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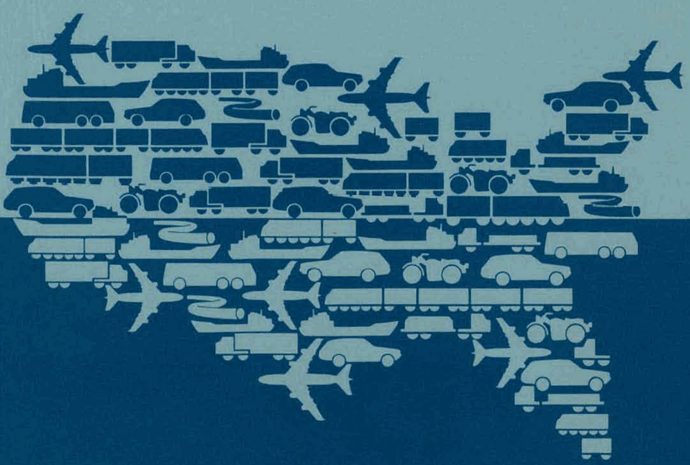

TRANSPORTATION ENERGY SYSTEMS

ENERGY & ENVIRONMENTAL SYSTEMS DIVISION

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AN ANALYSIS OF A COAL BROKERAGE FOR A MIDWEST SITE

by

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Energy and Environmental Systems Division

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prepared for

Office of Transportation Programs
Assistant Secretary for Conservation and Solar Applications
U.S. Department of Energy

This informal report presents preliminary results of ongoing work or work that is more limited in scope than that described in formal reports issued by the Energy and Environmental Systems Division.

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PREFACE

This report finalizes the project entitled "Effects of Increased Demand for Western Coal on the Midwestern Transportation System." The study produced the following four reports: [Refs. 1-4]

- A Survey of Electric Utility Demand for Coal;
- Industrial Demand for Western Coal - Great Lakes Region;
- Delivered Costs of Western Coal Shipped on the Great Lakes versus Eastern Coal for Eastern Great Lakes Hinterland Utility Plants; and
- An Overview of Future Western Coal Transport on Great Lakes Shipping.

The reports were prepared for Robert G. Christiansen, Office of Maritime Technology, Maritime Administration, and Daniel P. Maxfield, Office of Transportation Programs, Department of Energy. The project was initiated to determine whether increased Western coal shipments would prompt port development in the Great Lakes area. Research has concluded that Western coal transport is unlikely to create substantial increases in Great Lakes shipping before 1988. This final phase of the project further explores the Great Lakes regional coal demand and its distribution by considering the development of a coal brokerage as a transshipment terminal and local coal distributor of Western coal. This analysis considers a Western Great Lakes market and is oriented to a particular distribution area.

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1 INTRODUCTION

Increases in coal production resulting from rising utility and industry demand is virtually assured because of overwhelming petroleum price increases and fuel disruptions that have occurred since the 1973 embargo. These changes created the need for energy legislation that was oriented to meet the needs of existing coal users, in addition to others identified to convert from oil or gas to coal [Ref. 5]. Legislated programs have apparently set overly optimistic coal utilization goals to date because the high projections of coal use have not been realized. However, accelerated efforts toward decreasing the country's dependency on foreign petroleum, along with safety questions on nuclear power, has initiated action by the Carter Administration. This action again increases the likelihood of large volumes of coal deliveries to meet national energy needs. Based on these projected increases, it appears that only a sharp reversal of current political and economic trends could thwart the development of increased coal utilization in the next ten years.

New coal policies and prices are the prime determinants of the markets for coal use. Policies that have developed are directly affecting delivered costs. For example, the strip-mine law has made coal production costs for smaller eastern mines prohibitive [Ref. 6] and the Clean Air Act has reduced eastern coal demand by imposing strict sulpher dioxide controls in many coal-burning regions. The new policies are diverting the prime market away from Appalachian coal fields and creating a market for western coal, which has lower associated mining costs, but higher transportation costs. High mining costs and high sulfur content associated with eastern coal mining have made western coals more attractive to large electric generating plants. Since 54% of the U.S. coal reserves are west of the Mississippi River, large users can be assured of adequate future supplies of coal with lower environmental constraints. Buyers seem increasingly willing to pay higher transportation costs to receive western coal.

The sensitivity toward increasing fuel prices has prompted planning for more efficient transport of coal from mine-to-user so that even as the length of coal transportation hauls are increasing, energy intensity for coal over the long-haul route is decreasing. Therefore, western coal utilization in midwestern and eastern markets is likely to create more unit-train deliveries in order to minimize all costs incurred for coal shipments. Large quantity orders which are developed from compiling individual user needs enable coal buyers to capture economies-of-scale associated with large volume unit-train shipments.

1.1 PURPOSE

The purpose of this report is to present a concept called a coal brokerage, whereby the coal demand of an area is aggregated and served through a single facility in order to achieve the high volumes necessary to justify unit-train service. Once such a system is initiated, it is conjectured that coal users too small to individually receive unit-train orders can begin to capture the cost savings associated with large volume shipments.

In order to examine the coal-brokerage concept closely, the Green Bay-Kewaunee, Wisconsin region was chosen as the site for analysis because: 1) there had been speculation by lower peninsula Michigan utilities concerning a Wisconsin transshipment site for western coal; 2) the area's paper industry is a large coal user; 3) the Wisconsin Energy Office has researched coal consumption in depth, and has an available data base for industrial boilers and their fuel type; 4) line-haul rail routes allow for adequate access from western mines to utility and industrial coal users; and 5) there is no single user or facility currently large enough to handle unit train shipments.

1.2 ORGANIZATION

This paper details planning and design decisions for a coal brokerage and applies the concept to a study site. Section 2 introduces the coal-brokerage concept by first explaining the origins of the concept and its present applications. The most flexible aspect of a coal brokerage is the terminal design which is affected by numerous decisions relating to the coal flow and transportation network. These decision-making steps are described from the perspective of the terminal operator and require a cost analysis, the selection of appropriate coal-handling equipment, and a customer needs analysis for adequate responsiveness to carriers and shippers alike.

Section 3 describes the proposed coal-brokerage site. The geographical setting of the Green Bay region sets the stage for specific components directly affecting the operations of a brokerage, including the local transportation network, the existing coal distribution, and sites that are available for a coal brokerage. Unit trains with western coal serving the proposed site could potentially come to a Green Bay or Kewaunee terminal where coal may be shipped to local coal burners via rail or truck, or transshipped across Lake Michigan. The alternative locations and distribution measures are discussed.

Section 4 calculates coal demands and supplies a projection of future utility and industrial coal use applicable to a brokerage. Utility demand is estimated for Green Bay and western shore Michigan consumers, using existing demand and future power plant construction and boiler conversion information. The industry demand is estimated based on the coal needs of local paper and pulp mills, assuming that the largest boilers will convert from gas and oil to coal as the cost of petroleum products rise at more accelerated rates than coal. The utility and industry demands substantiate minimum quantities necessary to receive regular unit-train shipments to a coal brokerage.

Section 5 gives current prices that are implied by various functions of the brokerage operation. Three alternative brokerages are discussed in terms of their relative merits for terminal functions. The alternatives are evaluated by comparing prices now paid for coal, unit-train shipments, broker fees, local distribution, and Great Lakes shipping charges. Factors which may affect the costs over time such as unit-train rates, freight-on-board (FOB)* mine costs, the pricing policy of brokers, and escalating energy costs are also described.

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*FOB mine cost is the price charged for mining coal and loading it onto a railcar.

Section 6 summarizes the study findings with conclusions about the feasibility of a coal brokerage operation for the Midwest study site as well as other sites.

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2 THE CONCEPT OF COAL BROKERAGE

2.1 OVERVIEW

The coal-brokerage concept focuses on aggregating user demands and utilizing high-volume, low-cost transportation and handling to meet those demands. It allows small coal-using industries and utilities to benefit from the economic advantages of high-volume shipping achieved by unit trains. A common minimum volume for unit-train coal contracts is one million tons per year [Ref. 7]; therefore, that figure can be used as a minimum tonnage for brokerage feasibility. An operation which saves $1 or $2 per ton of coal will save several million dollars per year in fuel costs.

The concept of consolidating bulk commodity shipping is not new, but its application to coal delivery is uncommon. In the eastern coal industry, individual carloads of coal from area mines are collected to form unit trains which are transported to one user. The coal brokerage is different in that coal from one source is distributed to several end users; this is feasible because of the high output of western coal mines.

The coal-brokerage operation centers on a bulk handling facility. A terminal is necessary for receiving high-volume line-haul shipments, for storing these shipments, and for distribution to local users. Storage is necessary to smooth out the disparity between batch arrival and relatively continuous use of coal; therefore, the operation consists of: 1) high volume transportation from the mine; 2) a terminal for receiving, storage, and possibly transshipping; and 3) transportation from the terminal to the user.

In planning and developing a brokerage operation, the most crucial aspect is probably the design of the coal terminal. The terminal will be the major capital expenditure, since the availability of transportation service presumably exists; therefore, the next section outlines a decision-making process for designing a coal terminal.

2.2 OPERATIONAL PLANNING AND TERMINAL DESIGN

The design of a coal-supply operation involves the evaluation of choices and tradeoffs in light of goals of the coal-handling process. Such goals might include efficiency, cost savings, and reliability. The goals often conflict in particular decisions, such as a choice between a very efficient but expensive component, and a less efficient but less expensive component. Another goal important in a brokerage operation is flexibility, because a broker will be serving several types of customers. Two levels of the design phase are evident: 1) the terminal's role in overall coal supply; and 2) the nature of the facilities within the terminal once its function is defined.

