

Eulis Dale Witcher. FACTORS INFLUENCING THE LOCATION OF
CHEMICAL MANUFACTURING PLANTS IN WILMINGTON, NORTH CAROLINA.
(Under the direction of Dr. Edward P. Leahy) Department of
Geography, February, 1974.

The purpose of this study is to identify and evaluate the location factors responsible for the development of the chemical industry in Wilmington, North Carolina. The study analyzes the locational determinants of a major chemical plant and compares the factors responsible for the location of other chemical plants in the area. The Weberian least-cost framework with modifications for considering the influence of non-cost factors forms the theoretical basis for this study.

The approach used in this location analysis has been developed by evaluating the procedures employed by several authorities on industrial location and considers transportation factors, processing costs, site considerations and intangible factors.

Four major chemical manufacturing plants are presently operating in the Wilmington area, three of which have been located there within the last five years. The types of chemical manufacturing represented in the area are fertilizer

intermediates produced by W. R. Grace, dimethyl terephthalate (DMT) by Hercules, polyester fibers by DuPont and chrome chemicals by Diamond Shamrock. Six fertilizer mixing plants are also located in the area.

A survey of chemical plant management indicated the relative importance of the various location factors. The results of this survey show that the availability of a water-side site, market access and an abundant supply of water for manufacturing purposes were the most important factors in attracting the four major chemical plants to the Wilmington area. For the fertilizer mixing plants, market access and other transportation considerations were the major location factors.

In a detailed analysis of the Hercules DMT plant location, the Wilmington area is compared to alternative locations -- including other ports, certain raw material locations, and the market centroid -- on the basis of cost of market distribution and transportation of input materials. This analysis shows that the Wilmington area competes with or offers substantial advantages over all alternative locations considered. An evaluation of data from the U. S. Census shows that labor cost in North Carolina is also an advantage in attracting chemical manufacturing plants.

The future growth of the chemical industry in the Wilmington area will depend primarily on the development of the transportation system and the water, land and labor resources of the area. At present, one new chemical plant is planned for the area. Pfizer's selection of the Wilmington area for the location of a citric acid plant is based primarily on market access and water transportation and processing considerations.

FACTORS INFLUENCING THE LOCATION
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IN WILMINGTON, NORTH CAROLINA

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CHAPTER I

INTRODUCTION

The port city of Wilmington, North Carolina, has experienced rapid industrial development during the past five years. The development of three new chemical processing industries has accounted for 80 per cent of the total growth in manufacturing employment during this period. The factors responsible for this development of the chemical industry in Wilmington are the subject of this thesis.

Purpose

The primary purpose of this thesis is to identify and evaluate the location factors important to the development of the chemical industry in the Wilmington area. The study relies on a thorough investigation of location considerations and presents the findings in a manner that can assist industrial development organizations, both in the Wilmington area and other communities, in evaluating their area resources and determining guidelines for continued development through attracting industrial growth.

Study Objectives

This study focuses on three main objectives:

(1) an analysis of the locational determinants of a major chemical plant, based on a theoretical framework; (2) a comparison of the factors responsible for the location of other chemical plants in the area; and (3) an evaluation of the locational advantages of the area with respect to continued industrial growth.

Review of Theoretical Literature

The analysis of location factors requires a sound theoretical basis that can be applied to real-world situations. In establishing a framework for the following study, the Weberian least-cost approach with variations by Greenhut and Hoover was of major importance. Locational interdependence and the substitution approach were also considered.

The development of the least-cost approach to industrial location theory can be attributed to Alfred Weber,¹ a German economist. In Weber's approach to finding

¹Alfred Weber, Theory of the Location of Industries, trans. by C. J. Friedrich (Chicago: University of Chicago Press, 1929).

the least-cost location, transport costs are regarded as the primary determinants of plant location. Two other categories, labor costs and agglomeration economies, are considered to be factors which can divert a factory from the least-transport-cost location. Although Weber's theory has been subjected to considerable criticism, primarily due to its treatment of demand conditions as being spatially uniform, it remains a valuable basic framework for location analysis.

The concept of locational interdependence of firms is a second type of approach to location analysis with August Losch,¹ another German economist, being perhaps its best-known exponent. This approach is based on the maximization of profit through attempting to monopolize the largest possible portion of a scattered market. Constant spatial cost in obtaining raw materials and fixed production cost are assumed, causing this theory to have less application to real-world situations than the least-cost methodology. The primary value of the locational interdependence approach is in providing a basis for examining spatial variations in market size.

¹August Losch, The Economics of Location, trans. by W. H. Woglom and W. F. Stolper (New Haven: Yale University Press, 1954).

A number of attempts at integrating the least-cost and locational interdependence approaches have been made. Hoover¹ was among the first to emphasize the significance of least-cost locations while also providing a method for examining the locational effect of market areas. Another major attempt at combining these two approaches has been made by Greenhut² in his discussion of location factors which included transportation, regarded as the major determinant; processing costs; and demand, which he examined with respect to the interdependence of firms. Greenhut also examines special cost-reducing and revenue-increasing factors and introduces personal considerations that may influence the location of individual plants.

A general framework for the substitution approach has been developed by Isard³ and later applied to the location

¹Edgar M. Hoover, Location Theory and the Shoe and Leather Industries (Cambridge, Mass.: Harvard University Press, 1937); and The Location of Economic Activity (New York: McGraw-Hill, 1948).

²Melvin L. Greenhut, Plant Location in Theory and in Practice (Chapel Hill, N. C.: University of North Carolina Press, 1956).

³Walter Isard, Location and Space-Economy (Cambridge, Mass.: MIT Press, 1956).

of synthetic fiber production by Airov¹. This approach is based on the Weberian least-cost concept with various cost inputs substituted through alternative locations. A complex analysis of transport inputs and production costs for selected locations is conducted to determine which location offers the least-cost combination of these factors.

Following an evaluation of these various theoretical approaches, a least-cost framework with modifications for considering the influence of non-cost factors was selected to form the basis for the location analysis of the chemical industry in the Wilmington area. Market influence was measured by the cost of market distribution -- i.e., access to market.

Approach Used in Study

In the development of an approach for use in evaluating factors in the location of the chemical plants, consideration was given to the procedures employed by a number of authorities on industrial location including Greenhut, Yaseen and

¹Joseph Airov, The Location of the Synthetic-Fiber Industry: A Case Study in Regional Analysis (Cambridge, Mass.: MIT Press, 1959).

Will.¹ Each of these procedures emphasize the significance of transportation factors; processing inputs; site considerations; and, to a lesser degree, intangible factors, which are often decisive in a choice between several locations having similar transportation and processing cost characteristics.

The procedures used in this analysis are consistent with the guidelines described in other location studies specifically related to the chemical industry.² The major location requirements noted in these studies include the availability of water and transportation and labor inputs.

¹Examples of procedures used in industrial location analysis are found in M. L. Greenhut and M. R. Colberg, Factors in the Location of Florida Industry (Tallahassee, Florida: Florida State University, 1962); L. C. Yaseen, Plant Location (New York: American Research Council, 1960); R. A. Will, "Finding the Best Plant Location," Chemical Engineering, Vol. 72 (March, 1965), pp. 87-92; R. P. Boblett, "Factors in Industrial Location," The Appraisal Journal (October, 1971), pp. 518-526; and R. E. Carrier and W. R. Schriener, Plant Location Analysis: An Investigation of Plant Locations in Tennessee (Memphis, Tenn.: Memphis State University, 1969).

²Procedures for chemical plant location studies are described in L. J. Murdock "Selection of the Site for a Chemical Factory," Chemistry and Industry, Vol. 80 (August 5, 1961), pp. 1196-1204; "How DuPont Picks 'Em," Industrial Development and Manufacturers Record, Vol. 1 (March/April, 1954), pp. 8-14; and W. Weaver, "Appraisal of Chemical Plants," The Appraisal Journal (April, 1962), pp. 219-224.

Methodology

Preliminary information concerning the location of the chemical industry in the Wilmington area was obtained through a review of literature, including directories of manufacturers and studies concerning industrial development in the area; and by interviews with representatives of industrial development organizations, the North Carolina State Ports Authority, the Army Corps of Engineers and the Employment Security Commission. Commodities data and information concerning the use made by the chemical industry of the various transport modes in the Wilmington area was provided by the Army Corps of Engineers and the State Ports Authority. The local industrial development organizations and the Employment Security Commission supplied information on the employment trends and development characteristics of the industry. An evaluation of this background information provided direction for the more detailed investigation of location factors in the next phase of this study, a survey of the management of the chemical plants in the area.

The findings of the survey of chemical plant management identified the factors related to the location of each plant and formed a basis for comparing the location factors related to the different types of chemical manufacturing and

ranking these factors according to their importance in the Wilmington area.

A detailed location analysis of a major chemical plant was conducted on the basis of the survey findings and cost inputs for transportation and labor. Transportation data were obtained from private transportation companies and the Army Corps of Engineers. The centroid of the market for the subject industry was located to determine distribution costs. The costs of obtaining input materials were based on the transportation of these materials from the sources supplying the subject plant. Alternative locations were selected including the market centroid, certain input material sources, and competitive port locations. The alternative locations were compared to the Wilmington area on the basis of cost of distribution to the market centroid and of transporting input materials. Differences in labor cost were also evaluated for the alternative locations, based on data from the U. S. Census.

CHAPTER II

THE DEVELOPMENT OF THE WILMINGTON AREA CHEMICAL INDUSTRY AND ITS RELATIONSHIP TO THE TRANSPORTATION SYSTEM

The Wilmington industrial area¹ is located in the extreme southern portion of coastal North Carolina, bounded on the east and south by the Atlantic Ocean; on the north and northwest by two predominantly rural and underdeveloped North Carolina counties; and on the west by a South Carolina county (Figure 1). The two counties comprising the industrial area (New Hanover and Brunswick) are separated by the Cape Fear River, which forms the western boundary of New Hanover County and eastern boundary of Brunswick County. The port city of Wilmington is situated along the eastern bank of the Cape Fear River, south of its confluence with the Northeast Cape Fear River. Southport, the second largest community in the area, is located near the mouth of the Cape Fear River in Brunswick County.

The 1970 Census of Population showed a total of 107,219 persons living in the two-county area. The City of

¹For the purpose of this study, the "Wilmington Industrial Area" corresponds to the Wilmington Standard Metropolitan Statistical Area as defined by the U. S. Bureau of Census.

