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The Mining of Coal in Bristol, Rhode Island: Potential Methodology, Impacts, and Evaluation of Community Response

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Commercial coal mining in Rhode Island began in 1808, near Portsmouth, and terminated in 1959, in Cranston, on the present site of the Garden City Shopping Center. The Portsmouth venture operated until 1912; over a million tons of anthracite were mined. The Cranston mines yielded graphite; many thousands of tons were taken over a span of approximately 110 years (1). Rhode Island anthracite was reputed to be reluctant to burn, although it produced a hot fire once started (2). A 1915 government report on national coal deposits reported that "In the final great conflagration, Rhode Island coal will be the last thing to take fire" (3).

In the early part of this decade, Rhode Island coal was again an object of interest, this time by the Weston Observatory group of Boston College. In 1974 (the year after the Arab oil boycott), the staff received a National Science Foundation grant to study the coal reserves of the Narragansett Basin (4), a 900 square mile region bounded by Plymouth and Hanover Massachusetts to the east and north, and Woonsocket and Portsmouth R.I. to the west and south. (Fig. 1) To date, 24 test holes have been drilled (5); present estimates of the magnitude of the deposits are on the order of 9×10^8 tons, of which perhaps 15% may be found in Rhode Island. (Fig. 2) The areas examined in this state are in the coastal towns of Portsmouth (three test holes), in an area previously mined, and Bristol (seven test holes), a municipality in which commercial coal mining has not occurred, although coal apparently was discovered in the town in 1849, on Thames Street, in the vicinity of the test holes mentioned above (6).

This report will address the potential commercial mining of coal in the coastal community of Bristol, Rhode Island, with respect to methodology and community response. The attitude of the local community towards any mining proposal will greatly influence the course of development of the resource. In addition, maximum community participation is mandated by both Federal and State law (NEPA and the Rhode Island Coastal Zone Management Act, respectively) (7, 8). It is to be expected that the character of the response will be mediated to a great degree by the expected impacts of the mining operation. For this reason, the methods of extraction (present and potential), preparation and waste disposal, and their attendant impacts will first be discussed.

Narragansett Basin coal occurs in highly folded, wave-like seams, and is therefore not amenable to strip mining; extraction procedures would be through deep mining operations (9). The two major methods of deep mining in use are the room-and-pillar and longwall methods, the former the major means of extraction in the U. S. and the latter in Europe. In room-and-pillar mining, the coal is generally removed in two steps. About one third of the coal is extracted from "rooms" separated by "pillars" of unmined coal, with the pillar width one to three times that of the room (10). If the operation terminates at this point, it is considered to be a "partial extraction." In "complete extraction," part of the pillars themselves are extracted, working from the mine boundary back towards the entry shaft. Artificial timber-and/or steel-buttresses are used in conjunction with the remaining parts of the pillars to support the roof. This method extracts an average of 58% of the total coal seam. The safety of the room-and-pillar method is inversely related to depth, and it is best limited to fairly shallow mines, not exceeding a few hundred feet (the two Bristol major veins found by the Weston investigators were at 332 and 524 feet, respectively) (5).

The longwall method is used exclusively in Great

Britain, Germany and Belgium, and in most French and Polish mines (10). Here, coal is extracted by slicing along a series of long faces, 300 feet or more in length (figure 3). Hydraulic jacks support the roof at the face. As the face "advances" (for mining from the entry shaft to the outer boundary) or "retreats" (for coal mined from the boundary of the seam to the entry shaft, after the construction through the length of the mine of haulageways to provide access and ventilation), the strata cave in behind the support units. This method results in an 80 - 85% extraction of the seam. It is highly capital intensive, and has been used successfully in deep (500 - 600m), steeply sloping mines (9, 11).[a]

The induced caving method may be used in conjunction with either the room-and -pillar or longwall methods, and consists of controlled caving, usually working from the outer boundary of the mine back to the entrance shaft (9) (Fig. 4). The method is best suited for veins pitching at least 45°, where top rock will be most likely to remain intact without support until the excavation is backfilled (see below); it has been reported to result in increased yields (up to 90%) as well as increased safety.

A relatively recent method of extraction involves the use of hydraulic equipment. A high-powered stream of water, rather than the conventional cutting machines, is used to break up the coal (9). Pumps are used to transport the resultant coal-water slurry to the surface, where the water is removed and recycled. The water demands of this method are very high - at least an order of magnitude greater than the 20 gallons/ton normally used for dust and gas control (12). However, a very high pressure method currently under development at the University of Missouri, Rolla campus, uses only one gal/ton (13). The

(a) The general dip of the Bristol seams is between 30° and 40°, but is much steeper in some places (5).

hydraulic method is best suited for seams at least five feet thick; the thickness of the two major Bristol seams was found to be 5.9 and 26.6 feet, respectively (5).

The in-situ (underground) method of coal extraction is presently the subject of much research. The process of gasification itself is not new - it was first used, in the U. S., in the 1820's (6). However, in-situ gasification is still an experimental process. In this method, coal is converted into a combustible gas by partial burning in the presence of air, a steam-air mixture, or a steam-oxygen mixture (14). The gasifying agent reacts with the coal, creating a gas which is then forced to a series of collection wells. The gas may be used to run a turbine, which can then directly generate electricity. Capital and operating costs are very low, due to the elimination of extraction, waste disposal (the residue is left in the mine) and transportation to a preparation plant. In addition, the absence of these procedures is reflected in greatly diminished environmental impacts (but see below). However, precision control of the ignition process has not yet been achieved, the quality of the gas decreases as the fire moves along a seam, and the gas produced to date by this method has generally been of poor or variable quality (9, 14).

After the removal of the coal, it is shipped to a preparation plant (unless the method of extraction is in-situ gasification, in which case the resultant gas is transported via pipeline to the power plant). The chief means of transport include truck, rail, barge and pipeline. In the preparation plant, the coal is concentrated, cleaned of dust and surface deposits (a process which uses 700 - 800 gal/ton of coal) (12), and broken up and sorted by size.

It is then shipped to the power plant. A plant comparable in generating capacity to the Brayton Point power station would utilize approximately 2×10^6 tons of coal per year (15); the output of the Brayton Point plant is approximately 1.7×10^3 MW (16)

The waste from the preparation plant may be disposed of either above ground or below. About 25% of underground coal (national average) is rejected as waste and disposed of on the surface near the preparation plant (10). The amount of waste generated is basically a function of the dimensions of the entry shaft and the volume and quality of coal excavated. For an entry shaft ten feet square and a depth of 500 feet, 5×10^4 cubic feet of earth (2500 tons, assuming an average density of 0.05 tons/ft^3) will be removed in the establishment of the mine entrance. If 3×10^6 tons of coal-bearing rock are removed from a mine over a 20 year period, the resultant 0.75×10^6 tons of waste (assuming 75% coal and 25% waste, as above) would occupy an area approximately 400 feet square and 100 feet high.

The impacts of the various procedures outlined above, as perceived by the public, may be expected to play a major role in determining the reception given to a coal mining proposal; decisions will most likely be based on anticipated tradeoffs between positive and negative effects. The negative aspects may be expected to receive much initial publicity, and will be dealt with first.

Most excavation impacts may be divided into air, water and ground effects. Air pollution concerns deal chiefly with SO_2, CO and dust. Analyses of Bristol coal have revealed that it is extremely low in sulfur (0.06 - 0.07%), with concentrations about 10% that of typical Pennsylvania anthracite (4). The sulfur levels in Bristol coal would yield gaseous S emissions far lower than those permitted by current state standards (one percent sulfur by weight) and less than 10% of the SO_2 emissions associated with oil use (17, 18). The production and release of carbon monoxide is a problem especially prevalent in in-situ gasification, and is discussed below. Dust not controlled by wetting may settle on houses and biota and has also been implicated as an aggravating factor in respiratory ailments (18).

Water quality concerns are associated with acid drainage and siltation, and with the alteration of drainage patterns. Sulfur, in the presence of oxygen, water and bacteria, forms sulfuric acid. Over 5,700 miles of streams in Appalachia have had their water quality greatly lowered due to acid drainage (6). Groundwater may be contaminated by leakage of mine water into strata adjacent to the mine. The settling of particulate matter in streams may result in siltation, with consequent alterations in biota (20). The clearing of land and adjustment of drainage to provide easy access to the mine site may cause local flooding and increased erosion.

The major ground effect - and, by virtue of the difficulties inherent in its control (see below) - is that of subsidence, with blasting effects a secondary concern. Subsidence, a buckling of the earth with associated damage to buildings and utility lines, is a function of the geometry of the deposit (thickness, steepness), the method of mining (partial or complete extraction, with or without support), and the character (hard or soft) and depth of the overlying strata (6, 10). Maximum subsidence is associated with a thick, flat seam of shallow depth, completely extracted with minimum support, and a soft rock overburden. In-situ gasification presents particular problems as the path of movement of the fire is difficult to predict. Subsidence is therefore relatively uncontrolled, and may appear in the form of cracks (as opposed to a less damaging bending) in the earth's surface. Should this occur, the release of carbon monoxide produced in the gasification process could present a severe hazard to the people in the immediate vicinity (13). As for blasting, its necessity and degree are a function of the method of extraction and the rock type; in certain situations, mining may occur without any blasting at all.