Identifying coal flow from mine-to-user determines whether a terminal is necessary; the procedure is shown in Fig. 2.1. A utility will first decide the amount and type of coal for a given plant, which could involve a mixture of eastern, midwestern, or western coal. This decision depends on such factors as emissions, regulations, Btu requirements, prices, and plant tech-

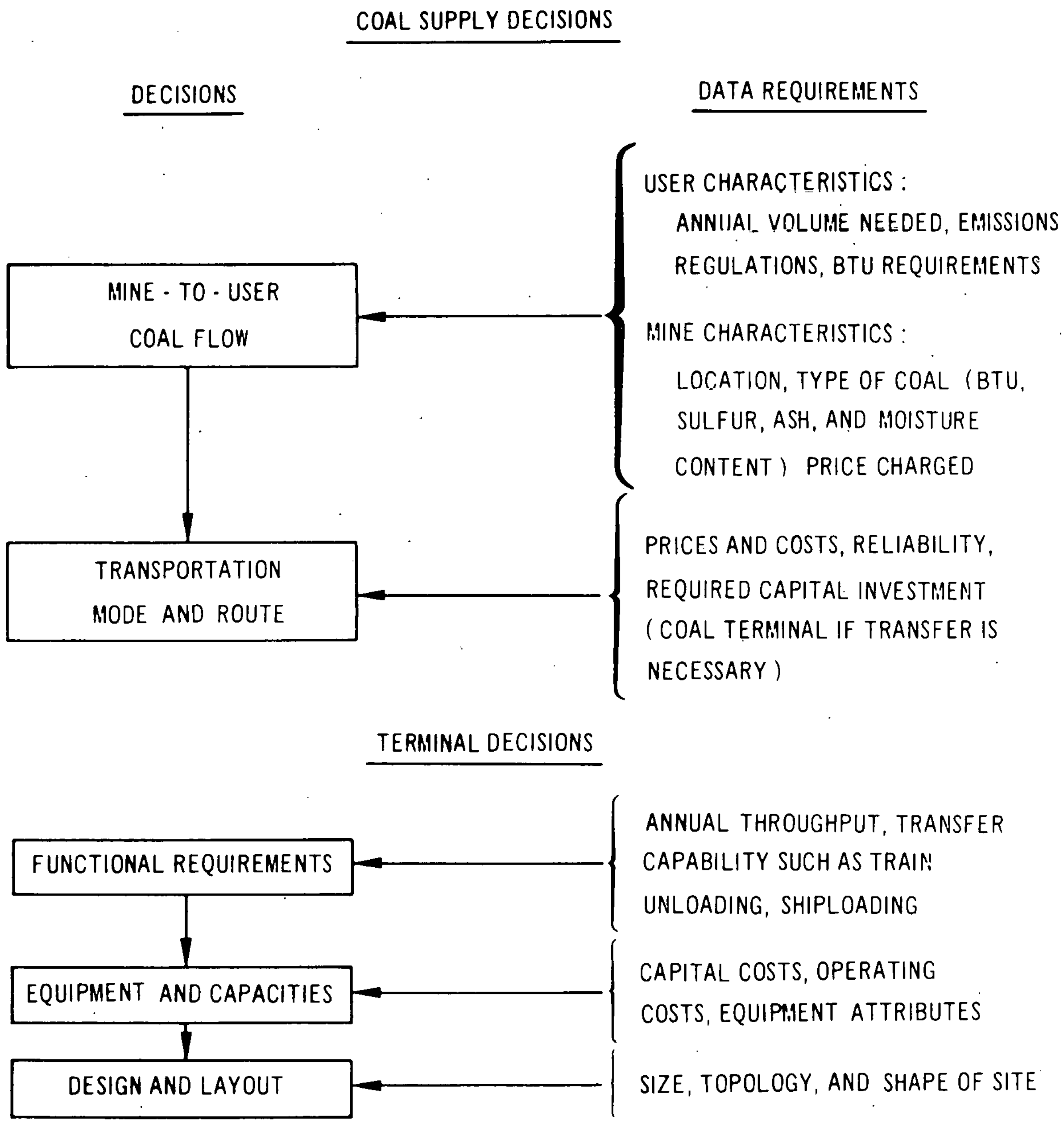

Fig.2.1. Planning and Design Decisions for a Coal Terminal

nology. Once annual volumes for each type are determined, mining contracts are developed with particular mines. Transportation mode and route are based on probable rates and costs of transfers, as well as long term reliability and other appropriate goals.

If modal transfer is involved in the route chosen, a terminal facility is required. Figure 2.1 also shows the steps incorporated for terminal design decisions. The functional requirements of the terminal are dictated by needed operational capabilities and throughput volume. Potential coal demand for an area is an estimate of the throughput volume for a coal-brokerage terminal. For example, a brokerage terminal would necessitate unit-train unloading, storage, truck loading, single-rail car loading, and possibly vessel-loading capability. An overview of coal-handling equipment is included in the Appendix.

The design of the terminal progresses by gathering cost information to evaluate tradeoffs, by negotiating with a railroad and shipping company to determine operational details, and by selecting coal-handling equipment based upon adaptability to the particular site and satisfaction of stated goals. The broker would investigate how unit-train rates might vary with time limits on unit-train dumping and how the cost of dumpers might vary by speed. A four-hour limit requires a high-cost rotary dumper as well as a work force that is ready for a train arrival at any time of day. A 24 hour limit means a lower-operating speed, and a cost-dumping system will suffice. The longer limit allows one shift of labor, since any off-shift arrival can be unloaded in the next day of work. These cost differences are compared with unit-train rate differences to determine which dumping agreement and equipment is most cost effective.

The shiploading end of the operation dictates live storage and presents another major decision. Ships are loaded directly from live storage, meaning that live-storage capacity of the terminal must significantly exceed ship capacity. Ship capacities typically range from 10,000 to 30,000 tons, with newer vessels as high as 60,000 tons [Ref. 8]. Shipping rates decrease as capacity increases, due to the economies of large capital investment, but the cost of terminal equipment increases as live storage increases. Again, the costs are weighed as before to determine the desired ship size and live-storage capacity. Ship size also determines the dock design, shiploader, and required turning basin.

The type and speed of the stacking/reclaiming function is the next component to be examined. A decision must be made as to the balance between a capital-intensive design, such as the highly automated stacker/reclaimers or the tripper/tunnel reclaim system of the terminal at Superior, Wisconsin, and a labor-intensive design involving manually operated crane shovels and other less expensive equipment (see Appendix). A capital-intense facility is efficient and economical at design volumes, but is a high cost investment ($30 million and more), and the large annual fixed cost of amortization results in a less economical operation when volumes drop [Ref. 9]. Labor-intense facilities require less capital investment and respond better financially to fluctuating volumes, but are not as efficient. Possible variation in coal demand, as is conceivable in a brokerage operation, should be investigated to aid such a decision. Reclaim speed is determined by balancing equipment costs as speed increases with damage charges for waiting vessels.

Acreage for a large volume site range from 50 to 260 acres, depending on stockpile size, track layout, and desired excess land for future growth [Refs. 10,11]. Available land will determine the shape and size of the stockpile. Track layout is affected by site attributes. A track loop is most desirable for unit-train unloading since it allows for a continuous operation without uncoupling or switching, but accommodating such an operation may require up to 200 acres of land [Ref. 12]. If a loop is not possible, parallel holding tracks are needed to allow for switching movements. Unit trains are typically 100 cars long; therefore, at least one mile of holding track is needed in this case.

A coal-brokerage terminal will supply the different needs of several customers which will affect and possibly complicate terminal design. Coal varies by Btu, moisture, sulfur, and ash content, as well as size. It is conceivable that several customers will differ in the types of coal preferred, thereby requiring that several types of coal be available from the broker. It is possible to manage separate stockpiles given the equipment which has been discussed, as has been done at a terminal in St. Louis, Missouri [Ref. 10]; however, coal crushers may need to be included in the design to serve size needs. Also different operating priorities among users, such as an emphasis on reliability by utilities or an emphasis on cost saving by a broker or industry, could lend to disagreement as to quality and reliability of the components.

2.3 POTENTIAL OPERATORS

The owner/operator of a brokerage could be one of a number of types of companies, each with a different set of operating priorities. It is possible that the broker would be one of the larger coal users in the area, such as a utility or industry, a transportation company, an existing coal-supply company, or a newly operating company.

A utility or industry may be a broker for several reasons. In order to meet certain minimum volume requirements for reduced coal-cost purchase or transportation rates, a large user may wish to contract for more coal than is needed and then sell the excess to local users. Since this operation already has a staff familiar with coal purchasing, the use of existing knowledge and administrative machinery would be valuable for further coal-supply operations. Also, land available for stockpiling and ready access to transportation receiving facilities could eliminate the need for a new terminal site.

There are also some disadvantages involved with a user assuming the role of a broker:

- The location of a utility may be distant from smaller industrial users;
- A user may not wish to assume a new responsibility, even if it could be profitable;*

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*Publicly owned utilities may be constrained from operating this type of "middleman" business for profit.

- A large industrial user would be able to discriminate against or favor other industries for competitive purposes;

- The operation would not be permanent because it could easily be terminated if the user finds the operation unprofitable, impractical, or otherwise undesirable. This point is perhaps the most serious weakness.

A transportation company, such as a railroad or shipping company, could also act as a broker. For example, American Commercial Barge Lines owns and operates a terminal at St. Louis [Ref. 9]. Most of the advantages would be more administrative than operational, because less negotiating and cooperation is needed. A railroad could design the terminal to better suit its equipment and procedures. It may not need to file rate tariffs since customers would pay a single delivered price for coal while no specified rail rate would ever be paid. Operating changes, such as train-frequency and dumping-time limits, would be simpler due to the absence of strict agreements. A shipping company could also design the terminal to its own specifications, eliminate the need for a demurrage charge policy, and change operations at will.

Finally, a coal supplier or operating company could act as a broker. Ortran is a company which was formed to operate the Superior terminal in Wisconsin [Ref. 13]. The company would own the terminal and contract with a mine, railroad, trucking company, and shipping company to deliver coal to customers. This type of set-up would allow long term flexibility since such a broker could change coal sources and carriers to provide the best service. A coal supplier would also have extensive experience in contracting with mines and serving customers. A possible disadvantage is that such a "middle man" would demand a higher profit margin since smaller enterprises are more vulnerable to uncertainties than are larger companies such as railroads and utilities.

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3 SITE DESCRIPTION

The Green Bay - Kewaunee region is in northeastern Wisconsin and includes Outagamie, Brown, and Kewaunee counties. The area is delimited by Lake Michigan, Green Bay, and the Fox River as shown in Figure 3.1. Total population of the three counties is 317,000 with 91,000 in Green Bay and 2,900 in the city of Kewaunee. The area is an agricultural and dairy-producing region, with industry located in Green Bay and along the Fox River. Major industries are paper and pulp manufacturing and food processing, particularly tissue paper and meatpacking. The city of Green Bay is located at the mouth of the Fox River on the southern end of the Bay, and is the industrial and retail center of northeastern Wisconsin. Kewaunee is located on Lake Michigan at the mouth of the Kewaunee River, and is 35 miles east of Green Bay.

Environmental factors which may affect future industrial development in the region center on air pollution and the preservation of the few remaining wetlands. Because of its concentration of paper mills and the existence of a coal-fired generating plant, Green Bay is designated as a non-attainment area in oxides, indicating that air pollution may constrain further industrial development [Ref. 14]. A wetlands basin extends along the Kewaunee River to Lake Michigan in Kewaunee, and is protected by the State of Wisconsin Department of Natural Resources. A wetlands area has also been created at the mouth of Duck Creek near Green Bay by a rising lake level and has created controversy concerning future industrial use of nearby bayfront land.

3.1 THE TRANSPORTATION SYSTEM

The transportation system of Northeastern Wisconsin consists of three railroads, adequate highways and streets, and port facilities for Great Lakes shipping. The Chicago and Northwestern Railway (CNW) and the Milwaukee Road serve northern, western, and southern points. The Green Bay and Western Railroad (GBW) serves points west to Winona, Minnesota on the Mississippi River where it connects with the Burlington Northern (BN). The GBW operates east to a transshipment point at Kewaunee. Two railroad ferry vessels operated by the Ann Arbor Railroad connect the GBW line at Kewaunee with Frankfort, Michigan. The Cheasapeake and Ohio Railroad Ferry line to Ludington, Michigan, which carries cars from the GBW, has been slated for abandonment [Ref. 7]. The ferries have a capacity of 20 to 22 freight cars and depart 2-4 times a day. Figure 3.1 shows the railroad and ferry routes.

