PHILADELPHIA'S RIVER RESOURCES

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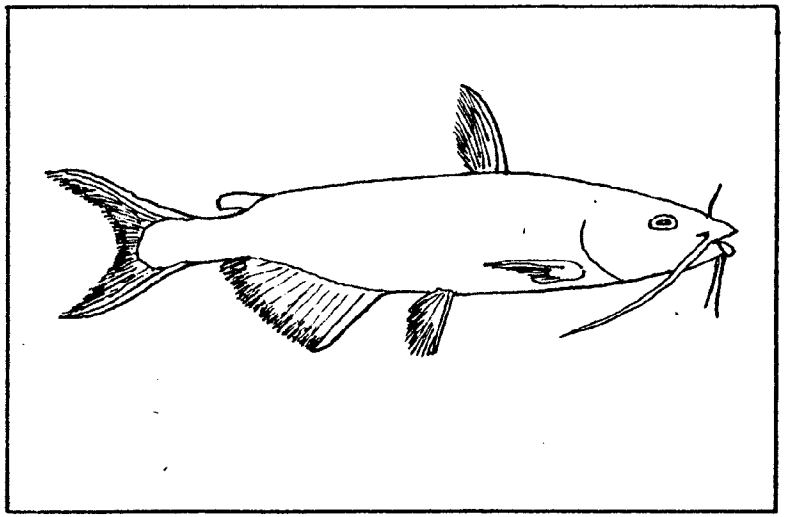

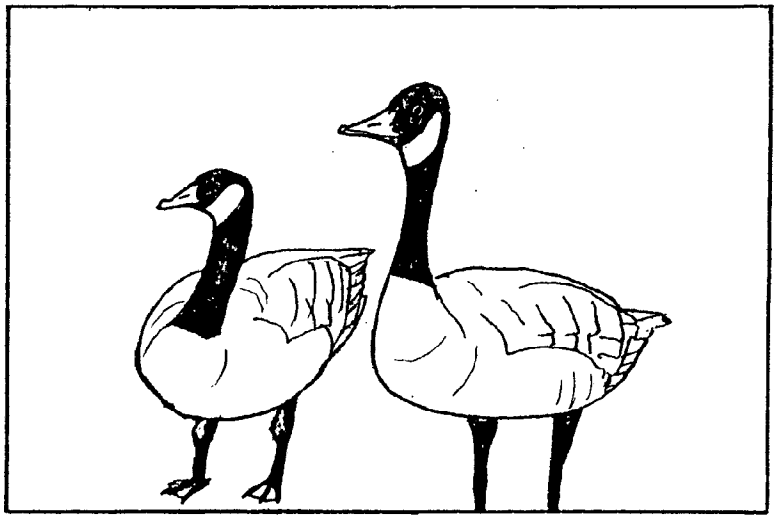

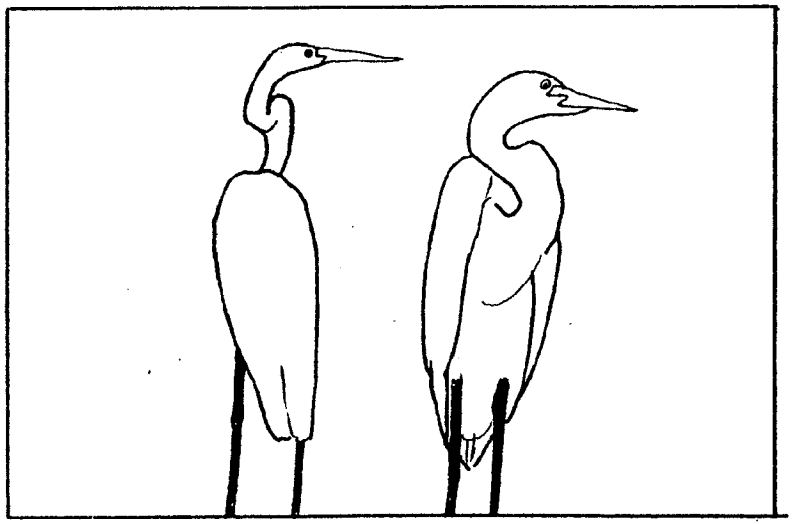

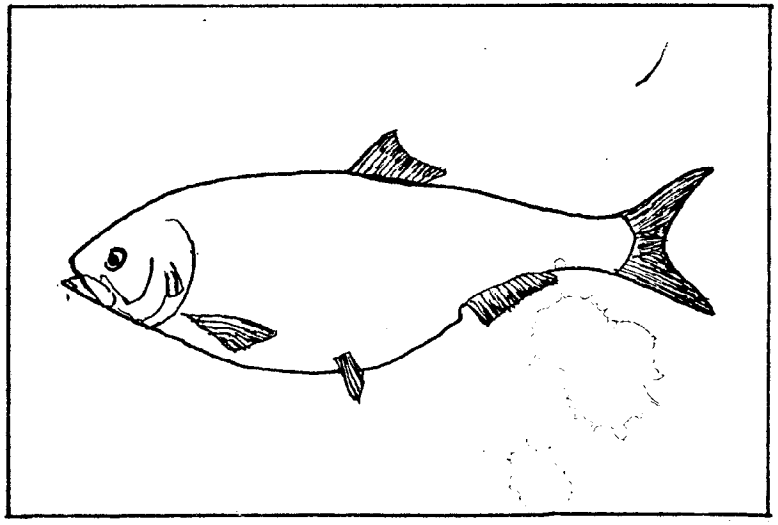

PHILADELPHIA'S RIVER RESOURCES

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INTRODUCTION

This technical report is a survey of the environmental conditions of Philadelphia's two principal rivers, the Delaware and Schuylkill Rivers, and of the riverfront lands bordering them. The report is intended to answer the following questions:

1. What is the water quality of the Delaware and Schuylkill Rivers, and how will it change in the future?

2. What kinds of fish live in Philadelphia's rivers and how will future reductions in pollution improve the fisheries?

3. Are there significant wildlife habitats and plant communities on riverfront lands?

4. In what ways do flooding, air pollution, noise, odor and other environmental problems affect riverfront areas?

This report concludes with recommendations for the improved management of the rivers and riverfront lands.

This report on Philadelphia's river resources is part of a larger planning effort. The Philadelphia City Planning Commission, with the assistance of other agencies, groups and individuals, has been preparing a comprehensive plan for the Philadelphia Riverfront. The focus of this work is to balance the demand for the many uses competing for riverfront land. These include port facilities, industry, utilities, recreation, housing, retailing and transportation. Several goals have been established to assist in this riverfront planning:

1. Promote port development.
2. Evaluate development opportunities for non-port related uses.
3. Foster residential and recreational access.
4. Enhance the aesthetic and environmental qualities of the Delaware and Schuylkill Rivers.

The planning process now underway for the riverfront has been proceeding on three levels. On the first of these levels, studies and functional plans are being developed to look at individual facets of the riverfront along the entire length of the Delaware and Schuylkill Rivers in Philadelphia. This report on river resources is the second functional plan to be completed (the first was the Port Facilities Study). Other functional plans include Riverfront Industry Analysis, Legal Implications for Development and Port Residential Zoning District. The second level of planning is detailed development plans for each of five riverfront districts, making recommendations on land use, zoning, urban design, transportation and other physical improvements. The third level of planning is directed at key sites or opportunity areas, including Penn's Landing, the foot of Washington Avenue, Fort Mifflin-Airport Area and 30th Street Station Area. For these sites detailed development alternatives will be evaluated in order to make specific recommendations on reuse and development.

In Table 1, the functional plans and the district plans comprising the riverfront

planning effort are listed along with their scheduled completion dates. Upon completion of the functional and district plans, a comprehensive plan encompassing the entire riverfront will be prepared.

TABLE 1: RIVERFRONT PLAN

Studies and Functional Plans	
Port Facilities Study	1978
River Resources	1981
Riverfront Industry Analysis	1981
Legal Implications for Development	1981
Port Residential Zoning District	1981
District Plans	
South Delaware Waterfront	1981
Central Riverfront	1981
North Delaware Waterfront	1982
Lower Schuylkill Waterfront	1982
Upper Schuylkill Waterfront	1982
Special Development Plans	
Foot of Washington Avenue	1981
Penn's Landing	1981
North Bridge	1981
Riverwalk	1982
Cramp Shipyard - Port Richmond Area	1982
Ft. Mifflin - Airport Area	1982
30th Street Station Area	1982
Comprehensive Riverfront Plan	1982

A variety of sources were used in the preparation of this report on Philadelphia's river resources. Several important published documents, identified in the references for each chapter, have been prepared by the U.S. Army Corps of Engineers and the Delaware River Basin Commission, and others are products of water quality planning efforts in the Philadelphia metropolitan region sponsored by the Delaware Valley Regional Planning Commission, the Pennsylvania Department of Environmental Resources and the Federal Environmental Protection Agency. By far the most important data source was the over two dozen water resources experts and biologists who were interviewed and who have made a significant contribution to the content of this report. In particular, the staff of the Planning and Technical Services Division of the Philadelphia Water Department provided a wealth of useful water quality data and valuable professional insight into the water resource management issues in the Delaware River Basin. For an understanding of fish population characteristics, the Pennsylvania Fish Commission was contacted numerous times for many helpful discussions. In addition to these two groups, staff of the Delaware River Basin commission, U. S. Fish and Wildlife Service and U. S. Army Corps of Engineers and many individual experts on fish and wildlife gave freely of their time and knowledge during telephone conversations. This technical report, therefore, can be considered a product of many individuals, although the author is responsible for data interpretation and for the management recommendations. Finally, appreciation is given to the Pennsylvania Department of Environmental Resources and the National Oceanic and Atmospheric Administration for the grant which contributed to the preparation of this report.

SUMMARY

The Philadelphia's River Resources report, part of a larger, comprehensive planning effort for Philadelphia's riverfront, is a survey of environmental conditions of the Delaware and Schuylkill rivers and of adjacent riverfront lands. It summarizes water quality data for the rivers and describes how water quality affects fish populations. It then makes projections of improvements to water quality and fisheries which will result from pollution abatement efforts in the estuary. Riverfront lands are surveyed for significant plant and wildlife communities and for environmental conditions such as flooding, air pollution and noise affecting riverfront areas. The report concludes with recommendations for improved management of the rivers and riverfront lands.

The Delaware and Schuylkill Rivers provide important resources for Philadelphians. They are throughfares for marine commerce, they yield drinking water and food, and they carry away wastes. But industrialization in the nineteenth century completely and irreversibly altered the river's original ecosystems; productive wetlands and shallows were filled or dredged, and until relatively recently raw sewage was discharged to the Delaware from over a half million homes and from thousands of industries, creating a foul-smelling, lifeless river. Construction of three sewage treatment plants in the 1950s eliminated the worst of the odor and pollution nuisances in the Delaware. And an even brighter future can be foreseen for the rivers as fish populations respond to a second round of water pollution reduction and to new fishery management efforts.

Pollution of the Delaware River by Philadelphia's sewage treatment plants is the most serious river resource issue. Sewage effluent is food for aquatic microorganisms which, in the process of breaking down the waste into gases and nutrients, rob the river of its gaseous dissolved oxygen. Without oxygen, fish cannot survive. The three sewage plants thereby create what is known as a "dissolved oxygen sag." When concentrations of dissolved oxygen are measured in summer both below and above Philadelphia, oxygen exceeds 6.0 milligrams per liter (mg/l); but in the central Philadelphia area the concentration plummets to near zero. When oxygen concentrations fall below 3.5 mg/l, few fish can survive. Particularly vulnerable to low oxygen are those game fish attractive to fishermen.

In 1961, an interstate compact created the Delaware River Basin Commission to provide a basin-wide stategy for pollution control. Following a thorough study of the estuary, the DRBC assigned to each waste discharger an allocation of allowable waste loads substantially lower than loads which were already being released. Significant steps by municipal dischargers toward achieving allowable waste loads were not taken until after the federal government passed in 1972 legislation which appropriated federal money to cover 75% of the cost of upgrading treatment levels. Although nearly a decade has gone by since the legislation was adopted, the City of Philadelphia has still only half completed its pollution abatement program. But by 1987 the $900 million pollution abatement program will be completed, and the quantity of organic matter discharged to the Delaware River by the City will be reduced by over 75%.

Philadelphia's pollution abatement program will greatly improve the Delaware's water quality. The DRBC goal is for dissolved oxygen through Philadelphia to not fall below 3.5 mg/l, a standard which is currently violated for the 15 mile stretch from the City's southern boundary to approximately the Betsy Ross Bridge. In the future, violations of the standard are likely to be reduced to a 6 mile stretch from Penn Treaty Park to the bend in the river at the Philadephia Naval Base. The recently completed Southwest Sewage Treatment Plant, which discharges near the City's southern boundary, has already greatly improved oxygen levels in the Delaware downriver of the City, particularly benefitting riverfront communities in Delaware County, Pennsylvania.

The Northeast Sewage Treatment Plant, when it is fully operational in 1984, will create the most significant river quality improvements for Philadelphia residents. Located near the Betsy Ross Bridge, this facility discharges wastes which are carried upriver by tidal action, disrupting aquatic habitats in the vicinity of the several yacht clubs and fishing access points. The upgrading of the Northeast plant will improve the summer levels of dissolved oxygen by a milligram per liter and should allow populations of game fish to increase significantly in the northern half of the Delaware Riverfront.

There are water quality parameters in addition to dissolved oxygen which affect the use of the Delaware River. Fecal coliform is a parameter which indicates contamination by human wastes, as fecal coliform bacteria are common inhabitants of the human intestine and may be carriers of disease viruses. Both the DRBC and the Pennsylvania Department of Environmental Resources have adopted a standard for fecal coliform which is violated frequently in the Delaware River below the mouth of Pennypack Creek. A more restrictive public health standard pertaining to body contact sports is only achieved in the vicinity of the City boundary at Poquessing Creek. The highest fecal coliform concentrations, about 100 times higher than the standard, occur near Penn's Landing in central Philadelphia.

Metals and other exotic substances occur only in trace quantities in the Delaware River and are thought to not pose problems for water users or to aquatic life. Ammonia and nitrate, two nitrogen compounds, meet environmental and health standards, and phenol, an organic substance which affects the taste of fish, is only rarely in violation of standards. Chromium and manganese levels achieve standards, and concentrations of lead, copper and iron only occasionally exceed standards.

The most serious issue regarding metals and other substances is the lack of scientific studies. There have been no studies to establish unambiguous standards for aluminum, zinc, lead and nickel. Although measured levels of these metals are generally regarded acceptable, this is not conclusively known. For two other toxic substances, arsenic and cyanide, there are no recent analyses to determine whether established standards are being achieved.

In contast to the Delaware River, the Schuylkill River, or at least that portion upstream of Fairmount Dam, has exceptionally good water quality. Dissolved oxygen standards are consistently met. Fecal coliform standards are apparently achieved, although not much verifying data is available. Because the Schuylkill River is industrialized upriver of the City and its headwaters are situated in a

coal mining area, the Schuylkill is subject to industrial effluent contamination. A soon-to-be released study by the U.S. Geologic Survey will give data on the occcurence of pesticides and organic compounds in the river's ecosystem, and some research indicates heavy metal contamination in the Reading area. But by the time the Schuylkill River reaches the Philadephia area, the river has largely cleansed itself. Water quality data collected by the Philadelphia Water Department at its two raw water intakes indicates that all established water quality standards are achieved, with the occasional exception of phenol compounds.

The tidal Schuylkill River, unfortunately, is seriously polluted. Below Fairmount Dam there are industrial wastewater discharges and frequent discharges of raw sewage from malfunctioning sewer overflow chambers. During summer, flow over the Fairmount Dam is very low, and the action of the tides traps pollutants in the upper portion of the Schuylkill Estuary. The net effect is to create a zone of water which, during summer, is virtually lifeless. The concentration of dissolved oxygen was only 1.0 mg/l in an August 1981 survey, grossly insufficient to sustain fish life. Apparently the water quality is not as poor during springtime. River flow is ample during spring, and migrating fish are able to reach the fishway at Fairmount Dam from the Delaware River.

Good populations of fish live in the Delaware River north of the Tacony-Palymyra Bridge and in the Schuylkill River above Fairmount Dam. In these portions of the rivers, dissolved oxygen concentrations are sufficiently high year round to support a resident population of game fish and to permit fish breeding. The principal game fish which can be caught by fisherman in the Delaware are white perch, several species of catfish and sunfish, white sucker and, during migration, shad and river herring. A larger variety of game fish may be caught in the Schuylkill, including small and largemouth bass, walleye, crappie and a large number of sunfish species, in addition to most of the game fish available in the Delaware River.

Between the Tioga Marine Terminal and Tacony-Palmyra Brige, the recreational fishery can only be classified acceptable. Dissolved oxygen levels, while generally achieving DRBC standards in summer, are suitable only for pollution tolerant fish. Catfish, white perch, carp, sunfish and eel may be caught in this section of the river in summer.

A major portion of the Delaware and Schuylkill Rivers cannot sustain recreational fishing. In the Delaware River from Fort Mifflin to Tioga Marine Terminal and in most of the tidal Schuylkill, dissolved oxygen concentrations fall to such a low level that no game fish can be sustained. Highly pollution tolerant, minnow-size fish, such as the mummichog and banded killifish, are two dominant fish in polluted waters.

Spring fish migration offers a unique fishing opportunity along Philadelphia's riverfront. In the February to April period, dissolved oxygen concentrations are generally high enough to allow the upriver migration of shad and river herring. These fish may be caught in the Delaware River along those riverfront areas which, come summer, do not sustain a resident fish population. For example, the river near Penn's Landing in summer is too grossly polluted to sustain game fish, but in spring shad and herring may be caught.

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The City's pollution abatement program, when completed in 1987, will greatly improve fish populations in the Delaware River. Good fishing should be available in the river from the Frankford Arsenal northwards. The only section of the river which is not expected to provide even acceptable fishing opportunities is the central portion, from Penn Treaty Park south to the Philadelphia Naval Base. The tidal Schuylkill River will also not significantly improve over the foreseeable future.

Water quality is not the only factor influencing fish populations. The physical conditions of the river affects the productivity of the river and its suitability for fish. Shallow water areas, as described in a special report by the U.S. Army Corps of Engineers, are critical habitats. Shallows, defined as submerged lands shallower than 10 feet, provide shelter, food and breeding places for fish. Disturbance of shallows by fill or dredging activity is strictly controlled by the U.S. Army Corps of Engineers through regulations issued pursuant to the federal Clean Water Act. Because there has been extensive loss of shallows in the past (scarcely 10 percent of Philadelphia's original extent of shallows remain today), federal policy is to forbid further loss unless proposed fill or dredging activity supports water-dependent uses of wide public benefit. The negative impact of disturbing shallows could be offset, however, by the creation of artificial shallows in other areas, an option being considered by federal regulatory and environmental agencies.