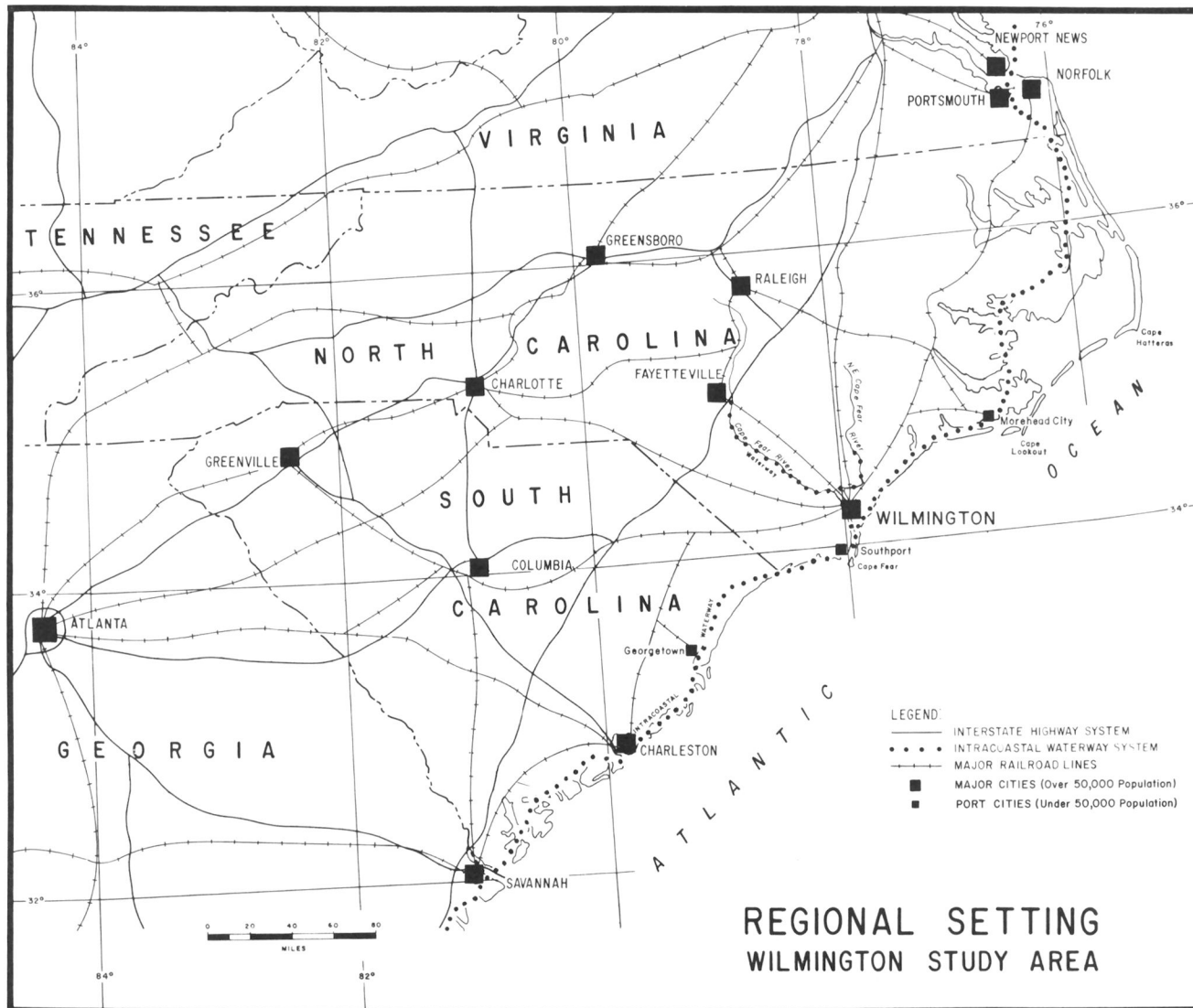


Figure 1

Wilmington had a population of 46,169, while 2,220 persons lived in Southport.¹

The Wilmington area has a mild climate due to its latitude and proximity to the Gulf Stream (40 miles offshore). Average monthly temperatures range from 48° in January to 80° in July. Average rainfall totals 51.3 inches annually and ranges from 2.9 inches in January to 7.7 inches in July.²

Industrial development in the Wilmington area is promoted by the Wilmington Industrial Committee and the Brunswick County Resources Development Commission, both community supported organizations. The East Carolina University Regional Development Institute also plays a vital role in attracting industries to this area by conducting economic and environmental studies for prospective industries.

Industry in the area can be divided into two groups which have different growth, income, productivity and investment characteristics. The first group, consisting of the

¹U. S. Department of Commerce, U. S. Bureau of Census, 1970 Census of Population and Housing: 1970 Census Tracts, No. 235, Wilmington, North Carolina, Standard Metropolitan Statistical Area, pp. 1-5.

²U. S. Department of Commerce, Environmental Science Services Administration, Local Climatological Data: Wilmington, North Carolina (Washington, D. C.: Government Printing Office, 1969).

older industries, includes the manufacturing of lumber products, apparel and textiles. This industrial group generally has low wage levels, little growth potential, low levels of productivity and relatively low capital investment per worker.

A second group of industries which has developed more recently is characterized by relatively high wages, strong growth potential, high productivity levels and high capital investment per worker. This group is represented in the Wilmington area primarily by machinery and equipment manufacturing industries and by production of chemicals.

The Wilmington Area Chemical Industry

During the past five years, the majority of growth in manufacturing employment has resulted from the development of three new chemical industries--DuPont, Hercules and Diamond Shamrock-- which together employ over 2,400 workers. In 1972, employment in all of the chemical plants accounted for approximately 3,100 workers or 26 per cent of the total manufacturing employment in the study area.¹

¹James E. Knight, Manager of Employment Security Commission office for Brunswick and New Hanover Counties, personal interview, March, 1973.

Before 1961, chemical production in the Wilmington area was limited to six fertilizer mixing plants. During that year, the first large-scale chemical complex--W. R. Grace's Carolina Nitrogen Corporation--began production of basic chemicals, primarily ammonia intermediates, for use in fertilizer production. This was the first chemical operation in the area to rely heavily on water transport for moving large volumes of bulk material. However, fertilizer production offered little industrial growth potential for the area due to the trend toward declining labor requirements and the problems related to seasonal demand fluctuations and product substitutions in this segment of the chemical industry.

The first non-fertilizer-related chemical plant opened in 1968 when Hercules, Incorporated, began the operation of its largest dimethyl terephthalate (DMT)¹ production facility. The following year, DuPont initiated the production of Dacron in what is now the largest chemical complex in the Wilmington area. The most recent addition to the list of chemical industries in the area is the Diamond Shamrock Chemical Company's plant which started production of chrome chemicals in 1971.

¹Dimethyl terephthalate is a chemical intermediate, produced from petrochemicals and used in the production of synthetic fibers.

The geographic distribution of chemical plants in the Wilmington area is limited to waterside sites along the navigable Cape Fear and Northeast Cape Fear Rivers north of the City of Wilmington. While it is recognized that the chemical industry, in general, uses water in many production processes, water transportation is also an important factor in the location of Wilmington area chemical industries, particularly those using large tonnages of bulk materials.

The use of water transportation by these chemical plants is examined in the following evaluation of the study area transportation system, which emphasizes the Wilmington port and harbor facilities since these represent one of the major locational aspects of the area. The purpose of this section is to examine the various transport modes associated with the operation of chemical manufacturing plants in the Wilmington area. These plants are located along the major highway, rail and waterway systems of the area (Figure 2).

The Wilmington Area Transportation System

Water transportation is the major transportation feature of the Wilmington area. A summary of commodity movements at selected southeastern ports (Table 1) indicates that Wilmington is competitive with Savannah and Charleston in total tonnages handled and surpasses other regional ports in

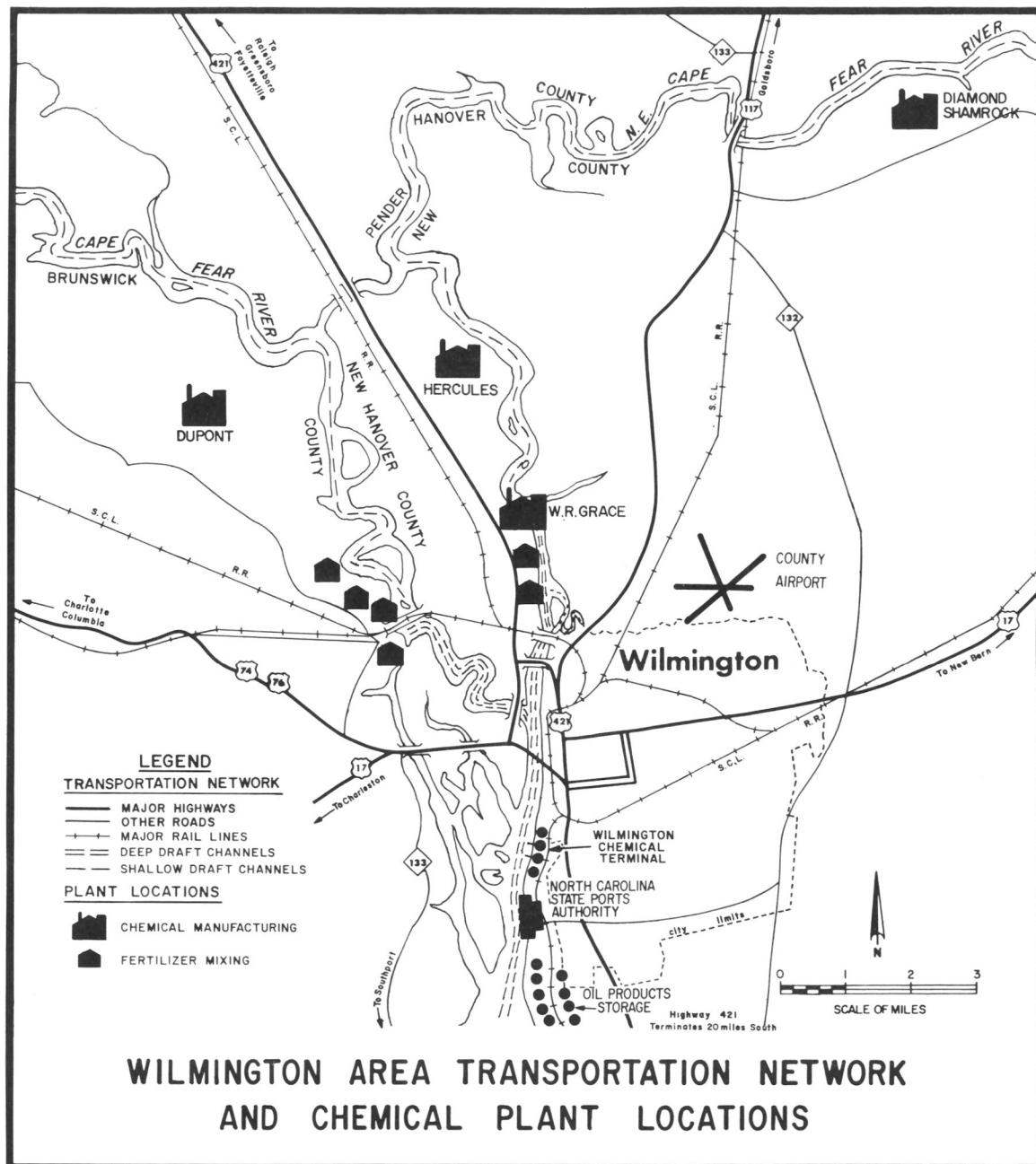


Figure 2

the shipping and receiving of chemical commodities.