A further negative impact of the extraction process concerns miner safety. Underground coal mining is the most hazardous occupation in the U. S. (6). Statistics for the ten major coal companies (1971, in volume produced) showed 0.3 - 1.5 deaths and 2.7 - 72.1 injuries/10^6 man hours; in total, these figures translate to over 100 deaths and 12,000 injuries each year (10). Coal miners have a greater (in some instances, far greater) insidence of occurrence of respiratory diseases (pneumoconiosis, or black lung, and silicosis, both of which particularly affect miners; asthma, emphysema), stomach and lung cancer and influenza than the general population (10).

Major problems associated with the preparation process include those relating to the transport of coal from the mine to the preparation plant itself and then to the power plant, and the impact of the preparation plant and its associated processes. Associated with truck traffic are increased congestion, vibration, noise, high fuel cost and pollution from the use of combustion engines. Rail traffic is limited by a lack of flexibility with respect to distribution points; a rail system is never as extensive as the corresponding road network. Vibration and noise pollution are the most likely environmental impacts. Barges are appealing from the point of view of a coastal community such as Bristol, but their use may result in harbor congestion with its associated problems. Their appeal is further limited if the reception point is not on or near the coast. Pipelines, once installed, are devoid of dust, noise, vibration, air pollution and safety hazards. However, with the exception of slurry transport, their use is severely distance-limited (18).

Impacts related to the preparation plant itself are associated with its construction and operation, land use, and, depending upon siting, affects of visual (aesthetic) disruption. Dust emissions may arise from the crushing and breaking of coal. Water used in processing becomes contaminated and must be cleaned before release to the environment. A preparation plant in Northern Appalachia processing 2 x 10^6 tons/year requires approximately 50 acres for a settling pond for sedimentation of particulates in the wash water; 40 more acres are needed for loading and handling, while the plant itself requires 5 acres (6).

Waste pile impacts may be characterized with respect to air, water and visual effects. In the past, improper handling of surface wastes has resulted in spontaneous combustion within the piles, giving rise to emissions of SO_2, H_2S, CO_2, CO, and NH_3 (10). These gases may cause defoliation and crop damage and may exacerbate respiratory ailments. The effects of the SO_2 may be felt far from the source of the pollution, by the falling of acid rain (see the formation of H_2SO_4, above). The percolation of water through waste piles may result in the formation of acid water and may also leach heavy metals (particularly iron) into the soil. Adverse visual effects associated with surface disposal may have secondary impacts in that property values in the area may decline; well-to-do residents may leave the area and the attraction of the area to businesses may decrease. It should be noted that dual systems are generally favored for the surface disposal of coarse and fine wastes. Coarse material is deposited on the waste pile directly, while fine material is usually transported as a slurry to an impoundment (10).

The above outlines the operations and (negative) impacts that would be expected to be central to the character of the reception with which a mining proposal would be received. However, measures mitigating or eliminating these undesirable effects as well as benefits which may accrue to the municipality must also be considered.

SO_2 emissions may be controlled by the installation of "scrubbers." However, as noted, the sulfur concentration in Bristol coal is such that emissions of this pollutant would not have to be regulated, according to present Rhode Island standards. The formation of acid water within the mine and possible contamination of groundwater may be prevented by the rapid pumping out of water leaking into the mine. The establishment of storage ponds would also be required. Correspondingly, siltation problems may be eliminated by the use of settling ponds.

Subsidence may be controlled by careful engineering in conjunction with backfilling - the disposal of mine wastes underground. Room-and-pillar mining in the U. S. has resulted in an average vertical subsidence of approximately 75% of the seam thickness. Backfilling reduces the maximum subsidence to about 50% of the seam thickness for complete extraction, and may eliminate subsidence completely for partial extraction (10). Backfilling also has the advantage of eliminating the problems associated with surface disposal outlined above. It should be noted, however, that certain disadvantages are associated with this method. If backfilling is done in conjunction with extraction, productivity decreases, relative to separate fill and mining operations (at present, room-and-pillar mining cannot occur concurrently with backfilling operations; longwall mining can). Backfilling also results in increased dust exposure to mining personnel (dust levels in many longwall extraction operations are already close to those permitted by Federal law). Fill machinery is also very noisy. This may present a safety hazard not only with respect to noise pollution, but also because experienced miners use the sounds of rock movements as signals of impending danger. Problems are also associated with each of the two methods used in backfilling operations. In the pneumatic method, material cannot be transported horizontally for distances greater than 2000 feet. In the hydraulic method, the use of pressurized water to introduce the fill may cause problems if the supporting pillars are weakened by water penetration (10). These problems, however, must be measured against the severity of the subsidence problem.

Backfilling represents the use of the mining operation itself to mitigate subsidence problems. In addition, structures may be built to achieve similar ends. New buildings may be required to meet certain standards designed to minimize susceptibility to subsidence (either very flexible or very rigid structures are recommended) (10). Pipelines and the associated joints should be flexible. Buildings of historic or architectural value may be partially protected by removing articles of particular concern, such as the stained glass windows of a church. Horizontal strains can be decreased by constructing trenches around these buildings (10).

Miner safety can be maximized by strict adherence to existing laws; the large range cited above for deaths and injuries among the ten major companies indicates that the poor safety record of the industry as a whole can be greatly improved without significantly affecting production levels.

Transportation impacts may be diminished by limitations on maximum vehicle size and by routing and scheduling arrangements. The location of both the preparation plant and power plant at the mine mouth would essentially eliminate transportations impacts. However, the construction of a power plant would itself entail a host of impacts.

Within the preparation plant, dust emissions may be decreased by electrostatic particle removal. The aesthetic impact of the structure can be mitigated by careful consideration of siting and design criteria. Trees may be used to screen the plant - semi-mature trees screen well but are expensive and require considerable maintenance; young trees are not as effective but are much cheaper and easier to maintain (18). An additional benefit of screening lies in the noise abatement qualities of the vegetation.

The method used to dispose of wastes determines the potential for impact. If underground disposal is used, problems associated with aesthetic effects and air and water quality can be eliminated. If surface disposal is the method of choice, the potential for adverse effects is high. However, proper management of the waste pile can reduce the degree and quality of the pollution greatly. Spontaneous combustion within the pile, with the attendant air pollution, can be prevented by mixing the pile to prevent size segregation (the presence of which facilitates the entry of air, which is necessary for combustion), and then compacting, to decrease air flow. The removal of large pieces of refuse (again, associated with air spaces) and the minimization of the carbon content of the waste also serve to decrease the possibility of combustion (6, 18). Water pollution may be controlled by preventing the percolation of water through the waste pile. Waste permeability may be decreased by compacting and sealing with concrete, asphalt or clay (the latter is cheapest and most practicable) (18). Surface drainage water may be diverted to minimize acid leaching. Impoundments are generally treated with lime to control (raise) pH and precipitate iron; they may also be lined to prevent seepage into groundwater (12). The Coal Mine Health and Safety Act (1969) includes regulations dealing with the proper surface disposal of wastes (21). Wastes may also be "disposed of" through usage in other areas. These include construction fill, the manufacture of lightweight aggregates, road base, anti-skid materials for roads, the manufacture of brick and use in insulation. At this time, only construction fill has the potential for use of large quantities of coal waste (10). Aesthetic effects may be improved by the use of vegetation. In Great Britain, waste piles, once complete, are planted over with Japanese fir trees (10).

An overview of the operations and adverse impacts associated with deep mining has been presented. As we are concerned with mining as it pertains to the town of Bristol, a brief characterization of the municipality is in order.

Bristol comprises 21.0 square miles, of which 10.2 are land and 10.8 inland water (Fig. 5). Most of the town's residential areas lie within one mile of the shore. The population in 1970 was 17,860 (22). The estimated population in 1975 was 18,700, with projections through 1990 at five year intervals of 19,000, 19,500 and 19,900 (23). In 1970, 18.6% of the population were foreign born; 77.8% of the immigrants were of Portugese extraction, and 9.8% of Italian (22). Approximately 20% of the populace speak English as a second language (24).

Two major sectors stand out demographically: the twon center, which is dominated by first and second generation immigrants, predominantly Portugese, and Poppasquash peninsula, which is populated largely by "Yankees" (landed gentry - estate owners). A traditional division of the municipality along socio-economic lines could result in the identification of three major groups: blue collar workers, white collar workers, and upper-class "Yankees" (24). An initial attempt at categorizing these groups with respect to their probable reaction to a mining proposal might be based on the expectation that the relative importance of environmental to financial concerns will be directly related to class membership, with potential economic benefits noted especially by blue collar employees and the threat of environmental degradation by the estate owners. However, generalizations of this nature may be misleading. Property owners in all three groups pay taxes. Similarly, although the quality and quantity of use may differ, marine resource users are to be found among all three groups.