No riverfront lands in Phiadelaphia retain their pre-colonial characteristics. Virtually all original wetlands and tidal flatlands were filled, and all native tree cover cut down. As a result of heavy industrialization and port development, three-quarters of the Delaware Riverfront is in piers, wharves and bulkheads, and most of the remainder has a rubble edge. The Schuylkill River has a more natural appearance. The Schuylkill riverfront for 4 miles above the Fairmount Dam is in landscaped parklands, and the west bank of the tidal Schuylkill for about one mile supports a growth of shrubs and trees.

Riverfront lands with significant concentrations of wildlife are scarce. East and West Parks along a three-mile stretch of the Schuylkill River are a major habitat for upland birds and mammals, as well as the winter residence for Canada geese and several kinds of hawks. Riverfront lands in Upper Roxborough are also significant habitats and have potential for future river-oriented recreation development. On the Delaware, there are two areas with significant wildlife concentrations. Near the Delaware's confluence with the Schuylkill, dredge disposal basins, sewage lagoons, the airport and vacant lands provide wetland and upland habitats. Twenty miles upriver, in the Torresdale section of the City, extensive areas of public lands and well vegetated private lands provide wildlife habitat. One particularly significant area is the former ash residue disposal area at the mouth of Pennypack Creek which has reverted back to fields supporting rabbit, pheasant and deer.

Flooding of riverfront lands during major storms is a significant environmental concern. The U.S. Army Corps of Engineers has prepared floodplain maps for rivers and streams in

Philadelphia. These maps show the extent of flooding during an event with a probability of occurring once in a hundred years. For the most part, flooding along the Schuylkill is confined to within 500 feet of the river bank and along the Delaware to within 2000 feet of the bank. The floodplain along the Schuylkill River consists of a floodway, which passes at high velocity the majority of flooding waters, and the floodway fringe, which is a backwater area where flooding waters are relatively shallow. Because it is subject to tidal flooding, the Delaware River has no floodway; riverfront lands along the Delaware prone to flooding are classifed floodway fringe.

City codes were amended in 1979 to conform with federal floodplain management guidelines in order to make Philadelphia properties eligible for federal flood insurance. These codes prohibit new obstructions within floodways. In the floodway fringe, however, new structures are allowed as long as commercial structures are adequately floodproofed and habitable space in homes is built above flooding waters.

There are several environmental nuisances along the Delaware and Schuylkill Rivers. Because industrial development has concentrated along the rivers, sources of odors and air pollutants are also concentrated there. Eighty-four percent of all industrial air pollutant emissions occur within riverfront census tracts. The principal centers of odors are along the riverfront; one is the oil refinery area on the east bank of the Lower Schuylkill, and the other is in the Bridesburg section of the North Delaware Riverfront. The Philadelphia International Airport, straddling the Philadelphia and Delaware County boundary in Southwest Philadelphia, is a major noise source, but fortunately arrivals and departures occur along paths over the river, away from residential areas of South and Southwest Philadelphia.

The concentration of industries along the river suggests that there may have been, or may continue to be, storage or disposal of chemicals which could be hazardous to workers and residents or which may pollute streams and rivers. It is extraordinarily difficult to detect buried materials. One hazardous waste site in the vicinity of the Delaware River was inadvertently uncovered during construcion of facilities for the southwest sewage treatment plant. Recently adopted federal, state and City regulations, however, will help control the storage and disposal of hazardous materials in the future.

This survey of water quality, fisheries and riverfront conditions has led to a set of recommendations. One of the most important is for new scientific studies of water quality and fish in both rivers. A major study is recommended to fully document the response of dissolved oxygen to reduced waste loads. The billion dollar pollution abatement program in the upper Delaware Estuary will greatly reduce the extent of the "dissolved oxygen sag". But until the benefits of higher oxygen levels can be fully documented and weighed against the costs of sewage treatment, no steps should be taken by the DRBC to reduce waste load allocations or to revise upwardly water quality standards. Fish population studies are also needed to establish baseline data against which improvements to the fishery resulting from pollution abatement may be measured. Such studies would also explain the relationship between fish populations and DRBC's water quality standards. Study is also needed to determine the edibility of fish caught in the Schuylkill and Delaware Rivers

because fish flesh can be rendered inedible by water pollution. As fishing activities expand in response to improved fisheries in the Philadelphia area, the potential for the river to be harvested may depend on studies establishing the healthfulness of eating the fish.

A second very important recommendation is for the development of public access to the rivers. The recreation potential of the Delaware River is improving along with the water quality. Quality improvements will be costly for Philadelphia residents, perhaps as much as a $250 premium in water and sewer bills for each residential customer for the improvements to sewage treatment. The enjoyment of the river for fishing, boating or pleasure walking along the river's edge is the principal benefit to residents of this improvement. But public access to the Delaware is extremely limited, consisting of a single public boat launch on the Delaware and a small fishing area at the foot of Princeton Street; four other boating facilities are private clubs. This deficiency in public access will be remedied by future construction of boat launches by the Pennsylvania Fish Commission at Hog Island, Frankford Arsenal and Princeton Avenue and by the City at the mouth of Pennypack Creek. Additional public access points could be sought on underutilized lands in the vicinity of the Betsy Ross Bridge and the Tacony-Palmyra Bridge. Development of boating facilities for low-power motor boats and for canoes and rowboats should also be pursued for the Schuylkill River. Two possible boating areas are in the upper reach of the pool behind Fairmount Dam, perhaps near Venice Island in Manayunk, and in the pool behind Flat Rock Dam near the Shawmont Station in Upper Roxborough.

As the promise of improved water quality in the Delaware River is realized, other management actions attain greater importance. Federal environmental laws and regulations have established a policy of protection of shallow water habitat areas. This policy should be supported by the City in recognition of the shallows' role in sustaining good populations of game fish. But if disturbance of shallows is unavoidable, artifical shallows should be created. There are stretches of riverfront in portions of the upper estuary where water is relatively unpolluted and where there is a deficiency of good habitats. These areas should be considered priority areas for habitat creation.

Fishery management, which has not been widely practiced in Philadelphia's rivers, should be accorded higher priority in the future. The most important need is for the construction of a fish ladder at Flat Rock Dam. The Fairmount Fishway, built at a cost of over one-half million dollars, has been very successful, with at least a thousand herring and shad ascending the ladder annually. But the full potential of the Fairmount Fishway cannot be realized, and the reestablishment of spawning areas for the American shad cannot be achieved, until a second dam is built at Flat Rock Dam. The stocking of such game fish as walleye, muskellunge and striped bass in the Delaware River is a second important fish management need, and the introduction of new fish species with potential for commercial harvesting should be encouraged.

Delaware riverfront lands with a natural cover of grasses, trees and shrubs are so scarce that priority should be accorded to preserving remaining areas. One area recommended for preservation is the filled dredge spoil basins at the U.S. Army Corps of Engineers'

Fort Mifflin Reservation, which together with the historic fort and proposed boat launch, could one day be part of an attractive recreation area. The other area recommended for preservation is the former ash residue disposal area at the mouth of Pennypack Creek which has reverted to a naturally productive field condition.

Some riverfront lands should be restored with landscape plantings. There are significant stretches of river frontage on the tidal Schuylkill River and north of the Betsy Ross Bridge on the Delaware River which are not actively used. As recreational boating increases on the rivers, the appearance of the riverfront takes on greater importance. The public relations benefit of landscaping to improve the river edge appearance may appeal to the owners of riverfront lands, many of whom are owners of large industries in the City. Landscape plantings would also increase populations of birds and small mammals.

For the most part, environmental laws provide adequate authority for control of floodplain development, air pollution and hazardous materials. Three environmental problems need to be addressed along the riverfront. Odors are a serious nuisance in Bridesburg and in the Lower Schuylkill, but analytical tools being developed by Air Management Services should help reduce the problem in the future. It is likely that riverfront sites will be proposed for hazardous waste disposal in the future. The competitive advantage to the City of having waste disposal facilities will have to be carefully balanced against potential pollution of water supplies and aquatic ecosystems. Third, redevelopment of industrial riverfront lands near central Philadelphia to residences increase the potential for conflicts with active industries nearby. The Air Management Code provides for the separation of land uses as a control strategy. Although this control has not been used in the past, it may become an appropriate tool in the future.

HISTORICAL PERSPECTIVE

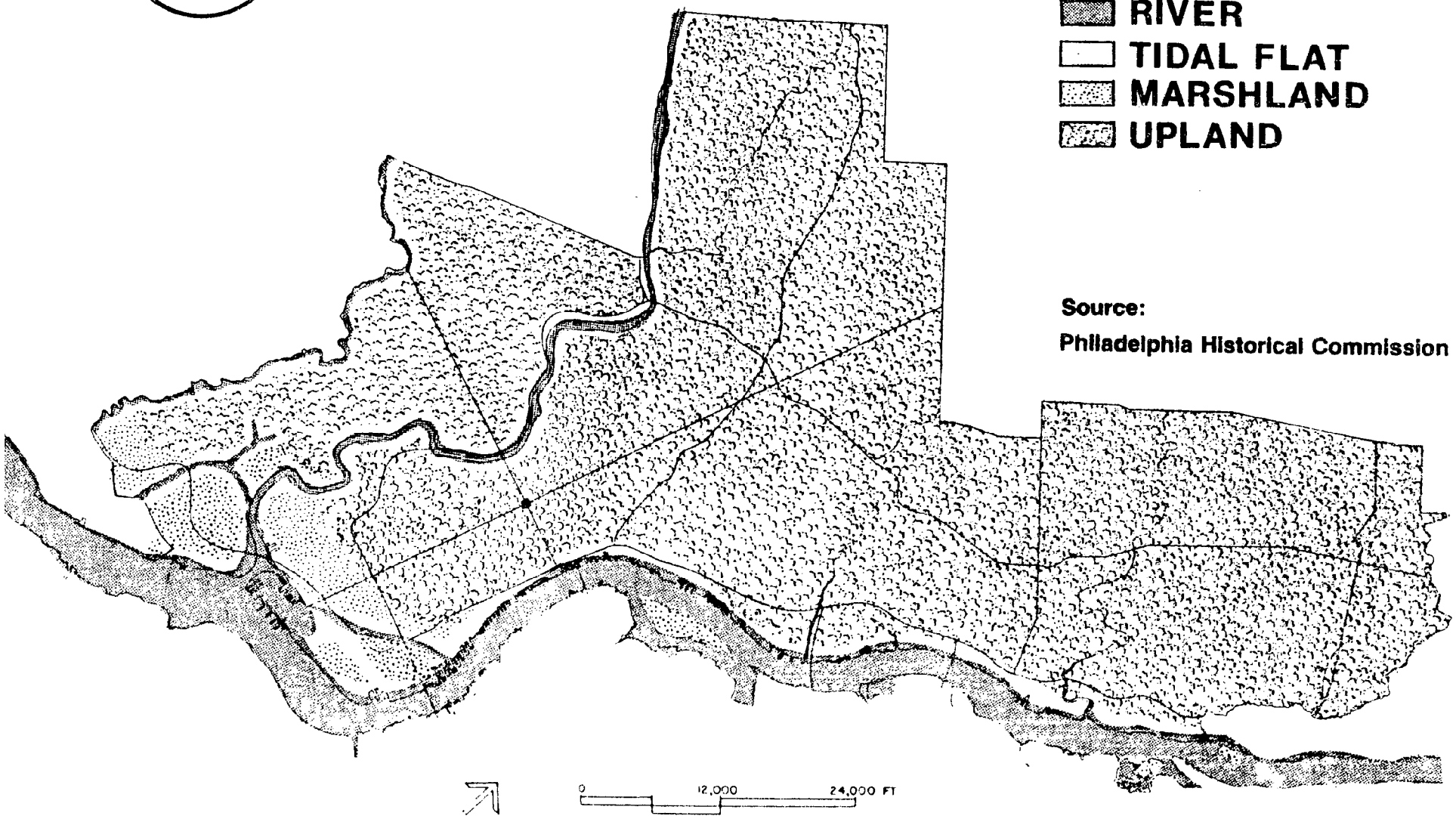
When the Swedish, Dutch and English first reached Philadelphia, they encountered a riverfront far different from today's. The mouth of the Schuylkill River was hidden by seven marshy, reed-covered islands separated by small streams with wide tidal flats. Firm ground along the Schuylkill was one and a half miles upriver of the mouth. This firm ground was marked by a bluff rising about 15 feet above the river's surface upon which grew cedars, sycamores and willows of great girth. The Swedes, who preferred high, firm ground to marshy land for their settlements, had established at least five forts or stockades on this high ground and had created plantations along the Schuylkill by the time William Penn established Philadelphia. Other Swedes, seeking suitable high ground further north on the Delaware River, established a settlement two and one-half miles upriver of the mouth of the Schuylkill at a site known as Wicaco, near the present day Gloria Dei (Old Swedes') Church. At this location, the extensive marshlands of South Philadelpia gave way to drier, wooded land. The Historical Conditions map is a hypothetical illustration of the original conditions of Philadelphia's riverfront.

Both Swedish communities settled on an escarpment, a significant physiological feature of Philadelphia. This escarpment is a sharply defined rise in ground elevation of about fifteen feet. It marked major changes in the soils and vegetation of colonial Philadelphia. Below the escarpment the ground was wet, subject to tidal flooding or periodic storm flooding and covered by reeds and marshland shrubbery. Above the escarpment, the soil was well-drained, fertile and covered with an immense forest. The forest had a tall, dense canopy and relatively open floor unencumbered by understory vines and brush.

This escarpment, which runs east to west across South and Southwest Philadelphia, makes a very significant northward turn at the river's edge. The escarpment runs parallel to the Delaware River from the Wicaco settlement for four and one-half miles upriver. At the edge of this escarpment the Delaware River is deep, and there is only a narrow tidal flat area. The combination of high, dry gound and deep water were two significant, physical features compelling William Penn to establish his city at this location on the river.

A third physical feature contributed to Penn's site selection of Philadelphia. The Schuylkill River bends eastward six miles upstream, mirroring a westward bend in the Delaware River. At this point there is scarcely two miles of land between rivers. Penn envisioned rapid commercial and residential development along both rivers which would ultimately join at Center Square where City Hall now stands.

HISTORICAL RIVERFRONT CONDITIONS



North of the original City site, the river edge generally consisted of a narrow tidal flatland, perhaps a hundred feet wide, rising slightly to marshy land and then giving way gradually to woodlands. Two major tributaries to the Delaware River, Frankford and Pennypack Creeks, provided access to interior lands. Inland along these creeks the communities of Frankford and Holmesburg, respectively, were established in the early 1700s.

Many local names in Philadelphia are old Indian names which reflect original environmental conditions of the area. Penn's site for Philadelphia City was called Coaquannock by the Indians, which means a grove of tall pine trees. The marshy fields of South Philadelphia provided two names, Passyunk, meaning a level place below hills, and Moyamensing, a place where pigeons roost. Similarly, marshy lands of Southwest Philadelphia provided the Indian name Kingsessing, meaning a place where there is a bog. Cohocksink means pinelands, and Shackamaxon translates to a place of eels. Wissahickon is an Indian name for catfish, a fish once plentiful in Wissahickon Creek.

Early settlers encountered rivers with a tremendous abundance of fish. One of the Indian names for the Delaware River, Lamasepose, meant "fish river." Migratory fish, notably shad and herring but also salmon and sturgeon, were a very significant food source for the early settlers. The Delaware's abundant fisheries also supported bass, catfish, eels, oysters, mussels, crabs and many other shell and fin fish which were important food sources for Philadelphia residents. The Schuylkill River was also a cultural resource, serving as a center for recreational activity. For ninety years after its establishment in 1732, the Schuylkill Fishing Company of the State of Schuylkill was a fishing society with a club house at the falls near Fairmount. It was forced, however, to move to a point downstream opposite Bartram's Garden when the dam at Fairmount blocked fish migration, and it closed permanently when pollution destroyed fish in the tidal Schuylkill.

The Delaware River has always had a deep channel which served well as a navigable waterway. Throughout the Philadelphia area the channel was at least 25 feet deep, sufficient to accommodate the draft of virtually any ship through the nineteenth century. The Delaware River, which varies in width from 1500 to 5000 feet, is typically about 4000 feet wide. The narrowest stretch is along the waterfront near central Philadelphia, the site of Penn's original settlement.

The physiography of Philadelphia and the configuration of the Delaware River both contribute to creating a river channel which has a maximum depth closer to Philadelphia than to the New Jersey riverfront. Similarly, the river bottom grades steeply toward the land such that the original extent of shallow water habitats, tidal flats and wetlands was less extensive on the Philadelphia side of the river than on the New Jersey side. Maps of river depths from the mid 1800s suggest that shallow water areas, productive aquatic habitats at the river margin submerged under less than 10 feet of water, typically extended only 250 feet from the edge of the river. The shallows probably reached a maximum width of about 750 to 1000 feet in areas downstream of where the river bows outward, for example south of the Richmond area and at the League Island area of South Philadelphia.

Modifications to the riverfront took place early in Philadelphia's history. Vast expanses of woodlands were cleared to provide open lands for farms and wood for housing, fuel and furniture. Within 50 years of Penn's arrival, virtually all original trees were removed from the Philadelphia County limits. Benjamin Franklin in his later years is reported to have lamented the loss of woodlands at the edge of the Schuylkill to industrial development supporting the coal market. During the first 100 years, the wetlands of South Philadelphia had been tremendously altered. Dikes to hold back flood and tide waters, ditches to drain fields and grading of knolls to raise the elevation of bottom lands, successfully brought thousands of acres of former wetlands into agricultural production. By the beginning of the nineteenth century, five islands on the west side of the Schuylkill had been joined to the mainland, and League Island had been greatly enlarged. In all, about 550 acres of tidal flatlands and 3500 acres of wetlands were filled in or drained, eliminating virtually all which originally existed. In addition, roughly 1400 acres of submerged lands were filled to create dry land. Although there may have been originally 7000 acres of shallow water habitats along Philadelphia's riverfront when William Penn arrived, today there remains only about 500 acres.

In the 1700s, lands along the lower stretch of the Schuylkill River below Fairmount Dam, on both east and west banks, were cultivated and manicured. Here were built the estates of wealthy Philadelphians. The first park outside of the original four city squares was developed at Grays Ferry. This park consisted of formal gardens open to the public. Grays Ferry at the time was a major entrance to the City; George Washington was greeted ceremoniously at Grays Ferry Park when he arrived in Philadelphia for his first inauguration.

The lands on both sides of the Schuylkill River south of central Philadelphia were devoted in the 1700s and early 1800s to agriculture and recreation. A half dozen hotels and inns were close to the river, serving visitors who sought reprieve from city life through fishing, attending horse races at Point Breeze Park (where refineries now stand) or any number of other recreational pursuits. This area was also a key agricultural area, supporting large herds of beef cattle and truck farms which supplied meat and fresh vegetables to City residents.