TABLE 1

COMMODITY MOVEMENTS AT COMPETITIVE SOUTHEASTERN PORTS
(1971)

Competitive Ports	Total Tonnage	Chemical Commodities Tonnage
Norfolk, Va.	47,120,158	654,544
Savannah, Ga.	7,231,944	301,337
Charleston, S. C.	6,945,951	321,286
Wilmington, N. C.	6,826,751	1,054,194 ^a
Morehead City, N.C.	1,289,768	480,029
Georgetown, S. C.	1,190,637	22

^aDoes not include the chrome ore, soda ash and fuel oil shipped to chemical plants in the area.

Source: U. S. Army Corps of Engineers, Waterborne Commerce of the United States, 1972: Part 1, Waterways and Harbors, Atlantic Coast (Washington: U. S. Government Printing Office, 1973).

An evaluation of commodities data compiled by the Wilmington District of the U. S. Army Corps of Engineers (Table 2) indicates that the chemical industry in the Wilmington area is dependent upon three of the available transport modes--water (ship and barge), rail and truck.¹ This data

¹It should be noted that the New Hanover County Airport--which provides both passenger service, with Piedmont Airlines, and air freight service--is not included in this discussion since it does not facilitate the transportation of chemical commodities.

TABLE 2

COMMODITIES SHIPPED BY WATER TO WILMINGTON
AREA CHEMICAL MANUFACTURERS IN 1971

Destination	Commodity	Transport Mode To Wilmington Area	Transport Mode To Plant Site	Annual Tonnage
Hercules	Paraxylene	Ship	Barge	400,000
Hercules	Methanol	Ocean-going barge	Barge	100,000
Hercules	Residual fuel oil	Ship	Barge	325,000
W. R. Grace (Carolina Nitrogen)	Anhydrous ammonia	Ship directly to site		162,000
W. R. Grace (Carolina Nitrogen)	Urea	Ship	Truck	75,000
W. R. Grace (Carolina Nitrogen)	Liquid fertilizer	Ship	Barge	50,000
Diamond Shamrock	Chrome ore	Ship	Rail	88,000
Diamond Shamrock	Soda ash	Ship	Rail	69,000
Diamond Shamrock	Spent pickle liquor	Barge	Rail	18,000
Diamond Shamrock	Residual Fuel Oil	Ship	Rail	52,000
Various fertilizer mixing plants	Bulk fertilizer materials	Ship	Rail	180,000
DuPont	Ethylene glycol	Ship	Rail	6,000
DuPont	Residual Fuel Oil	Ship	Truck	25,000

Source: George T. Swain, Jr., Chief, Navigation, Reports Section, U. S. Army Corps of Engineers, Wilmington District (unpublished survey of industries using Wilmington Harbor, Wilmington, N. C., 1972).

indicates that, in 1971, a total of approximately 1,550,000 tons (short tons) of inbound bulk materials, including fuel oil, entered Wilmington Harbor via ship or ocean-going barge in route to the chemical manufacturing plants in the area. Of this total, approximately 875,000 tons were transshipped to individual plants by barge; about 513,000 tons were transferred to trucks or rail cars for final movement; and 162,000 tons were not transshipped, but were carried directly to the plant site by ship or ocean-going barge.¹

Unfortunately, an evaluation of commodity movements by truck and rail could not be made available due largely to the competitiveness among the three carrier modes in the area, and to the individual chemical producers' reluctance to make these statistics available--which can also be attributed to the competition among the manufacturers in the area and those in other areas. However, an analysis of tonnage statistics provided in the Waterborne Commerce of the United States indicates that a relatively small volume of chemical products, approximately 41,000 tons, were shipped out through the

¹George T. Swain, Jr., Chief, Navigation Reports Section, U. S. Army Corps of Engineers, Wilmington District (unpublished survey of industries using Wilmington Harbor, Wilmington, N. C., 1972).

Wilmington port and harbor facilities in 1971.¹ Assuming no significant change has occurred in this trend, it can be concluded that chemical plants in the area rely primarily on trucking and rail transport in transferring their products to market areas.

In sum, it is apparent that all three transport mediums are utilized significantly by the chemical industry of Wilmington, with waterborne transportation used primarily for procurement of raw materials, while rail and truck carriers distribute the greatest volume of finished products. The following evaluation of available transport facilities will serve as a basis for determining the influence of each of these modes on the location and competitive operation of the chemical manufacturing plants in the study area.

Water Transportation

The utilization of the water transportation system by the chemical industry is influenced by the quality of two basic elements: the harbor and waterway system comprised of

¹U. S. Army Corps of Engineers, Waterborne Commerce of the United States, 1972: Part 1, Waterways and Harbors, Atlantic Coast (Washington: U. S. Government Printing Office, 1973), pp. 161-163.

deep and shallow draft channels¹, anchorage and turning basins; and terminal facilities, both public and private.

Wilmington Harbor consists of an extensive channel system which connects with three waterways--the Atlantic Intracoastal, Cape Fear and Northeast Cape Fear--making it a readily accessible transshipment point. The harbor with its deep draft channels accommodates all types of waterborne chemical carriers including ocean-going barges and tankers. The three waterways are used by shallow draft barges, primarily for transshipping materials from the terminal facilities located along Wilmington Harbor to the plant sites. This extensive harbor and waterway system makes water transportation available to an abundance of sites suitable for the location of chemical manufacturing plants.

Wilmington Harbor is, in effect, a tidal estuary which extends from the juncture of the Cape Fear River and Northeast Cape Fear River 30 miles southward to the Atlantic Ocean. A deep draft channel 38 feet in depth extends from Southport, near the mouth of the Cape Fear River, to the State Port Terminal in Wilmington. Channels ranging in depth from 24

¹"Draft" indicates the depth of water displaced by a vessel. Shallow draft channels range from 6 to 12 feet in depth and serve inland waterway traffic. Deep draft channels, ranging from 12 to 40 feet in depth, generally serve ocean-going vessels.

to 30 feet extend to a point along the Northeast Cape Fear River, three miles above its mouth, and along the Cape Fear River to Navassa.

The channel of the Cape Fear River is joined approximately 16 miles south of its junction with the Northeast Cape Fear River by the Atlantic Intracoastal Waterway (AIWW). The AIWW, which extends along the entire coast of the Wilmington area, enters the Cape Fear River from the east and follows it southward to Southport where it continues in a westerly direction.

A shallow draft channel, 7 to 12 feet in depth, extends up the Cape Fear River from Navassa to Fayetteville, North Carolina, (111 miles northwest of Wilmington). The shallow draft channel of the Northeast Cape Fear River extends to the town of Wallace, 56 miles upstream, at depths ranging from 6 to 13 feet.

The receipt and shipment of chemical commodities via waterborne carriage is handled by one of three types of terminals--the publicly operated State Ports Terminal, privately operated chemical terminals, and private terminal facilities operated by individual manufacturing plants (Figure 3).



Joseph F. Dunn

Figure 3 Wilmington Harbor. The State Ports Terminal (foreground) and the Wilmington Chemical Terminal (center, background) handle chemical commodities.

The largest berthing and cargo handling facility in the area is operated by the North Carolina State Ports Authority. This terminal, located just south of the city, contains extensive bulk liquid as well as dry cargo storage facilities.

Three privately operated chemical terminals receive and transship bulk materials in route to chemical manufacturing plants in the area. The largest of these, Wilmington Chemical Company, handled approximately 345,000 tons of waterborne chemical commodities in 1971. These commodities consisted primarily of sulfur, methanol, paraxylene, nitrogen and ethylene glycol.¹ Two smaller chemical terminals, Almont Shipping Company and Northeast Chemical Company, are oriented primarily toward the handling of bulk fertilizer materials.

At present, four of the chemical manufacturing plants operate private terminal facilities. W. R. Grace's Carolina Nitrogen Corporation, Grace Agricultural Products, and Swift and Company--all located along the Northeast Cape Fear River--have facilities capable of handling both deep and shallow draft vessels. Hercules, located further upstream, receives bulk shipments of raw materials and residual fuel oil by barge.

¹J. Dobson, Vice President, Wilmington Chemical Company, personal interview, March, 1972.

Rail Transportation

The Wilmington area is serviced by Seaboard Coastline Railroad Company, which was formed from the 1967 merger of the Atlantic Coastline Railroad Company and the Seaboard Airline Railroad Company. This merger enables the combined lines to enhance their competitive position within the transportation network of the area by cutting costs and offering improved service. At present, rail carriers are second to barge transport in the intermediate movement of raw materials from water terminals to chemical plants, carrying approximately 413,000 tons of these materials.¹

Truck Transportation

Wilmington is linked to other major metropolitan areas in North Carolina and South Carolina by five U. S. highways, four of which terminate in the Wilmington area. The major highway serving the chemical industry is U. S. 421 which parallels the Cape Fear and Northeast Cape Fear Rivers, north of Wilmington, and serves the State Ports Terminal and Wilmington Chemical Terminal, south of the city.

The quality of these highway linkages is relatively poor, with all but a few short sections of these highways

¹Swain, unpublished survey.

being narrow two-lane facilities.¹ The poor quality of these connections, and particularly the lack of a limited access highway connecting the port city to other industrial areas of North Carolina, has been a negative factor in Wilmington's efforts toward industrial development.

The significance of the highway, rail and water transportation facilities as factors in attracting chemical manufacturing plants to the Wilmington area is examined in the following chapters. A detailed analysis of transportation considerations, as well as other factors, in the location of the Hercules DMT plant is provided in Chapter III.

¹Wilbur Smith and Associates, Coastal Plains Regional Transportation Study (Columbia, South Carolina: 1969).

CHAPTER III

ANALYSIS OF FACTORS INFLUENCING THE LOCATION OF THE HERCULES DMT PLANT: A CASE STUDY

The factors influencing the location of the Hercules plant have been analyzed using the approach described in Chapter I. This analysis is based on the minimization of various cost inputs, but also considers non-cost factors. The Hercules DMT (dimethyl terephthalate) plant has been selected as the subject of this analysis because its raw material sources are limited, its market area is easily definable, and it is not atypical of chemical plants in the Wilmington area.

Guidelines for Hercules Case Study

In developing guidelines for this analysis, consideration was given to the previously discussed procedures employed by authorities on industrial location, particularly those related to the location of chemical plants.

As a preliminary step in determining the factors relative to the location of chemical plants in the Wilmington area, a preliminary investigation of location factors was made through personal contact with individuals responsible for promoting development in the Wilmington area. These contacts included the directors of the North Carolina State

Ports Authority, the Wilmington Industrial Committee, and the Brunswick County Resources Development Commission.

Based on the general guidelines used in studies conducted by industrial location specialists and the insight provided by the preliminary analysis of the Wilmington area, it was determined that a locational analysis of Wilmington area chemical producers should focus on four broad categories of location determinants.