Increased coal traffic would raise several issues. Large coal shipments bound for Green Bay via the GBW line would pass through a residential section of the city which could be objectionable to the local community [Ref. 14]. Shipments via the CNW would pass through a less populated area a mile to the north. If BN unit trains were to arrive on the GBW line, a GBW-CNW link would need to be built in the outskirts of the city to use the favorable CNW entrance. It is entirely possible that CNW would provide the unit-train service, and would probably oppose such a link.

If trains are to arrive in Kewaunee, they must travel via the GBW line east of Green Bay and cross an old bridge over the Fox River. The bridge

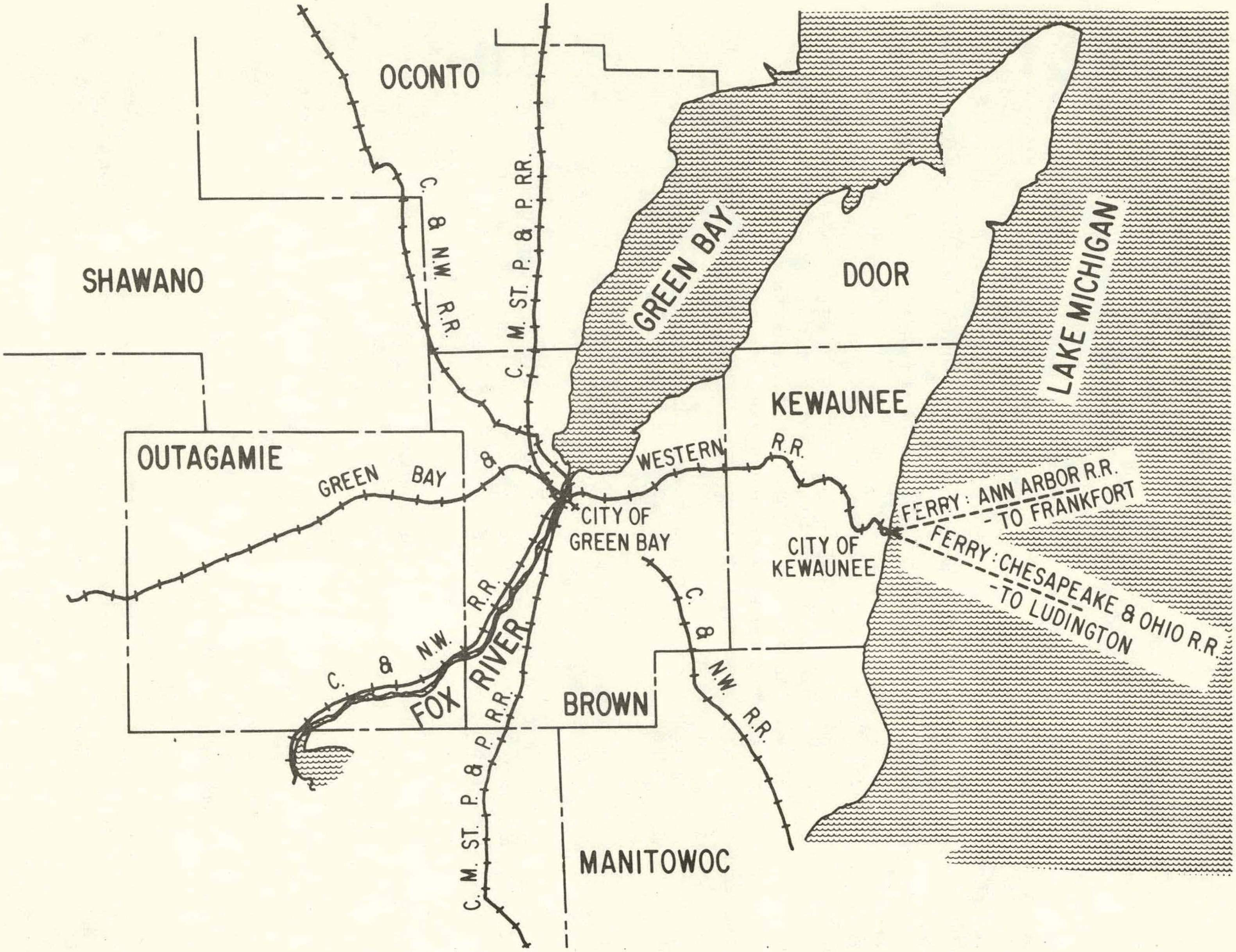

Fig. 3.1. The Northeastern Wisconsin Region

is regularly out-of-service (2-3 times per year for several days) due to damage by ships which are negotiating a narrow turning radius and an awkward approach angle. Such closures are costly to the paper mills on the east side of the river, and could seriously hinder dependable unit-train service to any coal terminal east of the river [Ref. 7].

Green Bay is served by highways linking it with cities in the Fox River Valley, with points along the Lake Michigan shoreline, including Kewaunee, and with the upper peninsula. Three highways form a divided highway belt around the city. The street system is a basic grid adapted to the Fox River, with adequate arterials through main corridors which serve the industrial areas. The major circulation constraint is the Fox River which divides the city in half with four roadway bridges crossing the river. Congestion arises during passage of vessels through the bridges. Kewaunee is served by one state highway which runs west to Green Bay and one which runs along Lake Michigan connecting with Manitowoc and Sheboygan to the south and Door County to the north.

Green Bay and Kewaunee are both Great Lakes port cities. Green Bay is a gateway port because of its navigable river and access to Great Lakes shipping routes. The river channel is six miles long, 24 feet deep, and has a turning basin capable of handling present-day 700 foot vessels; however, it is too small for the new 1000 foot vessels [Ref. 15]. The seven bridges crossing the river have draw or swing spans for vessel passage. Due to ice, the port is closed for three to four months of the year.

The port at Green Bay handled 2.5 million tons of cargo in 1978, most of which was domestic inbound tonnage [Ref. 16]. The port's outbound cargo and foreign import/export traffic is quite small. Major inbound commodities are coal, cement, petroleum, and limestone. Industries along the Fox River use dock facilities for inbound shipments and storage of bulk materials. Most bulk unloading is accomplished by vessels equipped with self-unloading systems.

The port of Kewaunee consists of a river channel 20 feet deep and 1500 feet long. The only port traffic is the car-ferry service. About one million tons move through the port annually, consisting mainly of food products, lumber products, pulp, paper, chemicals, and petroleum [Ref. 17]. Very little originates or terminates at Kewaunee. The port is open year round with few winter closures prompted by severe ice conditions.

3.2 COAL FLOW

Coal flow of the three counties centers on the port of Green Bay, as Kewaunee does not handle coal. Green Bay's port received 1.5 million tons of Appalachian coal from Ohio ports in 1978; there were no outbound shipments [Ref. 18] and coal is not currently arriving by rail. Major coal receiving entities are the Pulliam coal-fired generating plant of Wisconsin Public Service Corporation, the Fort Howard Paper Company, the C. Reiss Coal Company, and the Northern Coal Supply Company, which is owned by Fort Howard Paper Co. All four are located on the river, have port facilities, and maintain stockpiles. C. Reiss has dockside unloading facilities (crane mounted clam shell shovel), while the others require self-unloading vessels. Reiss is the main wholesaler of northern and eastern Wisconsin with stockpiles in Ashland, Duluth, Sheboygan, Manitowoc, and others, and distributes coal by truck and rail from its Green Bay dock primarily to pulp and papermills within 50 miles.

3.3 AVAILABLE SITES

Kewaunee and Green Bay both have an available site for a coal terminal and offer potential advantages for a brokerage. Green Bay has a vacant industrial site called Bayport located along the bay shore west of the Fox River (see Fig. 3.2). This site is seen as an avenue for industrial and port growth without extensive channel improvements [Ref. 16]. The Port envisions a major industrial center, possibly including a bulk handling facility for coal and cement, with docking facilities for new 1000 foot vessels which are too large to use the existing river channel. A plentiful amount of land is available (600 acres), allowing ample room for stockpiling and track layout. Its location on the bay easily allows for its use as a bulk-vessel transshipping and receiving point for Great Lakes shipping. This would allow continued use of the existing channel, bridges, and dock facilities without extensive improvements. Bayport also has a good location for rail transportation. If the CNW line into the city was used, unit trains would not pass through residential and commercial areas of the city and would not cross the GBW bridge; however, two problems are evident at the Bayport site. One involves the plan for necessary bayfill for docking. The plan calls for an L shaped peninsula of fill to provide a turning basin for the new larger vessels, and this raises environmental questions. Fill itself can damage the ecology of the bay, and can also have an impact on the nearby protected wetlands. The second problem is that ice prevents shipping for three months out of the year.

A Kewaunee site which has been proposed for development as a coal distributor/transshipping point lies north of the Kewaunee River between a GBW main line and a formidable bluff, and is shown in Fig. 3.3. The 40 ft. bluff on one side and protected wetlands on the other side limit acreage to 30 acres. Acreage for another site south of the river, also shown in Fig. 3.3, is constrained by the wetlands along the river. The limited size of the site constricts a coal storage and holding track capacity, as well as growth potential. The major advantage of a Kewaunee site is that its port operates year round, meaning less stockpiling and constant supplies for Michigan users.

3.4 BROKERAGE ALTERNATIVES

The relative advantages and disadvantages of broker sites at Kewaunee and Green Bay created the need for various brokerage alternatives. Each alternative is a type of operation and terminal set-up which could conceivably serve a given coal demand using the brokerage concept. The alternatives involve general terminal functions, and do not include the design decisions discussed above. These decisions are difficult to predict since they are very detailed and vulnerable to changes in operational priorities and costs.