Critical changes to the Delaware and Schuylkill Rivers occurred in the second and third decade of the 1800s. The early stages of the industrial revolution bombarded the City. Railroad networks were built at a rapid pace, with numerous terminals extending to the riverfront. The Port Richmond terminal and its coal pier are key landmarks still standing today of the industrialization of Philadelphia and its riverfront. More significant for the rivers, extensive canal systems were completed. This was especially important to the Schuylkill River, which due to its rapid waters and shallowness prior to canal construction had not been a convenient navigation waterway. With canals, the Schuylkill River became an important thoroughfare for coal and wood deliveries to Philadelphia and for export of manufactured goods to inland markets. The construction of a dam across the Schuylkill

River at Fairmount for municipal water supply interrupted the migration of anadromous fish. This dam and similar dams upstream converted the rapidly flowing river into a series of large, quiet pools. While the Fairmount Dam interrupted fish migration and the original character of the river, its significant role in Philadelphia's water supply required the City to prevent upstream industrialization along the river for the seven mile stretch up to Manayunk. This portion of the river was thereby available later for park development. At Manayunk, a set of locks permitted passage of boats over the Flat Rock Dam, and the water falling through the canal served to provide at one time some one dozen paper and fabric mills with a source of power.

Industrialization in the mid 1800s had a tremendous impact on Philadelphia's riverfront. Neighborhoods near the Delaware River, such as Fishtown, Kensington and Richmond, which had been small fishing and farming communities, were transformed in several decades into densely settled neighborhoods serving manufacturing and transportation industries which had congregated at or near the riverfront. Along the 2 to 3 mile stretch of Schuylkill Riverfront below the Fairmount Dam, a dense development of industries, utilities and rail facilities were built, causing the removal of the many estates along the river and the loss of the gardens at Grays Ferry.

Explosive population and industrial growth caused deterioration of water quality in the rivers. Before the mid 1800s, residential sewage was discharged generally in backyard privies, but because of public health problems, large drains were installed during the last half of the century to drain sewage to the rivers. There was no sewage treatment. The City's extensive network of streams were buried in large brick culverts, serving both as waste conduits and stormwater channels. Of the approximately 250 miles of streams originally in Philadelphia, only 100 miles remain open today. It was not until the 1820s, when pollution threatened to contaminate drinking water supplies drawn from the Delaware, that the City instituted some centralized sewage treatment for the northeast section of Philadelphia. Because the Schuylkill River below Fairmount Dam was not a potable water source, sewage collection and treatment from the Schuylkill basin was not as high a priority as in the upper Delaware estuary. The waste from as many as a half million people were discharged directly to the tidal Schuylkill through the first part of the twentieth century.

Coal mining in the upper reaches of the Schuylkill River basin seriously affected the river. Mining activities sent millions of tons of culm, composed of coal and clay particles, into the river. This culm destroyed fish habitats, filled in behind dams, damaged public water supplies and reduced the capacity of the river to carry stormwater. By the turn of the twentieth century, the Schuylkill River had been made virtually lifeless. This situation was largely corrected between 1947 and 1951 when 26 million cubic yards of sediment were removed by the Schuylkill River Desilting Project and several dams were installed to control further movement of culm downstream.

While the water in both rivers was being poisoned by coal mining and by discharge of effluent from industries and residents, lands along the riverfront during the second half of the 1800s were being vastly altered. Millions of tons of refuse were dumped in marshy lands as a convenient disposal place and to create dry, buildable lands in anticipation of future growth. Along the Schuylkill, the first oil refinery was established in the 1860s, and in the early part of the twentieth century oil companies began buying vast land areas along the east bank of the lower Schuylkill, turning farmlands and estates into what has become part of the largest refinery complex on the East Coast. In the process, archeological evidence of the first settlements of white men in Philadelphia was lost. Many manufacturing companies were also established along both the rivers, especially metal working and chemical industries. A large number of piers were built for wood coal and general cargo.

Conditions along the river and riverfront reached a nadir in the early 1950s, when population and industry were at their peak and before pollution controls were instituted. At this time, the Delaware River around Philadelphia was widely known as the "black waters," which were reported to give off such bad odor as to be a health threat to shipmen and dock workers. While environmental conditions along the river have improved somewhat, due to improved sewage treatment and reduced industrial discharges, the river is still recovering from the tremendous assault which began in the first half of the nineteenth century.

ENVIRONMENTAL CONDITIONS

Philadelphia is situated on two major physiographic provinces, the ten thousand year old Atlantic Coastal Plain and the billion year old Piedmont Province. The divide between these two is known as the fall line. The fall line, which corresponds roughly to the 120 foot contour, is marked by a falls on the Delaware River at Trenton, denoting the limit of tidal influence, and on the Schuylkill River by the Fairmount Dam, which before 1824 was also a natural falls and is still the limit of tidal influence. The falls on both rivers were generally considered the natural limit to commercial-size ships.

Philadelphia's climate is classified subtropical, with mild winters and a regular rainfall pattern. The mean annual temperature is 54° Farenheit, with average monthly temperatures varying from 32° F in January to 76° F in July. Philadelphia has ample rainfall. Average annual precipitation is 41 inches, and it is fairly evenly distributed over the year. Approximately 22 inches of this rainfall evaporates or transpires through plants back to the atmosphere. The remaining 19 inches of rainfall reaches streams either as direct storm runoff (25%) or as base flow (75%). Because there is greater evaporation and transpiration losses during summer than winter, a far smaller proportion of rainfall reaches streams during summer. For example, while the average monthly flow in the Schuylkill River is 3,050 million gallons per day (MGD) in March, flow in summer is frequently less than 1,000 MGD.

Philadelphia is contained wholly within the Delaware River Basin, a 12,765 square mile watershed which is 330 miles long from the Bay

to its headwaters in New York State. The Schuylkill River, a major tributary to the Delaware River, has its origins 110 miles upstream in Schuylkill County, within anthracite coal fiels. The Poquessing, Pennypack, Frankford/ Tacony and Darby/Cobbs Creeks are the principal streams draining Philadelphia and emptying into the Delaware River. The Wissahickon Creek is a major tributary to the Schuylkill River, with its origins in central Montgomery County.

The quality of water in rivers and streams within Philadelphia has been significantly affected by urbanization. The Delaware River water quality is very poor, with the level of oxygen in the water falling far below that necessary to sustain fish life. Other heavily polluted streams in Philadelphia are Cobbs Creek and Tacony Creek, which receive on occasion the overflow of sewage from combined sewers within their watersheds. The Wissahickon, Pennypack and Poquessing Creeks have, in general, acceptable water quality. Although these three streams tend to be polluted by upstream communities, they apparently improve in quality as they flow through the City.

Philadelphia's riverfront lands at one time where very productive. Soils formed from coastal sediments vary in texture from loam to clay and are situated on gently rolling to nearly level land. Before grading, filling and development altered these soils, they supported a magnificent forest of principally oak, hickory and chestnut trees, and later they supported vigorous agricultural production which contributed to the growth of Philadelphia. Although wildlife populations have been vastly reduced through the centuries, such mammals as the deer, fox, rabbit, racoon, skunk, muskrat, rats and mice still occur on those several isolated riverfront parcels with field or forest cover. Several riverfront lands are well known by bird-watchers for their perching and ground bird populations, and nearby marshlands and tidal flats are resting areas for migrating waterfowl.

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MAP NOTES (CHAPTER III)

Historical Riverfront Conditions

This is a hypothetical illustration of the original environment of Philadelphia's riverfront abstracted from early maps and atlases and the Scharf and Westmacott history of Philadelphia

SOURCES: Melish, John. 1819. Map of Philadelphia. Philadelphia: Tanner, Vallance, Kearney and Co.

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WATER RESOURCES

WATER QUANTITY AND QUALITY

WATER QUANTITY AND UTILIZATION

The Delaware and Schuylkill Rivers have been vital to the growth of the Philadelphia metropolitan area. The Delaware River is sufficiently wide and deep to have sustained the growth of one of the largest ports in the world. Water flow in the Delaware and Schuylkill is relatively stable in comparison to flow in rivers in western and southwestern U.S. The abundant supply of fresh water in the Delaware River estuary virtually guarantees Philadelphia residents and business adequate water supply. Because the Delaware is not prone to flash floods, riverfront properties do not have a high risk of damage during floods. Although the Delaware River is able to support a wide mix of different uses, occasionally there are conflicts among them. For example, although the river is able to assimilate several hundreds of thousand pounds of organic material daily, Philadelphia's waste load discharges overtax this capacity. This causes low water quality which is damaging to aquatic life and which interferes with recreational enjoyment of the river. With proper management of the Delaware River's many resource uses, utilization of the river can be expanded in the future.

FLOW CHARACTERISTICS

The quantity of water flowing in the Delaware and Schuylkill Rivers is enormous. The annual average water flow in the Delaware River is 7,400 million gallons per day (MGD) measured at the falls at Trenton. Because of the tidal nature of the River below Trenton, measures of flow are not meaningful below the falls. At the Fairmount Dam, the flow of the Schuylkill River is 1,830 MGD on an annual basis. This quantity of flow in the two rivers represents a daily discharge of about 640,000 gallons of water for each square mile of drainage area in the watershed.

There is considerable variability in the volume of water flowing in the rivers from season to season because flow is influenced by seasonal variations in rainfall patterns and evaporation (see Table 2). When examined in terms of average monthly flows, there is approximately a seven-fold difference in the Delaware River's flow between March and April, the months of peak flow, and September and October, the months of low flow. In the spring, average flows are about 17,000 MGD, while in fall flows are about 2,600 MGD. The Schuylkill River exhibits less seasonal variation, a four-fold difference between spring and fall. The average monthly flow of the Schuylkill in spring is about 3,050 MGD, while in fall it is 750 MGD.

TABLE 2: FLOW CHARACTERISTICS OF PHILADELPHIA RIVERS

Flow Condition	Schuylkill River at Fairmount	Delaware River at Trenton
	(in million gallons per day)	
Flow of Record	86,000	208,000
High 4 Day Average	16,000	74,000
Average High Month	3,050	17,000
Average Annual Flow	1,830	7,400
Average Low Month	750	2,600
Low 4 Day Average	460	1,800
Low Flow of Record	15	840
Flow Objective D.R.B.C.	---	1,950

SOURCE: C.O.W.A.M.P.-208 Study. Chester-Betz Engineers, 1975 (Chapter IV, draft)

During rainy periods or extended dry weather, flows exhibit wider variations than do average monthly flows. During four days of the year, or roughly 1% of the time, flows in the Delaware River during wet weather will be 10 times the average annual flow. On the other hand, flows will fall to one quarter of the average annual flow during extended periods of dry weather. A 40-fold difference in extremes of river flow commonly occurs during the year.

Even more extreme flow variation can occur. During extreme drought conditions, flows may fall to very low levels. On the average, every ten years there is a seven day period when flows in the river fall to nearly 10% of the average annual flow. At this unusually low flow level, there can be serious consequences. Drinking water supplies may become tainted with high chloride levels, waste assimilation and dilution is poor, and aquatic life suffers from low dissolved oxygen concentrations. At the other extreme is severe flooding. The largest flow ever recorded for the Schuylkill River, an event having a return frequency of about 100 years, was the flood of October 4, 1869. On this day, the flow in the Schuylkill reached 86,000 MGD, about 50 times the average flow. The greatest recorded flow on the Delaware River, with about a 150 year recurrence frequency, occurred on August 1955, when a flow of 208,000 MGD passed the falls at Trenton. This is about 28 times the average flow. In comparing the 10 year drought flows with the 100 year frequency flood flows, there is a 300 to a 400-fold difference in extreme high and low flow conditions on the Delaware and Schuylkill Rivers.

WATER USAGE

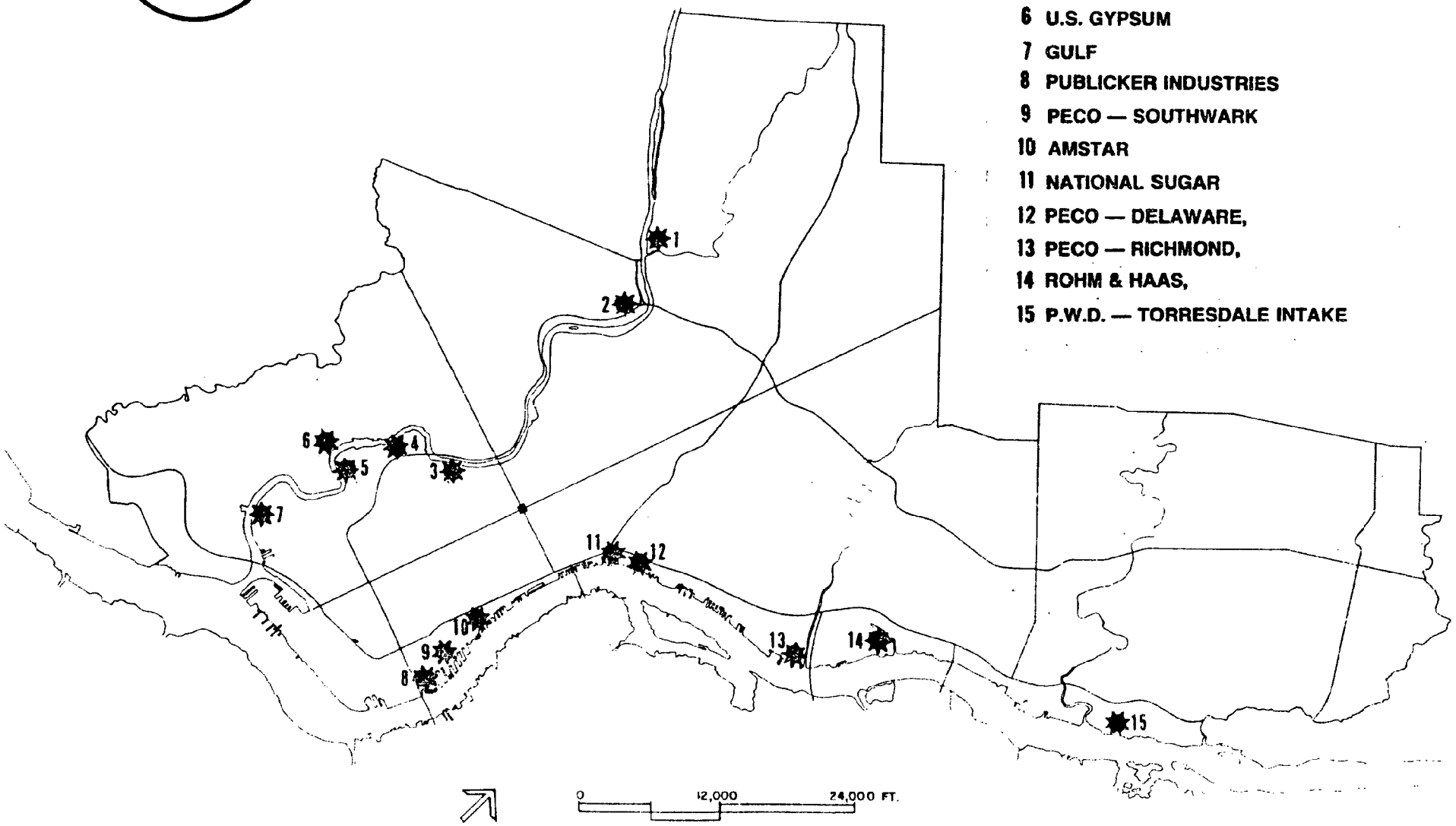
The Delaware and Schuylkill Rivers in the Philadelphia area accommodate a wide variety of uses, for example, drinking water, cooling water, industrial processing, waterborne commerce and recreation.

The rivers are the drinking water supply for approximately 2.2 million people. The Philadelphia Water Department, the largest municipal user, withdraws approximately 410 million gallons per day (MGD) from the two rivers, roughly 60% from the Delaware River and 40% from the Schuylkill River. Four other municipal water authorities, three in Bucks County and one in Trenton, withdraw about 50 MGD of water from the Delaware. As raw water sources, both rivers generally have provided dependable supplies and have acceptable quality. After processing through the City's water filtration plants, the drinking water is in compliance with all federal drinking water standards. Table 10 at the end of this chapter summarizes the quality of the City's filtered drinking water supply.

The Delaware and Schuylkill Rivers are a source of cooling water for the Philadelphia Electric Company's Electric generating stations (see the Water Withdrawers map). There are three PECO stations on the Delaware River, the Southwark, Richmond and Delaware plants, which utilize a combined volume of 530 MGD. This water is used for once through cooling, a process by which the water is discharged back to the river soon after it has been withdrawn to cool the oil fired boilers that power electric generators. PECO's Schuylkill station on the tidal portion of the Schuylkill utilizes 100 MGD for cooling. Two Public Service

WATER WITHDRAWERS

1 P.W.D. — QUEEN LANE INTAKE
2 P.W.D. — BELMONT INTAKE
3 PECO — SCHUYLKILL
4 CELOTEX
5 ARCO
6 U.S. GYPSUM
7 GULF
8 PUBLICKER INDUSTRIES
9 PECO — SOUTHWARK
10 AMSTAR
11 NATIONAL SUGAR
12 PECO — DELAWARE,
13 PECO — RICHMOND,
14 ROHM & HAAS,
15 P.W.D. — TORRESDALE INTAKE



Electric and Gas generating facilities on the New Jersey side of the Delaware withdraw 730 MGD for cooling.