Further, a middle class blue collar worker who is an avid fisherman might be vehemently against a mining proposal, while a "Yankee" landowner living on a fixed income might be inclined to view such a proposal more favorably. Perhaps the most reasonable statement is that one cannot generalize - decisions will be made on an individual basis, with each voter weighing potential financial benefits (tax reductions, employment opportunities) against perceived environmental amenities.

The heart of the town - central Bristol - is of particular interest as significant coal seams were discovered in this area by the Weston investigators. This district contains about 12% of the town's land area but about 50% of its population (55% in 1965) (25). It is characterized by contrasts - housing units range from tenements to estates, with a number of buildings of historic value (26). Land uses are varied and interspersed; industrial, residential and commercial uses are found in no particular pattern (25). The area is a focal point for immigrants; succeeding generations tend to move to the newer (and relatively rapidly growing) sections of town (northeast, northwest).

The work force, in 1970, totaled 7,899 (22); the estimate for 1976 was 8,400 (23). Manufacturing concerns employed 58% of the total (1970 data). In 1976, 55% of those employed in manufacturing were in the rubber and plastics industries, and 19% in textiles and apparel (27). The median family inome was $9732 in 1969; the state average was $9736 (22). The property tax rate is $57.24/$1000, with approximately 70% valuation, and is the major source of income for the municipality.

Of the town's eight land use zones, four are residential, two business, one manufacturing and one Public Urban Development. The major sites zoned for manufacturing are the Minturn Farms site (116 acres), now being usd as a town dump, and the Metacom Avenue site (275 acres) (28). Approximately 60% of the town's land area is considered as developable undeveloped land (28).

The town's school system consists of eight elementary and one senior high school. The percentages of school-age children relative to total town population and the student:teacher ratio (38% and 16.5, respectively) are identical to the state averages (23). Average expenditure per pupil in 1975 was $1312, while the comparable figure for the state was $1330 (23). According to the 1970 census, the median school year completed for residents over 25 years of age was 10.0 years; the state average was 11.5 years.

Major recreational facilities include four private and two public marinas, four beaches (one public), Colt Memorial State Park, a golf course and yacht club (both private) and numerous playgrounds. The town is contemplating the establishment of a multipurpose park at the site of the old railroad yard on Thames Street. The area includes the location of the thickest seam of coal discovered to date by the Weston group.

The towns two major roads are Metacom Avenue (RI Rt. 136) and Hope Street (RI Rt. 114). Both these roads are heavily utilized and are not considered adequate to handle large volumes of high speed traffic (28). The likelihood of construction of the East Shore Expressway, a proposed limited access highway traversing the town from north to south along its eastern border, is presently considered to be improbable at best (29).

The Bristol extension of the Providence-Worcester railroad line is inoperative at the present time, although the line was used to carry passengers through 1938 and freight until 1973 (30). The tracks, which run along the western shore of Bristol Harbor and then follow Narragansett Bay for a total distance (Bristol to Warren) of four miles must be completely replaced, at an estimated cost of \$250 - \$400,000 per mile. In addition, the eleven miles from Warren to East Providence are in need of repair at an estimated cost of \$150,000 per mile (30). The entire route between Bristol and Warren passes through residential neighborhoods.

The town receives its water through the Bristol Water Company, from four surface reservoirs fed by the Palmer and Kickemuit Rivers. The system has a daily pumping capacity of 13×10^6 gallons; average consumption is 5×10^6 gal/day.(27) The soil is largely silt-loam (31) and the water table is high. No underground aquifers have been reported (6). A problem has recently arisen relating to the quality of the drinking water; concentrations of chloroform three times that permitted by federal standards (100 ppb) have been reported (32). In addition, various companies have reported the water pressure to be unreliable, particularly at night (24). For the past two years, a voluntary water use restriction has been in effect. The management of the water company has stated that it is not willing to (indeed, cannot) supply new industry with water (32). The company is part of a national conglomerate which apparently has decided not to invest in updating the present (old) system on the grounds that the area is not expected to show significant growth in the near future. This prognosis was based in part on a state projection that growth in the municipality was expected to occur at approximately the 2% level through 1990 (24). The water company policy can only serve to put a damper on industrial development, the lack of which will only substantiate the parent company's belief that the growth rate in the area does not warrant investment. The Providence Water System is looked to by the town for assistance in the future. However, no plans have been made towards this end. The estimated cost for a project providing relief through the resources of the Providence system is $13,000,000 (32). The effects of this constraint on the prospects for and reception of a future proposal to mine are difficult to predict. If the water supply problem remains acute, it is difficult to envision the establishment of a new industry, especially one with a high water demand. It should be noted, however, that the major utilization of water in the mining process occurs in the preparation, and not the extraction, phase. In addition, should the demand for energy (as reflected in the price to the consumer) be sufficient, a coal concern may deem an investment in the water system of the town to be a reasonable condition for operation. The consequences of a decrease in industrial investment might be reflected in the reception given to a mining proposal. A slowdown in growth, with decreased employment opportunities for the local populace, could be followed by an increase in emigration, with a subsequent fall in the tax base, decreased municipal services, etc. Under these circumstances, a proposal by an industry to locate in the area might be especially well received, perhaps at the cost of environmental considerations.

The Bristol Sewer System, one of the oldest in the state, has a capacity of 4×10^6 gal/day, with a daily flow approximately one half this rate. Funding for an improvement of the system has been authorized, and an engineering study is in progress (24). It should be noted that mining companies are not permitted to release waste-water into the municipal treatment system; they are responsible for the management of the sewage generated by the mining operations (21, 8).

The flood hazard zone encompasses the shoreline to a height of 14 feet above mean sea level, and also includes marshes northeast of Colt State Park and the areas bordering Silver and Walker Creeks.

An unusually high percentage of the town's land area - over 20% - is or has been proposed to be placed on the National Register of Historic Places (33). Among these sites is the Bristol Waterfront Historic District, (Fig. 6) an area of particular interest in that a number of test holes were drilled within the district(without the knowledge of the Rhode Island Historical Preservation Commission). (Fig. 7) Other major historical sites include all of Colt Memorial State Park and the Mount Hope farm. These areas are south of the region of greatest interest with respect to coal, (Fig. 2) but could be impacted upon should support facilities (for example, a preparation plant) locate in their vicinity.

From the above descriptions, the town of Bristol may be seen to have several characteristics which, in total, distinguish it from other municipalities in the state. Chief among these differentiating aspects are its large foreign-born population and the high percentage of its population within one mile of the coast. The waterfront is considered by the populace to be a town resource (24). In 1974, a proposal for the construction of a private marina was turned down by the town council after it met with considerable opposition from the community. The railroad yard (adjacent to Thames Street) was to have been fenced off and used for boat storage and repair; 400 slips were to be installed along the shore. The opposition was based on the contemplated denial of access, and fears of increased congestion and a decreased view from the addition of a large number of vessels to the harbor.

It is likely that much of the opposition to a mining proposal would similarly be based on environmental grounds. There is presently no organized environmental group in the town, but it is not difficult to imagine a rapid coalescence of interested individuals in response to a major proposal such as that entailed by coal mining. Proponent, as well as opponent, groups would be expected to form, those in favor of the proposal basing their views largely on job and tax relief considerations.

The number of jobs created is a function largely of mine production (output), production per worker, mine life and the cost of output (6). Mine-related employment can be classified into three categories: management, miners and service. Management will probably be brought in ("imported") and it is therefore assumed that none of these positions will be available locally. In contrast, most of the mining and service jobs created by the opening of the mine would be filled locally. It is estimated that, given a coal resource of 10^7 tons and a 20 year mine life, 73 management, 216 mining (184 filled locally) and 82 service (66 filled locally) positions would be created. Of the total of 371 jobs, 250 would be available for area workers and 121 would be filled from outside the region. The creation of 250 positions for local workers is comparable to the employment opportunity created by the establishment of a medium-size industry (the largest manufacturing concern in Bristol in terms of employment is P. F. Industries, Inc., a footwear concern employing 600 workers (34).

