better screening / shredding at the primary shredder.

2. Additional crews and operating hours at both the Elk River and Newport processing facilities in order to increase overall throughput.
3. Technical improvements at the Elk River, Red Wing and Wilmarth combustion facilities to eliminate downtime associated with removal of agglomerated aluminum in the combustion grate assemblies. Much of this work has already taken place at Elk River and improvements have been realized.
4. Replacement of existing waste contracts with new contracts that better allow for utilization of total projected MSW throughput capacity. It is anticipated that new contracts can provide far greater flexibility to the participating counties at a lower overall cost than is presently paid by the counties.

Table 10 summarizes the 1999 RDF throughput by facility with the maximum RDF throughput projected hereunder.

Table 10 – RDF Combustion Increase (tons/yr)

Facility	5 Year Historical Avg.	Projected RDF Throughput	Projected Increase (tons/yr)	Projected Increase (%)
GRE	293,900	320,000	26,100	9 %
Red Wing	198,073	225,000	26,927	14 %
Wilmarth	193,134	225,000	31,866	16 %
Combustor Total	685,107	770,000	84,893	10 %

As indicated above, a total maximum increase in RDF throughput capacity of 84,893 tons/yr is projected to be achievable between the three RDF combustion facilities.

C. Existing RDF Processing System

Total maximum annual throughput capacity from the processors could be 1,000,000 tons/yr of MSW. With improvements, the maximum MSW required for the combustion capacity projected is 905,881 tons/yr, assuming an 85% yield at the processors. Therefore, a surplus capacity of 94,119 tons/yr of MSW from the processors could be available over the projected maximum requirement for the combustion facilities. This equates to a potential RDF surplus of 80,000 tons/yr from the processors, assuming an RDF yield of 85%.

D. Existing Mass Burn Capacity

The only mass burn facility in the system is the Hennepin Energy Resource Company (HERC). The plant is permitted to burn up to 365,000 tons per day of MSW and currently runs at approximately 1220 tons per day. The plant is capable of burning at the permitted limit of 365,000 with a combined capacity/availability of only 82.5%. The plant normally runs at a much higher capacity and therefore must reduce production near the end of the year so that the permit limit is not exceeded. Based upon industry averages for newer mass burn facilities, such as HERC, the facility should be able to realize an overall availability near 92%, which would result in a increase of 42,030 tons per year in overall throughput if the permit limit were higher.

E. Other RDF Options

Several additional RDF combustion options were identified and evaluated as a part of the overall study. Realization of this additional combustion capacity may require additional processing lines at one or both of the existing processing facilities. Other RDF combustion options evaluated were as follows:

1. RDF Co-firing

Seven facilities were identified as having potential capacity for RDF co-firing. Sixty-five other coal and biomass facilities were also identified, but removed from consideration due to technical limitations. Total potential capacity, potential constraints and cost projections were identified and presented in the report. While technically feasible, this option may be considered cost prohibitive. Additional study is recommended with respect to this option, if projected costs are not considered prohibitive.

2. WLSSD

Approximately 44,000 tons per year of equivalent MSW combustion capacity is potentially available at this facility, assuming an RDF yield of 85 percent. Not unlike RDF co-firing, this additional throughput capacity may be considered cost prohibitive. Further evaluation is also recommended for this option, if projected costs are not considered prohibitive.