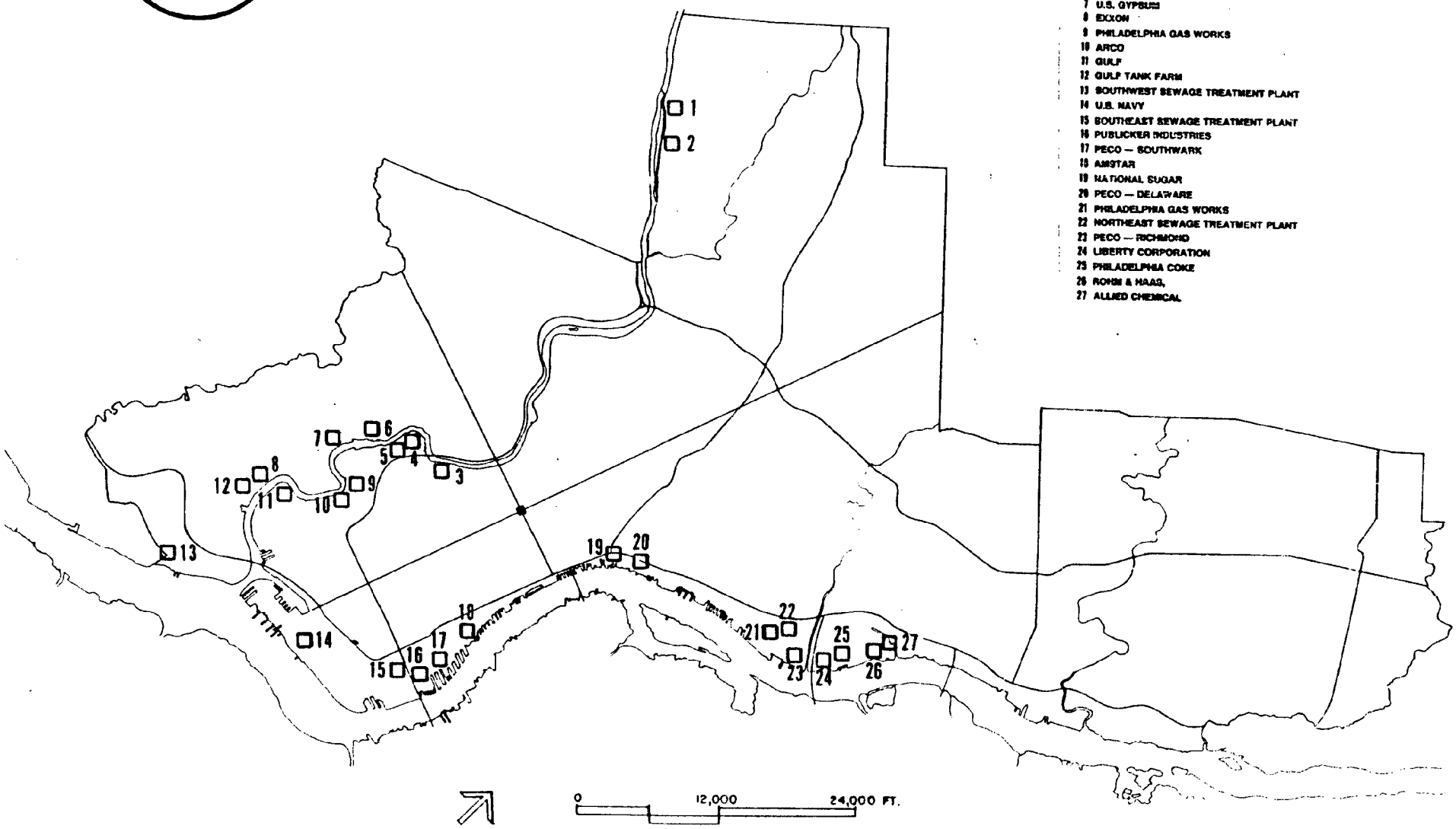
The Schuylkill and Delaware River are significant sources of water for industries, for both process water and cooling water (refer to the Water Withdrawers map). There are 55 industries in the zone from the falls at Trenton to the State of Delaware which withdraw a total of 700 MGD from the rivers. Fourteen of these firms are within Philadelphia, ten withdrawing from the Delaware River and 4 from the tidal portion of the Schuylkill River. Some of the larger industrial water withdrawers along the riverfront are Amstar (23 MGD), National Sugar Refining Company (18 MGD), Publicker Industries (52 MGD), Gulf Oil Refinery (41 MGD), Rohm and Haas (10 MGD), Atlantic Richfield Company (9 MGD) and Philadelpia Coke (5 MGD). The Philadelphia Water Department supplies 99% of all industries in the City with municipal water; these industrial customers utilize about 20% of the 360 MGD delivered to Philadelphia customers by the Water Department.

Although not commonly recognized as a water use, the waste assimilation capacity of the Delaware and Schuylkill River is a very significant resource for the Philadelphia region. There are 125 wastewater dischargers in the Pennsylvania portion of the Delaware Estuary (see Wastewater Dischargers map). Biological activity in river degrades organic wastes either into substances which may be recycled in the aquatic ecosystem or into gases which are released to the atmosphere. Waste loads delivered to surface waters are commonly expressed as pounds of "BOD" per day. BOD is an abbreviation for biochemical oxygen demand, which is the amount of oxygen consumed during the biological and chemical processes that break down organic matter. The Delaware Estuary from the Bay to the falls at Trenton receives about one million pounds of BOD daily, of which about 425,000 pounds is discharged in the vicinity of Philadelphia's riverfront. Approximately 300,000 of this waste load is discharged by the City's three sewage treatment plants, and roughly 30,000 pounds is discharged by 25 Philadelphia industries. Municipal sewage treatment facilities other than Philadelphia's discharge to the Delaware Estuary about 190,000 pounds of BOD daily. Industries discharge roughly 270,000 pounds to the estuary. Tributary streams, which are the receiving surface waters for inland municipal and industrial discharges, deliver approximately 250,000 pounds of BOD daily to the estuary.

The water quality of the Delaware River is significantly altered and stressed by the concentrated disposal of BOD in the Philadelphia area. Bacteria consume virtually all of the dissolved oxygen in a 15 mile stretch of the Delaware south of Frankford Creek during its breakdown of organic material. However, by the time the river has flowed about 30 miles downstream of Philadelphia, assimilation of the BOD load has been substantially accomplished, and the water quality has recovered.

The Delaware Estuary has one of the world's largest ports for marine commerce. Known collectively as "Ameriport," the ports in the Delaware Estuary constitute the largest freshwater port in the world and, with 29.5% of the share of waterborne commerce, are the second largest of North Atlantic

WASTEWATER DISCHARGERS



ports. The 67.5 million tons of cargo imported and exported from the Philadelphia ports in 1980 largely consisted of bulk petroleum, ore and sugar. Nine thousand manufacturing firms and at least 100,000 jobs in the Delaware Valley are estimated to be dependent on port activities. The two major facilities in the estuary for the shipping of containerized cargo are located in Philadelphia; they are Packer Avenue Marine Terminal in South Philadelphia and Tioga Marine Terminal in the Richmond section of Northeast Philadelphia.

Port activities have had a major physical effect on the Delaware River. One effect has been dredging activities. Prior to the initiation of dredging in 1885, the Delaware River in the Philadelphia vicinity typically had a maximum channel depth of about 25 feet, but only an average depth of 17 feet. In 1885, the U.S. Congress authorized channel dredging to 26 feet, and a series of subsequent amendments to the original authorization now have the U.S. Army Corps of Engineers dredging to a depth of 40 feet in the Delaware River south of Allegheny Avenue. The spoil from dredging activities was typically discharged, prior to recent environmental controls, in tidal wetlands. The Fort Mifflin site at the mouth of the Schuylkill River was one of the first diked dredge spoil disposal sites in the nation. In addition to dredging, the river's edge was drastically altered along the majority of Philadelpia's riverfront by bulkheading, dredging and filling for development of wharves, piers and berths for shipping activities. In other cases, rubble and dirt were dumped at the river's edge in order to fill in tidal flatlands to create buildable lands.

The Delaware River is a major recreational resource. The Riverfront Recreation map identifies 34 different facilities which support cultural or recreational activities close to the Schuylkill and Delaware River within Philadelphia. But recreation planners consider the Delaware River poorly developed to recreation, especially in terms of municipally owned river access points and boating facilities. Although there are 60 boating facilities, including yacht clubs, boat launches and marinas, in the Delaware Estuary from the falls at Trenton through to the Delaware State line, only 7 are in Philadelphia. There are only five facilities in the estuary which are publicly-owned -- 4 municipal boat launches and a Pennsylvania-owned marina and boat launch. The Linden Street boat access ramp is one of these public facilities, and the only one in Philadelphia. Twenty-eight of the 60 facilities are private boat and yacht clubs.

Boating facilities provide launching points for power and non-power boats. The Pennsylvania Fish Commission conducted a boating and angling use survey for two stretches of the Delaware Estuary, from the Tacony-Palmyra Bridge to the mouth of the Neshaminy Creek and from the Neshaminy Creek north to the falls at Trenton. For the first segment above the Tacony-Palmyra Bridge, a boating fleet of about 410 boats, 320 power boats and 90 non-power boats, could be typically encountered in this segment of the river on a weekend day with favorable weather. On weekdays, there are typically 65 boaters when the weather is favorable. There were commonly 40 fishermen angling on the New Jersey and Pennsylvania shores, according to the Fish Commission Survey (see Table 3).

RIVERFRONT RECREATION

1 VALLEY FORGE BIKE TRAIL
2 SHAWMONT TRAIL AND FISHING ACCESS
3 MANAYUNK CANAL TOWPATH TRAIL
4 CANOE LAUNCH
5 PHILADELPHIA CANOE CLUB
6 WEST PARK AND TRAIL
7 EAST PARK AND TRAIL
8 BOAT HOUSE ROW
9 FISH LADDER
10 FAIRMOUNT WATERWORKS
11 SCHUYLKILL RIVER PARK
12 BARTRAM'S GARDENS
13 TINICUM NATIONAL ENVIRONMENTAL CENTER
14 FORT MIFFLIN
15 PIER 30 TENNIS
16 HERITAGE SHIP GUILD
17 RAINBOW RIVER TOURS
18 PENN'S LANDING
19 RIVERFRONT DINNER THEATER
20 PENN TREATY PARK
21 PULASKI PIER PARK
22 PROPOSED FRANKFORD ARSENAL BOAT LAUNCH
23 WISSINOMING YACHT CLUB
24 PEKORA'S MARINA
25 PROPOSED PRINCETON AVENUE BOAT LAUNCH
26 QUAKER CITY YACHT CLUB
27 PROPOSED MOUTH OF PENNYPACK CREEK PARK
28 PENNYPACK STREET FISHING ACCESS
29 LINDEN STREET BOAT ACCESS
30 COLUMBIA YACHT CLUB
31 PLEASANT HILL PARK
32 PRIVATE RECREATION AREA — DELAIRE AND BAKER'S BAY
33 DELAWARE RIVER YACHT CLUB
34 FOERD CONFERENCE CENTER

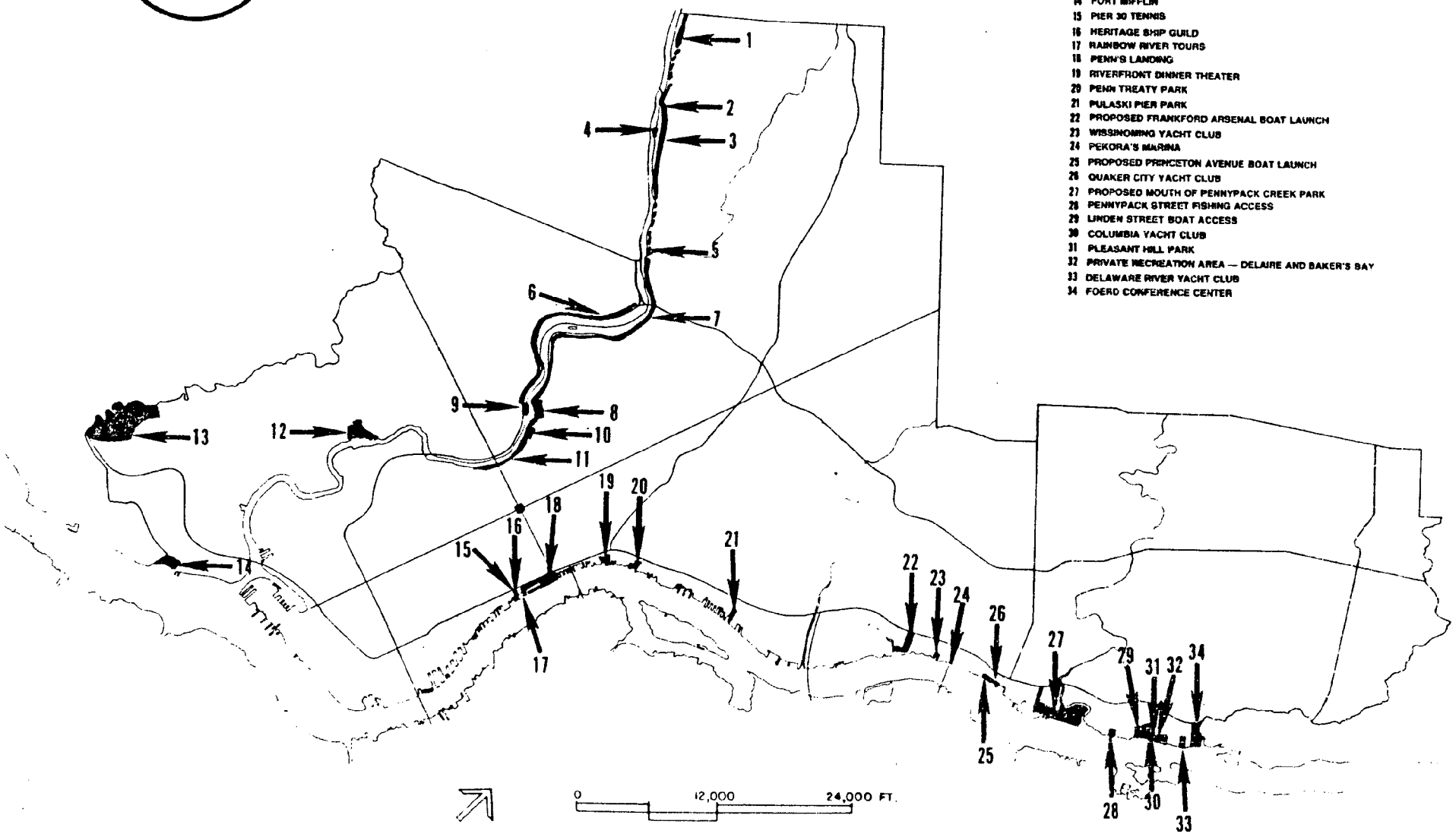


TABLE 3: DELAWARE RIVER RECREATIONAL USE SURVEY
TACONY PALYMRA BRIDGE TO NESHAMINY CREEK (8 Miles)

	APRIL AND MAY		JUNE TO LABOR DAY		POST LABOR DAY	
	Avg. of Daily High Count	Avg. of First Quartile of High Counts	Avg. of Daily High Counts	Avg. of First Quartile of High Counts	Avg. of Daily High Counts	Avg. of First Quartile of High Counts
Weekday						
Angling						
- Shore	10	23	12	26	4	7
- Boat	--	--	3	8	0	0
Boating						
- Power	--	--	24	47	20	31
- Non-Power	--	--	7	17	3	5
Weekend and Holiday						
Angling						
- Shore	22	38	24	42	10	14
- Boat	--	--	4	12	3	5
Boating						
- Power	--	--	174	321	31	43
- Non-Power	--	--	40	88	25	54

SOURCE: Pennsylvania Fish Commission raw counts;
Philadelphia City Planning Commission analysis

The upper Delaware Estuary is not a commercial fishery, but this was not always the case. In 1896, the shad fishery captured close to 4 million shad, a commercial venture which employed over 2,000 men and which in current dollars would yield a catch valued at about to $10 million. Pollution in the estuary had, until recently, virtually eliminated shad from the upper estuary. Over the last several years, however, about 200,000 have migrated upriver each spring. The Delaware Estuary was once also one of the principal sturgeon fisheries in the United States, a fishery which was particularly active during the height of sturgeon popularity in the second half of the nineteenth century. Over-fishing caused the sturgeon population in the late nineteenth century to decline dramatically. When pollution abatement programs are successfully completed in the estuary, commercial fisheries for shad and other fish will greatly benefit.

WATER QUALITY IN THE DELAWARE ESTUARY

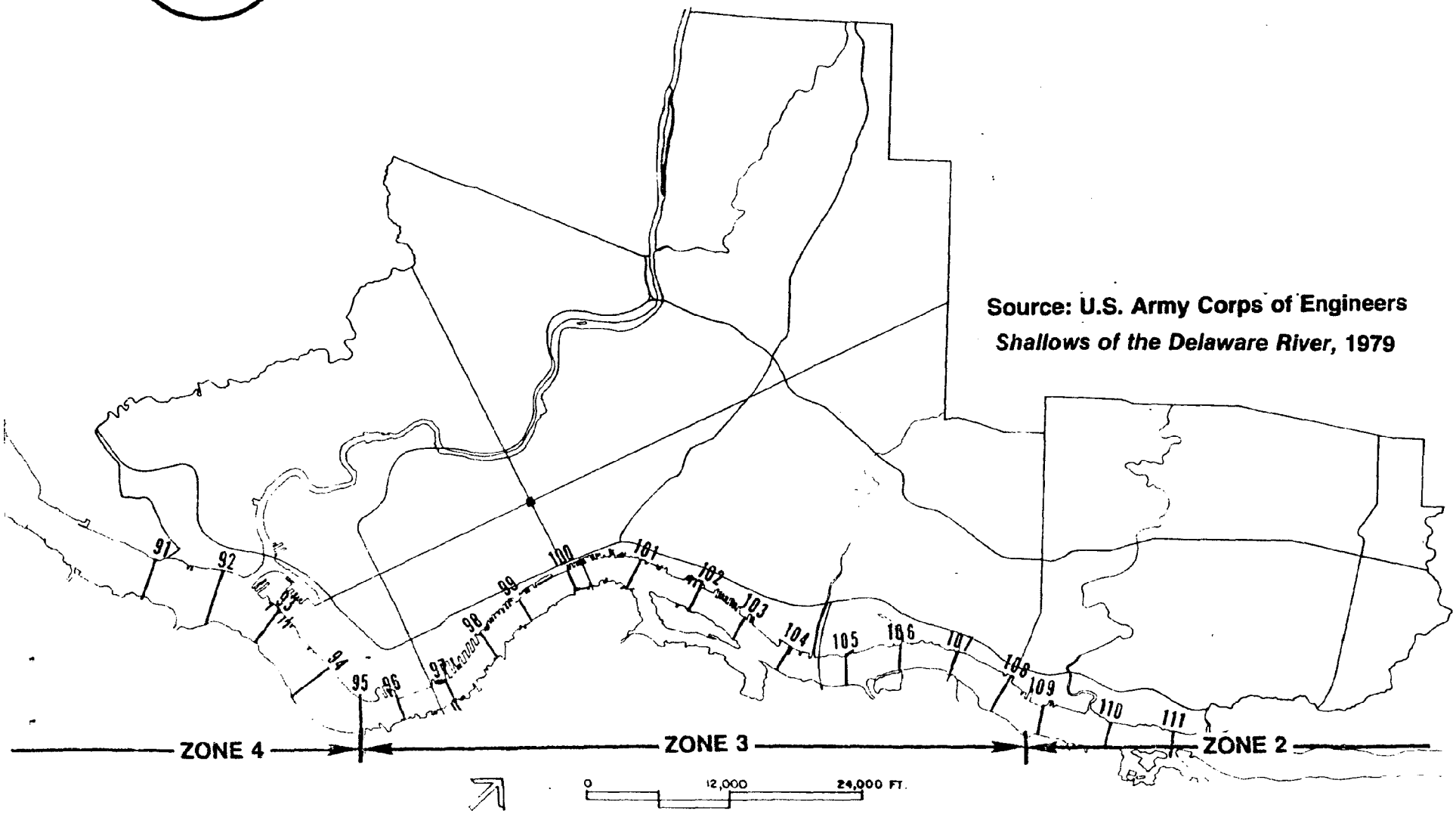
The Delaware Estuary between Philadelphia and Wilmington is highly polluted. The concentration of dissolved oxygen is extremely low during summer and early fall, and the level of fecal coliform bacteria is very high year round. As a result, this portion of the estuary cannot support a healthy aquatic ecosystem, nor is it safe for swimming.