The broadening of the town's tax base will undoubtedly be advanced as a major benefit by mining proponents. However, several questions must be addressed before estimates of the benefits can be made. A number of possibilities exist with respect to the basis of assessment: the difference between construction costs and depreciation, a comparable analysis of similar sales, the replacement value, predictions of the quantity of recoverable coal, the actual quantity produced, and a percentage of the selling price. A number of these options, however, have features which make them relatively undesirable, particularly from the point of view of the community. The sunk capital cost of a mine is generally far less than its actual value. The definition of "similar sales" introduces a constraint in that it is difficult to wholly equate coal sales due to differences in coal quality and use, and in supply - demand relationships, between different regions. The return to the community would steadily decrease with time using the replacement method, as the mine itself decreases in value as the coal is removed. Estimates of recoverable coal may change with time - new seams may be discovered, or known seams may contain less coal than expected. Property taxes based on the amount of coal extracted have the advantage of being easy to administer as the measurement is straight-forward. Although this does not allow for changes in price levels, coal quality and production costs, these variables can be incorporated into the tax calculation. Changes in value due to inflation may also be incorporated into the calculation of the tax rate. The use of the sales price as a basis for the property tax takes into account the above variables, which are dealt with in the market place. Should the value of the coal increase, the town shares in the gain in profits; should it decrease, the company does not have to pay a rate based on a prior, higher value. States using this "percentage of gross value" system use the difference between the sales price and the costs of processing as the basis for computation. (However, this penalizes the efficient processor).

A number of mining states apply a severance tax to the industry on the grounds that the removal of a natural resource from the earth represents an irretrievable loss to the state. The severance tax is a means of replacing a part of this lost value. The rates are calculated as a set amount of money per unit of production, a percentage of the value of production, or a combination of the two (35). The factors considered in setting the rates include the costs related to environmental and socio-economic impacts, and revenue expectations. The severance tax as a percentage of the selling price/ton ranges from 0.06% to 22.01% (Colorado and Montana, respectively) (Fig. 8). Some states use a portion of the severance tax receipts to establish a trust fund. The interest is used to aid communities impacted by the industry and for reclamation projects; the principal cannot be spent until a given amount has accumulated in the fund. This system allows for the availability of funds to mitigate impacts which occur after the cessation of the mining operation. The question of the distribution of revenues generated by the imposition of this tax must be considered by the communities desiring to share in the receipts. Generally, the distribution is controlled by the state; revenues go directly to a general fund and/or to the communities impacted by the mining. Alabama permits local governments on the county level to impose a severance tax in addition to that levied by the state.

Property tax receipts from mining operations may be utilized to lower the property tax rate applied to homeowners and/or other industries, to increase the quality and/or quantity of services offered by the town, or a combination of these. Revenues would undoubtedly be utilized to accomodate the increase in services required as a consequence of the influx of non-local mining personnel. Services affected would include schools, health, police and fire, utilities, etc. The demand for housing would also be expected to increase. It should be noted, however, that all of the new employees would not be expected to settle in Bristol. The demographic effect of dispersion may be seen by examining the relative effects of an influx of 150 families into the town of Bristol and into the Providence SMSA. This figure represents an increase of 3% in the population predicted for the town in 1990, while the population of the region in question would be expected to increase by only 0.1%. The effects mentioned above are those which would be significant over the long term; short-term impacts relating to construction of the facilities required for mining would be expected to differ in quality and/or quantity and require an analysis in themselves; these will not be considered here. Just as the development of an industry is associated with an increase in demand for a host of services, its termination may result in the imposition of cutbacks in various town-supported areas. The severity of these latter impacts, however, may be mitigated if production does not cease abruptly, but rather decreases over a period of time, so that the entire work force is not terminated at once.

The mining of coal in the Narragansett Basin, and specifically in the town of Bristol, may be viewed from a national, state (and regional) and local perspective. On the national level, the utilization of coal may play an increasing role in meeting our energy demands. New England imports virtually all its energy needs (Fig. 9); coal produced in the Basin could contribute perhaps 20% of the demand anticipated for the region in 1990 (6). Towns in the mining region would, of course, be impacted most directly.

For coal mining, permits would be required on the federal, state and local levels, as specified by NERC regulations,[a] the RI Coastal Zone Management Plan, and local ordinances, respectively. Unfortunately, although public participation is considered to be an essential component of the decision-making process on each of these levels, a tendency has existed to rely on professionals, with the public relegated to a secondary (if that) role. The problems inherent in this approach have been discussed by Sewell (36); unless the alternatives chosen by the "experts" reflect the values of the public, they are likely to be rejected. This may be avoided by a deliberate effort to involve the "person in the street" to the greatest extent possible in the earliest stages of the deliberation process.

Perhaps public input has not received full consideration because the information base of private citizens has not been considered sufficient by the decision makers to permit the citizen to contribute significantly to environmental evaluations. One of the keys, therefore, to a successful involvement of the community, especially for a project as major and

(a) National Energy Regulatory Commission as technical as coal mining, concerns the quality, quantity, and accessibility of information made available to the public. The response of the community is most likely to be given careful consideration by the decision-makers if the citizens are fully aware of the issues and their implications. The mailing of information according to a list of "key" agencies (as practiced, for example, by the Army Corps of Engineers)(37) reaches established groups, but essentially passes over the vast majority of the local populace, who are the chief "impactees" of the project. Information must therefore be made available to the people at large. If this information is to be of use to the citizen, it must be presented in a concise, clearly written statement, containing the proposal and the predicted impacts. If the report is to be received as a credible document, it must also be complete, and, to the greatest extent possible, unbiased. Major assumptions used in the formulation of the report must also be stated.

The attitudes of the townspeople with respect to areas of concern (values) and to the proposal itself may be assessed by use of a written questionnaire. Maximum flexibility may be achieved by including both open- and closed-ended questions (38). The questions must be specific, clearly worded, and relevant. If it is considered desirable to further assess the attitude of the people, the questionnaire may be followed up by the interviewing of a sub-sample of the original group.

These surveys should serve to spotlight areas of concern and may be useful in anticipating problems that may arise, thereby facilitating conflict resolution. In addition, responses may be broken down according to the socio-economic background (or some other classification)

of the respondents so that the concerns of
various groups can be addressed specifically.

The demographic composition of the town of Bristol would present the preparers of the information document and the written and oral questionnaires with a number of interesting problems. The high percentage of people for whom English is a second language necessitates the use of multi-lingual documents, and where necessary, interviewers. Also, first-generation Americans may be suspicious of government officials and of forms requiring information that may be of a personal nature (age, income, etc.). These attitudes might be reflected in a particularly poor percent return from this group, thereby biasing the overall results. The involvement of local media (newspapers, television, radio), particularly those operating in Portugese or Italian, and elected officials, may serve to minimize this problem. The early, large-scale involvement of the community as described above would serve not only to satisfy the legal requirements mandated by the various levels of government, but, perhaps more importantly, should provide a framework in which disputes can be settled to the mutual satisfaction of the parties concerned.

CONCLUSIONS and RECOMMENDATIONS

The issues of concern may be subdivided into technical, legal, economic and political areas.

Included in the technical realm are considerations dealing with coal extraction, transportation, preparation and waste disposal.

Given the low sulfur concentration in Bristol anthracite and the present state of the art with respect to the management of coal-related air and water pollution, it is expected that the maintenance of ambient air and water quality levels would not constitute a significant constraint to the operation of a coal mine in the municipality. In addition, direct land use conflicts due to extraction requirements need not arise, as entry shafts may be placed on undeveloped sites. The seams may then be reached by tunneling horizontally at depth. The major areas of concern relating to the methodology of the mining operation would therefore focus upon subsidence effects and land, and possibly water, use conflicts associated with the preparation process.

Subsidence problems would be most severe in the densely populated town center. This area also includes a number of historic sites, particularly the Bristol Historic Waterfront District; the town has plans to construct a waterfront park in the district, along Thames St. For these reasons, it is recommended that complete extraction not be permitted in this area. Partial extraction should be permitted only under rigorously controlled conditions, and consideration should be given to removing the area altogether from consideration as a mine site. Subsidence insurance should be made available by the state to all homeowners in (above) the mining region. It is also recommended that special construction standards be promulgated for all new structures. This is of particular import as the sector of maximum coal potential in the town coincides with the region of most rapid residential growth.

It is likely that the problems associated with in-situ gasification will be mitigated and possibly eliminated within the next ten to twenty years. Underground gasification is clearly the method of choice for coal extraction on environmental grounds. As such, the utilization of this method may well warrant a delay in the development of the resource relative to a more immediate exploitation using room-and-pillar and/or longwall methods.

The presence of seams in a flood hazard area should not constitute a constraint on extraction, as long as all entry, exit and ventilation shafts are well above the hazard zone.

The use of either trucks or rail as a means of transporting the extracted coal to the preparation plant are precluded by the inability of the present road system in Bristol to accommodate substantial increases in traffic volume, and the present state of disrepair of the Providence-Worcester Line, especially between Bristol and Warren, but also between Warren and East Providence. The rejection of the 1974 marina proposal by the town indicates that public access to and use of the waterfront is an area of concern to the people. This diminishes the attractiveness of the use of barges to transport the coal. However, the two situations are not entirely comparable, as the marina would have benefitted a small sector of the community, while tax benefits from the opening of a mine would accrue to the town as a whole. A possible resolution of this conflict may lie in the designation and development of a sector of shoreline that is subject to relatively light use for the purpose of barge operations. A less detrimental form of transport, from an environmental perspective, must await the development of pneumatic and/or hydraulic pipelines capable of transport over significant distances. It should be noted that the location of the preparation plant at the mine mouth would not eliminate this problem, as the prepared product would still have to be transported to the power plant. The mine mouth should, however, be placed as close as possible to the loading point designated for shipment; that is, near the shoreline for barge transport.