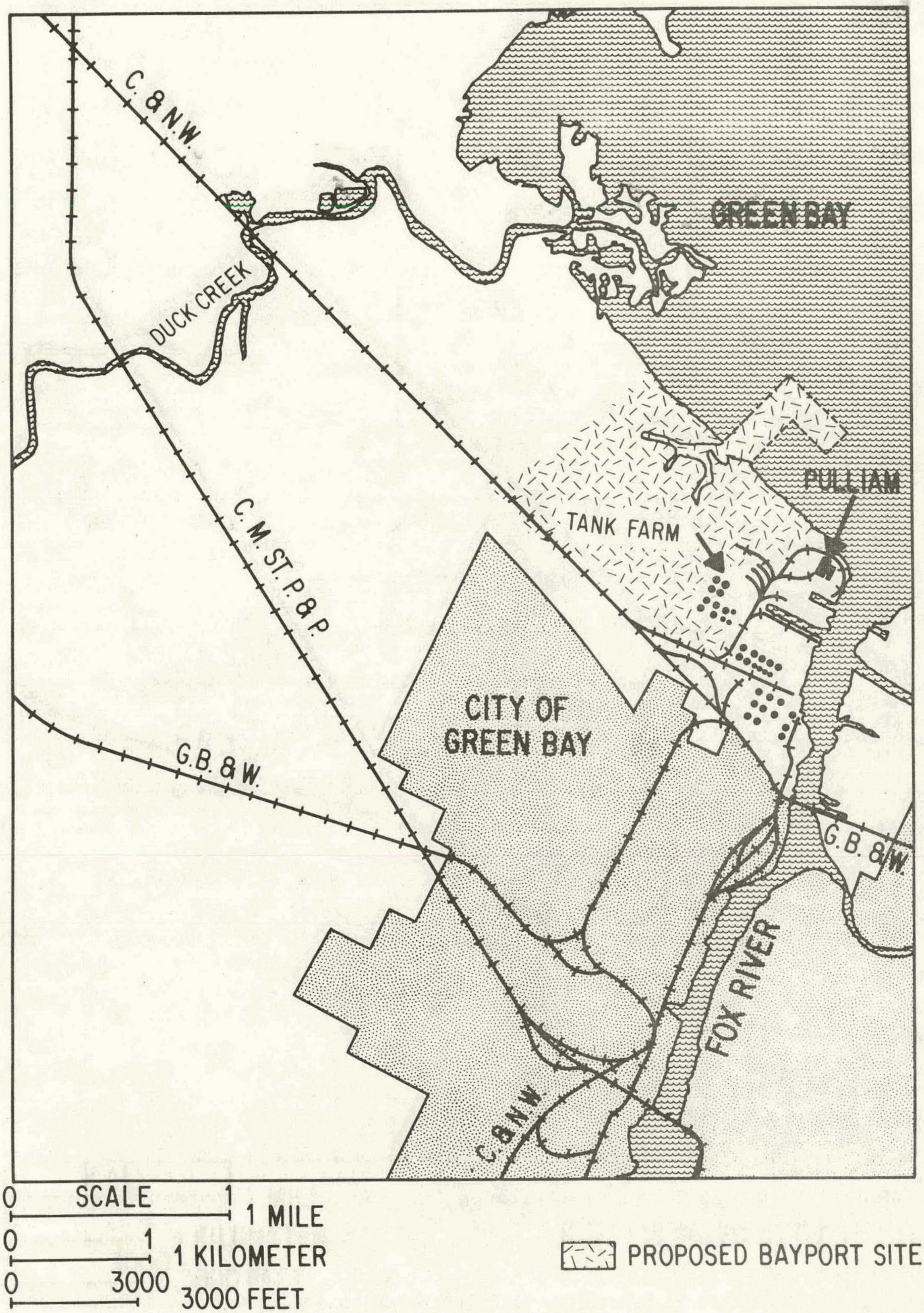

Fig. 3.2. The Bayport Brokerage Site

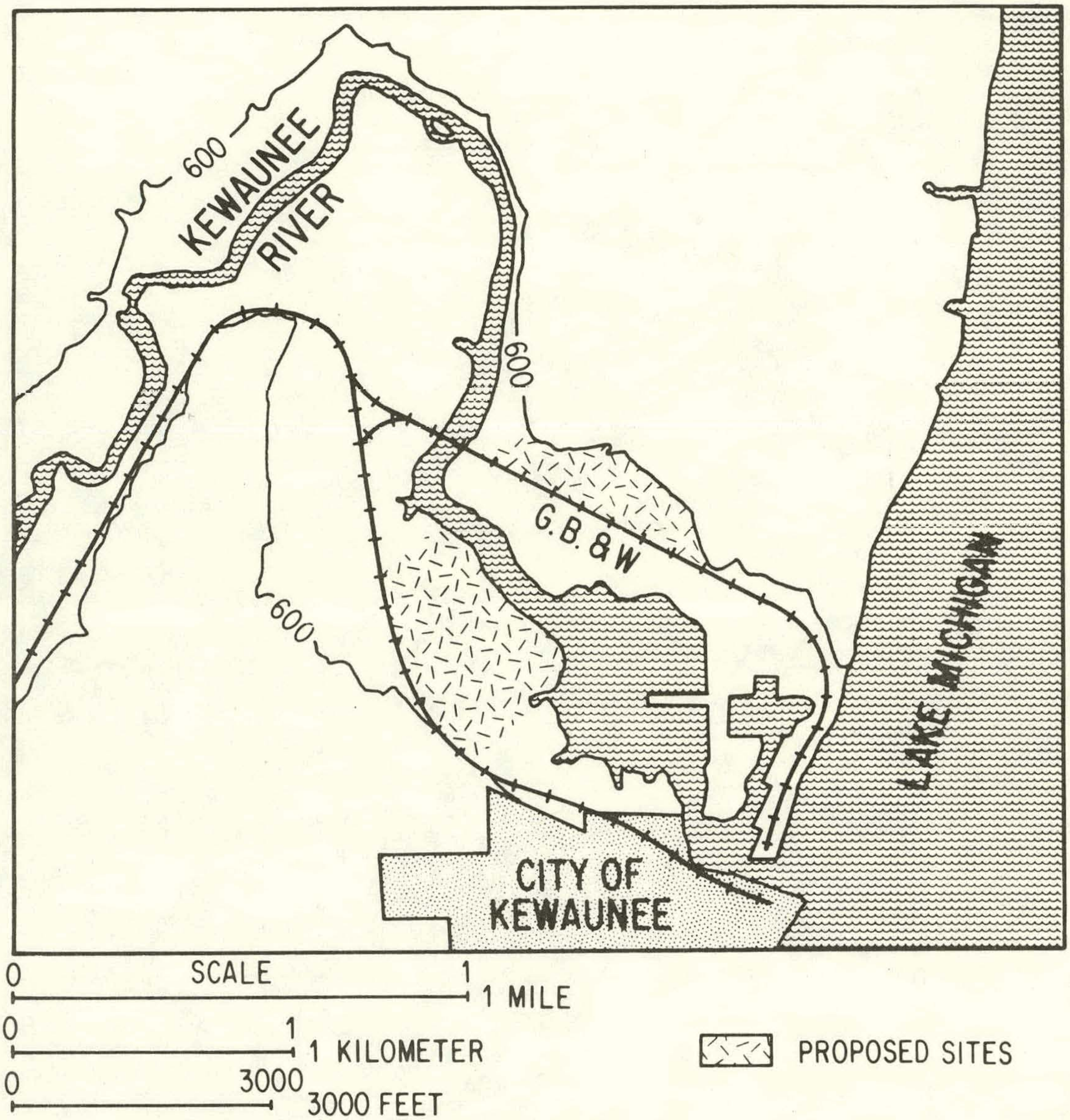

Fig. 3.3. The Kewaunee Brokerage Site

The first alternative consists of a major coal terminal at the Bayport site in Green Bay. Unit-train coal would be stockpiled, distributed locally by rail or truck, and loaded onto lake vessels for delivery to other Great Lakes coal users. Advantages of a Green Bay site include nearness to users (many within a three-mile radius) and plentiful land for efficient train unloading and stockpiling. A disadvantage includes the suspension of transshipping in winter months, requiring stockpiling by Michigan users.

Another alternative is to send a proportion of unit trains to a Kewaunee facility. This would exploit the advantages of year-round shipping from Kewaunee. For example, unit-train deliveries might alternate between Kewaunee and Green Bay; therefore the second alternative would include building two smaller terminals. The Green Bay site would receive, store, and distribute coal as before, but without transshipping. The Kewaunee site would receive, store, and transship the coal to Michigan utilities. Disadvantages include the loss of scale economies from using two smaller terminals, and limited land for storage at the Kewaunee site.

A third alternative is a modification of the second, and addresses the storage problem at Kewaunee. The need for storage can be eliminated if coal is loaded directly onto a vessel from the unit train. No stockpile managing equipment and less land are needed with this system. A disadvantage is the requirement of accurate timing between rail and vessel arrivals, which increases costly idle-vessel time.

Other alternatives were considered, but rejected for various reasons. A single central facility in Kewaunee was rejected because of the storage problem and because of the 35 mile westward "backtrack" from Kewaunee to the Green Bay users. The distance is not economically wise for a large volume trucking operation and could have serious local roadway maintenance and environmental impacts. Another idea involved the depositing of a specified number of full-hopper cars in Green Bay by the unit train on its way to Kewaunee. The cars would be locally distributed without the need for a terminal facility in Green Bay, while the rest of the train was unloaded at a Kewaunee facility. The major problem here is that unit-train rates would not apply due to the "breaking" of the train.

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4 UTILITY AND INDUSTRIAL COAL USE

4.1 OVERVIEW

An analysis of a coal brokerage must first examine current and projected levels of coal demand at utilities and industries to be served by the brokerage. In this case, the brokerage would serve coal needs of the three county area of Wisconsin, and would also be capable of serving other Great Lakes coal users due to the transshipping potential of the area. The lower peninsula of Michigan is the most likely candidate for such transshipping by virtue of its proximity. Therefore, the analysis centers on industrial and utility coal use in the Kewaunee - Green Bay region and the lower peninsula of Michigan, along the shore of Lake Michigan.

All coal users of these areas were evaluated. Michigan industrial users near the shore showed no substantial demands and were thus omitted. Public records of utility coal use and future plans, along with industrial boiler data, were used to derive present and projected demand levels, as detailed in the following discussion. Total demand is calculated assuming that it can be satisfied with western coal, even though western coal is unlikely to capture the market completely. Michigan utility coal demands may determine the feasibility of the brokerage because their volumes account for a substantial portion of projected volumes through the facility.

4.2 UTILITY DEMAND

The utilities in Wisconsin and Michigan likely to benefit from a major coal terminal are the Pulliam plant in Green Bay, and the Holland, Muskegon, and West Olive plants in Michigan. Two new coal burning plants presently under construction in Grand Haven and Jackson, Michigan were also considered. Demand data for 1972-1978 utility coal use along with new power plant coal utilization data collected through a telephone survey was used to get base year and projected coal utilization for each site [Ref. 1]. Figure 4.1 shows that coal shipment volumes are quite different for the utilities, but annual demands for each do not change substantially through the years.

Eastern and midwestern mines are the predominant coal sources of these utilities. About ten percent of Pulliam's coal comes from Montana, which makes Green Bay the largest western coal consumer on Lake Michigan. Pulliam's use of western coal has been declining since 1975, and contracts with the Montana mine are not expected to be renewed when they expire in 1980. The remainder of Pulliam's coal and Michigan utility coal arrives from Kentucky, Pennsylvania, West Virginia, Indiana, Illinois, and Ohio.

Table 4.1 shows current and projected coal use at the Pulliam Plant in Green Bay. It is unlikely that Pulliam's coal shipments will increase in the years to come because of the relatively stable nature of commercial and residential energy demand. Because no new construction is planned, and there are no plans for added boiler capacity, projection for future coal use is projected at the present rate of consumption.