The City's three sewage treatment plants are the principal cause of this pollution. Approximately two-thirds of the organic load discharged to the river in the Philadelphia area is from the three sewage treatment plants. During dry weather conditions, these treatment plants release 90% of the fecal coliform bacteria discharged to the whole Delaware Estuary. This pollution load, however, will be significantly reduced by the late 1980s when the $900 million pollution abatement program is completed by the City. Organic waste loads will be halved, and chlorination of the effluent will greatly reduce coliform bacteria contamination.

The basis for pollution abatement in the estuary was established when the Delaware River Basin Commission (DRBC) was created by a four state compact in 1961. This commission has broad water resource management responsibilities, setting the parameters within which the City's pollution abatement program is designed. DRBC has established water quality objectives for the Delaware River. The estuary is divided into four separate zones for which different sets of objectives have been established. Philadelphia is situated within three zones--Zones 2, 3 and 4 (see DRBC Zones and River Mile Index map). Zone 2 covers the northern stretch of riverfront, and Zone 3 covers most of the southern portion. The boundary between the Zones 2 and 3 is at river mile 108.4, which is approximately at the southern end of Northern Shipping downstream of Pennypack Creek. The boundary between Zones 3 and 4 is at river mile 95.0, which is at the bend in the Delaware River at the Navy Yard.

The water quality objectives for Philadelphia's three zones are different. When DRBC set their objectives for the three zones, they first established future water uses which the water quality on the river would be expected to sustain following pollution abatement. The most significant decisions DRBC had to make regarded the extent to which aquatic habitats

DRBC ZONES AND RIVER MILE INDEX



Source: U.S. Army Corps of Engineers
Shallows of the Delaware River, 1979

should be improved in the estuary. The river was recognized as providing three kinds of uses for fish--the passage of anadromous (migratory) fish, the maintenance of resident fish and the propagation of fish. The DRBC decided that all zones would be expected in the future to permit passage of anadromous fish and the maintenance of a resident fish population but that only Zone 2, in the northern stretch, should in the future have sufficiently high water quality to permit propagation of fish. These water use objectives require considerable changes to existing habitat conditions because poor water quality presently blocks passage of shad in spring, and even the most hardy fish can barely survive the deoxygenated waters which occur in the Delaware during summer.

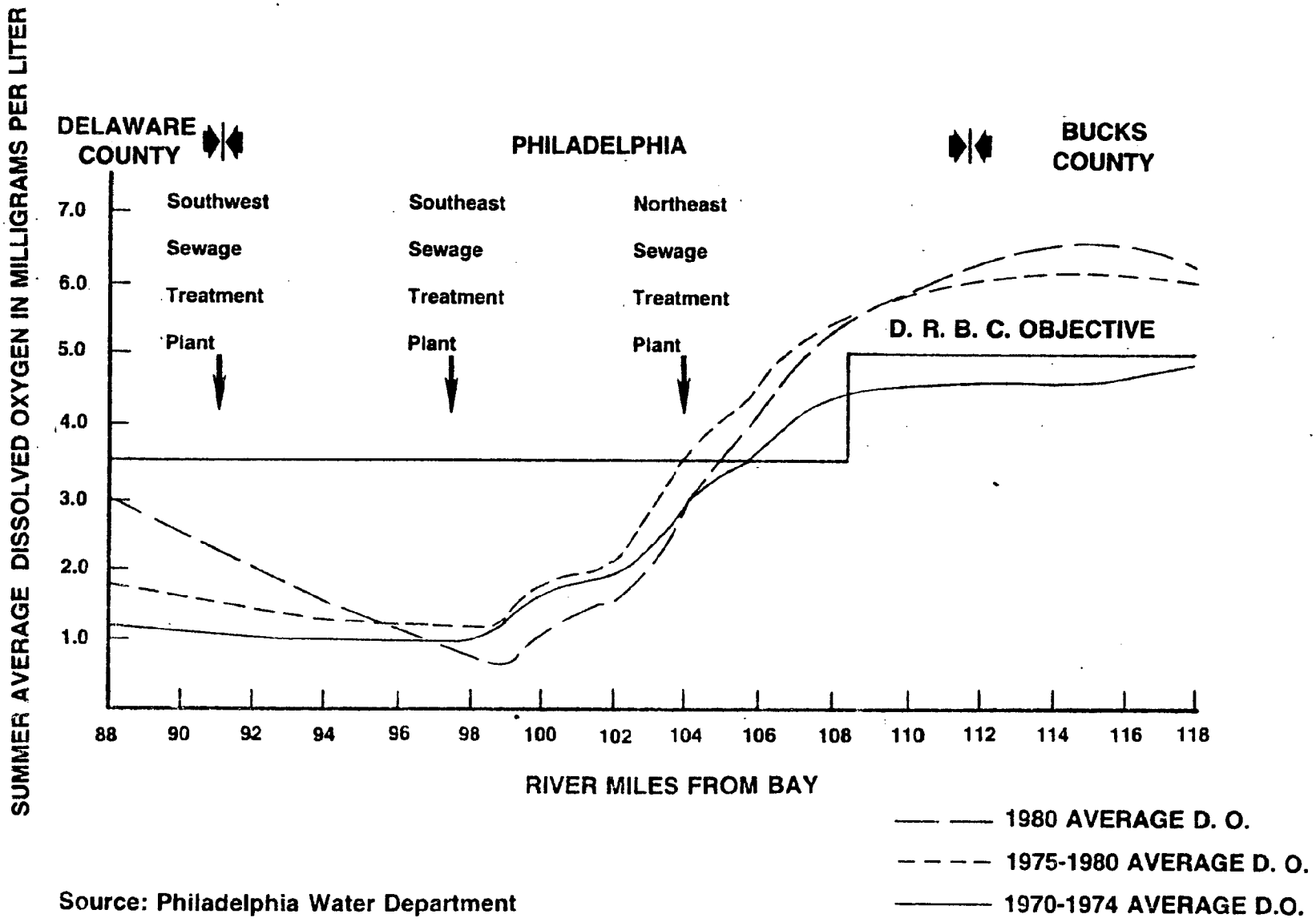
On the basis of these water use goals, the DRBC established water quality objectives. These objectives are physical parameters of the water which are considered by water quality experts to be necessary conditions to support designated uses. There are a large number of water quality parameters for which standards have been set by regulatory agencies. The DRBC sets standards for 13 physical and chemical parameters in the estuary. The Pennsylvania Department of Environmental Resources adds to these standards additional ones. The DER has standards for 23 parameters for the Schuylkill River and 28 for the Delaware Estuary. All the tributary streams to the Delaware and Schuylkill also have water quality standards applied to them. The water quality standards for the Delaware and Schuylkill Rivers are presented in Tables 11 and 12 at the end of this chapter.

Although a large number of parameters have been set for the Delaware and Schuylkill Rivers, not all are of equal importance. The most important parameter is dissolved oxygen because fish life is dependent on oxygen levels and because dissolved oxygen is directly affected by waste dischargers. Some of the other standards reflect principally geologic or climatic conditions, rather than pollution discharge. This is true of the turbidity and total dissolved solids standards. Other standards are seldom violated, even in thoroughly polluted waters; this includes nitrates, pH and phosphorus. Other standards have been set in a way which makes the determination of violations almost impossible. Zinc and copper standards, for example, are established proportionate to toxicity levels as determined by complicated bioassay techniques. Bioassays have not been performed for estuary ecosystems, so in effect standards for these elements have not been established. The several water quality parameters in addition to dissolved oxygen which are of importance to the estuary are fecal coliform, chlorides and metals and other substances occuring in trace amounts.

DISSOLVED OXYGEN

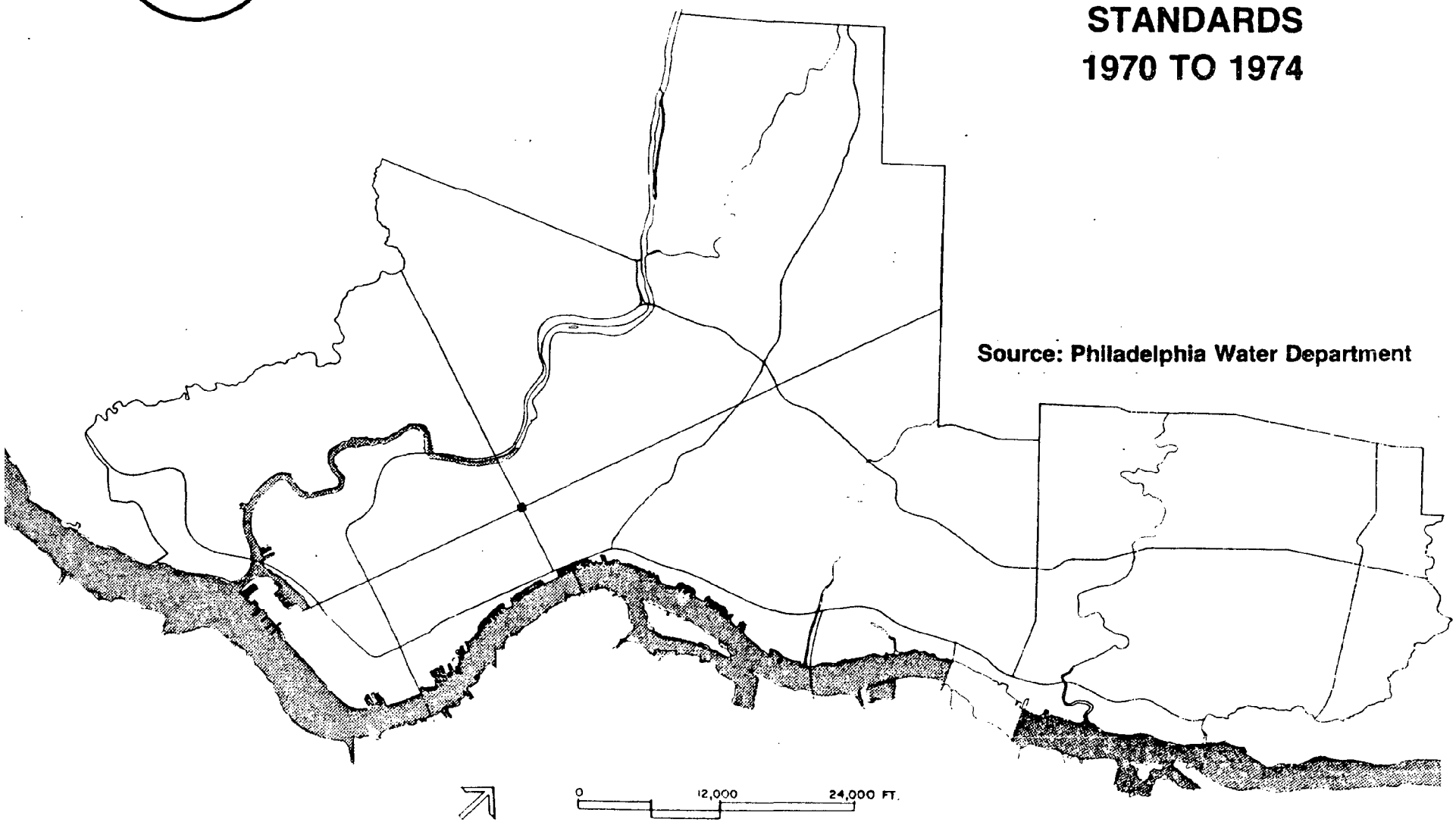
The most critical water quality objective is the concentration of dissolved oxygen. Scientists established a general relationship between the survival of adult fish in river systems and the concentration of oxygen gas in the water. Based on this relationship, the DRBC determined that dissolved oxygen concentrations should not be less than 3.5 milligrams per liter of water (mg/l), measured

DISSOLVED OXYGEN PROFILE OF DELAWARE ESTUARY

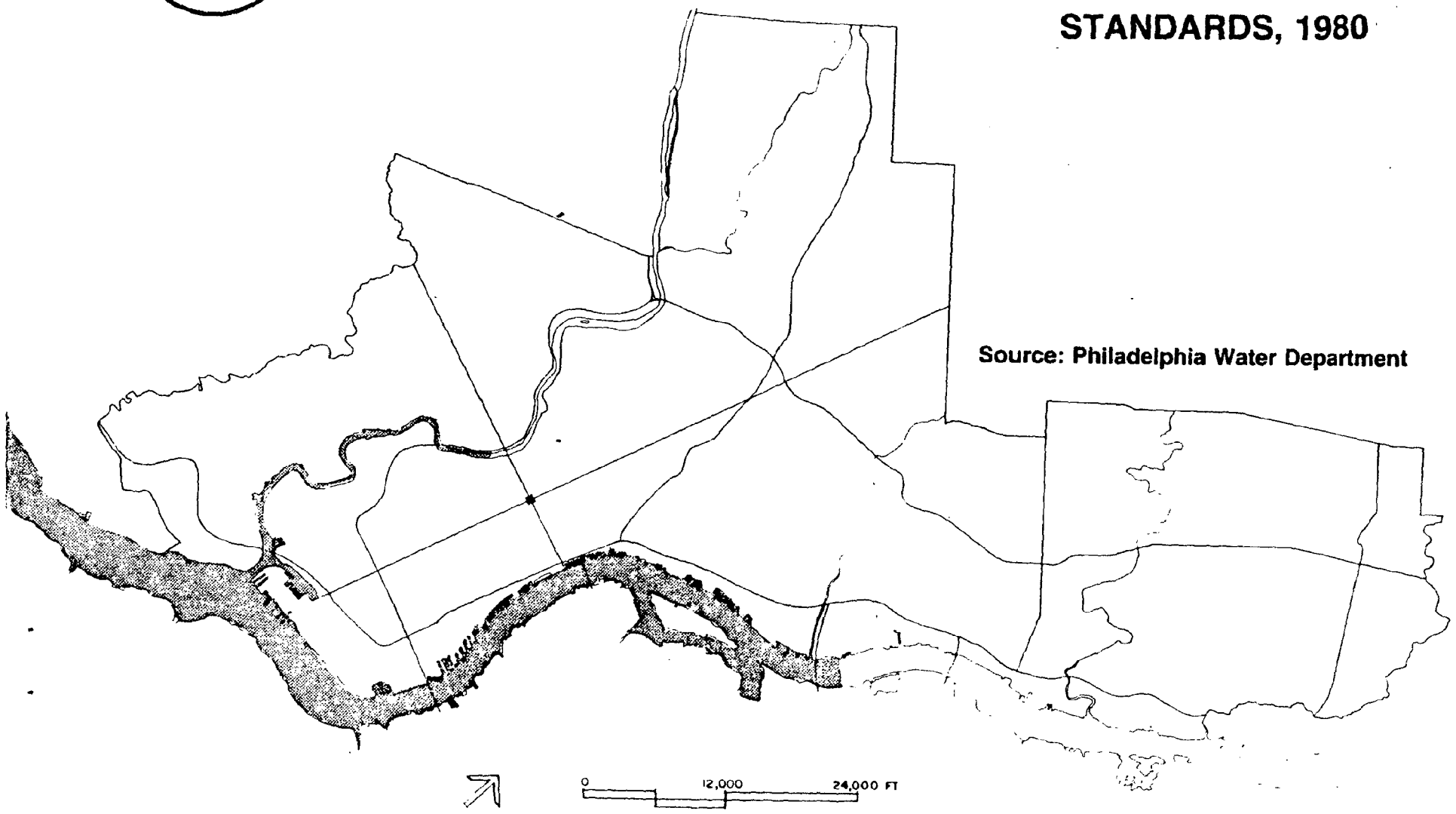


Source: Philadelphia Water Department

DISSOLVED OXYGEN VIOLATIONS — 1970-1974



DISSOLVED OXYGEN VIOLATIONS — 1980



as a minimum daily average. This standard was applied to both Zones 3 and 4. Because juvenile fish are more sensitive than adult fish to low oxygen, a more restrictive standard of 5.0 mg/l minimum average daily concentration was established for Zone 2 to sustain the fish propagation objective for this zone. In all zones, an additional dissolved oxygen objective was established for spring and fall seasons in order to allow passage of migratory fish. Migrating fish have higher oxygen needs than resident fish because of their greater exertion during migration. Consequently, the dissolved oxygen objective is a minimum dissolved oxygen concentration of 6.5 mg/l expressed on a seasonal average basis from April 1 to June 15 and from September 16 to December 31.

In the Philadelphia area, the Delaware River frequently violates dissolved oxygen standards. The graph in Table 4 illustrates the dissolved oxygen "profile" during summer seasons in the Delaware for 1980 and for the five-year period 1970 to 1974 and the six-year period 1975 to 1980. Violations of dissolved oxygen standards are shown on two accompanying maps, one for the 1970 to 1974 period and one for the 1980 summer season. In Philadelphia there is a dissolved oxygen "sag" in a stretch of river in which the concentration of dissolved oxygen plummets from nearly 9.0 mg/l near Trenton to below 2.0 mg/l near Center City Philadelphia. The lowest dissolved oxygen levels occurs in the vicinity of the Walt Whitman Bridge, a section of river which is influenced by waste discharges from all three sewage treatment plants. At this location the average concentration of dissolved oxygen was 0.6 mg/l in the summer of 1980 and on occasion it fell to near zero. Table 5 summarizes dissolved oxygen conditions in a different way, giving ten-year average dissolved oxygen concentrations by season for Philadelphia's portion of Zones 2, 3 and 4. The graph, table and maps indicate that the Delaware River violates the DRBC dissolved oxygen standard in summer in both Zones 3 and 4, but that Zone 2 generally meets standards. The river north of the Tacony-Palmyra Bridge generally is good quality.

Water quality in the upper portion of Philadelphia's riverfront improved during the 1970s. Data collected by the Philadelphia Water Department indicates that above the Tacony-Palmyra Bridge there has been a 1.0 to 2.0 mg/l increase in dissolved oxygen concentrations. The summer season average dissolved oxygen in the Torresdale area during the 1970 to 1974 period was 4.6 mg/l. Water Department data suggest that during normal summer weather conditions the summer season average presently will be about 6.5 mg/l. This improvement is due to pollution abatement by upstream industrial and municipal waste dischargers.

The passage of anadromous fish in fall and spring requires that there be higher dissolved oxygen in the river than allowed by the minimum daily average standard. The DRBC has set a 6.5 mg/l seasonal average objective for spring and fall to reflect this higher oxygen need. Water Department data over the 1970 to 1980 period, summarized in Table 5, indicates that this standard is not met in Zone 4, but is met in Zones 2 and 3. In Zone 4 the seasonal average dissolved oxygen in spring is 5.2 mg/l and in fall 5.1 mg/l.