The location and design of the preparation plant must be selected with care to minimize the creation of adverse aesthetic effects and land use conflicts. Within the town, both Minturn Farms and the Metacom Avenue Industrial Site are zoned for manufacturing and have the requisite area to contain both the mine mouth and the plant itself. However, unless the capacity of the Bristol-Warren-Barrington water system is markedly upgraded, the high water demands of the preparation plant may effectively preclude its location within this region. Wherever the plant is located, every effort should be made to minimize adverse visual impacts with possible subsequent declines in surrounding property values. Should this occur, the financial benefits accruing to the town would be correspondingly diminished; if accompanied by emigration, an alteration of the social structure of the municipality could also occur.

Should the preparation plant not be located in Bristol, a number of the adverse effects cited above would be avoided. This option should therefore be given full consideration.

In addition, the town would not have to deal with the potential impacts of the associated waste pile. It is recommended that this problem be minimized altogether by utilizing the waste as backfill (thereby facilitating subsidence control), construction fill, etc.

A major legal problem involves the lack of a mineral rights law in the state. It is recommended that the coal company be permitted to buy the rights to the mineral while leaving the surface property rights to the homeowner. To preclude the driving up of the purchase price to levels untenable to the company, the municipality and/or state should examine the possibility of claiming the subsurface land through eminent domain. The laws of other mining states may be examined for relevance and applicability. All permits issued should clearly delineate the geographic areas which are restricted (that is, may not be excavated). Permits should allow for revision due to changes in mining methodology, pollution treatment, the economic situation, etc. A compensation provision may be included to protect the investment of the mining concern, although this may not be in the interest of the municipality and state (if the company is entitled to compensation which cannot be met, the contemplated change in the permit may not be put into effect). The company should also be held responsible for any mining-related environmental impacts occuring a specified number of years after the closing of the mine. Finally, the possibility of extraction of underwater deposits (as occurs in Wales) should be investigated. This would require a modification of the RI Coastal Zone Management Act which prohibits mining in state waters "...until such time as sufficient technical and research data is shown to this Council to prove under what condition said extracting and mining may be carried out without adversely altering the marine environment or conflicting with other use of tidal waters."[8] The legal requirements of other mining states, particularly Pennsylvania (which has perhaps the strictest regulations of the coal states), and the European nations should also be examined and utilized to the maximum extent possible.

A severance tax should be established based upon the market price/ton received by the company. Receipts from this tax should be utilized to mitigate mining impacts. Municipalities adversely affected but not receiving property tax income from the mining operation should receive special consideration. The establishment of a trust fund from severance tax receipts is strongly recommended to provide a source of funds for the alleviation of impacts occurring after the cessation of mining activities. Over the long term, consideration should be given to the placement (if necessary, retraining) of miners in other positions after the resource has been extracted.

Public participation should be facilitated by the preparation of an information document outlining the proposed operation and the expected impacts with respect to degree and temporal and spatial occurrence. Responsibility for this document would lie with a committee composed of coal company and environmental interest group representatives. The document should be mailed to all households in the community after an initial publicity campaign utilizing the local media, elected officials, and various community organizations (churches, fraternal organizations, etc.). The information sheet should be followed up by the saturation mailing of a questionnaire to survey the concerns and attitudes of the people with respect to the proposal outlined in the information document. Expenses should be borne by the company - an "investment" demonstrating its adherence to the federal and state requirements for the consideration of community response. In addition, public interest groups (RI Lung Association, Ecology Action For RI, Save the Bay, RIPIRG, etc.) should be kept fully informed as to the status of the proposal from the outset. Also, it is recommended that the municipalities potentially subject to impact form a permanent commission consisting of local elected officials, and environmental group and mining company representatives with responsibility for coordinating the efforts of the concerned parties to regulate and develop the resource and to facilitate conflict resolution. Findings and recommendations would be reported to the governors of the affected states as well as to the governing bodies of the municipalities.

Finally, it should be noted that this report has dealt with the use of coal as an energy source, However, carbon-based minerals are also used as sources for various organic chemicals, including plastics and drugs. It is conceivable that at some time in the future, assuming the development of alternative energy sources, that coal will be valued more as a chemical base than as a fuel. The more immediate value of coal as an energy source should therefore be weighed against the conservation of this resource for other, future use.

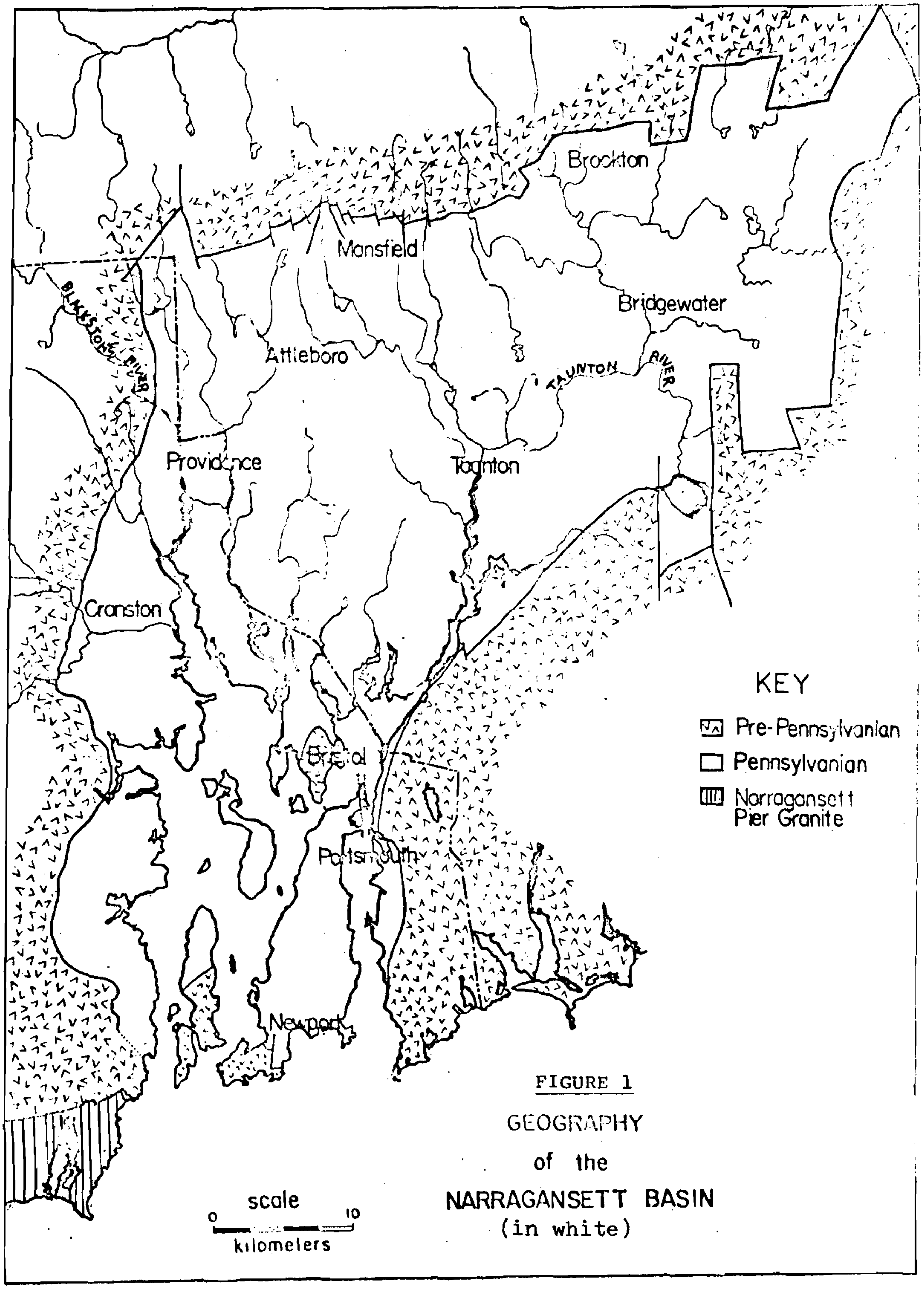


FIGURE 1

GEOGRAPHY of the NARRAGANSETT BASIN (in white)

Source: Ref. 4.