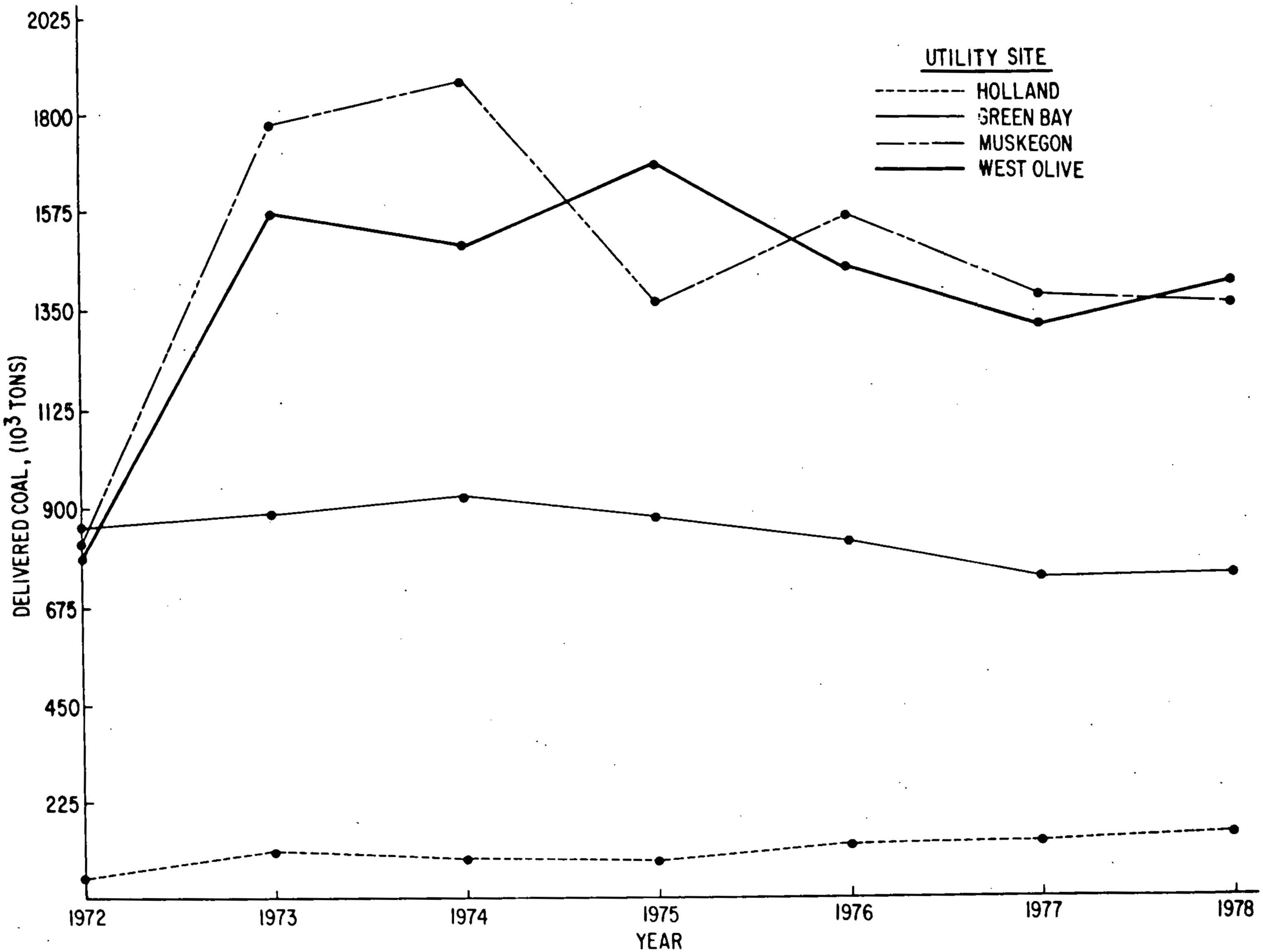

Fig. 4.1. Delivered Coal to Utility Sites, 1972-1978

Table 4.1. Current and Projected Utility Coal Demand (10^3 Tons)

Utility Site	Base Year Value 1978	Projection Years 1980	1985	1990	2000
WISCONSIN					
Green Bay	767	767	767	767	767
MICHIGAN					
Grand Haven	0	0	212	212	212
Holland	146	146	146	146	146
Jackson	0	1000	1000	1000	1000
Muskegon	1366	3308	3308	3308	3308
West Olive	1416	1416	1416	1416	1416
TOTAL	3695	6637	6849	6849	6849

Sources: Refs. 1 and 19

Prospects for other Wisconsin utilities 50 miles or more from Green Bay are not likely to affect coal receiving and distribution patterns because cost benefits will be offset by excessive local transport costs. Two new Wisconsin Public Service Corporation (WPSC) generating plants in central Wisconsin, and another plant which was ordered to convert to coal from oil and gas are all planning to consolidate their coal orders in an effort to reduce long haul transport costs of western coal [Ref. 19]. Because Pulliam is also a WPSC plant, future western coal shipment plans may call for special provisions to the Green Bay utility.

Current coal consumption and projections by Michigan utilities are also included in Table 4.1. The projections are based on new generating capabilities and new power plant construction schedules. The Muskegon plant will have additional generating capacity by 1980 that will more than double its current coal use. Two new plants at Grand Haven and Jackson in Ottowa County will be fully operational by 1982 and together will require 1.2 million tons of coal. Consumer's Power Company is considering a waste-to-fuel conversion plant that will burn coal as a supplement, but no construction date has been set [Ref. 19]. Present rates of coal consumption for plants with no expansion plans are assumed to continue.

Other Michigan utility plants considered are at Traverse City, Presque Isle, and Escanaba. Traverse City, located in the northern area of the lower peninsula, has inadequate port facilities for coal shipments. The 0.6 million ton-per-year plant receives Kentucky coal by rail and pays the highest rate in the state. The two other utilities which are located in the upper peninsula receive coal through the Superior terminal. It is unlikely that they will consider another source due to low rates made possible by access to Detroit Edison's high-volume operation.

4.3 INDUSTRY DEMAND

While a coal brokerage is likely to decrease delivered coal costs more markedly for industrial coal than for utilities, industrial fuel-users are not required to have long term fuel contracts as are utilities. It is, therefore, substantially more important to establish solid coal demands with committed orders from industry users, so that sufficient savings from a coal brokerage can be guaranteed. The following discussion is a brief overview of industrial coal consumption for the state of Wisconsin, followed by area-specific detail for Green Bay which includes boiler survey data on current coal consumption trends. Projections of future use are based on trend extrapolation and boiler fuel conversions. The discussion of industry coal demand is specific to the Green Bay area, and emphasizes the energy requirements of the paper industry.

4.3.1 Current Consumption Trends

The state of Wisconsin uses coal and nuclear power (61% and 31%, respectively) as its major energy sources. This is unique to energy resources used in most other states, which show general reliance on petroleum products, especially in industrial use. Coal competition with other fuel sources has prompted decreased fuel costs to such an extent that the energy costs for Wisconsin are lower for all user sectors than the national average. However, post-embargo inflation rates have resulted in rapid cost increases for industrial electricity; even with this, the current prices are lower than the national average. Commercial kWh sales have shown the highest growth rate, while industrial sales have stabilized [Ref. 20].

The pulp and paper industry is the largest consumer of purchased electricity in the state of Wisconsin; whereas for the nation, the largest industrial consumer is primary metals. Purchased electricity consumption of the Wisconsin paper industry grew at an average annual rate of 5.9% from 1958 to 1976. Coal is by far the dominant resource used in electrical generation in the industry, although the proportionate share of total energy produced by fuel oil and natural gas have risen. Coal demand has remained constant at 1.6 million tons per year, but fuel oil and natural gas consumption have risen at an annual rate of over 10% [Ref. 20].

In order to estimate current fuel consumption in Green Bay area industries, data on boiler-fuel use was analyzed. Boiler-fuel choice is a function of steam output for a given boiler size and utilization rates of the boiler. Coal-boiler costs exceed that of oil-fired boilers, which in turn costs more than natural gas-fired boilers. As utilization of boiler capacity increases, the cost of fuel, operation, and maintenance also increases. Coal is chosen over oil for a particular boiler size when the total annual cost of coal is less than the total annual cost of oil [Ref. 21].

Smaller paper and pulp mills with boilers rated at less than 100 MBtu/hr generally consume gas and oil. Medium and large boilers use coal and process wastes as the main fuel sources. Process wastes include bark, sawdust, wood chips, and black liquor. The paper industry has initiated a nationwide movement of converting these by-products to produce energy [Refs. 22-24]. In the Green Bay region alone, there has been a 20% increase in energy supplied by process wastes.

Table 4.2 shows the energy consumption by fuel type for paper mills in the Green Bay area. When this data is translated into actual coal shipments, there is an existing demand of 0.8 million tons of coal annually.* The energy consumption patterns from 1974-1977 of the same paper mills showed that delivered coal grew at an average annual rate of 1.75% [Ref. 23]. Only in 1975 has there been a decrease in coal demand for the region.

The consumption data given in Table 4.2 of the Green Bay region shows that the fuel used by the largest industrial boilers is coal, and that the energy output accounts for the largest total shares; in this case, 78% of the total energy output [Ref. 23].

4.3.2 Future Coal Demand

The Green Bay region should experience a 17% increase in delivered coal by 1990. This projection is based on the likelihood that oil and gas boilers will be converted to coal. The projection for industrial coal demand for Green Bay should then increase over time as follows:

DELIVERED COAL

Year	10^3 Tons
1976	771
1985	918
1990	927
2000	927

Conversions of all boilers over 99 MBtu/hr now burning oil and gas are assumed to convert to coal by 1990, in fulfillment of the Energy Supply and Environmental Coordination Act of 1974 [Ref. 24]. The Green Bay industrial gas oil boilers that might someday be slated for conversion to coal have a design firing capacity greater than the 99 MBtu/hr, and are defined as a Major Fuel

Table 4.2. Energy Consumption in Green Bay Region Paper Mills, 1976

	Plant Energy Output (MBtu/hr)			
Fuel Type	150-500	501-2000	>2000	Total
Coal	645.3	3295.00	13491.6	17431.9
Oil	57.7	31.36	549.2	638.3
Gas	8.5	1656.00	4687.8	6352.3
Wood	0.0	175.71	3731.3	3907.0
Total	711.5	5158.10	22459.9	28329.5

Source: Ref. 23

*Based on the conversion of the equivalent heat content of coal, where one ton is equal to 22.6 x 10^6 Btu.

Burning Installation (MFBI). Other recent legislation concerning MFBIs include the Powerplant and Industrial Fuel Use Act of 1978 [Ref. 25]. The act prohibits petroleum or natural gas if the installation was formerly coal burning and can still burn coal without substantial modifications, or if it is financially feasible. It should be financially feasible for the MFBIs included as conversion sites in this analysis to convert to coal.*

While the Department of Energy stresses increased coal usage in order to reduce our petroleum consumption, the Environmental Protection Agency stresses more stringent air quality control on coal burning facilities. The added coal consumption in the Green Bay Region is not likely to adversely affect air quality. Brown, Kewaunee, and Outagamie counties are in attainment for sulfur dioxides and suspended particulates [Ref. 26], and projections show improvements in air quality [Ref. 27]. Based on current EPA, SO_2 and particulate emissions standards, the small increases that have been projected will not have adverse effects on the future air quality of the region.

*Based on twenty year life expectancy of the existing gas and oil burning boiler.

5 COST ANALYSIS

5.1 INTRODUCTION

A crucial aspect of brokerage feasibility is its cost competitiveness with present coal delivery operations. If the delivered price of western coal to users via a broker is not competitive with present prices, the brokerage will not be economically feasible.