TABLE 5: DISSOLVED OXYGEN CONCENTRATIONS BY ZONE 1970-1980

Season	Zone 2	Zone 3	Zone 4
Spring (4/15 to 6/15	8.8 (1.9) 6.5 standard	7.5 (2.7) 6.5 standard	5.2 (3.0)* 6.5 standard
Summer (6/15 to 9/15)	5.2 (1.4) 5.0 standard	3.1 (2.1)* 3.5 standard	1.2 (1.0)* 3.5 standard
Fall (9/16 to 12/31)	9.2 (2.5) 6.5 standard	7.5 (3.5) 6.5 standard	5.1 (3.7)* 6.5 standard

NOTE: The first number is the average dissolved oxygen in milligrams per liter of all sample from within each zone for the eleven year period 1970 to 1980, inclusive. The number in parentheses is the standard deviation of the average. Below these numbers is the dissolved oxygen objective established by the Delaware River Basin Commission. The asterisks indicate violations of standards on a seasonal basis.

SOURCE: Philadelphia Water Department, Planning and Technical Services Division, 1981.

The block to fish passage, however, is not complete, even if water quality fails to meet the seasonal objective. This is because there is sufficient variability in dissolved oxygen from day to day to provide "windows" in the block. For example, a heavy period of rain can charge the Delaware with high water flows containing dissolved oxygen in excess of 10 mg/l. As long as these windows last for several days, shad and other river herring may make their way through the 20 mile long block in the Philadelphia area and swim to spawning areas near Easton, Pennsylvania, another 80 miles upriver.

FECAL COLIFORM

Fecal coliform is a bacteria common to the human intestinal tract. The presence of fecal coliform in water indicates contamination by human waste. These bacteria are not in and of themselves hazardous to human health, but they may be carriers of disease. Coliform bacteria can carry, for instance, polio and hepatitis viruses. Standards for fecal coliform are expressed in terms of the number of bacteria colonies which can be grown in a laboratory medium from 100 milliliters (ml) of sampled water. The standard for the Delaware River is 770 colonies per 100 ml expressed as a geometric average of five samples. The graph in Table 7 shows the profile of fecal coliform in the summer of 1980, and Table 6 summarizes fecal coliform concentrations by zones for the 1970 to 1980 period. The estuary below Philadelphia's sewage treatment plants has between 3500 and 8500 colonies per 100 ml. These concentrations suggest that direct body contact with the Delaware River may be a health hazard. The coliform levels are considerably lower, however, in the Torresdale section of the river where the mean falls below 200 colonies most of the time. At this level, the water may be suitable for contact sports.

TABLE 6: FECAL COLIFORM CONCENTRATIONS BY SEASON AND ZONE

Season	Zone 2	Zone 3	Zone 4
Spring 4/1 to 6/15	231	2619	5485
Summer 8/16 to 9/15	168	3619	8524
Fall 9/16 to 12/31	197	4123	6321

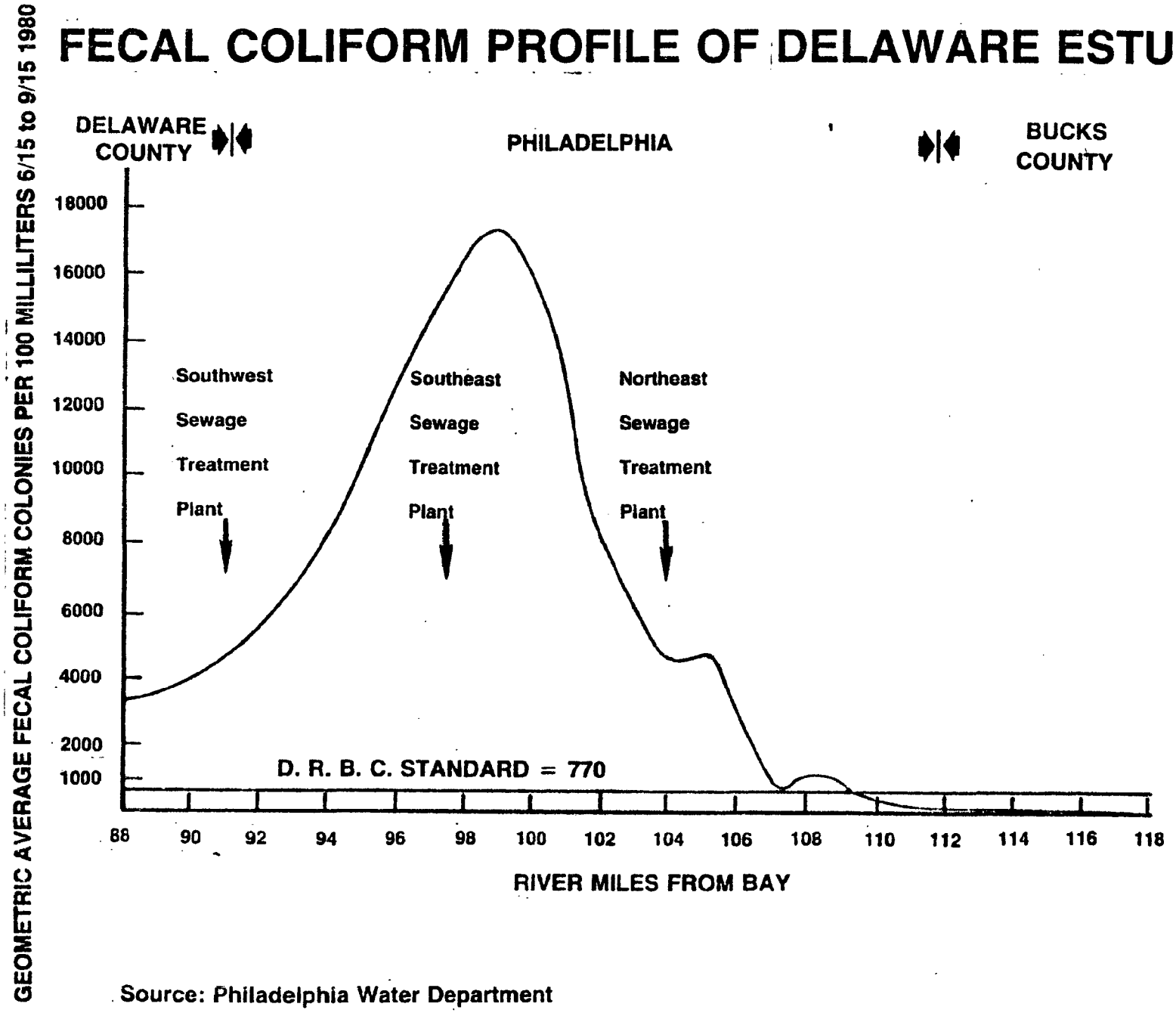
NOTE: These values are the geometric mean number of bacterial colonies per 100 milliliters of river water for all samples within each zone for the eleven year period 1970 to 1980, inclusive. The DRBC standard is 770 bacterial colonies per 100 milliliters.

SOURCE: Philadelphia Water Department, Planning and Technical Services Division.

CHLORIDE

Chlorides have a special importance in the Delaware River as an indicator of sea salts mixing with fresh water. Because Philadelphia and other communities in the

FECAL COLIFORM PROFILE OF DELAWARE ESTUARY



Source: Philadelphia Water Department

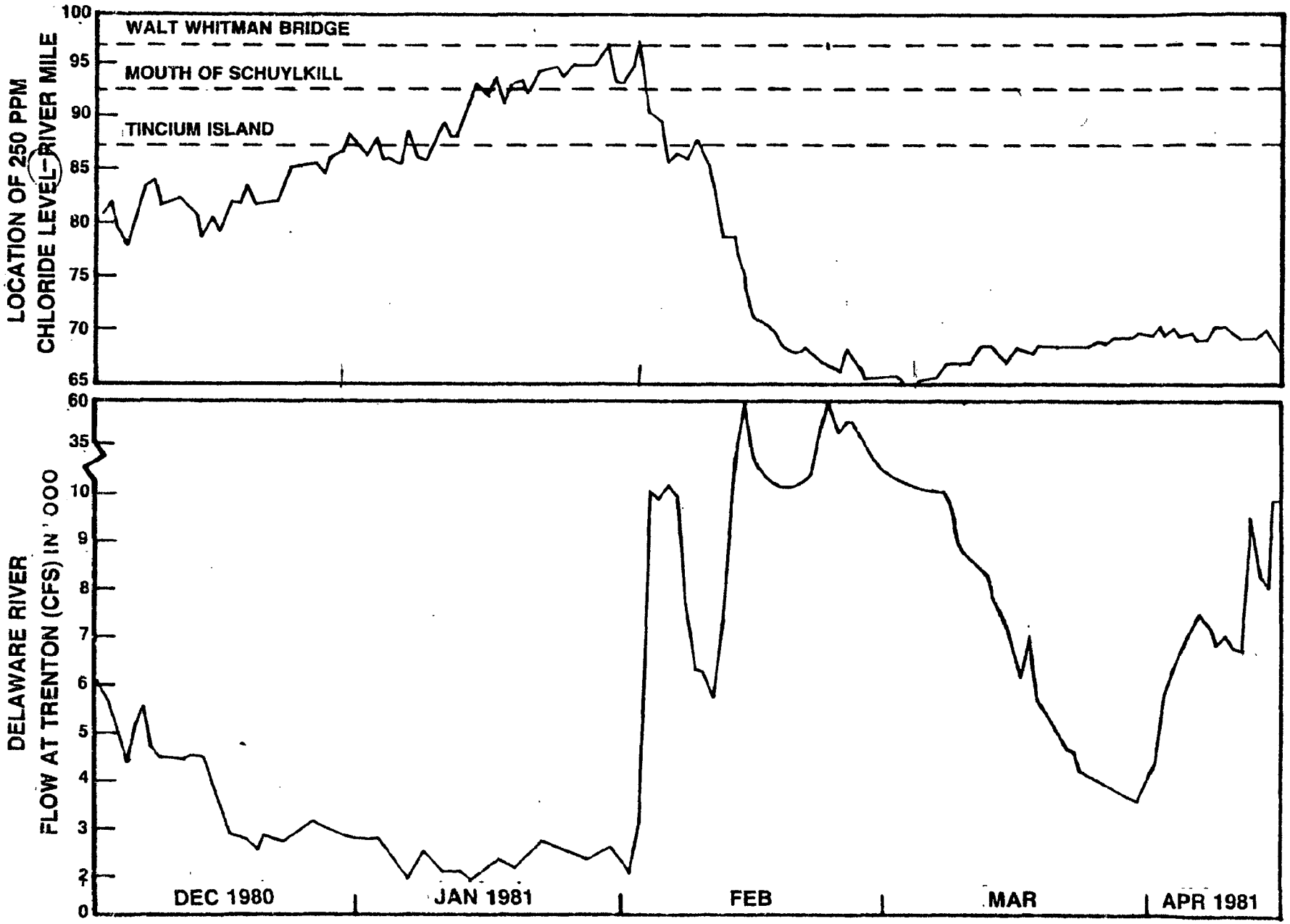
upper estuary depend on the Delaware for fresh water supplies, it is important that the river not become tainted with sea salts above the Schuylkill River. The natural level of chlorides in the water entering the estuary is 10 milligrams per liter, but close to the Delaware Bay chloride levels are a hundred times higher. Hydrologist have defined the "salt line" in the estuary, indicating significant sea salt concentrations, as that location in the river where the concentration of chlorides is 250 milligrams per liter. This "salt line" fluctuates considerably during the year, moving from a point 5 miles below Wilmington, Delaware, in winter to its normal summer location at Marcus Hook, Pennsylvania. This fluctation is the result of changes in the flow of freshwater entering the estuary at Trenton. Because river flows are lower in summer than in winter, the flushing of sea salts from the estuary is less in summer, thereby permitting salts to move upriver. This relationship between river flow and the movement of chlorides in the estuary is illustrated in the graph of Table 8.

The chloride concentration is not as significant, however, as the concentration of dissolved sodium which accompanies chlorides in salt water. When chloride levels reach 250 mg/l, the corresponding sodium level is 140 mg/l, a concentration of health concern when water is consumed by persons with heart disease and high blood pressure. The DRBC established in the 1960s an objective of maintaining chloride levels below 250 mg/l in the Delaware River at its confluence with the Schuylkill and of keeping the concentration below 200 mg/l within the stretch of river between the Navy Yard and Northern Shipping Company, the northern boundary of Zone 3. Zone 2, which includes the raw water intake of the City's Torresdale Filtration Plant, is not to exceed 50 mg/l. More recent studies by staffs of the DRBC have recommended relaxing these chloride standards. The recommendation is for chlorides not to exceed 121 mg/l upriver of river mile 98.

Chloride standards are not so much critical to protecting Philadelphia's water supply as that of southern New Jersey. Water from Delaware River seeps into underlying coastal sediments which serve as aquifers from which such communities as Camden and Cherry Hill withdraw public water supplies. If the river were to contain high chloride and sodium concentrations in the area between the Benjamin Franklin Bridge and Schuylkill River, groundwater supplies for New Jersey communities could become polluted. The chloride standard recently recommended by DRBC staff is consistent with protecting New Jersey aquiters.

To achieve existing and proposed chloride standards in the estuary, DRBC determined that flow in the Delaware River at Trenton should not be less than about 3000 cubic feet per second (cfs), which is equivalent to 1950 million gallons per day (MGD). During normal seasons, flow in the river typically falls below this level about 10% to 15% of the time. But with a program of "conservation" releases from reservoirs in the upper Delaware River Basin, the flow objective can be achieved during a year with normal precipitation. When drought depletes normal base flows, the diminished flushing action permits salty ocean water to push up the estuary and enter the Philadelphia area. DRBC is not able to maintain their flow objectives, in part

DELAWARE RIVER FLOW - WATER QUALITY-THRU 4/15/81



because water is diverted from the basin for use by New York City and northern New Jersey in quantities which prevent adequate conservation releases. During such periods of drought, violations of the chloride standard occur, and the "salt line" migrates in the Delaware above the Schuylkill River confluence.

The most severe drought of record occurred during the first several years of 1960 and was worst in 1965. During this drought the salt line moved further up the Delaware Estuary than on any previous occasion. The chloride concentration rose to 50 mg/l within one mile of the water intake for Torresdale, and it reached 250 mg/l at the Benjamin Franklin Bridge.

This drought revealed an important aspect about the Delaware Estuary as a water source for Philadelphia. The existing chloride standards are virtually impossible to achieve during drought. But under even the most severe conditions, the water quality at Philadelphia's Torresdale intake is acceptable. At no point was the City's raw water intake threatened with serious tainting from sea salts which would have made it impotable.

METALS

Metals are a significant water pollution concern in the basin because their presence in small concentrations may disrupt aquatic ecosystem and because there are industries along the riverfront which use metals. A portion of those industrial metals may reach the estuary. Juvenile fish and minnows, and their food sources consisting of small insects and other invertebrates, can be killed by concentrations of metals in the 10 to 100 parts per billion levels. The loss of this segment of the ecosystem, in turn, can interrupt other aquatic life, especially the larger, commercial and game fish which feed on young fish and minnows.

Metals for which DER has set water quality standards include nickel, zinc, iron, cadmium, chromium, maganese, lead, aluminum and mercury. The status of metals in the estuary is difficult to assess for several reasons. Because chemical analyses are expensive and the presence of small quantities of metals difficult to detect, data on heavy metals in the estuary is scarce. For example, data on arsenic and mercury are rarely gathered. The standards set by DER are phrased in an awkward way. The standard for zinc, for example, is expressed as a concentration that must not exceed one-hundredth the zinc concentration at which 50% of a population of an "important representative" fish species die within 96 hours of exposure to it. This same kind of standard is used for aluminum, zinc and nickel. But these analyses, called bioassays, have not been performed for estuarine waters, so that there is no direct way to determine whether concentrations measured by chemical analysis do or do not violate standards.

The metal concentrations in the Delaware Estuary are generally thought to not pose constraints on the aquatic ecosystem, nor are they likely to in the future. Table 11 at the end of this chapter summarizes data on metals in each of Philadelphia's three zones. Several metals, such as chromium and maganese, meet established water quality standards. Concentrations of lead, copper and iron may occasionally

exceed standards in certain portions of the river, typically close to the river's edge and near industrial areas. For example, out of 3100 samples analyzed by the Water Department for lead, the average concentration was about 0.007 mg/l and only 18 exceeded the 0.05 mg/l standard. Although the standards for aluminum, zinc and nickel are ambiguously worded, these metals are generally regarded as safe for aquatic habitats and human consumption. Unfortunately, there is virtually no data available for arsenic, although a standard has been set for this element.

Occasional elevated levels of metals are not likely to interfere with aquatic ecosystems. With the severe stress placed on the estuary ecosystem by low dissolved oxygen, the effects of metal concentrations are inconsequential. But even after the pollution abatement program is completed in the estuary, the impacts of occasional violations of metal concentrations on aquatic organisms are likely to be masked by remaining organic loading stresses on the Delaware Estuary ecosystem in the Philadelphia area.

OTHER WATER QUALITY STANDARDS

There are other substances occurring in trace quantities for which standards have been set by DER. These include cyanide, phenols and nitrogen compounds. The concentrations of these compounds are presented in Table 11 at the end of this chapter. Cyanide is a compound formed of carbon and nitrogen which is very toxic. The standard for cyanide is 5 parts per billion. No recent analyses for cyanide are available, but historically the cyanide standard has been occasionally exceeded. Phenol is an organic compound which, even at concentrations in the part per billion range, can taint the flavor of fish caught for consumption in the Delaware. The phenol standard is thought to be only occasionally violated in the estuary. Nitrogen compounds consist of principally ammonia nitrogen and nitrate nitrogen. Nitrate in concentrations of 10 milligrams per liter in drinking water can be a health hazard when consumed by infants. Nitrate levels in the estuary do not exceed the 10 mg/l standard. Ammonia nitrogen, which is released by sewage treatment plants, is only toxic to fish at concentrations many times higher than occurring in the estuary. But even at the 1 part per million concentration, ammonia can cause depletion of oxygen from the water. Bacteria use dissolved oxygen to convert ammonia to nitrate and in the process deplete oxygen that is needed by fish and other aquatic organisms.

In the first half of the century, odors were the most significant water quality issue in the City. The rotten egg odor associated with hydrogen sulfide gases emanating from the Delaware River was so overpowering as to make workers along the riverfront physically ill. Breezes from the east during summer would bring the foul odors as far east as City Hall. Stench was a principal reason why citizens petitioned federal, state and city governments to initiate actions to reduce pollution in the river. The resulting construction of three sewage treatment plants in the 1950s and early 1960s eliminated the most objectional odors.

DER has established water quality standards for odors. This is a scale with units ranging from 1 to 256, with 24 established as the threshold of unacceptable odors. The units on the scale are the denominator of the fraction by which the sampled water must be diluted with filtered water in order for odor not to be detectable. For example, the river would not meet the standard if odor was detected when 5 ounces of the river water still smelled when diluted to 1 gallon. The Delaware River is generally regarded as violating this standard during the summer season in Zones 3 and 4. Although the odors in the river once were so bad as to seriously interfere with non-contact recreation as sailing and boating, odors in the river, even while in violation of this standard, do not seriously interfere with recreational activity.