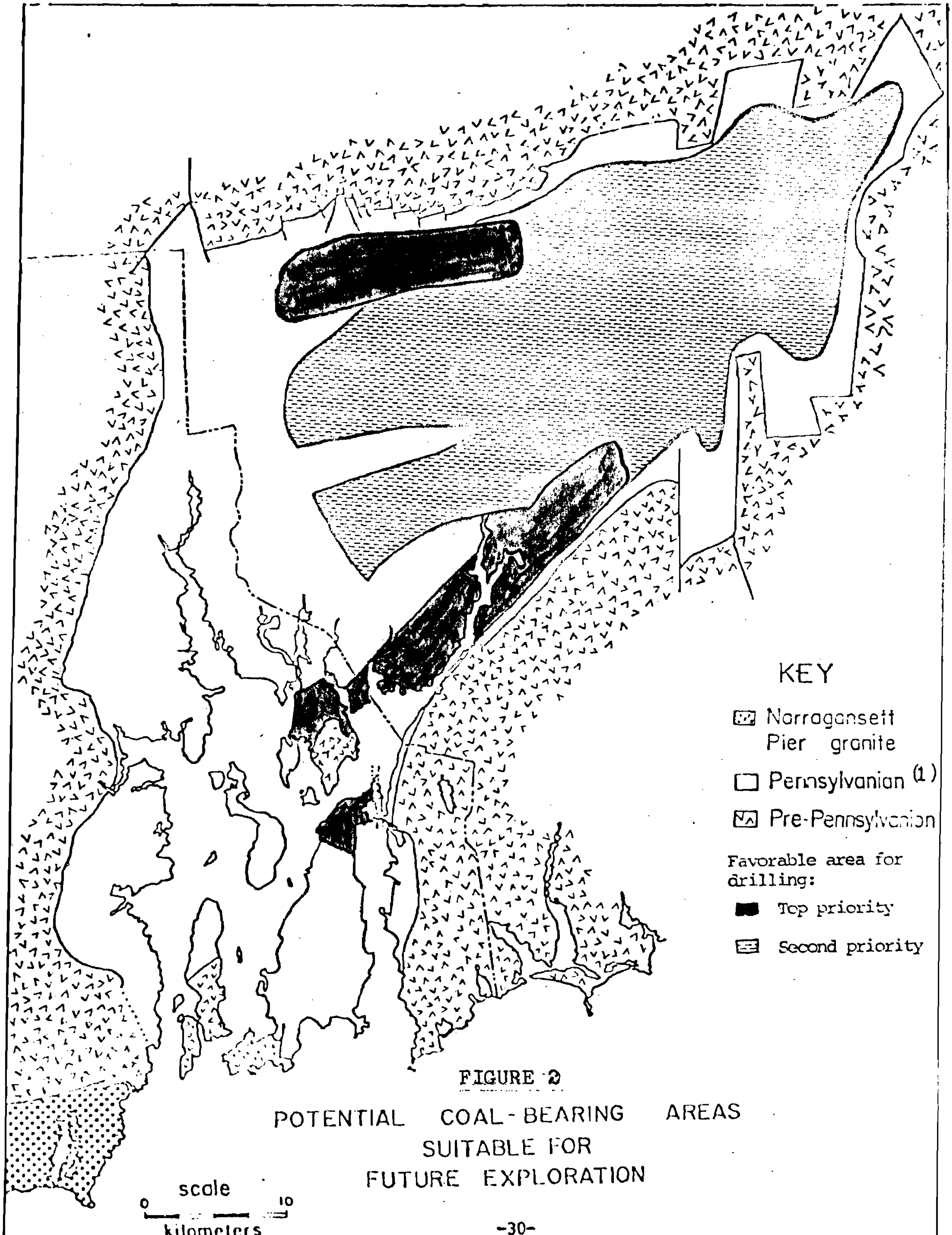


FIGURE 2

POTENTIAL COAL-BEARING AREAS SUITABLE FOR FUTURE EXPLORATION

(1) The Narragansett Basin is Pennsylvanian in age. Source: Ref. 4.

LONGWALL MINING

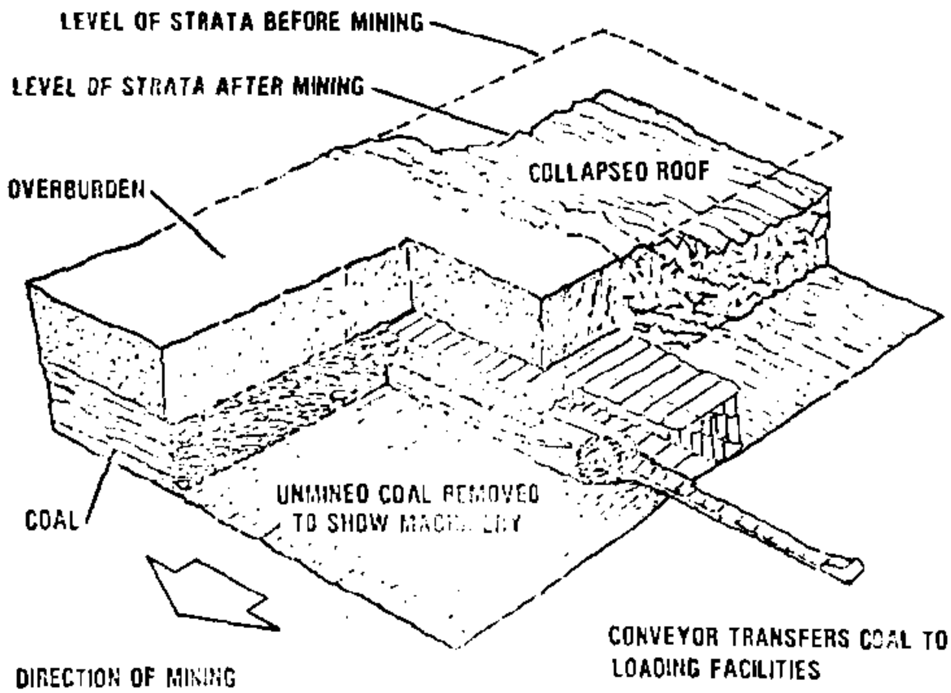
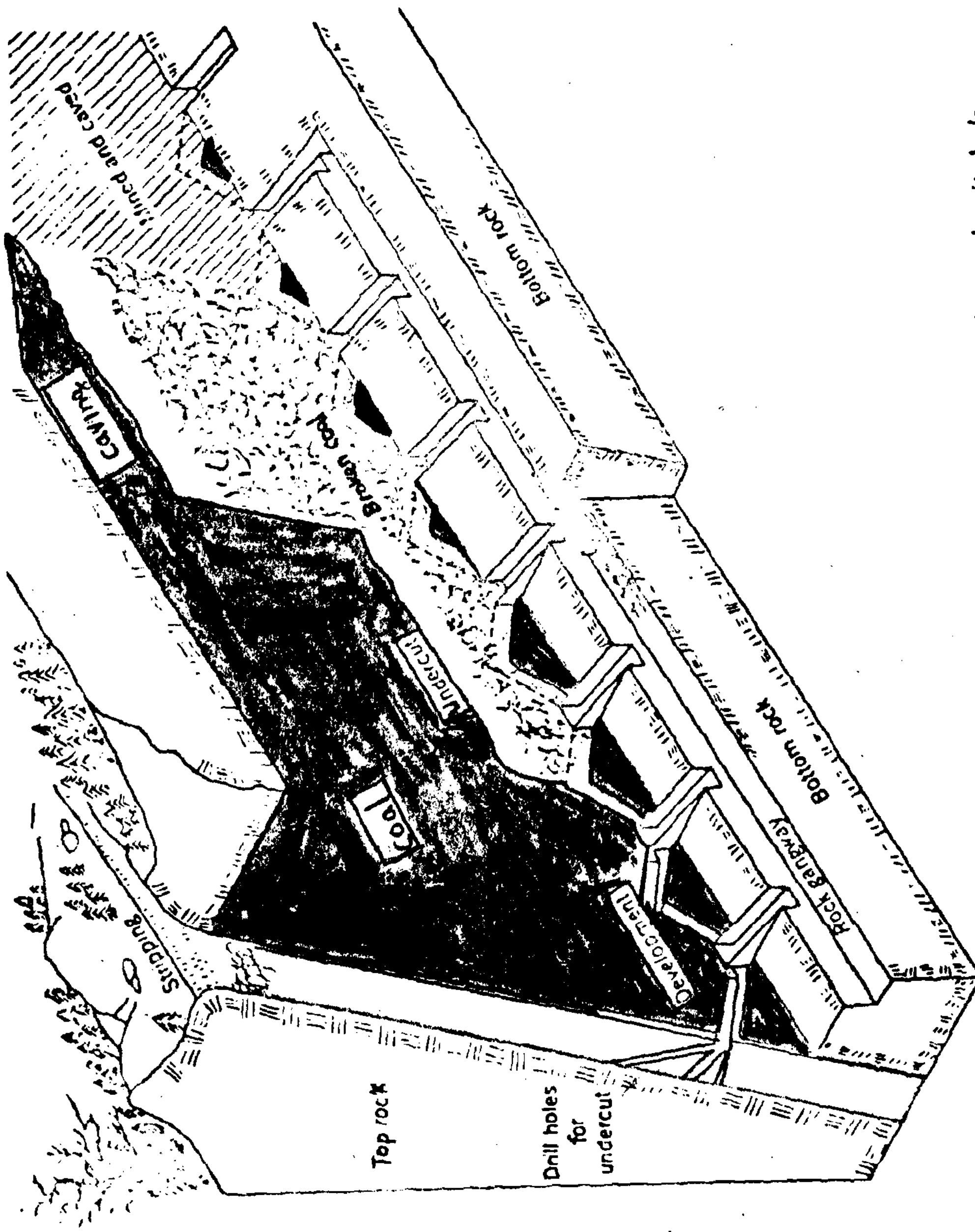


FIGURE 3

Source: Ref. 11.