This analysis is based on prices or rates charged for components of a mine-to-user journey (i.e., mining, unit-train load, receiving and loading, local distribution). The focus of this paper is on competition between the price which would actually be paid to the broker and prices presently being paid; therefore, there is no need to examine actual costs of producing the individual components. A study of actual costs is helpful in determining the level below which long run prices cannot go, but the aim here is to examine prices which include profit margins. The term "cost" will be used in further discussion to mean that a price charged to the broker is a cost incurred in the operation.

5.2 COST COMPONENTS FOR A BROKERAGE OPERATION

A way of deriving the delivered price is to identify the cost of each component for a mine-to-user journey. Such components include freight-on-board (FOB) costs, unit=train rates, brokerage-facility costs, local distribution costs, and Great Lakes shipping costs for Michigan users. Estimates of these costs by the alternatives are shown in Table 5.1 and were obtained by surveying similar present-day operations.

FOB mine cost is the price charged for mining coal and loading it onto a railcar. This price is primarily dependent on the type of mine and the amount of coal purchased. The FOB mine cost shown is for the Decker Mines of Montana and assumes the purchase of four million tons per year [Ref. 3]. The previous chapter indicates that the total of Green Bay utility and industry demands and eastern Lake Michigan utility demands are likely to exceed this amount.

Unit-train rates are primarily dependent on distance traveled and annual tonnage. Other reasons for rate variations include dumping time requirements, car ownership, minimum train size, presence of competition, and general uncertainties of rate negotiations. Since these various reasons make it difficult to obtain a point estimate for a given distance and tonnage, rate ranges are shown in Table 5.1. This data applies to a 1030 mile Decker - Superior route, and is used due to geographical similarities with a Decker - Green Bay route [Ref. 3]. The latter route is roughly 100 miles longer, but is not likely to significantly affect this rate range. Zimmerman's unit-train Model (Ref. 28) in which Rate in $/ton = 1.5 + .0077x (distance, in miles) + 1.38 x (annual volume, in thousands of tons), yields $10.20 per ton for a 1130 mile and 4 million ton per year operation. The model is several years old, thus effects of inflation would put this estimate within the given rate range.

Table 5.1. Estimated Costs of Western Coal for Three Alternative Locations ($/ton)

Price Component	Western Coal for Terminal Location Alternatives		
	Green Bay	Green Bay/ Kewaunee	Green Bay/ Kewaunee (no storage)
FOB Mine*	11.00	11.00	11.00
Unit Train	10-14.00	10-14.00	10-14.00
Broker Facility			
a. Green Bay	1.50- 2.25	1.50- 2.25	1.50- 2.25
b. Kewaunee	-	1.50- 2.25	.50- .85
Great Lake Vessel			
a. Green Bay to Mich.	1.11		
b. Kewaunee to Mich.		.63	.63
Local Distribution			
a. Rail	1.68- 2.84	1.68- 2.84	1.68- 2.84
b. Truck	1.00- 1.50	1.00- 2.50	1.00- 2.50
Delivered Price:			
Wisconsin, by local rail	24.18-30.09	24.18-30.09	24.18-30.09
Wisconsin, by local truck	23.50-28.75	23.50-28.75	23.50-28.75
Pulliam	22.50-27.25	22.50-27.25	22.50-27.25
Michigan	23.61-28.36	23.13-27.88	22.13-26.48

*Freight-on-board mine

Handling costs at the brokerage facility depend on its capacity and capabilities. The transshipping cost of $1.50/ton shown in the table as the low end of a range has been confirmed by a coal terminal engineering firm as an industry standard for a high technology, high capacity (10 million tons per year) facility with rail dumping, storage, and shiploading capability [Ref. 10]. Lower volumes can drive this cost as high as $2.25/ton [Ref. 10], and is used as the upper end of the range. The balance of capital and labor used, as discussed earlier, can also account for variation within this range. A study at the University of Minnesota [Ref. 28] derived transshiping costs of $2.00 and less for volumes of 1 million tons and more, which substantiates the range shown. A range of $0.50/ton to $0.85/ton for direct rail-to-water transfer without storage capability is shown under the third alternative. The price of $0.85 has been quoted by an Illinois mining company and by a New York utility [Refs. 29,30].

Transshipping coal to Michigan Utilities involves a Great Lakes shipment from the brokerage site. The figures in Table 5.1 assume six mills per ton-mile [Ref. 31] with an average trip length of 105 miles from Kewaunee to

Michigan and 185 miles from Green Bay to Michigan. The Michigan utilities considered are on lakefront sites, and the asumption is made that there is no need for local truck or rail transfer. The cost of unloading is assumed to be included in the Great Lakes vessel shipping cost.

Local rail and trucking figures were obtained from conversations with local railroads and paper companies, since such rates are very site specific. The tariff ranges from $1.68 for a local switch by the GBW to $2.84 for a 20 mile movement between Green Bay and Kimberly, Wisconsin by the CNW [Refs. 32,33]. The two rates thus set a range for local rail distribution. The local truck rate paid is $1.00/ton for a two-to-three mile haul [Ref. 34], and is used as a minimum. A $.05/ton-mile estimate [Ref. 35] is used to get a $1.50 maximum, assuming that most coal customers are within 30 miles. Rates will vary by type of carrier and volume handled.

5.3 COST COMPARISON

The delivered prices for the various delivery modes and destinations are obtained by adding appropriate cost components. For example, delivered price to Green Bay by rail (shown in Table 5.1 as "Wisconsin by local rail") is the sum of FOB mine, unit train, Green Bay broker facility, and local rail costs, while delivered price to Michigan utilities is the sum of FOB mine, unit train, Kewaunee or Green Bay facility, and lake shipping costs. The pulliam price is a special case in that the utilities location next to the brokerage site decreases or eliminates local distribution costs.

Before a comparison of present prices and estimated broker prices can be made, a conversion is necessary. Eastern and western coals differ in their heat content, so that examining prices paid per ton of coal is not an accurate method of comparing prices paid for energy. The estimated delivered prices of Table 5.1 have been converted to dollars per million Btu, assuming a heat content of 9600 Btu/lb for Decker coal [Ref. 3], and are shown in Tables 5.2 and 5.3. Current prices paid by Green Bay and Michigan utilities and Wisconsin industries are also shown and were obtained by assuming 12,000 Btu/lb for the eastern and midwestern coal presently used.

In comparing current prices with estimated broker prices, several observations can be made. Broker prices to the Pulliam generating plant in Green Bay are within the same range of prices presently paid (Table 5.2). The upper ranges of prices paid by the Muskegon and West Olive utilities fall within or above the range of prices possible via a Wisconsin broker. This means that western coal prices via a broker are slightly competitive and could offer savings in some instances. This competitiveness means that other aspects, such as price trends of the future and environmental factors, will influence decisions concerning use of western coal.

Table 5.3 shows that a coal brokerage would provide substantial cost savings to Green Bay industries. This is a result of high purchase and transportation prices which are presently paid for the lower volumes of coal used by industries. An individual industry rarely uses more than 100,000 tons of coal per year, while utilities rarely use less than 200,000 tons [Ref. 35]. The pulliam plant pays $30 to $35 per ton of eastern coal and uses 800,000 tons, whereas Green Bay industry using less than 50,000 tons per year pay

Table 5.2. Price of Coal Delivered to Pulliam Green Bay and Lower Michigan Utilities ($/MBtu)

Utility Sites	Eastern and Midwestern Coals*	Western Coal for Terminal Location Alternatives		
		Green Bay	Green Bay/ Kewaunee	Green Bay Kewaunee (no storage)
Pulliam (Wisc.)	1.22-1.33	1.17-1.42	1.17-1.42	1.17-1.42
Muskegon (Mich.)	.98-1.35	1.23-1.48	1.20-1.45	1.15-1.38
West Olive (Mich.)	1.15-1.64	1.23-1.48	1.20-1.45	1.15-1.38
Holland (Mich.)	1.69	1.23-1.48	1.20-1.45	1.15-1.38

*Assumes 12,000 Btu/lb

Sources: Refs. 1 and 20

Table 5.3. Delivered Coal Prices to Industrial Users ($/MBtu)

Annual Amount Used (10^3 Tons)	Eastern and Midwestern Coals*	Western Coal for Terminal Location Alternatives		
		Green Bay	Green Bay/ Kewaunee	Green Bay/ Kewaunee (no storage)
0 - 50	1.87-2.08	1.22-1.56	1.22-1.56	1.22-1.56
51 - 100	1.66-1.87	1.22-1.56	1.22-1.56	1.22-1.56

*Assumes 12,000 Btu/lb.

Sources: Refs. 1 and 20

$45 to $50 per ton [Ref. 36]. A brokerage for western coal can save $0.30 to $0.50 per MBtu, and a savings of $0.50 per MBtu for a plant presently burning 50,000 tons of eastern coal per year will result in a total savings of $600,000 per year.

5.4 FACTORS AFFECTING COSTS

Some reasons for variation in the component costs have been discussed, but there are other factors that may change the cost competitiveness of western coal via a broker. Unit-train rates for western coal have been rising very rapidly in the last few years, and could continue to rise as rapidly in the years to come. The most publicized case [Ref. 37] involved the city of San Antonio, Texas, which built a western coal-fired generating plant, and then experienced unit-train rate increases from $7.90/ton to $18.18/ton within five years. Detroit Edison has experienced a 40% increase in western coal rates in the past three years (Ref. 13) and Burlington Northern railroad is presently involved in seven ICC rate cases concerning western coal to midwestern utilities [Ref. 38]. Railroad deregulation could spur even further escalations.

There are numerous reasons why railroads have increased their rates recently. One is that western railroads have kept coal rates abnormally low in the past to encourage use of the little used western coal, but now that demand is increasing the rates must be escalated to meet true costs. Another reason is that rail-rate agreements with shippers are not contracts, thus rates can be increased as long as ICC approvals are granted. Also, unit-coal trains are wearing out trackbed faster than previously thought; therefore, more upgrading is necessary [Ref. 39]. Presently, western railroads are undergoing extensive track improvement. It is conceivable that once the major upgrading programs are finished and rates become reasonably close to costs, unit-train coal rate increases will slow down considerably. It is impossible to predict when that point will come; therefore, it is uncertain how long the present rate of increases will continue.

There is little evidence of dramatic cost trends in the other components, beyond expected increases due to inflation. It is conceivable that FOB mine costs will increase at a slower rate in the west than in the east, due to labor union problems, wage increases, and stripmining laws in eastern mines [Ref. 3]. Western mines use non-union labor, and may escape rapid wage increases. This situation will favor western coal in the near future.

Another factor which will affect competitiveness is the pricing policy of the broker. The analysis presented assumes no price variation as a function of quantity used. Prices are commonly higher for lower volume customers, and a broker is likely to set his prices accordingly. Also, since a monopoly or cartel for the region may result from the formation of such a broker, smaller users may not be able to achieve a corresponding price reduction if the broker decides to price as a monopolist and maximize profits. This does not mean that brokerage coal may not be competitive with other coal sources, only that potential total savings for the area may be reduced due to pricing policies.

Finally, the most obvious cost factor that has and will continue to affect all freight movements is rapid escalation of energy costs. It is likely that energy product price increases will have the most pronounced effects on local coal deliveries (i.e., broker-to-user site). An increase in fuel prices are apt to make industries with rail access less vulnerable to high local transportation costs. The utilities and industries that are rail accessible are likely to find costs for their brokered coal more stable over time than shippers that are dependent on trucking which is a more energy intensive mode.