Turbidity is a water quality parameter established by DER and DRBC which is not related directly to wastewater discharge. Turbidity is caused by suspension of solid particles which can interfere with fish respiration. Turbidity standards are measured in units which are based on the distance at which a white disk submerged into the water can no longer be discerned. Violations of the turbidity standard occur during high river flows when stormwater laden with silt and clay is discharged to the river. Silt and clay are washed off of farmlands, suburban lawns and city streets and then discharged to tributaries feeding the river. Another source of suspended particles is the scouring of riverbottom sediments by high velocity river flows, resuspending particles which had settled out of suspension when previous stormflows subsided. Turbidity in the Delaware Estuary is also caused by dredging activity necessary to maintain channel depths for navigation. The Pennsylvania Fish Commission has recommended that maintenance dredging be avoided during periods of fish migration because there is evidence that high turbidity intereferes with migration.

In summary, dissolved oxygen and fecal coliform are the two water quality parameters of greatest significance to the existing and future use of the Delaware River. The severe dissolved oxygen "sag" below the Northeast Sewage Treatment Plants serves as a serious block to the migration of shad, herring and other migratory fish and also causes a serious depletion of resident fish populations. Fecal coliform levels are a public health hazard which makes the river unsuitable for swimming or accidental body contact. Metals and other exotic substances occurring in trace quantities are not a serious problem for ecosystems and are not considered a significant threat to Philadelphia's water supply. Odors and turbidity are water parameters which do not generally interfere with the recreational use of the river or with aquatic ecosystems.

WATER QUALITY IN THE SCHUYLKILL RIVER

In contrast to the Delaware River, the Schuylkill River in Philadelphia has mostly good water quality. The Schuylkill River Basin as a whole is a heavily industrialized basin, sustaining mining activities in the head waters and receiving waste discharges from such significant urban areas as Reading, Norristown and Conshohocken. But there is subsantial recovery of water quality as the river reaches

Philadelphia, and it is within Philadelphia that the Schuylkill is its cleanest. The condition of the Schuylkill River in comparison to water quality standards is given in Table 12 at the end of the chapter.

Dissolved oxygen standards are generally met in the Schuylkill River above Fairmount Dam. The DRBC has set a standard of 5.0 mg/l minimum daily average, with no value less than 4.0 mg/l permitted. A continuous water quality monitoring station is operated by the U.S. Geologic Survey at Columbia Avenue. During low flow conditions in late July 1979, on only one day was 4.0 mg/l dissolved oxygen recorded, but in 1979 there was no day with an average dissolved oxygen level 5.0 mg/l or less. For the most part, water upstream of the Fairmount Dam has 7.0 to 12.0 mg/l oxygen, considerably higher than the oxygen content of even those zones of the Delaware Estuary which are unpolluted. This is attributable to the turbulent flow in the Schuylkill River which oxygenates the water.

There is no reliable set of data on fecal coliform. The fecal coliform standard for the Schuylkill River is 200 colonies per 100 milliliters (based on a geometric mean of five samples). It is generally thought that the non-tidal Schuylkill River achieves fecal coliform standards. If there are violations, these would occur during times of summer low flows. The Schuylkill River is probably suitable for body contact recreation, in accord with this designated use for the river.

There may be violation in the Schuylkill River of DER's water quality criteria for metal and phenols, but probably not within Philadelphia's stretch of the Schuylkill. Studies indicate elevated levels of heavy metals and organic chemicals such as pesticides and polychlorinated biphenys (PCBs) within fish flesh. Water samples and sediment samples in Philadelphia's section of the Schuylkill have not found such substances in high concentrations. It is thought that fish growing in the Reading section of the River, which is prone to industrial chemical contamination, might ingest metals and organic substances which taint them for consumption when they migrate to the Philadelphia area. A study sponsored by the Harrisburg office of the U.S. Geologic Survey has been studying this issue in the Schuylkill River and will soon be issuing a report.

The water quality in the tidal Schuylkill is much poorer than the non-tidal portion. Below the Fairmount Dam, the Schuylkill River is affected by tidal action, which brings polluted water from the Delaware River upstream. The tidal portion of the Schuylkill also received about .64 million gallons of wastewater discharge daily from 5 industries, as well as cooling water discharge from a PECO generating station. The tidal Schuylkill is also subject to sewage discharge from malfunctioning storm overflow chambers. The Pennsylvania Fish Commission surveyed fish populations and measured dissolved oxygen concentrations in August 1981. They encountered exceptionally low concentrations of dissolved oxygen down river of the Market Street Bridge. The Fishery Manager believes that there is not sufficient flow over the Fairmount Dam to flush pollutants out to the Delaware Estuary, and as a consequence pollutants accumulate within the tidal Schuylkill. There were very

few fish during the August survey downstream of Market Street Bridge.

Apparently water quality is not so poor in the tidal Schuylkill as to be a serious block to migrating fish in spring and fall. The fish ladder at Fairmount Dam permits several tens of thousands of fish to pass annually from the tidal to the non-tidal Schuylkill River, demonstrating that the water quality is high enough to permit migration. Some researchers believe that the abundance of sludge worms in organic laden, silty riverbottom sediments is a good food source and that dissolved oxygen is generally satisfactory to support fish in spring when flows are high.

PROJECTION OF FUTURE WATER QUALITY

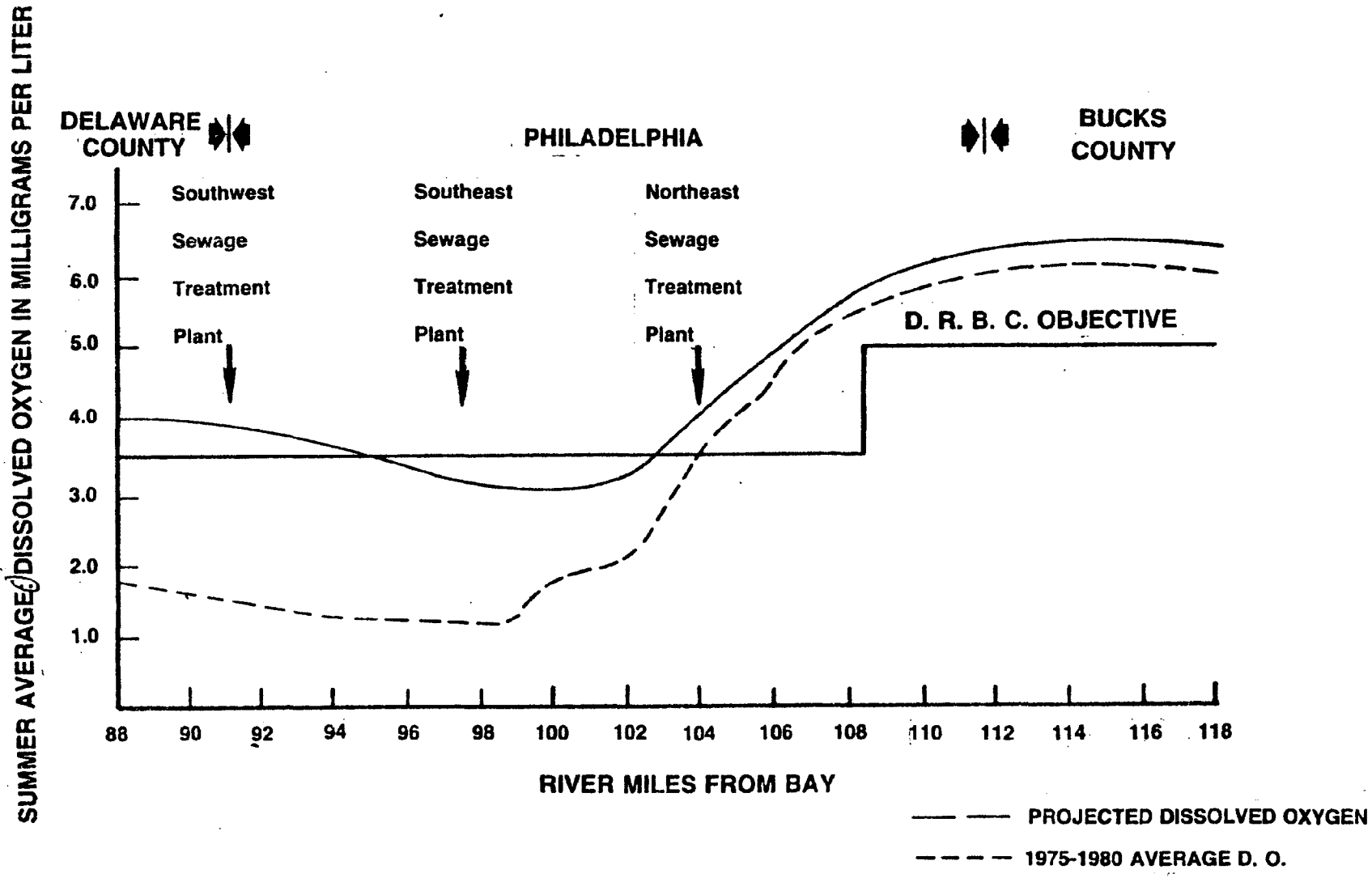
Projecting future water quality of the Delaware Estuary is a difficult exercise. Between 1976 and 1978, the Delaware River Basin Commission constructed a water quality model for the Delaware Estuary, a more sophisticated version of a model built during the 1960s. This earlier model had been used to assign waste loads to dischargers in the basin based on the model's prediction of the capacity of the estuary to assimilate wastes. The updated model was thought necessary as a tool to refine waste load allocations. In spite of the great application of computer power and scientific knowledge to the sophicated model, it has not been fully validated and is not yet capable of reliably predicting future water quality. The DRBC hopes to have this new model fully operational in 1982.

Those investigators who have worked closely on modeling efforts in the estuary generally concur that the current waste load allocations assigned to waste dischargers are too high to meet DRBC's dissolved oxygen objectives. Treatment levels very much higher than those to which the City's sewage treatment plants have been designed would be necessary to achieve a minimum of 3.5 mg/l of dissolved oxygen through zones 3 and 4. One study sponsored by the U. S. Environmental Protection Agency in 1973 indicated a 99.5% removal rate for organic material would have to be achieved by sewage treatment plants in order to meet DRBC objectives. The results of this study are illustrated in the profile of projected dissolved oxygen given in Table 9. The plants are currently being designed and built for about 91% removal. In addition, reductions in other substances which exert an oxygen demand might be necessary. In particular, ammonia nitrogen and nitrogen bound in organic substances, when converted by bacteria to nitrate nitrogen, can cause oxygen depletion. Treatment plants are being upgraded to remove only about 20% of this "nitrogenous oxygen demand." Facilities considerably more expensive than the $900 million ones now under construction would be necessary to reduce this source of oxygen demand.

While there are questions about the adequacy of current waste load allocations, vast improvements to water quality nevertheless will be registered by pollution abatement projects recently completed or currently underway. The Projected Dissolved Oxygen Violations map, when compared to the maps of current and past conditions, shows that the area of river violating standards will be reduced significantly.

The pollution abatement program for Philadelphia continues to advance. The City's Southwest Treatment Plant, near the airport below the Schuylkill River confluence, is

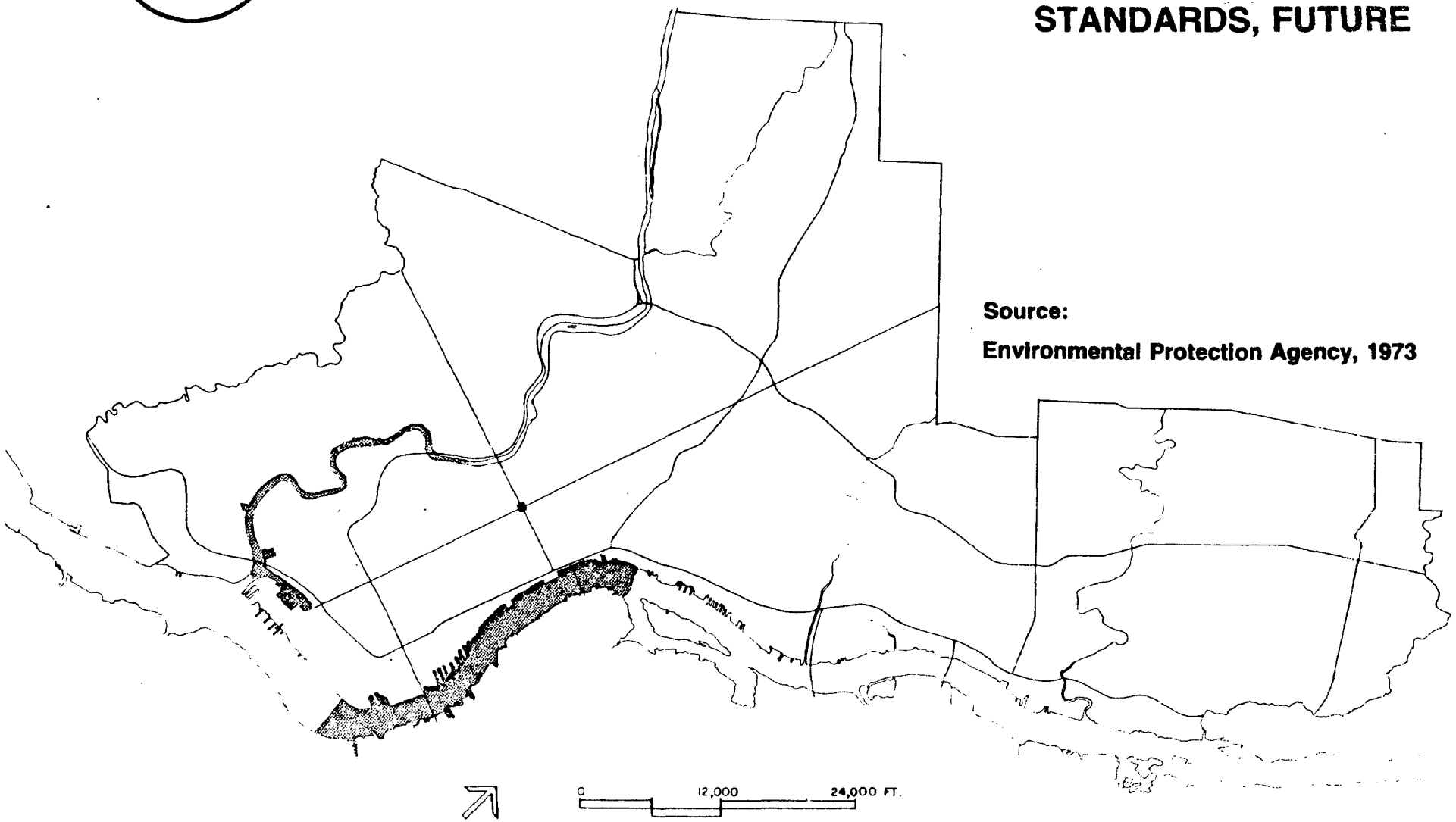
PROJECTED DISSOLVED OXYGEN PROFILE



Source: Environmental Protection Agency, 1973

PROJECTED DISSOLVED OXYGEN VIOLATIONS

AREAS VIOLATING STANDARDS, FUTURE



Source:

Environmental Protection Agency, 1973

close to achieving effluent criteria set for it, eliminating about 75,000 pounds of the over 100,000 pounds of biochemical oxygen demand that had previously been discharged to the river. The City is on an active construction schedule for completion of the Northeast sewage treatment plants in 1984 and the Southeast plant in 1986. When these two plants are in full operation in 1987, the BOD loads will be reduced from 198,000 pounds to about 40,000 pounds. The overall reduction in BOD discharged by Philadelphia plants eventually will be 77%, from the 330,000 pounds discharged per day in 1978 to about 72,000 pounds daily in 1987.

The upgraded Southwest Sewage Treatment Plant was put in operation June 30, 1979, and it created immediate and significant improvements to downstream water quality. In the 1970s, mean dissolved oxygen during summer was 1.5 mg/l in the vicinity of Little Tinicum Island, but in 1980 the mean was 3.0 mg/l, a full doubling of oxygen in this section of the river. Water Department data suggests that the improvement further downstream, in the Marcus Hook and Wilmington area, is even more substantial than 1.5 mg/l, and that the oxygen concentration may be as high as 4.5 mg/l.

Upgrading the Northeast Sewage Treatment Plant should improve water quality in Zone 2 in the upper reach of Philadelphia's riverfront. Because of tidal action, waste discharge from the Northeast plant can contribute to the degradation of water as far as 10 miles north of the plant. The abatement program may increase the dissolved oxygen concentration by as much as 1.0 mg/l on a minimum daily average basis during summer in the vicinity of the Tacony-Palymyra Bridge. At the mouth of Pennypack Creek, dissolved oxygen may increase from 6.0 mg/l to 6.5 mg/l. When pollution from the City of Trenton 20 miles upriver is reduced in compliance with DRBC allocations, dissolved oxygen in the Torresdale area may possibly increase to a summer average of 7.0 mg/l.

The other major sewage treatment facility along Philadelphia's riverfront, the main plant of the Camden County Municipal Utilities Authority, is not on a definite abatement schedule, although components are currently being upgraded. This plant discharges about 40,000 of BOD per day. Should this plant not be upgraded, it will become the largest single point source discharge in the estuary, and it will significantly interfere with the potential improvement of water quality in Zones 3 and 4.

Assuming all major municipal dischargers are finally upgraded, the dissolved oxygen concentration in the Delaware River is still likely to fall short of the dissolved oxygen criteria by one-half to one milligram per liter in Zone 3. The objectives for this zone is a minimum daily average of 3.5 mg/l. The 1973 EPA study concluded that it is likely that the minimum daily average dissolved oxygen during the summer season may be only 2.3 mg/l at the low point in the oxygen sag (see Table 9). The study also suggests that during critical low flow periods dissolved oxygen may fall to as low as 0.5 mg/l. Delaware River Basin Commission's updated model should be able to reevaluate in 1982 this earlier conclusion.

Throughout the estuary, the standard for dissolved oxygen in spring and fall is 6.5 mg/l in order to provide for passage of

migratory fish. While this standard is frequently violated under current conditions in the lower part of Zone 3 and throughout Philadelphia's portion of Zone 4, compliance with the standard apparently will be achieved when the City's pollution abatement program is completed. Currently the seasonal average dissolved oxygen is about 5.0 mg/l for spring and fall in zone 4 and 7.5 mg/l in zone 3. The expected concentrations in spring and fall after the abatement program are roughly 7.0 mg/l in Zone 4 and 8.0 mg/l in Zone 3, which are concentrations in compliance with the standards.