ANTHRACITE RECOVERY BY INDUCED CAVING



Original conception of induced caving applied to steeply pitching anthracite beds.

Figure 4.

SOURCE: Bureau of Mines Report of Investigations 5013

Source: Ref. 9.

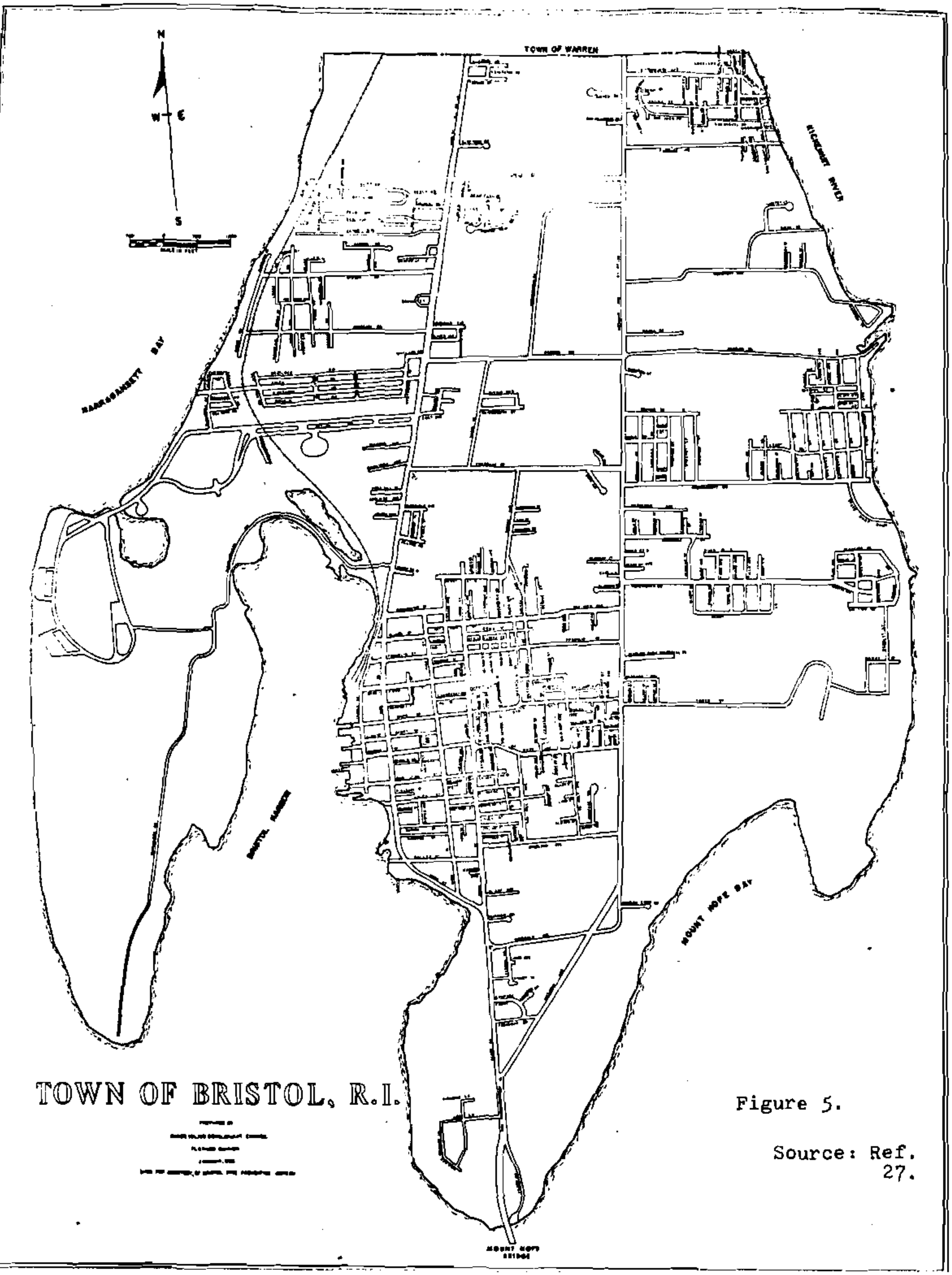


Figure 5.

Source: Ref. 27.

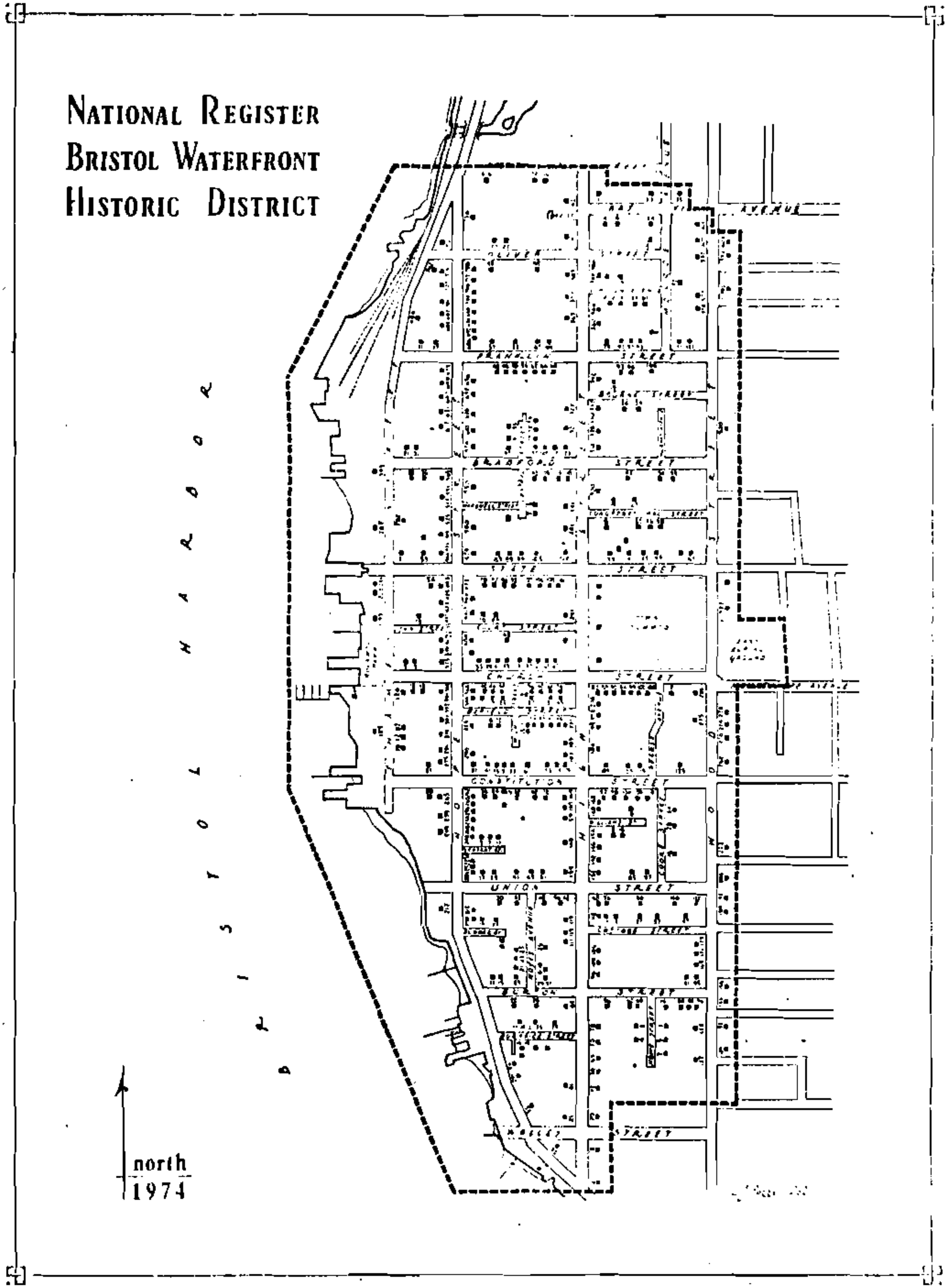


Figure 6. Source: Ref. 26.