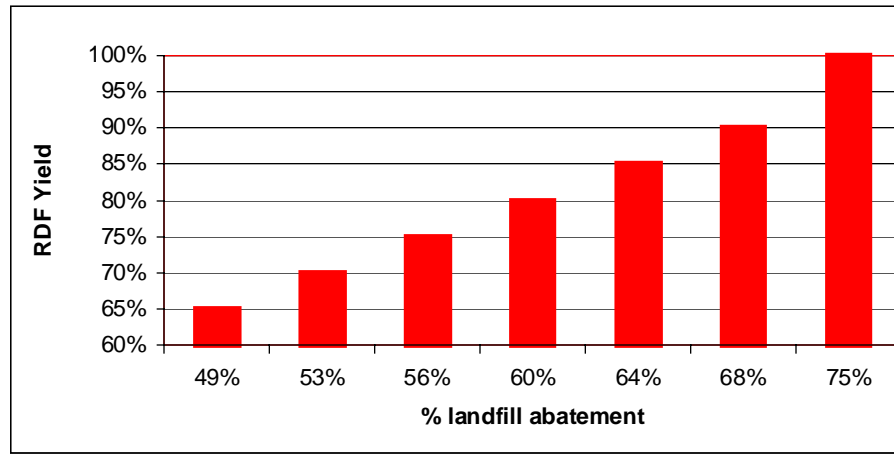
3. Densified RDF

The technical and economic feasibility, as well as overall merits of densified RDF (pelletizing) was addressed. This option was considered as a possibility for enhanced RDF co-firing. This option was found to be economically cost prohibitive.

F. Yield and Landfill Abatement

RDF yields at the processors can be adjusted substantially at the discretion of the operators. If the yield is relatively high, a higher percentage of the MSW is combusted resulting in a lower overall quantity of material going to the landfill. The combustion ash may increase, but the reduction in processing residue results in a net decrease to the landfill. If the yield is relatively low, large quantities of residue that contains combustible material is sent to the landfill which could result in landfill surcharges in addition to the overall increase in landfilling. Figure 6 below shows the relationship between yield and landfill abatement assuming that combustion results in a 25% ash yield. As illustrated by this graph, mass burn technologies produce the lowest percentage of material that must be landfilled. Also, RDF processors should be required to meet a minimum RDF yield of 85% at all times.

Figure 6 – Yield vs. Landfill Abatement



G. Conclusions

1. The existing RDF processing system has been determined to be “burn limited” meaning more RDF can be produced at the two processors than can be utilized at the three combustors. If all recommended improvements are implemented at the combustion facilities, an additional 85,000 tons of RDF can be burned annually.
2. HERC is capable of processing an additional 42,030 tons of MSW if the existing permit cap is modified.
3. The economic viability of RDF co-firing at local coal fired plants as identified herein is questionable, in light of other combustion alternatives. In addition, implementation may be very difficult due to environmental issues, negative perceptions and perceived overall risk.
4. WLSSD offers a technically viable alternative for additional RDF combustion capacity, but the costs are likely prohibitive.

H. Recommendations

1. Implementation of the following modifications at the RDF combustion and processing facilities are recommended:
 - Reduction in undergrate combustion air temperatures and improvements to fuel bed distribution at the combustion facilities in order to minimize downtime for grate cleaning is recommended.
 - Installation of eddy current separators at either the processing or combustion facilities is recommended in order to further minimize aluminum agglomeration in the combustion grate assemblies, as well as improve recycling rates.
 - Installation of additional screening equipment, or improvements to the primary shredder at the Ramsey/Washington processing facility is recommended in order to minimize the amount of long stringy material present in the RDF fuel stream being delivered to the Wilmarth and Red Wing combustion facilities. Consideration should also be given to diverting certain commercial loads containing this type of material to the HERC facility, in exchange for equivalent

MSW not containing long stringy or other objectionable material. Mass burn type facilities can more easily combust this type of material due to the lack of fuel conveying equipment where long and stringy material may accumulate.

- Installation of a bulky waste shredder at the ERRRF processing facility should be considered in order to reduce the quantity of TLO's, assuming contract incentives can be negotiated to minimize TLO's.

2. The technical feasibility and economics of the following options should be considered:

- Construction of new mass burn facilities

Newly constructed mass burn facilities have historically been more economical when compared to newly constructed RDF type facilities. Lower costs are the result of:

- Processing costs are eliminated
- Energy revenues maximized because no combustible residue is landfilled.
- Landfill abatement is increased by approximately 5%.
- Transportation costs may also be reduced.

In addition, RDF processing facilities are not presently removing recyclable materials, with the exception of ferrous material, which can be removed from the ash residue at mass burn facilities.