Transportation Costs

Transportation factors include the cost of moving input materials from their most economical source to the plant site. Market influence is also measured as a transport cost since economy in distribution is a primary basis for gaining a competitive market advantage.

The availability of various modes of transportation influences the cost of moving input materials and distributing products. Since the most outstanding transportation feature of Wilmington is the deepwater port facilities, a comparison of water transportation to other transport modes is important to this study.

Processing Costs

Previous studies of chemical plant locations have shown labor cost and relations to be significant considerations. The availability of an adequate supply of water is usually required for chemical processes, for cooling purposes, and as a discharge carrier for plant effluents. These last two uses require that the regulations of local pollution control laws also be considered. The cost of power is also evaluated, primarily to determine the impact of Carolina Power and Light Company's proposed nuclear power plant presently under construction near Southport.

Suitable Site

The availability of a site meeting the requirements for construction of a chemical plant is an important consideration. The requirements usually include a large tract of land, adjoining an adequate source of water for processing, and accessible to transportation facilities.

Intangibles

Intangibles are non-measurable factors which often influence a location decision when there is little cost differential between areas that are being considered. Among the most significant intangibles are community considerations,

including the physical and cultural attractiveness of an area and the efforts of local development agencies, and the entrepreneurial skill and corporate philosophy reflected by the individual industry.¹

A check list of factors (Appendix A) was used as a guideline for discussing the basis for location decisions with the management of the individual chemical plants in Wilmington. The check list includes questions related to linkages and transport modes used in the various types of chemical manufacturing. The response of Hercules management to this survey forms the primary basis for the following DMT plant location analysis.

Hercules DMT Production

The Hercules DMT (dimethyl terephthalate) production unit, located along the Northeast Cape Fear River, began operation in 1968. DMT, the primary product, is one of two chemical intermediates used in the manufacture of polyester fibers, including: DuPont's "Dacron"; "Kodel" produced by Eastman Kodak; Beaunit's "Vycron"; and a number of polyester

¹Discussions of the influence of intangible factors are found in Will, "Finding the Best Plant Location," pp. 91-92; and L. T. Wallace and V. W. Ruttan, "The Role of the Community as a Factor in Industrial Location," Papers and Proceedings of the Regional Science Association, Vol. 7 (February, 1961), pp. 133-142.

products turned out by Chemstrand, Allied Chemical, Firestone, Goodyear, and other manufacturers. The Hercules plant also produces TPA (terephthalic acid), an alternative to DMT used by Fiber Industries in the production of "Fortrel" polyester.

Hercules' Wilmington plant is the largest DMT production unit in the United States currently producing 600 million pounds of DMT per year. This annual capacity will be doubled in 1974 when additional production facilities are completed, increasing the potential output to 1200 million pounds of DMT or, alternatively, to 900 million pounds of DMT and 250 million pounds of TPA.

Hercules has one other DMT plant in the United States located in Burlington, New Jersey. The Company's overseas DMT operations include one plant in Middelburg, Netherlands; one plant in Tokuyama, Japan; and two facilities in Matsuyama, Japan. Domestic DMT production by competing firms is concentrated primarily in the Gulf Coast region. However, DuPont is now constructing a DMT production facility near Wilmington, located on the same site as its Dacron plant.

The components used in the Hercules production of DMT are two petrochemicals--methanol and paraxylene. Approximately 800 million pounds of paraxylene and 200 million

pounds of methanol are required for the plant's present annual output of 600 million pounds of DMT. Residual fuel oil, about 650 million pounds annually, is also a major requirement.

Transport Cost as a Location Factor

Transportation factors were major considerations in Hercules' decision to locate a DMT manufacturing unit in the Wilmington area. The management of the Hercules DMT plant indicated that the transportation advantages which influenced the company's location decision were the existence of deep-water port facilities and the competitive situation of Wilmington relative to the location of the market for DMT.

Hercules Linkages

Both major raw materials used by Hercules in the production of DMT are products of other Hercules plants. Paraxylene, a by-product of crude oil refining, is produced in Puerto Rico by the Hercor Refining Corporation, a company formed by Hercules and the Commonwealth Oil Company. Paraxylene is shipped from Hercor's refinery directly to Wilmington by barge. Hercules ships methanol to Wilmington from its plant in Plaquemine, near Baton Rouge, Louisiana, by ocean tankers. Residual fuel oil is shipped to Wilmington from refineries in Maracaibo, Venezuela, and Curacao, Dutch West

Indies.

Paraxylene and methanol are unloaded at the Wilmington Chemical Terminal, where they are stored until needed at the Hercules plant upstream. Both these materials and the fuel oil are transported to the Hercules site by barge. The availability of a location with direct access to water transportation and suitable for constructing docking facilities was a major factor in Hercules' selection of its present site. The "storage-in-transit" facilities available at the Wilmington Chemical Terminal were also a consideration.

The competitive advantage offered by Wilmington relative to market distribution was cited by Hercules management as being of major importance. The national market for DMT is located in the Southeast--concentrated primarily in North Carolina, South Carolina and Tennessee.¹ Approximately 95 per cent of all DMT produced in the Hercules Wilmington plant is distributed to this market. The remaining five per cent is shipped to foreign markets including Europe, Turkey, India and South America.

¹The Textile Organon in its June, 1969, survey of "World Man-Made Fiber Producers" indicates that twenty out of a total of twenty-two polyester fiber production units in the United States are located in the Southeast.

Hercules officials indicated that almost all DMT produced in Wilmington is distributed in molten form in asbestos-insulated tank trucks. This relatively new method of DMT distribution represents a considerable cost savings compared to the older method of shipment in solid form in open bin freight cars or in molten form in tank cars requiring heating equipment. The distribution time for trucks is limited, however, due to the fact that their insulated tanks can keep DMT in a molten form for periods of only 12 hours. Wilmington has an advantage over most other port locations in being located within 12 hours driving time of most polyester plants.

Comparison of Transport Cost for Alternative Locations

A comparison of transportation costs associated with the production and distribution of DMT at various locations is shown to provide a basis for evaluating the advantages of the Wilmington location. The alternatives for the location of a Hercules DMT plant include a raw material source, the expansion of an existing facility, the point having best access to the market and an alternative port location near the market.

Hercules sells DMT on a "delivered" or uniform price basis to all customers. Information regarding the locations

of these buyers is considered by Hercules management to be confidential due to the competitiveness of their business. To determine distribution costs, it is deemed desirable to locate a centroid for the total market area and then treat this nodal point as being representative of the market for Hercules. The following technique was used to locate this centroid:

1. Twenty polyester plants are accepted as constituting the market for DMT from the Hercules plant in Wilmington. These plants are all located in the Southeast (Figure 4).
2. It is assumed that each of the twenty plants represents a market of equal size.
3. An abscissa and an ordinate were established congruent with the parallel 34° north and the meridian 88° west, respectively.
4. Co-ordinates were measured off for the twenty plant locations.
5. The co-ordinates of the centroid, x_c and y_c , were then established by solving the two equations:

$$x_c = \frac{\sum_{1}^n x}{n} \quad \text{and} \quad y_c = \frac{\sum_{1}^n y}{n}$$

Following this technique, the centroid of the market area

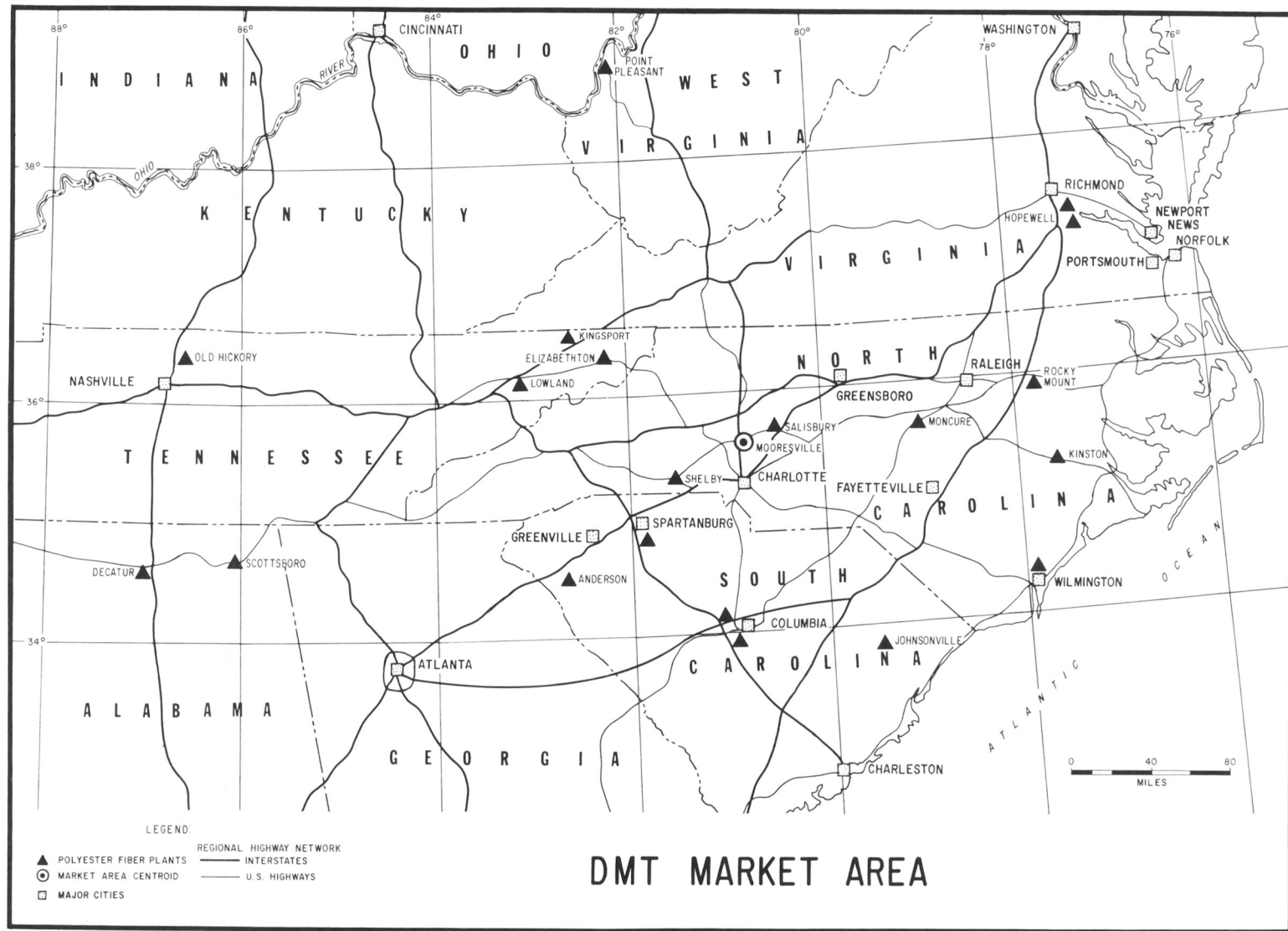


Figure 4

is found to be near Mooresville, North Carolina.¹

The following locations are selected as being possible alternatives to Wilmington for the production of DMT by Hercules:

1. Baton Rouge, Louisiana - the location of Hercules' methanol production facilities and an area offering potential savings in fuel oil transport cost.
2. Mooresville, North Carolina - the assumed centroid of the DMT market served by the Wilmington plant.
3. Burlington, New Jersey - the location of Hercules' older DMT plant, which could be expanded to serve a larger market.
4. Charleston, South Carolina - an alternative port location which, like Wilmington, is on the periphery of the market area.