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6 SUMMARY AND CONCLUSIONS

The coal-brokerage concept is the aggregation of coal demand to allow small industries and utilities which use coal to benefit from the economic advantage of high-volume shipping. The broker could be a utility or industrial transportation company, or a coal-supply company. An area with total coal demand high enough to justify unit-train delivery can be considered a candidate for brokerage operation. Other necessary attributes include adequate rail access to coal mines, moderate concentration of coal users, adequate roadway and rail access to local users, adequate site for a coal terminal, and minimal environmental impacts of site development. Access to waterborne transportation is desirable because the ability to serve distant coal users on waterfront sites will increase the volume handled and enable further cost reductions associated with higher volumes.

The feasibility of a brokerage operation depends on the cost competitiveness of brokered coal, the likely volume, and the likely variability in volume. Cost competitiveness determines the potential for cost savings and is essential in generating demand for brokerage coal. A likely or guaranteed volume is needed to assure the feasibility of unit-train service and for use in terminal design. Some commitments must be made by the larger users in the area to insure that minimum volumes can be achieved. Without such support the establishment of a broker operation is too risky an investment. Variability in volume over time will determine how well the terminal and operation must be able to respond to fluctuations, both financially and operationally. Such variation would be more prevalent in a brokerage than in other coal-handling operations since a brokerage would serve several independent customers free to change their coal supply at will. Total coal demand of the Green Bay-Kewaunee, Wisconsin area and three utilities on the lower peninsula of Michigan numbers well beyond the one million ton/year minimum volume needed for a brokerage operation. The area is served by railroads with access to mines and has several coal users easily accessible by rail or truck. Green Bay's Bayport site is near major users and can serve transshipping needs, while a Kewaunee site is also available and can provide year-round shipping. Potential problems of a brokerage in the area include increased use of an old rail bridge, impacts of coal traffic on residential areas, possible impacts on protected wetlands, and an acreage constraint at the Kewaunee site.

A cost analysis of brokerage alternatives shows that western coal via a broker can offer significant savings for the Green Bay industrial users. Prices of brokered coal are competitive with prices paid at the Pulliam plant in Green Bay and are slightly less competitive for Michigan utilities. The Michigan utility demands comprise a significant portion of the total demand and are important in supporting the volume assumed in the cost analysis. Brokered coal should continue to be competitive into the future if unit-train rates continue to rise as rapidly as today. The brokerage feasibility in this case requires confirmation of the utility demand. Because utilities are required to commit to given volumes of delivered coal for a length of time, the stable demand implied by these committed orders would then minimize variability in total volumes. Therefore, it appears that the Green Bay-Kewaunee area is a good candidate for a feasible brokerage operation.

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APPENDIX

COAL-TERMINAL COMPONENTS

A coal-brokerage terminal requires facilities to unload unit-coal trains, manage a stockpile and transfer coal from that stockpile onto other modes for distribution. The distribution modes in the case study include truck, rail, and Great Lakes vessels (to allow for shipment to Michigan utilities). Other coal handling equipment, such as train loaders and vessel unloaders, are not discussed here. Figure A.1 shows the three main terminal functions and equipment options for each.

Train unloading is accomplished by either bottom-discharge or rotary dumping. Bottom discharge involves opening hopper car bottoms and dropping coal through the tracks into bins or an open pit. Coal is fed from the pit or bin onto conveyor belts which bring it to a stockpile. Bottom discharge is found in older and smaller facilities, and is often used as a backup system for rotary dumpers. Bottom discharge allows unloading of the train without uncoupling; however, it is dusty and quite vulnerable to frozen hopper doors and cold in the winter.

A rotary dumper is shown in Figure A.2. The cars are individually turned over and the coal is dumped into a bin, which again feeds a conveyor belt. This type of dumping is technially more sophisticated and is found in higher volume operations than bottom discharge. "State-of-the-art" rotary dumping includes rotary couplers, automatic train control, and continuous unloading. Rotary couplers allow cars to enter the dumper and be dumped without any uncoupling. Automatic train control is a mechanism within the dumper which moves and aligns the cars with minimum use of locomotives [Ref. 10]. Continuous unloading means that the train is dumped in one pass without breaking the train into segments. Terminals in areas with cold winters will often have thaw sheds covering the track that leads to the dumper. These sheds are heated to thaw the outer layer of coal in the cars to allow dumping. The dumper itself is covered, which minimizes dust problems.

Rotary dumpers are rated by their speed, as measured in tons per hour (tph). Speed depends on how quickly cars can be aligned and dumped and how quickly conveyor belts can carry coal away from the bin. The Superior Wisconsin coal terminal is rated at 3500 tph [Ref. 12], while a newer terminal in St. Louis, Missouri can unload at 4000 tph [Ref. 10]. This rate range results in a three-to-four hour dumping time for 10,000 ton unit trains, which is common for high volume operations [Ref. 28]. Older dumpers which require uncoupling can require ten hours or more for unloading.

The second subsystem of a brokerage terminal is the management of a coal stockpile. This is a system which moves coal from the dumping area onto a stockpile (stacking) and removes coal from the stockpile (reclaiming). Figure A.3 shows three types of stackers. The stationary stacker is most commonly used; it is little more than an angled conveyor belt which drops coal at a raised end onto a single conical pile. The radial stacker is a stationary stacker which can rotate about its lowered end forming a semicircular pile. A traveling stacker is rail-mounted and moves as it stacks, so as to form long wedge-shaped piles, allowing for larger storage capacity. It is fed