- Conversion of existing RDF facilities to mass burn type facilities
- Conversion of existing stoker type coal fired facilities to mass burn facilities
- Installation of additional RDF combustion / boiler trains at the existing RDF combustion facilities

3. Contract negotiations with the vendor to simplify and extend the contracts and expand capacity should be considered. Contract term should be extended for 10 years beyond the existing term. Since debt service will be eliminated for the new 10 year extension, and given that throughput capacities should be higher than what has been historically achieved, the disposal costs for the contract extension period should be considerably lower than presently charged. The negotiated costs should then be compared against all other disposal cost options available, including those identified above to determine the best economic option for disposal capacity. Recommended contract structure should be as outlined in Section VI herein.

GLOSSARY OF TERMS

Availability	The percentage of the year that a unit is in operation.
Capacity	The average percentage of a unit's design rating that it operates at while the unit is available.
Collection	The aggregation of waste from the place.
Commercial	Non-residential sources of waste including businesses, schools, government facilities and other institutions.
Curbside Collection	Collection of waste (garbage, recyclables, yard waste, etc.) from residences at the point of generation.
Disposal	The discharge, deposit, injection, dumping, spilling, leaking, or placing of any waste into or on any land or water so that the waste or any other constituent thereof may enter the environment or be emitted into the air, or discharged into any waters, including ground waters. (Minn. Stat. 115A.03, Subd. 9)
Generation	The act or process of producing waste. (Minn. Stat. §115A.03 Subd.11)
Landfill	A waste facility permitted by the Minnesota Pollution Control Agency that is designed or operated for the purpose of disposing of waste on or in the land. (Defined as "disposal facility" in Minn. Stat. §115A.03, Subd.10)
Landfill Abatement	Actions that avoid landfilling of waste, such as waste reduction, recycling, or resource recovery.
Landfill Surcharge	A surcharge applied to waste tipped at landfills; can include State, county, and local surcharges.
Major Appliances	Also commonly referred to as "white goods". Includes items banned by State law from disposal with solid waste (clothes washers and dryers, dishwashers, hot water heaters, heat pumps, furnaces, garbage disposals, trash compactors, conventional and microwave ovens, ranges and stoves, air conditioners, dehumidifiers, refrigerators and freezers). (Minn. Stat. §115A.03,Subd.17a)
Materials Recovery Facility	Facility designed for centralized sorting, processing, and/or grading of collected recyclable materials for marketing

Minnesota Pollution Control Agency	State Agency responsible for overall environmental quality of the state, primarily through enforcement of State rules issuing of permits and education for compliance. Commissioner is appointed by the Governor.
Municipal Solid Waste (MSW)	Garbage, refuse and other solid waste from residential, commercial, industrial and community activities that the generator the waste aggregates for collection with some exclusions as specified in Minn. Stat. §115A.03, Subd.21)
Non-processible Waste	Waste brought to a resource recovery facility but which cannot be mechanically processed due to its physical characteristics or potential harmful effects.
Processible Waste	Acceptable waste brought to a recovery facility that may be mechanically processed using the existing technology at the facility.
Processing	The treatment of waste after collection and before disposal. Processing includes but is not limited to reduction, separation, resource recovery, physical, chemical, or biological modification, and from one waste facility to another. (Minn. Stat. §115A.03, Subd.25) For purposes of certification of unprocessed waste, per Minn.Stat. §473.848, “storage,” “exchange,” and “transfer” are excluded (see unprocessed waste).
Outage	A period of time when a facility is not in operation. “Scheduled“ outages are planned for maintenance and “forced” outages occur due to equipment or system failure, or functional cleanings.
Recyclable Materials	Materials that are separated from mixed-municipal solid waste for the purpose of recycling, including paper, glass, plastics, metals, automobile oil, and batteries. Refuse-derived fuel or other material that is destroyed by incineration is not a recyclable material. (Minn. Stat. §115A.03, Subd. 25a)
RDF	Refuse derived fuel.
RDF Yield	The ratio of RDF produced to the total quantity of solid waste received at the processing facility.
Recycling	The process of collecting and preparing recyclable materials and reusing the materials in their original form or using them in manufacturing processes that do not cause the destruction of

recyclable materials in a manner that precludes further use. (Minn. Stat. §115A.03, Subd. 25a)

Refuse Derived Fuel (RDF) The product resulting from techniques or processes used to prepare solid waste by shredding, sorting, or compacting for use as an energy source. It consists of lighter weight materials such as paper products, with most metals, glass and other non-combustible materials removed.