In each case the sources of raw material are assumed to remain the same, with the exception of Baton Rouge which can obtain fuel oil from nearby sources (Figure 5).

¹For a detailed discussion of this problem, see Philip W. Porter's "What is the Point of Minimum Aggregate Travel?," Annals of the Association of American Geographers, Vol. 53, No. 2, June, 1963, pp.224-232; and Arnold Court's "The Elusive Point of Minimum Travel," Annals of the Association of American Geographers, Vol. 54, No. 3, September, 1964, pp. 400-403. Practical application of this technique is shown by Yaseen in Plant Location, pp. 19-21.

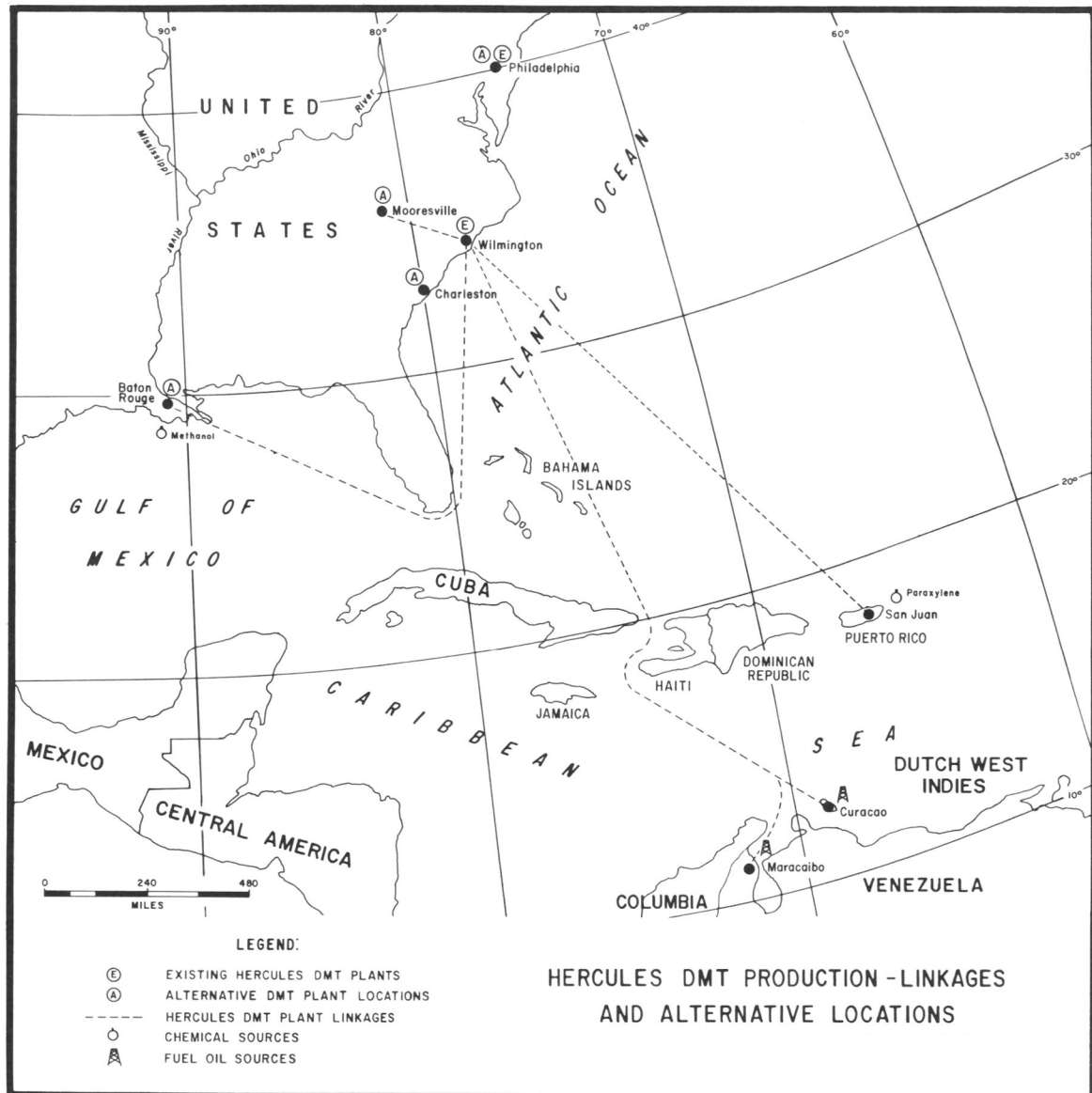


Figure 5

All market distribution costs are computed based on delivery to Mooresville, except in the case of Mooresville where distribution cost are based on the average distance (173 miles) to all polyester plant locations.

The cost per 100 pounds of transporting each raw material and distributing DMT is shown for all alternative locations (Table 3). These costs are shown for the transport mode which is most economical for each transportation link. These cost comparisons reflect class rates, except in cases where exception rates and commodity rates¹ are presently in effect for transporting certain commodities. Where possible, the rates actually being paid by Hercules are shown.²

All raw materials would be transported from source to site by water, except in the case of Mooresville--the only non-port location--where an additional rail linkage would be required. This additional link would increase cost inputs

¹Due to competitive considerations and operating conditions in certain areas, exception ratings on certain commodities are established which supersede the standard class rates and can in turn be superseded by commodity rates which are restricted to apply between specific points on given articles.

²Transport cost data were supplied by the U. S. Army Corps of Engineers, Seaboard Coastline Railroad and Bulk Haulers, Inc.

TABLE 3

TRANSPORT MODES AND COST PER 100 POUNDS FOR
OBTAINING RAW MATERIALS AND DISTRIBUTING DMT

Alternative Plant Location	Methanol From Baton Rouge		Paraxylene From Puerto Rico		Fuel Oil From Venezuela		DMT Distribution Market ^a	
	Transport Mode	Cost Per 100 lbs.	Transport Mode	Cost Per 100 lbs.	Transport Mode	Cost Per 100 lbs.	Transport Mode	Cost Per 100 lbs.
Wilmington, N. C.	Tanker	\$.41	Ocean-going barge	\$.26	Tanker	\$.20	Truck	\$.60
Baton Rouge, La.	Tanker	.06	Ocean-going barge	.34	Barge	.06 ^b	Rail	1.43
Mooresville, N. C.	(Tanker)	(.35)	(Ocean-going barge)	(.26)	(Tanker)	(.20)	Truck	.47
	(Rail)	(.48)	(Rail)	(1.39)	(Rail)	(.96)		
	Total	.83	Total	1.65	Total	1.16		
Burlington, N. J.	Tanker	.53	Ocean-going barge	.30	Tanker	.25	Rail	1.30
Charleston, S. C.	Tanker	.38	Ocean-going barge	.26	Tanker	.20	Truck	.65

^a Distribution cost is computed between alternative locations and Mooresville, the market centroid, except in the case of Mooresville where the distance is assumed to be 173 miles, or the average distance between Mooresville and the various market area locations.

^b It is assumed that a Baton Rouge plant would obtain fuel oil from local sources.

NOTE: A charge of \$.06 has been added, where applicable, to cover the cost of short-haul barge transportation. According to unpublished data supplied by the Army Corps of Engineers, this cost would apply to the short-haul carriage--i.e., from port to plant site, or refinery to plant site in the case of Baton Rouge--of all three of the raw materials being considered. All terminal charges are included in the basic costs.

Source: Data provided by the U. S. Army Corps of Engineers, Seaboard Coastline Railroad, and Bulk Haulers, Incorporated.

for the Mooresville site considerably. Distribution to market by truck would provide a cost advantage for Mooresville, Wilmington and Charleston.

The actual transportation costs involved in producing 100 pounds of DMT has been computed for each of the alternative plant locations (Table 4). These transport costs represent the amount of each raw material required for DMT production times the freight rate in effect for that material. These inputs combined with distribution costs indicate the total transportation cost for each location.

Baton Rouge would have a cost advantage of from \$.16 to \$.31 over the other three port locations in obtaining the raw materials necessary for producing 100 pounds of DMT. The additional cost of land transportation would eliminate the Mooresville location from consideration, leaving Wilmington and Charleston as the two alternatives having distribution cost advantages. These distribution cost savings are greater than the savings on raw material inputs for Baton Rouge, enabling Wilmington and Charleston to have the lower total cost. Due to its proximity to the centroid of the market, Wilmington has a slightly lower transport cost than Charleston.

TABLE 4

TRANSPORTATION INPUTS FOR PRODUCING AND DISTRIBUTING
100 POUNDS OF DMT FOR ALTERNATIVE PLANT LOCATIONS

Alternative Plant Location	Cost of Transporting Raw Materials			Total Raw Material Transport Cost	Distributing 100 Pounds of DMT to Market ^a	Total Transporta- tion Cost
	33 Pounds of Methanol From Baton Rouge	133 Pounds of Paraxylene From Puerto Rico	108 Pounds of Fuel Oil From Venezuela			
Wilmington, N. C.	\$.14	\$.35	\$.22	\$.71	\$.60	\$ 1.31
Baton Rouge, La.	.02	.45	.06 ^b	.53	1.43	1.96
Mooreville, N. C.	.27	2.19	1.25	3.71	.47	4.38
Burlington, N. J.	.17	.40	.27	.84	1.30	2.14
Charleston, S. C.	.12	.35	.22	.69	.65	1.34

^a Distribution cost is computed between alternative locations and Mooreville, the market centroid; except in the case of Mooreville where the distance is assumed to be 173 miles, or the average distance between Mooreville and the various market area locations.

^b It is assumed that a Baton Rouge plant would obtain fuel oil from local sources.