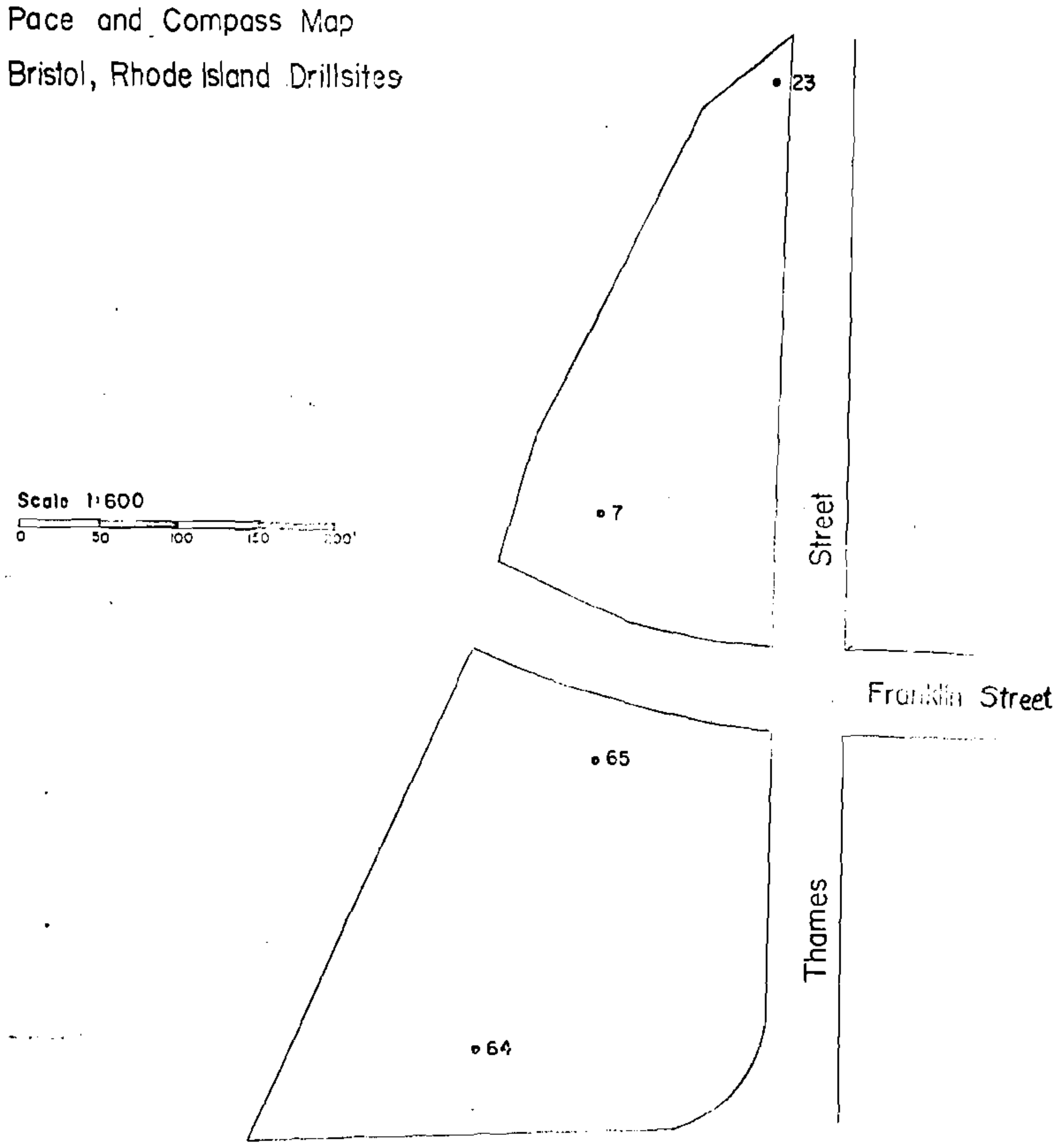


Figure 7. Source: Ref. 6.

ESTIMATED AVERAGE SEVERANCE TAX PAID PER TON BY STATE IN 1975*

State	*Estimated average severance tax paid per ton*	*Estimated average taxable value per ton*	*Estimated average selling price per ton FOB mine*
Montana	$1.44	$ 4.80	$ 6.52
Kentucky	.68	17.00	21.79
North Dakota	.52	N/A	3.17
Wyoming(a)	.24	5.00	6.00
Tennessee	.20	N/A	20.00
Alabama	.135	N/A	24.98
New Mexico	.08	5.98	6.97
Ohio	.04	N/A	13.50
Arkansas	.02	N/A	32.76
Colorado	.007	N/A	Not available

N/A = Not applicable.

(a) Wyoming tax is paid the year after production. These estimates are based on 1975 production - the tax to be paid in 1976. The 1974 tax paid in 1975 averaged 14 cents per ton.

Figure 8.

Source: Ref. 35.

NEW ENGLAND SOURCES OF ENERGY

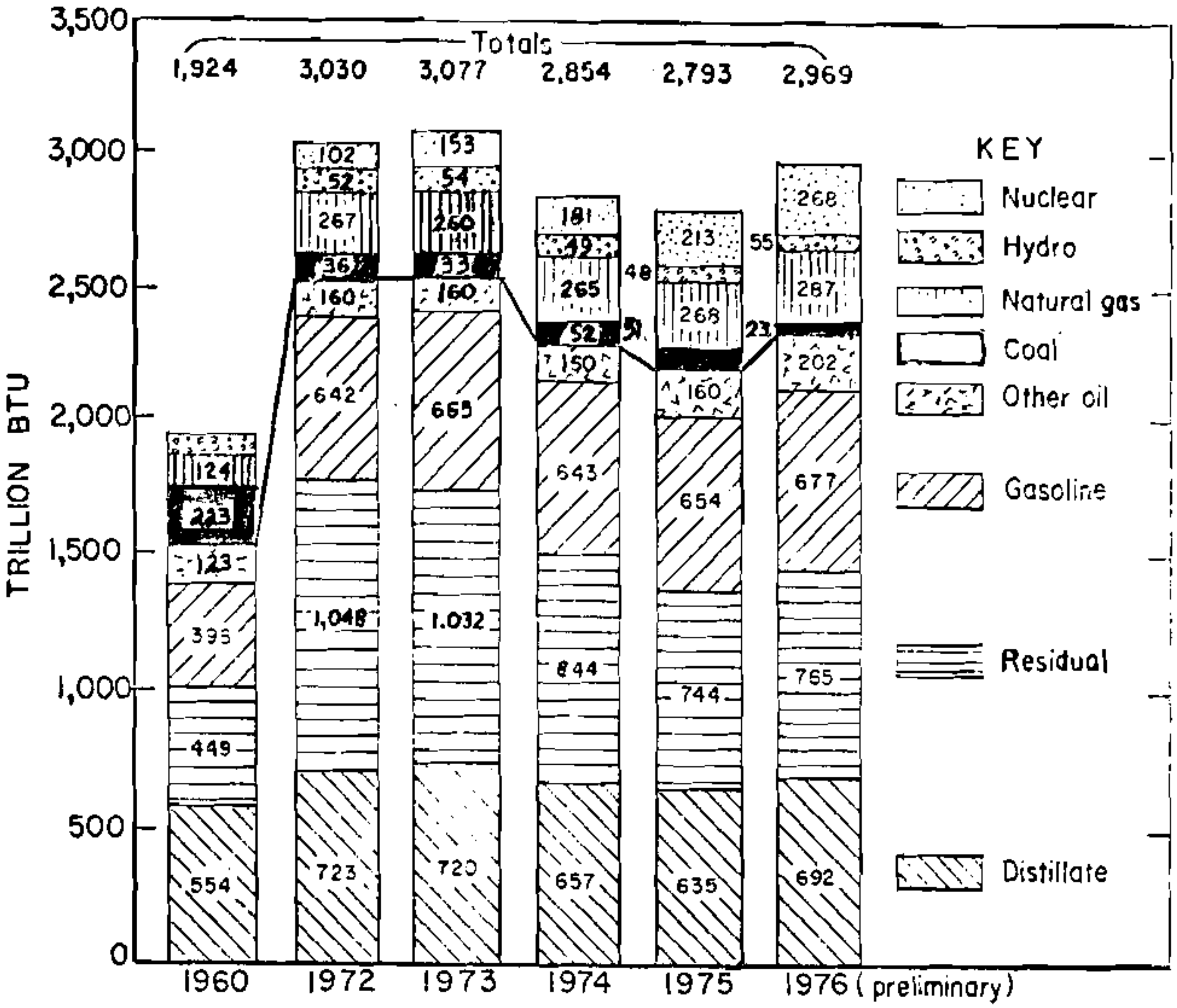


Figure 9.

Source: Ref. 1.

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