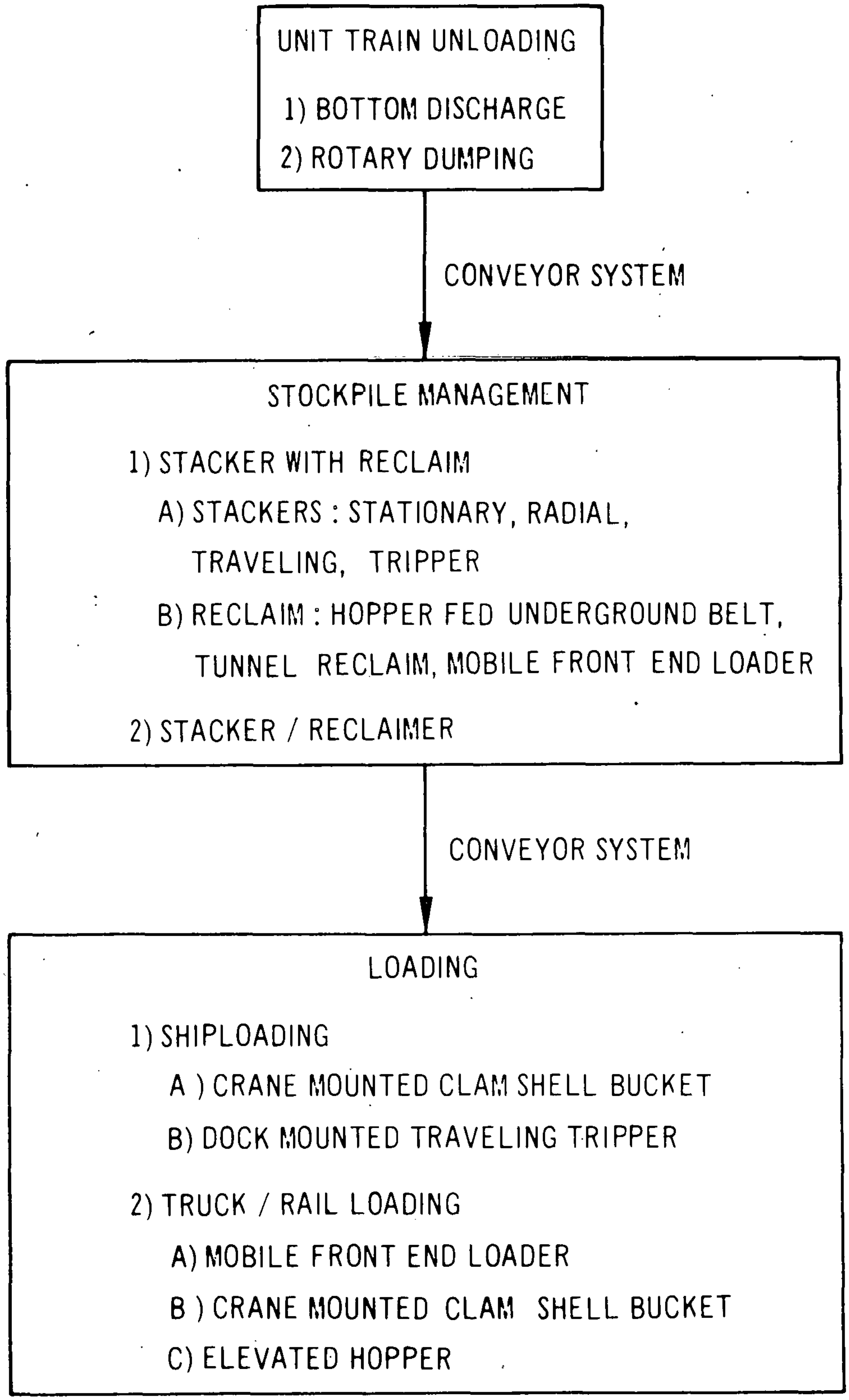

Fig. A.1. Coal Terminal Equipment Options

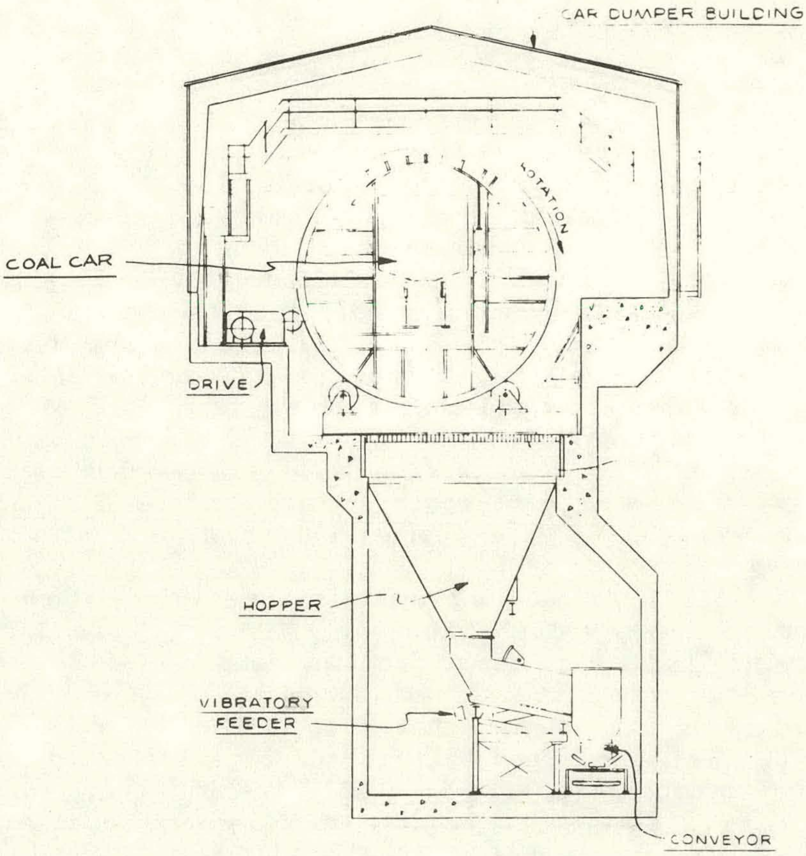

Fig. A.2. Rotary Car Dumper

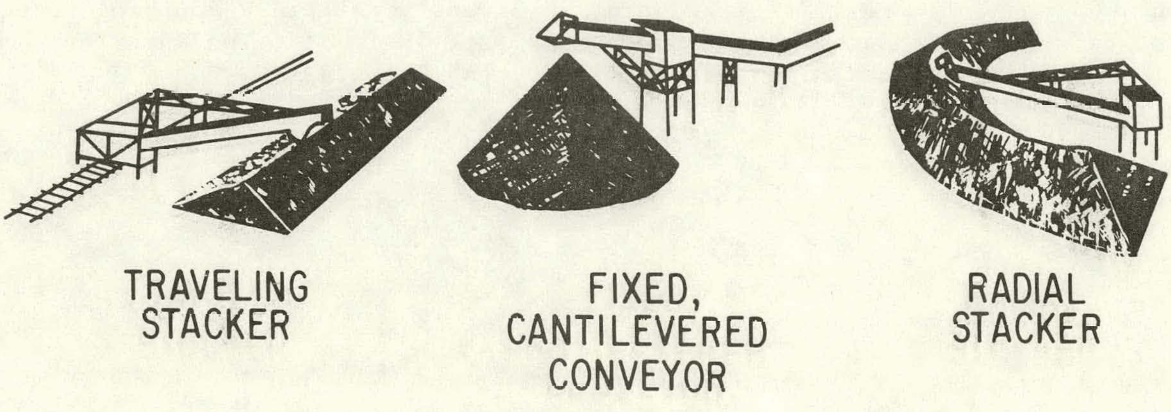

Fig. A.3. Stacking Equipment

by a conveyor belt which runs parallel to the stockpile. Hoppers beneath the piles feed onto underground conveyor belts which serve the reclaiming function [Ref. 8].

Terminals handling more than one million tons-per-year include more sophisticated types of stacking and reclaiming. The most common system centers on a single piece of equipment, called a stacker/reclaimer, and is shown in Fig. A.4. It is a rail-mounted machine which both stacks and reclaims from the top of the pile. A boom extends over the pile equipped with a conveyor belt. It stacks by dumping coal from the belt onto the pile similar to the stationary and radial stackers. It reclaims by using a bucket wheel mounted on the end of the boom to scoop coal from the pile and dump it onto the same belt which escorts the coal to where it is needed. The boom must be able to move up and down to reclaim as much of the pile as possible, as well as rotate so it can both stack and reclaim piles on both sides of the track. The belt in the boom is reversible to accommodate both operations. Many stacker/reclaimers can operate automatically as well as manually [Ref. 8].

The traveling tripper with tunnel reclaim, shown in Fig. A.5 is another type of large-volume handling system. It is operational at the Superior Terminal [Ref. 12]. Coal from the dumper is fed to a single elevated conveyor belt. A traveling tripper is a mechanism which drops coal off the belt anywhere along its length, thus a continuous pile is formed beneath the elevated belt. An underground belt is fed by a feeder which travels along a partial tunnel beneath the pile into which coal has fallen [Ref. 12]. This type of reclaim is similar to other underground reclaim, except that a continuous tunnel has replaced individual hoppers or bins in this operation.

Stacking and reclaiming systems are rated by their live-storage capacity and speed. Live storage is that part of the pile which is readily accessible to the reclaiming equipment, as opposed to dead or permanent storage which must be bulldozed into the live-storage area. Figure A.6 shows the live- and dead-storage portions of a stockpile with stationary stacking and underground reclaim. Live-storage capacity usually ranges from 15,000 to 60,000 tons or more. Stacking speed is directly related to dumping speed, and stacking rates range anywhere up to 4,000 tph [Ref 8]. The Superior terminal reclaims at a record high rate of 11,000 tph [Ref. 12].

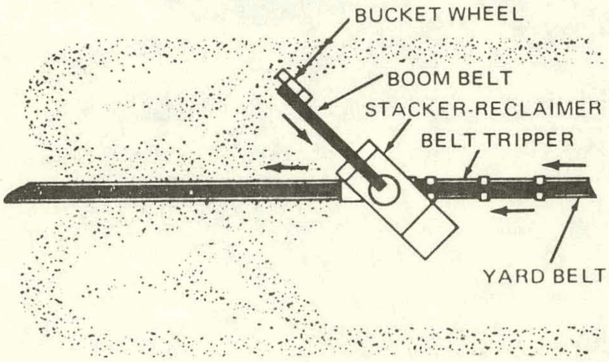

Fig. A.4. Stacker/Reclaimer

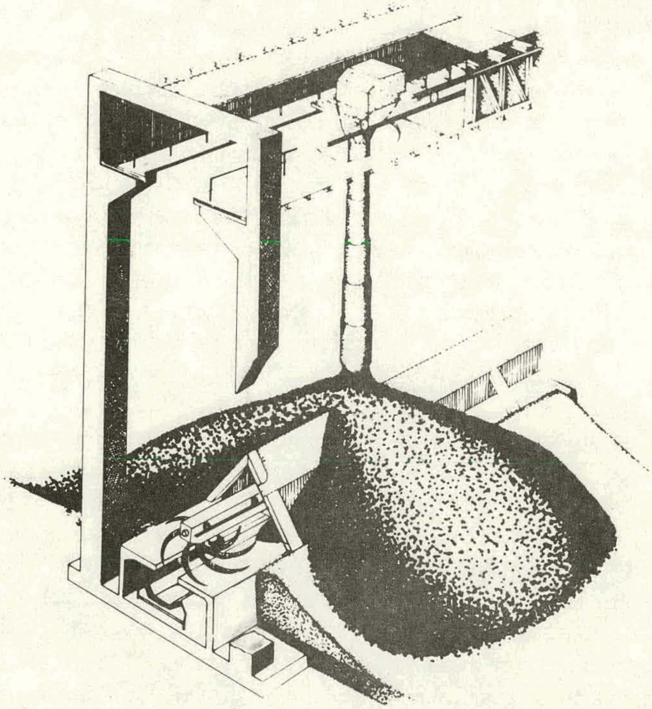

Fig. A.5. Tripper with Tunnel Reclaim

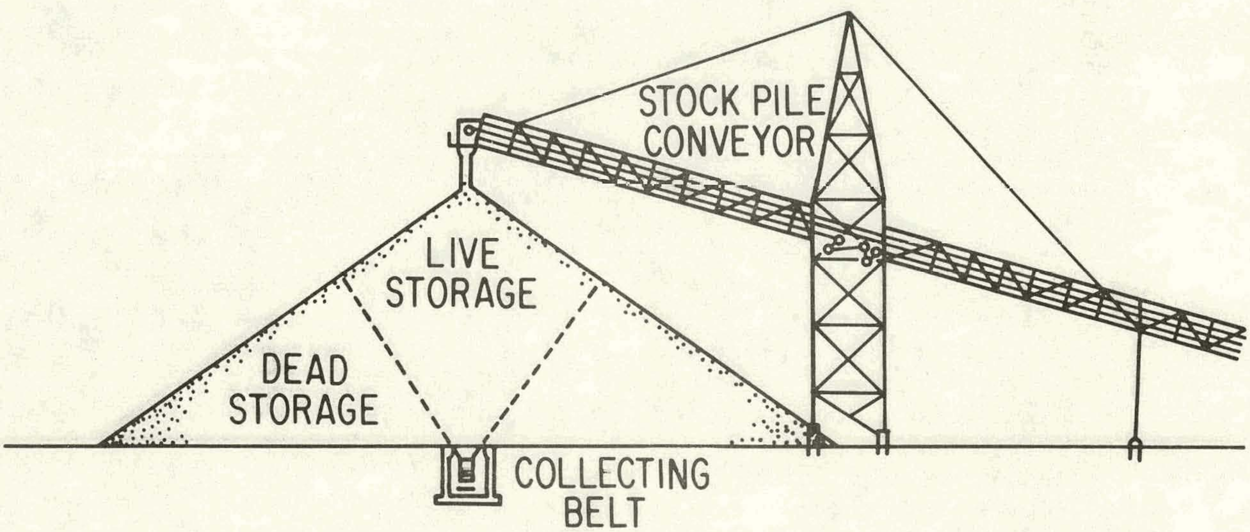

Fig. A.6. Live and Dead Storage Portions of a Stockpile

Loading facilities come in a variety of forms depending on purpose and sophistication. The simplest method for truck and rail loading is use of mobile front end loaders, which scoop coal from a pile and dump it into a truck or rail car. A crane mounted clam shell bucket can load trucks, railcars, or vessels. A more modern system is the use of an elevated hopper which is fed from the top by a conveyor belt from the reclaiming system [Ref. 13]. Rail cars or trucks are positioned beneath the hopper and loaded from chutes. The most modern shiploading systems are a dock mounted traveling tripper and chute that operates at the Superior terminal, and the Rail-to-Water facility in Chicago, Illinois, as shown in Fig. A.7. A conveyor belt extends along the length of the dock, while a traveling tripper guides coal from anywhere along the belt into its chute aimed at the ship's hold. The chute must be movable to allow for balanced loading. Loading rates are directly related to reclaim rates because loading systems are fed by reclaim systems.

The three major components of a coal terminal are connected by conveyor belt systems. Conveyor belts range from 48" to 72" wide and are rated by tons-per-hour. Belt arrangements can allow for more than one component to operate at a time, such as coal from the dumper directly to a vessel loader. Scales for weighing coal for accounting purposes are commonly belt mounted [Ref. 10]. Belts are often covered for dust control.

Complete capital requirements and their costs for a rail-to-water terminal of ten million tons-per-year are shown in Table A.1. The shiploading figure shown is for a large loading system, and it can be assumed that a Great Lakes vessel loading system will not significantly differ in costs. The table gives cost estimates for rotary dumping, stacking/reclaiming, and shiploading as discussed; it also shows the significant cost of other needed equipment. Approximately 40 people are required to operate such a terminal, including general labor, supervisors, equipment operators, mechanics, electricians, and clerks [Ref. 38].

Table A.1. Capital Requirements for a Rail to Water Coal Terminal

Equipment and Capital Needed	Approximate Cost (in millions)
Rotary car dumper	$ 3.0
Stacker/reclaimer	3.0
Shiploading system and dock	4.0
Conveyor systems	2.0
Parallel or loop track for 110 car unit train	1.0
Dumper shed	.5
Ground storage	2.0
Loaders and graders	.5
Dust prevention (sprays, dusthoods)	1.0
Maintenances and administration buildings	1.0
Contigency and working capital	4.0
TOTAL CAPITAL	$22.0

Source: Ref. 38