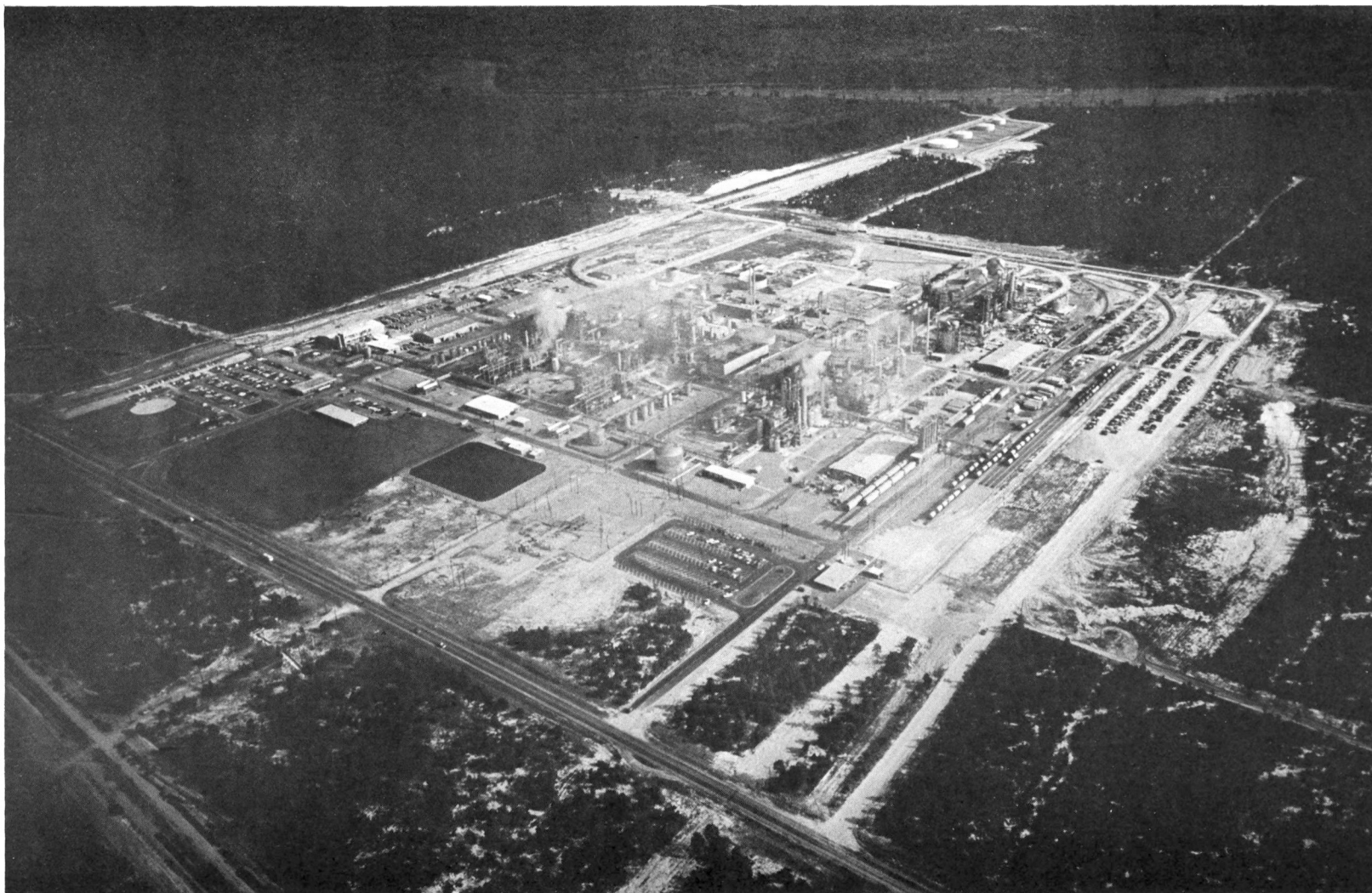
Source: Data provided by the U. S. Army Corps of Engineers, Seaboard Coastline Railroad, and Bulk Haulers, Incorporated.

Suitable Site

Hercules management indicated that the availability of an industrial site meeting requirements for size, availability of water for processing and access to water transportation was second only to transport costs considerations in attracting Hercules to the Wilmington area. The Hercules DMT plant site requirements included a large parcel of land (almost 100 acres is presently utilized), suitable for industrial construction, above historical flood levels, located along a river which has historically carried a volume of water more than sufficient to meet operational needs. Transportation requirements included having direct access to a navigable waterway with a sheltered area, free from strong currents, for construction of docking facilities. Adequate highway and rail access were also required (Figure 6).

Processing Cost Factors

The processing cost factors influencing Hercules' location decision were the characteristics of the labor force of the area and the availability of an adequate water supply. Power cost and availability were not considered significant.



Hercules Incorporated

Figure 5 Hercules DMT Plant - Wilmington. Site requirements for the Hercules DMT Plant included a large tract of land with an available supply of water for processing and access to water, highway and rail transportation facilities.

Labor

Hercules has a labor force at present of about 250, which will be increased to over 400 when the additional production facilities are completed in 1974. The cost associated with these labor requirements was a consideration in selecting the Wilmington area.

Median hourly wage levels have been compared for the states containing the previously examined alternative sites (Table 5). This comparison indicates that North Carolina's wage levels are below national averages and offer competitive advantages over northern states. The wage level for chemical workers in North Carolina is much lower than that of Louisiana; however, there is little difference between the southern states when comparing the wages of the total labor force.

In addition to relatively low wage levels, the Wilmington area has had a history of amiable labor relations. The North Carolina "right to work" law has strongly limited the amount of time lost to strikes throughout the state.

The Hercules officials indicated that when the Wilmington location was selected, there was an insufficient supply of skilled labor in the area. This problem was overcome through training programs conducted by Hercules and the

TABLE 5

MEDIAN HOURLY WAGES FOR CHEMICAL
WORKERS AND THE TOTAL LABOR FORCE
IN SELECTED STATES

State	Chemical Workers	Total Civilian Labor Force
North Carolina	3.37	2.63
Louisiana	4.79	3.02
New Jersey	4.42	3.79
South Carolina	3.66	2.62
National	4.16	3.42

Source: Calculated from: U. S. Department of Commerce,
Bureau of the Census, U. S. Census of Population: 1970,
Detailed Characteristics for the United States and for
selected states.

Cape Fear Technical Institute while the DMT plant was under construction.

Water

A basic requirement of the Hercules operation is a large volume of fresh water for processing and cooling. The Northeast Cape Fear River is the source of this supply. Hercules management indicated, however, that an adequate water supply was a prerequisite for all locations considered and not a final determining factor.

Although the Hercules DMT plant discharges cooling water and some treated effluents into the Northeast Cape Fear River, water pollution controls were not a factor in the location decision. The State of North Carolina was enforcing strict pollution control laws at the time of Hercules' decision to locate near Wilmington; however, the DMT plant was designed to include treatment facilities which would meet the more stringent standards that were expected to be adopted by the Federal Environmental Protection Agency.

Intangibles

The non-economic factors which influenced the Hercules location decision were the positive attitudes demonstrated by local organizations and also the availability of

educational facilities. The promotional activities of the Industrial Committee were considered very effective in creating an awareness by Hercules officials of the locational advantages offered by the Wilmington area. The joint efforts of the Wilmington Chemical Terminal and State Ports Authority to accommodate the storage and freight handling needs of Hercules were also significant. The importance of Cape Fear Technical Institute has already been mentioned with respect to conducting training programs for the initial work force.

CHAPTER IV

LOCATION ANALYSIS OF WILMINGTON

AREA CHEMICAL INDUSTRIES

A general location analysis of all chemical plants in the Wilmington area was conducted concurrently with the detailed study of the Hercules dimethyl terephthalate (DMT) plant location. Knowledgeable representatives of the various chemical plants were interviewed using a questionnaire (Appendix A) designed to collect background information and determine the significance of sixteen selected location factors relative to each plant. The background data provides insight into the production and transportation requirements of each plant, while the significance ratings of (2) for "important" and (1) for "a consideration" reveal the ordinal relationship of the location factors. The plant representatives were encouraged to elaborate on the importance of various factors and expand the list if necessary.

Because of their greater importance to the economy of Wilmington and their differing location requirements, the major chemical manufacturing complexes are distinguished from the smaller, relatively homogeneous fertilizer mixing plants in the analysis.

Selected factors are rated according to their significance in the location of the DuPont, Diamond Shamrock, W. R. Grace and Hercules plants (Table 6). The locations of all chemical plants are shown in Chapter 2 (Figure 2).

DuPont -- Polyester Fibers

DuPont's Wilmington plant is the newest of three facilities for producing Dacron, the trade-name for DuPont's polyester fibers. The two older Dacron plants are located in Kinston, North Carolina--approximately 90 miles north of Wilmington--and in Old Hickory, Tennessee. Competitive polyester fiber plants are located primarily in the Southeast (Figure 3).

DuPont has substantially increased the Dacron production capacity of its Wilmington plant since operation began in 1968. The most ambitious expansion program, which is presently underway, will double the present capacity for producing Dacron fibers. The primary factors responsible for the location and subsequent expansion of DuPont's Wilmington plant are market access, lower processing costs and the availability of a suitable site. The following analysis is based on the survey response by a representative of the Wilmington plant, verified by members of a DuPont location research team.

TABLE 6

SIGNIFICANCE RATING OF FACTORS IN THE LOCATION OF CHEMICAL
MANUFACTURING PLANTS IN THE WILMINGTON AREA

Location Factors	Significance Rating ^a					Total Points
	Hercules	DuPont	Diamond Shamrock	W. R. Grace		
<u>Transportation inputs</u>						
Access to sources of input materials	1	1	1	1		4
Access to markets	2	2	1	2		7
<u>Availability of water transportation:</u>						
a) Deep water port facilities	2	---	2	2		6
b) Waterway sites	2	---	1	2		5
Rail facilities	1	1	1	1		4
Highway facilities	1	1	1	1		4
<u>Processing Costs</u>						
Labor: a) Lower wages	1	2	1	---		4
b) Amicable relations	1	2	1	---		4
<u>Water for processing and cooling:</u>						
a) Abundant supply	2	2	2	1		7
b) Pollution controls	---	2	---	1		3
Power	---	1	---	1		2
<u>Availability of suitable site</u>						
Adequate size	2	2	1	1		6
Waterside location	2	2	2	2		8
Accessible to transportation facilities ..	2	1	1	2		6
<u>Intangibles</u>						
Community efforts	2	2	1	---		5
Entrepreneurial skill	---	1	---	1		2

^aRating System: 2 Points - Important; 1 Point - A Consideration.

Source: Survey of management of Wilmington area chemical plants conducted in November and December, 1972.

Transportation Inputs

DuPont's plant location, like that of Hercules, was strongly influenced by its proximity to major market areas. The textile industry is the largest buyer of Dacron; and Wilmington, while peripherally situated with respect to the market, is located within 200 miles of such major textile centers as Greensboro and Charlotte, North Carolina. The State of North Carolina leads the nation in textile production.¹

The DuPont representative indicated that access to input materials was a consideration. The raw materials for the manufacture of Dacron are ethylene glycol, a petrochemical which is shipped from Louisiana and Texas to the Wilmington area by ocean-going tanker; and DMT, carried by truck from the Hercules DMT plant near Wilmington and by rail from DuPont's own DMT plant located near Philadelphia, Pennsylvania. DMT production units, which DuPont is presently constructing at its Wilmington Dacron plant site, will begin supplying all of that plant's DMT requirements in 1974.

¹North Carolina Department of Natural and Economic Resources, "North Carolina -- A State on the Move", Raleigh, 1973, pp. 2-3. (Mimeographed.)

The availability of adequate rail and highway facilities were considerations. However, DuPont was the only major chemical manufacturer which considered the water transportation facilities of Wilmington to be of no importance in its location decision.