Residue Waste materials remaining after processing waste for the separation and recovery of materials or energy.

Resource Recovery Reclamation for sale, use, or reuse of materials, substances, energy or other products contained within or derived from waste. (Minn. Stat. §115A.03, Subd. 27) Resource recovery is typically used to refer to the recovery of energy and usable materials during the processing of mixed-municipal solid waste.

Resource Recovery Facility A waste facility established and used primarily for resource recovery, including and appurtenant facilities such as transmission facilities and transfer stations primarily serving the resource recovery facility. (Minn. Stat. §115A.03, Subd. 28)

Solid Waste Garbage, refuse, sludge from a water supply treatment plant or air contaminant treatment facility, and other discarded waste materials and sludges, in solid, semisolid, liquid, or contained gaseous form, resulting from industrial, commercial, mining, and agricultural operations, and from community activities, but does not include hazardous waste; animal waste used as fertilizer, earthen fill, boulders, rock; sewage sludge, solid or dissolved material in domestic sewage or other common pollutants in water resources, such as silt, dissolved or suspended solids in industrial waste water effluents or discharges which are point sources subject to permits (in federal law), dissolved materials in irrigation return flows: or source, special nuclear, or by-product material as defined by The Atomic Energy Act of 1954, as amended. (Mim. Stat. Sec. 116.06, Subd.22)

Solid Waste Management Coordinating Board A board formed under a Joint powers Agreement, consisting of two Commissioners from each of the six metropolitan counties, plus two ex-officio members: the Director of the Minnesota Office of Environmental Assistance and the commissioner of the Minnesota Pollution Control Agency. SWMCG is established to coordinate solid waste planning and programming on a regional basis

Source Reduction	An activity that prevents generation of waste or the inclusion of toxic materials in waste, including: (1) reusing a production in its original form; (2) increasing the life span of a product; (3) reducing material or the toxicity of material used in production or packaging; or (4) changing procurement, consumption, or waste generation habits in smaller quantities or lower toxicity of waste generated. (Minn. Stat. §115a.03, Subd 26b)
Source Separation	Separation of recyclable, compostable, or other materials by the waste generator prior to collection.
Superheater tubes	A section of tubes in a boiler that heat steam to some temperature above the “saturation” temperature.
Tipping Fee	The fee charged by solid waste facilities to waste haulers, collectors, or other parties for the privilege of depositing or “tipping” waste.
Transfer Station	An intermediate waste facility in which waste collected from any source is temporarily deposited to await transportation to another waste facility. (Minn. Stat. §115a.03, Subd 33)
Unacceptable Waste	Waste that is not acceptable at a resource recovery facility under the term of the service agreement.
Waste	Solid waste, sewage sludge, and hazardous waste. (Minn. Stat. §115a.03, Subd 34)
Waste Management	Activities which are intended to affect or control the generations of waste and activities which provide for or control the collection, processing and disposal of waste. (Minn. Stat. §115a.03, Subd 36)
Yard Waste	Garden wastes, leaves, lawn cuttings, weeds, shrub and tree waste, and prunings . (Minn. Stat. §115a.03, Subd 34)

Appendix A

Process Flow Diagram Elk River Resource Recovery Facility

Appendix B

Process Flow Diagram Ramsey/Washington Resource Recovery Facility

Appendix C

Site Diagram Great River Energy Combustion Facility

Appendix D

Site Diagram

Hennepin Energy Resource Company

Appendix E

Mass Burn and RDF Capital and Operating Costs