Processing Costs

Processing costs were much more important in the location of DuPont's Dacron plant than in the location decisions of any of the other chemical producers in the area (Table 6).

DuPont presently employs approximately 1,900 workers in its Wilmington plant, and its employment level will increase to almost 3,000 when the additional Dacron production lines and the new DMT facility go into operation in 1974. Low wages and amicable labor relations in the area were major factors in the location of this plant. The good labor relations experienced in the Wilmington plant's first years of operation were noted by DuPont representatives as influencing the Company's decision to expand its facilities.

The production of polyester fibers requires an enormous quantity of water for cooling, processing, discharging effluents and producing steam. The Cape Fear River provides a more than ample volume to meet these requirements.

DuPont representatives also indicated that pollution control requirements, primarily maximum temperature levels, were less stringent in the Wilmington area than in some other locations which had been considered.¹

Availability of a Suitable Site

The availability of a large industrial site with direct access to a water supply was required for the development of the Dacron facility. DuPont selected a 2,200-acre site along the Cape Fear River about twelve miles north of the City of Wilmington. DuPont representatives noted two additional site factors: (1) the site had to be free from potential flooding and (2) the site had to be located far enough from the City of Wilmington to avoid possible municipal restrictions and residential complaints.

Intangibles

Community organizations, primarily the Committee of 100, influenced DuPont's decision through promoting the Wilmington area and finding a suitable site. DuPont representatives also felt that the entrepreneurial skill shown by the Company's location research team was a consideration.

¹DuPont representatives were not at liberty to discuss alternative locations, except to indicate that they were in the Southeastern United States and were not port locations.

Diamond Shamrock -- Chrome Chemicals

The Diamond Shamrock chrome complex at Castle Hayne, north of the City of Wilmington, is the newest chemical manufacturing facility in the area. The complex is Diamond Shamrock's only facility for producing sodium bichromate and chromic acid and replaces the Company's old operations at Painesville, Ohio, and Kearny, New Jersey.

The manager of the Diamond Shamrock plant noted that the port facilities, abundant supply of water and availability of a riverside site were the outstanding considerations in choosing the Wilmington location.

Transportation Inputs

The primary raw materials used in the manufacture of chrome chemicals are chrome ore from South Africa, soda ash from Diamond Shamrock's own plant in Painesville, Ohio, and sulfuric acid from local sources. The availability of deep-water port facilities for receiving chrome ore, which accounts for the highest tonnage of raw material input, was the most important transportation factor. The possibility of utilizing barge transportation to the site was a consideration, although chrome ore is now transshipped from the State Port facilities to the site by rail.

The chemicals produced by the Diamond Shamrock plant are distributed to a nationwide market which includes the textile industry, various metal industries, the pharmaceutical industry and the pulp and paper industry. The location of Wilmington relative to the textile and pulp and paper industries of the South was a consideration.

Processing Costs

The major processing cost requirement was an abundant supply of water for cooling, processing and discharging effluents. The Diamond Shamrock plant requires about 800,000 gallons per day, despite the fact that most of the water is recycled. This requirement is supplied by the Northeast Cape Fear River.

The plant manager indicated that pollution controls were not a consideration. Approximately 20 per cent of the plant's total capital cost was allotted to pollution control, with the majority of this expenditure going into the construction of a waste treatment system.

Wage levels and labor relations in the Wilmington area were minor location considerations.

Availability of a Suitable Site

The chrome chemicals plant site includes 150 acres located along the Northeast Cape Fear River. The major site consideration was the availability of land along a river which could supply the tremendous water requirements of the plant.

Access to transport facilities was a minor site consideration. A spur line already served the site; and, as previously indicated, barge transportation via the navigable Northeast Cape Fear River remains a possibility.

Intangibles

The North Carolina State Ports Authority played a minor role in attracting the chrome chemicals plant by insuring that adequate berth space and unloading equipment would be provided for shipments of raw materials bound for the plant.

W. R. Grace -- Fertilizer Intermediates

W. R. Grace's Carolina Nitrogen complex is the company's only facility for manufacturing intermediate nitrogenous fertilizer materials. Transportation inputs and site requirements were the major considerations in the decision

by W. R. Grace to locate in the Wilmington area.

Transportation Inputs

The availability of deepwater port facilities and a site with access to a navigable waterway were requirements for the W. R. Grace nitrogen plant (Table 6). The primary materials used in producing nitrogen intermediates are ammonia and urea produced from natural gas by W. R. Grace's ammonia unit in Point Lisas, Trinidad, and transported to Wilmington in deep draft tankers. Ammonia is shipped directly to the plant site in tankers especially designed for W. R. Grace with cryogenic systems for maintaining a necessary temperature of -27 degrees Fahrenheit, thereby avoiding the high additional cost of transshipping the ammonia in refrigerated barges or rail cars. Urea is unloaded at the State Port terminal and carried by truck to the plant site.

Market access was also an important location factor. The products of Carolina Nitrogen--anhydrous ammonia, nitric acid, ammonium nitrate and processed urea--are distributed to fertilizer mixing plants which combine them with phosphate and potash materials for marketing. The primary market area for the Company's nitrogen products was considered to be North Carolina, South Carolina, Virginia and Georgia. Included in this market are W. R. Grace's own fertilizer

mixing plants in Wilmington and Statesville, North Carolina; Charleston, South Carolina; and Norfolk, Virginia. Wilmington occupies a more centralized location relative to this market than the two alternative locations that were considered--Norfolk and Savannah (see Figure 1).

Processing Costs

Processing costs were minor considerations in the development of the Carolina Nitrogen plant. The plant manager noted that the water supply, pollution controls and power supply were evaluated.

Availability of a Suitable Site

The availability of a waterway industrial site with good access to port, highway and rail facilities was required for the Carolina Nitrogen plant. The plant site lies between U. S. Highway 421 and the Northeast Cape Fear River, and is served by a main line of Seaboard Coastline Railroad. The Northeast Cape Fear was dredged by the Army Corps of Engineers to the Carolina Nitrogen plant site to accommodate the deep draft tankers carrying ammonia.

Analysis of Location Factors

The availability of a waterside site, market access and an abundant supply of water for manufacturing purposes

were the most important factors in attracting the four major chemical manufacturing plants to the Wilmington area. This conclusion is based on the total points assigned to the various factors by representatives of the four plants (Table 6).

Site characteristics appear to be the most important group of factors. The representatives of all four plants indicated that waterside locations were required. The Cape Fear and Northeast Cape Fear Rivers supply water for processing to all four plants and provide a transport mode for W. R. Grace and Hercules. Size requirements and access to transport facilities were rated as either important or a consideration by the representatives of all four plants.

Market access was the most important transportation factor. Port facilities were required by Hercules, W. R. Grace and Diamond Shamrock--indicating that these three companies were searching for the transshipment point which would also serve as an economical location for distribution.

An abundant water supply was the only processing factor significant in the location of all four plants. Labor factors were important only to DuPont which has, by far, the greatest labor requirements.

Intangibles were generally recognized as being of minor or of no significance. The efforts of two community organizations, the Industrial Committee and the State Ports Authority, were considered to be of some importance.

The checklist of location factors was expanded by DuPont representatives to include two additional site factors-- flood potential and distance from urbanized areas.

Fertilizer Mixing Plants

Four of the six fertilizer mixing plants in the Wilmington area participated in the survey to determine the reasons for their Wilmington locations. These plants are operated by Swift Chemical Company, the Wilmington Fertilizer Company, the Royster Company, and W. R. Grace (a separate division from Carolina Nitrogen). All four plants mix nitrogen, phosphate and potash materials to produce final fertilizer products. Fertilizer mixing plants comprise the oldest existing sector of the chemical industry of the area. Both the Swift and the Wilmington Fertilizer plants started their operations in the late 1800's, while the Royster Company opened its plant in 1929 and W. R. Grace started operating about 1950. The factors which were considered by representatives of these plants to be responsible for their Wilmington locations are summarized in the following

discussion (Table 7).

Transportation Inputs

The fertilizer mixing industry in Wilmington is strongly oriented toward transportation. Market access was a major location factor for the mixing plants, just as it was for the large-scale chemical producers of the area. The market for these fertilizer mixing plants is limited to North and South Carolina, with one plant manager indicating a market radius of approximately 120 miles.

For mixing plants, unlike the larger chemical producers of the area, rail facilities were also considered to be of major importance. Representatives of three mixing plants considered highway facilities important, while port facilities were only considerations in three cases. All three modes are used in obtaining raw materials, while distribution is made by rail and truck.

Access to input materials was an important factor for the W. R. Grace mixing plant and a consideration in the location of the Wilmington Fertilizer and Swift plants. The mixing plants obtain phosphate from Aurora, North Carolina, and western Florida; most nitrogen materials from Carolina Nitrogen, in Wilmington; and potash from Europe.

TABLE 7

SIGNIFICANCE RATING OF FACTORS IN THE LOCATION OF FERTILIZER
MIXING PLANTS IN THE WILMINGTON AREA

Location Factors	Significance Rating ^a				Total Points
	Wilmington	Royster	Swift	W. R. Grace	
<u>Transportation inputs</u>					
Access to sources of input materials.....	1	---	1	2	4
Access to markets.....	2	2	2	2	8
Availability of water transportation:					
a) Deep water port facilities.....	1	---	1	1	3
b) Waterway sites.....	---	---	---	---	---
Rail facilities.....	2	2	2	2	8
Highway facilities.....	---	2	2	2	6
<u>Processing costs</u>					
Labor: a) Lower wages.....	1	---	1	---	2
b) Amicable relations.....	1	---	1	---	2
Water for processing and cooling:					
a) Abundant supply.....	---	1	1	1	3
b) Pollution controls.....	---	---	1	1	2
Power.....	---	---	---	---	---
<u>Availability of suitable site</u>					
Adequate size.....	---	---	---	---	---
Waterside location.....	---	1	1	1	3
Accessible to transportation facilities..	1	1	1	1	4
<u>Intangibles</u>					
Community efforts.....	---	---	1	---	1
Entrepreneurial skill.....	---	---	---	---	---

^a Rating System: 2 Points - Important; 1 Point - A Consideration

Source: Survey of management of Wilmington area fertilizer mixing plants conducted in December, 1972.

Other Factors

All other factors were of minor or no importance in the location of fertilizer mixing plants (Table 7).

The analysis of factors in the location of existing plants serves as the basis for the following discussion of the potential of continued growth of the Wilmington area chemical industry.

CHAPTER V

THE FUTURE DEVELOPMENT OF THE WILMINGTON AREA CHEMICAL INDUSTRY

The analysis of chemical plant locations in Chapters III and IV has shown that the primary location factors have been the availability of riverside sites, market advantages and water transportation facilities. The efforts of community organizations, the availability of rail and highway facilities, and the characteristics of the labor supply in the area have also been important considerations. It can be assumed that future development of the chemical industry in the area will be dependent on these location factors.

Future Changes in Location Factors

Improvements in the transportation system of the Wilmington area should encourage industrial growth. However, two factors related to processing costs may have a negative effect on the future development of the chemical industry.

Transportation Factors

The forecasting of changes in market conditions and raw material availability is beyond the scope of this study. However, an assessment of planned improvements to the transportation system of the area indicates that accessibility to Wilmington will be greatly improved in the near future.

The most significant highway transportation improvement presently being considered is the extension of I-40 from its intersection with I-95 (Figure 1) to the Wilmington area. If approved, this highway facility would provide a direct connection to Raleigh and the Research Triangle Park, a center for chemical and other types of research, and greatly improve access to the heavily industrialized Piedmont region, a major market for the chemical industry in Wilmington.

The facilities of the North Carolina State Ports Authority and the Wilmington Chemical Terminal have been expanded to meet the cargo handling and storage requirements of new industries. New storage and docking facilities are presently being constructed at both terminals to accommodate the expansion of the chemical plants in the area. Representatives of both agencies indicated that facilities will be increased as demand is created by new or expanding

industries. The U. S. Army Corps of Engineers is presently conducting a study to determine the feasibility of widening and deepening channels to serve existing industries.

The Seaboard Coastline Railroad is now constructing a new freight yard and a new bridge across the Cape Fear River. These new facilities will improve rail traffic throughout the Wilmington area and are being constructed specifically to improve access to the State Ports Terminal and Wilmington Chemical Terminal.

Processing Costs

Two processing cost factors, a potential labor shortage and a new recreational development, may have a negative effect on future industrial development. In recent years, the demand for labor in the area has increased at a faster rate than the supply. Less than one per cent of the Wilmington area work force is presently unemployed.¹ The planned expansion of existing industries could create competition for labor, a situation which could discourage new industrial development.

¹Knight, interview.

A new second-home community is being developed on Bald Head Island, at the mouth of the Cape Fear River, which could restrict the development of chemical plants along the Cape Fear and Northeast Cape Fear Rivers. More concern for water pollution control will be a definite result of this new recreational community, the first such development along the Cape Fear River. This concern could lead to the requirement for more costly pollution controls and possibly the blockage of some industrial developments.¹

Intangibles

The citizens of the Wilmington community, in general, should continue to show a strong interest in the growth of the chemical industry through their support of the Wilmington Industrial Committee and the Brunswick County Resources Development Commission. The expanding efforts of the East Carolina University Regional Development Institute will also have a positive effect on future industrial development in the Wilmington area.

¹An example of this situation occurred in 1971 when the objections of home owners at resorts on Hilton Head Island, South Carolina, halted the development of a major chemical plant which was to be located upstream from the Island, along the Broad River.

Potential Industrial Development - Citric Acid Production

Representatives of the industrial development organizations of the Wilmington area indicate one major chemical plant is presently planned for the area. Pfizer, Incorporated, has announced plans for construction of a citric acid plant on an 800-acre tract along the Cape Fear River near Southport. The plant is scheduled to begin operation in 1976 with an initial employment level of 250.

Pfizer's existing citric acid plants are located in Brooklyn, New York, and Graton, Connecticut. The Company has overseas facilities in Ireland, Australia and Argentina.

The Director of Facility Planning for Pfizer indicated that many coastal locations between Maryland and Texas had been considered for the development of this new facility. The major reasons for the selection of the Southport location include market considerations, water transportation, water for processing, site availability and community efforts.

Transportation Inputs

The recent growth of the National market for citric acid, used primarily by the food industry, is the primary reason for Pfizer's plans for a new plant. The access of Southport to the southeastern portion of this market was

noted as a major location factor.

According to Pfizer management, the proposed plant would rely on water transportation for obtaining the majority of the input materials including molasses, paraffin, sulfuric acid and caustic soda. Citric acid would be distributed primarily by truck and rail, with Sea-land (trailers on board ship) movements to California also being a possibility.

Processing Costs

The availability of an abundant fresh water supply was the major processing cost factor for the citric acid plant, which will initially require an estimated 40,000 gallons per day. Labor relations in the Wilmington area were also a consideration.

Availability of a Suitable Site

The site near Southport is of sufficient size and adjoins the fresh water supply needed for the operation of the citric acid plant. The plant will also require direct access to waterway facilities. The Cape Fear River, at the proposed site, has a channel depth (40 feet) which is more than sufficient for handling ships bringing raw materials to the plant.

Intangibles

The Brunswick County Resources Development Commission was responsible for generating interest in the Southport area. The Carolina Power and Light Company, through efforts to gain a major new customer, assisted Pfizer in land acquisition.

Conclusion

Chemical manufacturers have located plants in the Wilmington area due to a combination of factors which include: the availability of large industrial sites along rivers supplying fresh water for processing and providing an alternative transportation mode for obtaining raw materials; the advantages of location near a transshipment point--i.e., the deepwater port facilities of Wilmington; and the nearness of the Wilmington area to the markets for these chemical plants.

This conclusion is based on the response to the survey of chemical plant managers which was conducted through personal interviews to assist the respondents in the interpretation of the questions and to encourage them to elaborate on important factors and identify any additional considerations which were omitted from the survey check list. Although

it is realized that some minor factors may have been overlooked, this research technique has identified the major location requirements of each plant and has provided a measure of their importance.

The analysis of transportation, processing, and site factors has shown the value of the least-cost theory. Some of the less obvious examples include the cost of market distribution, the cost savings provided by adequate rail and highway facilities, the availability of waterside land which could be purchased and developed at a feasible cost, and the cost savings realized through good labor relations. This study has not attempted to show the cost considerations for each factor, but has assumed that the entrepreneurs of the various companies have evaluated the factors on a least-cost basis and, through compromises, location decisions have been made. Intangible factors have also been considered, but this study has shown their effect to be much less significant than cost factors.

The future growth of the chemical industry in the Wilmington area will depend primarily on the development of the transportation system and the water, land and labor resources of the area. Major changes in market demand and raw material supplies could affect entire segments of the

chemical industry, including plants in the Wilmington area. However, present indications are that the chemical industry in the Wilmington area will continue to develop.

APPENDIX A

INDUSTRIAL LOCATION CHECK LIST
FOR CHEMICAL MANUFACTURING PLANTS
Wilmington, N. C.

I. GENERAL

- A. Name of Company _____
- B. Respondent _____
Position _____
- C. Is this plant the company's only manufacturing
facility of this type? _____
Location of other facilities _____
- D. First year of operation _____
- E. Proposed expansion _____
- F. Products (1) _____
(2) _____
(3) _____

II. TRANSPORTATION

- A. Sources of raw materials and components, market areas,
and modes of transportation utilized. (If more than
one mode is used to carry a material, please indicate
the approximate per cent of total tonnage carried by
individual modes.)

1. Raw materials and components (including fuel)	Location of Source	Mode to the Wilmington Area	Mode to Site
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

2. Products	Principal Market Area	Mode From Wilmington Area	Mode From Site
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

- B. Are special transport facilities required? _____
If so, please describe. _____
- C. What changes have been made in the types of transport modes utilized (ex., water to rail)? _____
Are changes anticipated? _____

III. LOCATION FACTORS

- A. Please rate the following factors as to their significance in the decision to locate in the Wilmington area. Please elaborate on any factors and expand the list if necessary.

<u>FACTORS</u>	<u>IMPORTANT</u>	<u>A CONSIDERATION</u>	<u>NO IMPORTANCE</u>
<u>Transportation Inputs</u>			
Access to sources of input materials	_____	_____	_____
Access to markets	_____	_____	_____
Availability of water transportation:			
a) Deepwater port facilities	_____	_____	_____
b) Navigable waterway	_____	_____	_____
Rail facilities	_____	_____	_____
Highway facilities	_____	_____	_____
<u>Processing Costs</u>			
Labor: a) Lower wages	_____	_____	_____
b) Amicable relations	_____	_____	_____
Water for processing and cooling:	_____	_____	_____

	<u>IMPORTANT</u>	<u>A CONSIDERATION</u>	<u>NO IMPORTANCE</u>
a) Abundant Supply	_____	_____	_____
b) Pollution	_____	_____	_____
Controls	_____	_____	_____
Power requirements	_____	_____	_____
<u>Availability of Suitable Site</u>			
Adequate Size	_____	_____	_____
Waterside	_____	_____	_____
Accessible to Trans-	_____	_____	_____
port facilities	_____	_____	_____
<u>Intangibles</u>			
Community efforts	_____	_____	_____
Entrepreneurial skill	_____	_____	_____
<u>Others (list)</u>			

B. What alternative locations were considered? _____

APPENDIX B

INTERVIEWS

CHEMICAL PLANTS

PERSONNEL

Diamond Shamrock Chemical
Company, Castle Hayne, N. C.

Chester Rudolph, Plant
Manager

E. I. duPont de Nemours and
Company, Wilmington, N. C.

J. J. Howerin, Jr.,
Environmental Control
Supervisor

W. R. Grace and Company,
Wilmington, N. C.

David S. Sharp, Nitrogen
Plant Manager
R. V. Fulk, Fertilizer
Plant Manager

Hercules, Incorporated,
Wilmington, N. C.

Franklin T. Parkinson,
Plant Manager
Warren W. Rich, Assistant
Manager

Pfizer, Incorporated, Chemical
Division, New York

John H. Nicholson, Director
of Facility Planning

Royster Company, Home Office,
Norfolk, Virginia

J. Frank George, Jr.,
Vice President

Swift Agricultural Chemical
Corporation, Wilmington, N.C.

R. A. Sisk, Regional
Manager

Wilmington Fertilizer Company,
Wilmington, N. C.

George Sloan, Jr., Vice
President

PUBLIC AGENCIES

Brunswick County Resource Development Commission, Southport, N. C.	Jackie H. Stephenson, Director
North Carolina Department of Natural and Economic Resources, Division of Commerce and Industry, Raleigh, N. C.	William Strickland, Director
North Carolina Employment Security Commission, Wilmington, N. C.	James Knight, Director of Wilmington office
North Carolina State Ports Authority, Wilmington, N. C.	James W. Davis, Executive Director Henry Jackson, Traffic Operations Manager
U. S. Army Corps of Engineers, Wilmington District, Wilmington, N. C.	George T. Swain, Jr., Chief of Navigation Reports Section Charles Hollis, Engineer
University of North Carolina at Wilmington, Wilmington, North Carolina	Duncan P. Randall, Chairman of the Department of Geography Joseph F. Dunn, Professor of Economics
Wilmington Chamber of Commerce Wilmington, N. C.	Ed Menke, Development Manager
Wilmington Industrial Development Commission, Wilmington, N. C.	Hugh Branch, Executive Director

TRANSPORTATION COMPANIES

Bulk Haulers, Incorporated, Wilmington, N. C.	Ralph Simmons, Traffic Manager
Seaboard Coastline Railroad, Columbia, S. C.	Earl Johns, Traffic Manager
Wilmington Chemical Terminal, Wilmington, N. C.	J. Dobson, Manager

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