Achievement of dissolved oxygen objectives may also be adversely affected by DRBC's inability to maintain the flow objective at Trenton. Waste load allocations were based on the assumptions that a minimum discharge of 1,950 MGD (or 3000 cfs) would be maintained. When river flow falls below this level, there is less water to dilute and assimilate wastewater effluent. During drought conditions, the average water temperature in the Delaware also tends to be higher than normal. Because warm water is less able to hold dissolved oxygen than cool water, the combined effect of low flows and high temperatures may significantly lower dissolved oxygen levels over those which occur during normal summer seasons. Flow maintenance through conservation releases from reservoirs in the upper reaches of the Delaware River Basin would help achieve water quality objectives. But whether the failure to maintain flows significantly affects dissolved oxygen in the estuary has not been conclusively demonstrated.

Under federal regulations, the City has been implementing a program for restricting discharge of heavy metals and exotic organic substances into City sewers. This program, requiring industrial pretreatment of wastewater effluent prior to discharge to sewer, is necessary for two reasons. Industrial chemicals may disrupt the biological and physical processes which are responsible for treating wastewater plants, thereby risking non-compliance with effluent criteria. Undesirable industrial substances may be removed during treatment within the sludge residue of the treatment process. Because of the ban of ocean disposal, sludge is being given away or marketed as a soil amendment and conditioner for homeowners, golf course operators and other landowners. Therefore, it must meet high standards of quality and safety. It is imperative for the successful disposal of sludge that it not become contaminated by metals and organic chemicals. As the result of the City's enforcement of pretreatment regulations, the amount of metals and organic substance being discharged to the estuary by Philadelphia industries has declined substantially over the last three decades, although no specific estimates are available. In part this reduction has occurred because of the national decline in manufacturing sector jobs in northeastern U.S. cities like Philadelphia.

Fecal coliform levels in the estuary will be dramatically improved by the City's pollution abatement program. The City is the predominant source of coliform in the estuary. The new treatment process includes chlorination of the effluent to destroy bacteria. Fecal coliform levels, even so, are likely to remain above the standard in the lower stretch of the river downstream

of the three plants because of bacteria discharge in stormwater and residual bacterial contamination of wastewater effluent. However, the likelihood of periodic bacterial contamination of Zone 2 above the Tacony-Palmyra Bridge will be nearly eliminated and standards for body contact recreation may be achieved year round. This may open up the possibility of body contact recreation in the Torresdale section of the river.

FISHERIES AND AQUATIC HABITATS

The Delaware and Schuylkill Rivers were once major fisheries. William Penn complained in the late seventeenth century that small skiffs on the Delaware were endangered by sturgeon leaping out of the water during their spring migration. Fishing was a major commercial enterprise in early Philadelphia, providing an important food source for Philadelphians and a significant export commodity. Nearly 20 million pounds of shad were caught in the Delaware Bay and River in 1896, the peak year for shad harvesting when each net took in on the average 8 tons of shad. The fisheries were a cultural and social resource; for example, the State of Schuylkill for 150 years was a fraternal organization devoted to fishing, having their headquarters above the falls on the Schuylkill River. But by the middle of the twentieth century, the fisheries had been decimated. The combination of overfishing, dam construction and water pollution reduced to less than 10% the abundance of fish in the Delaware Estuary, and many species once common in the estuary are only seldom encountered today. Sturgeon and striped bass have largely disappeared, and only in the last decade has shad returned in significant numbers. Three quarters of Philadelphia's stretch of the Delaware River is grossly polluted in summer, with the concentration of dissolved oxygen so low that most game fish cannot survive. The Areas of Recreational Fishing map shows those areas where a good population of game fish can be sustained and those areas which because of pollution have stressful environments for game fish.

FISH POPULATION CHARACTERISTICS

The condition of the fisheries and aquatic habitats has not been well documented for Philadelphia's stretch of the Delaware River. Aquatic ecosystems are such enormously complex organizations of plant and animal organisms that in-depth scientific investigations are generally confined to only small geographical areas or to just a few components of the whole system. Some researchers merely count the kinds of organisms in a habitat area, but do not proceed to describe relationships among species nor how one habitat area compares to others. Research projects tend also to be "one-shot" efforts occurring over a brief time span. Such studies cannot demonstrate changes to fish populations over a period of several years nor changes to populations when condition of temperature, water quality or water quantity are altered. As a consequence, the condition of aquatic habitats and fisheries in the Delaware Estuary involve many generalizations and informed judgments. Much of the information available on the kind of fish in Philadelphia's rivers and their characteristics is summarized in Table 13 at the end of this chapter.

A useful way of examining habitats and fisheries is with the concept of the "biological health" of a river. A biologically healthy river supports an abundant, diverse and productive population of fish, whereas an unhealthy river sustains few numbers of fish and few different fish species. Population characteristics of fish are significant because they integrate a host of physical, chemical and biological characteristics of the river; borrowing business terms, this is the "bottom line" of ecosystem processes. Aquatic ecosystems may become degraded by the depression of oxygen levels due to excessive wasteloads, the destruction of vegetative shelter for juvenile fish through riverfront filling, the loss of suitable nesting areas for fish breeding and any number of similar actions which affect the livability of the river for fish. The net result is loss in total number of fish which the river can sustain and in the kinds of fish which find the remaining habitats suitable.

Fish populations can be described by three characteristics -- abundance, diversity and production. Abundance is the number of fish occurring in a given area of river; fish abundance is typically greater in clean water than polluted water. Diversity in the number of different species is a significant indicator of biological health. In polluted rivers, pollution sensitive species, which comprise most game and commercial fish, are rare, and only the several kinds of pollution tolerant fish are common. The third factor is biomass production, or the weight of fish which is produced in the aquatic ecosystem.

There are no surveys of fish in Philadelphia's riverfront which satisfactorily provide measures of abundance, diversity and biomass production. The preponderance of fish survey data consists of lists of the number of specimens of each species collected during a series of collections. These collections generally were conducted as part of environmental assessments required by federal regulations prior to permit issuance to electric utilities for discharging cooling water. The several fish surveys which have been performed for the Delaware Estuary cannot be readily compared with each other because of the variability in collection techniques by which samples were taken, in the section of the river sampled and in the year and season of sampling.

Fish abundance is generally higher where river water is good quality than where water is polluted. Fish survey data compiled in 1973 by the U.S. Fish and Wildlife Service shows a pattern of increasing fish abundance at five stations along the Delaware River at which water quality progressively improves (see Table 14 at the end of the chapter). Philadelphia and Chester trawling samples yielded on average 2 and 4 specimen fish, respectively. At Trenton and Bristol, where the water is clean, 25 and 50 specimens per collection were gathered. Summary data for the following year, 1974, indicates the same kind of relationships, about 10 times more fish per collection from Trenton and Bristol stations than from Philadelphia and Chester stations. This clear pattern cannot be discerned, however, in sampling studies performed for electric utilities. A U.S. Army Corps of Engineers study summarized fish surveys performed in the early 1970s. In 1974, an average of 67 specimens per seine were collected in the Philadelphia to Chester area, although a different study in 1972 collected only 44 specimens per seine from the cleaner

Croyden and Bristol stretch of the river. No information provided in the Corp's report accounts for the observed differences between these studies.

Species diversity is low in polluted water. Because few kinds of fish are able to survive low oxygen levels in polluted water, the several pollution-tolerant fish species constitute the largest proportion of fish caught during surveys. In non-polluted waters, by contrast, a large number of different species may be caught in significant numbers. Data for the Philadelphia's portion of the Delaware Estuary indicates that the diversity of fish declines steadily from Torresdale downriver to the Hog Island area, a reflection of increasing water pollution. Fish surveys summarized by the U.S. Army Corps of Engineers indicate that 3 to 4 species account for over 90% of all fish specimens collected from polluted waters downstream of the Southeast Sewage Treatment Plant. These species are, in order of abundance, mummichog, banded killifish, silvery minnow and pumpkinseed (a sunfish). Except for the pumpkinseed, these dominant fish species are not gamefish, as they are typically smaller than 3 inches and weigh only several ounces.

In relatively unpolluted waters near Torresdale, species diversity is significantly higher. Eight or 9 species constituted 90% of all fish caught during surveys conducted in the 1970s (see Table 15 at the end of this chapter). In the surveys near Torresdale, mummichog is a smaller proportion of all fish caught than in surveys near Hog Island. Instead of constituting 40 to 60 percent of the catch as in polluted waters, mummichogs are typically less than 15% of the catch in clean water. In unpolluted waters, river herring, including alewife, shad, blueback and other herring species, may account for 10% to 55% of the catch, depending on the success of migration through the oxygen block downriver. Herring are typically a pound in weight and are of recreational and commercial importance. Unpolluted waters also support white perch and channel catfish, two other game fish which are rare in polluted water. There is a greater variety of small fish species in clean water than in polluted water. In addition to the mummichog, silvery minnow and banded killifish, which are also common in degraded waters, unpolluted waters have the spottail shiner and satinfish shiner in significant numbers.

As many as 50% of fish species originally occurring in Philadelphia's portion of the Delaware Estuary may no longer exist here. A study prepared by the Academy of Natural Sciences compared surveys from the early 1900s with collections in 1972, finding 21 species which had disappeared from collection sites from Wilmington, Delaware, upriver to Florence, New Jersey. Several of the notable species absent in 1972 are sturgeon, smelt, redfin pickerel, smallmouth bass and several species of sunfish.

The researches observed that, while existing water quality conditions cannot support these species, there is a species pool in tributaries and in cleaner waters which could one day serve to "re-seed" the Delaware Estuary when pollution is reduced.

Surveys of fish can provide an indication of fish production in the Delaware Estuary. In polluted waters, the predominant species are

small fish of minnow size; but in clean water a high proportion of surveyed fish are large. For example, the mummichog typically weighs two ounces, whereas the alewife and herring each weigh one half pound and the shad about 2 pounds. Extrapolating from the surveys summarized by the U.S. Corps of Engineers, a hypothetical seine collection of fish from polluted waters near Hog Island would yield 3 to 5 pounds of fish, whereas a seine collection from unpolluted water near Bristol would yield 10 to 20 pounds of fish. Surveys may yield considerably greater fish weights if schools of herring are netted, in which case many hundred pounds of fish may be caught per collection.

In spite of serious pollution in the Delaware Estuary, there is a significant fishing potential north of the Tacony-Palymra Bridge (see Table 13 at the end of this chapter). This is the only area in Philadelphia, aside from the Schuylkill River, in which a natural recreational fishery is available to residents. The principal sport fish are carp, catfish, sunfish, white sucker and white perch. Surveys by the Pennsylvania Fish Commission indicate that white perch is a prized sport fish which apparently could sustain significantly increased fishing in the northern stretch of Philadelphia's riverfront. While there are some sunfish and smallmouth bass in the upper estuary at present, their populations are limited by the lack of shallow water areas with high oxygen levels, their preferred habitat.

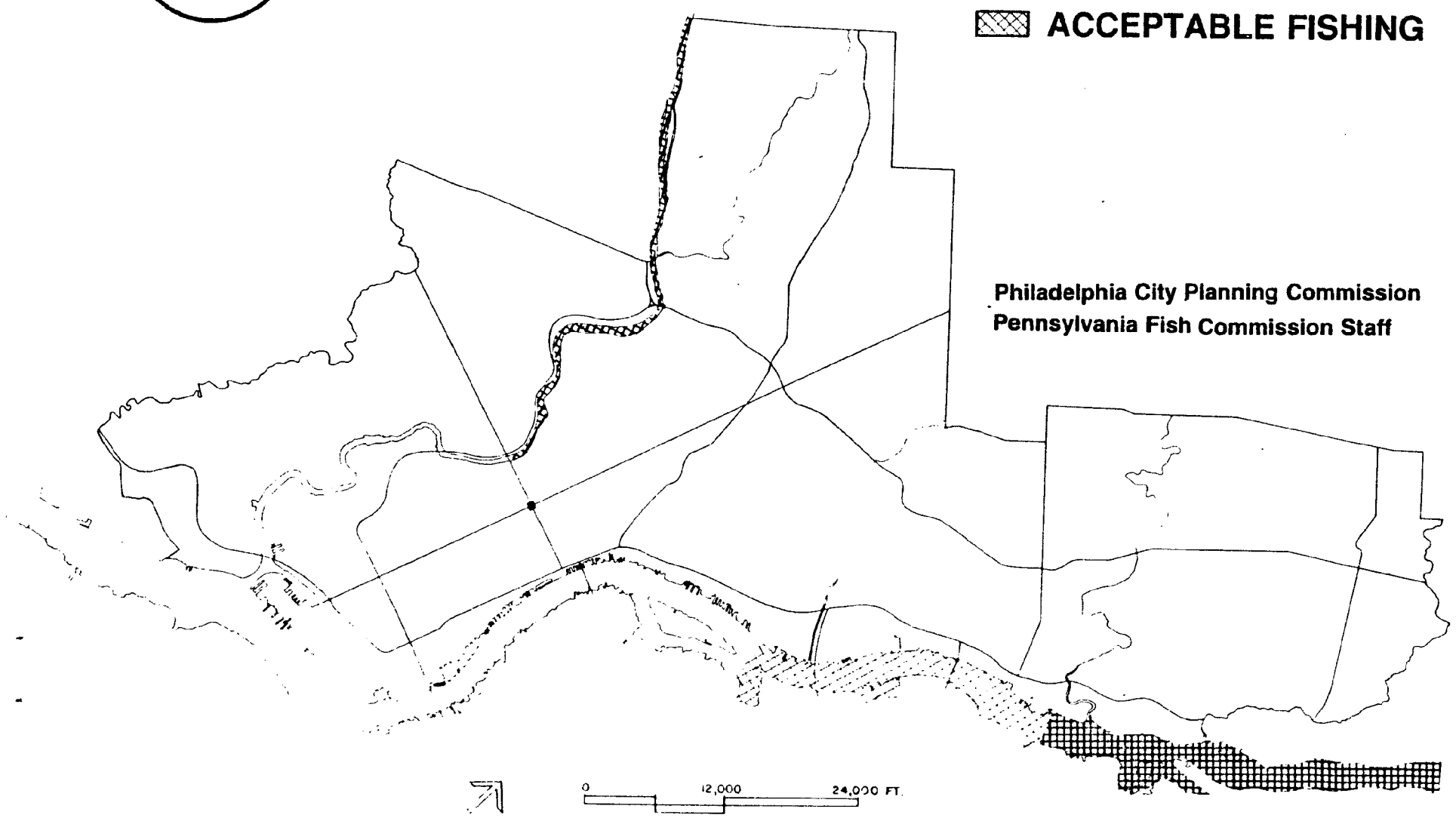
In the stretch of Philadelphia's riverfront between Tioga Marine Terminal and the Tacony-Palmyra Bridge, the fisheries are stressed by summer low dissolved oxygen conditions. This portion of the river generally achieves the D.R.B.C. standard of 3.5 mg/l minimum daily average dissolved oxygen. But even at this oxygen level, only those fish species which are moderately to highly pollution tolerant are able to survive. Catfish, white perch, carp, eel and sunfish are the pollution tolerant game fish which can be caught in this stretch of the riverfront during summer. In spring and fall, when dissolved oxygen concentrations are typically higher than in summer and when herring, shad and other anadromous fish are migrating, the recreational value of this stretch of the river is very good.

A major portion of the Delaware and Schuylkill Rivers is too thoroughly polluted to sustain a recreational fishery. In the Delaware from the City boundary at Fort Mifflin north to the Tioga Marine Terminal and in the Schuylkill from its mouth upriver to Market Street, dissolved oxygen concentration in summer violate standards, and frequently concentrations fall below 1.0 mg/l. At this level, virtually no game fish can be expected to survive. Fish life in this zone consists primarily of highly pollution tolerant, minnow-size fish such as mummichog and killifish.

Although pollution currently restricts shad migration, the one or two hundred thousand shad which manage to migrate upstream support an active sport fishery group in the Trenton area. In the next decade, fish managers in the Delaware hope to see shad runs approach one-half million fish; this could support a much more active sport fishery. Even those stretches of the Delaware which because of low oxygen cannot support resident fish may offer fishing opportunities during the migratory season.

Surveys by the Pennsylvania Fish Commission indicate that fish abundance, diversity and

AREAS OF RECREATIONAL FISHING



production are very good in the Schuylkill River. The excellent fish populations in the Schuylkill are consistent with the reported high oxygen levels. In the Fish Commission's recent management report, thirty-three fish species were identified, a higher number than is usually encountered in the Delaware River. (Stream sampling procedures may account for some of the difference in species collected; seines and trawling techniques are used in the Delaware, and electrofishing is used in the Schuylkill River.) The Fish Commission's catch on the Schuylkill was dominated by redbreast sunfish and smallmouth bass, two favorite game fish. Other game species commonly caught were pumpkinseed, green sunfish, bluegill, catfish, crappie and perch. Walleye, a highly valued game fish, have been caught during Fish Commission surveys, and local fishermen have reported prize walleye longer than 2 feet and weighing more than 40 pounds. The Fish Commission has measured annual fish growth for several common fish. Typical growth of bass and sunfish during their second year is about 2 inches and during the third year about 1 inch. This is considered by the Fish Commission to be rapid growth rates, indicative of good habitat conditions.

The reputation of Philadelphia's Schuylkill River has been enhanced by newspaper reports of its high quality fishing opportunities. Articles have appeared in the City's leading newspapers and the Philadelphia Magazine. A recent article (11/8/81) in the Philadelphia Inquirer's Today Magazine contained the following laudatory and eloquent description.

> Since I began fishing the Schuylkill four years ago, I've been amazed time and time again at the abundance and diversity of the life teeming in its waters....In my opinion the water below Flat Rock Dam is a piscine treasure trove....(and) the water halfway between Flat Rock Dam and Green Lane Bridge....I call the.... "the golden mile" because of its beauty and superb fishing. Thank God the Schuylkill makes glad the City of Philadelphia.

SHALLOW WATER HABITATS

While pollution levels are presently the most significant limitation on fish populations, as the water becomes cleaner the physical condition of the river edge and bottom becomes increasingly important as a factor in fish populations. The river edge and bottom condition of most importance to fish is shallow water habitat areas, the most productive zone in the river ecosystem. Shallow water habitat areas are submerged lands covered by less than 10 feet of water. The riverbottom in these areas receives enough sunlight to support "primary food production," meaning the growth of algae, submerged rooted plants and other green plants. These plants are grazed by crustacea, snails, worms and other invertebrates. Grazers are, in turn, food for minnows, shiners, mummichogs, killifish and other small fish which spend their lives in shallows. These small fish are prey for game fish which are normally deep water residents but which enter shallow areas to feed. Shallows are also important for game fish because plants in the shallows provide young game fish shelter against predators. Plants in shallow areas also give off oxygen which, combined with the turbulence and wave action of shorelline areas, produce water which is more highly oxygenated in shallow areas than in deep water areas. Fish are

attracted to highly oxygenated water. High oxygen levels are especially important to juvenile fish and migrating fish which have higher oxygen requirements than other fish. Shallows are significant also for waterfowl because worms, clams and rooted plants on the riverbottom are accessible to diving ducks.

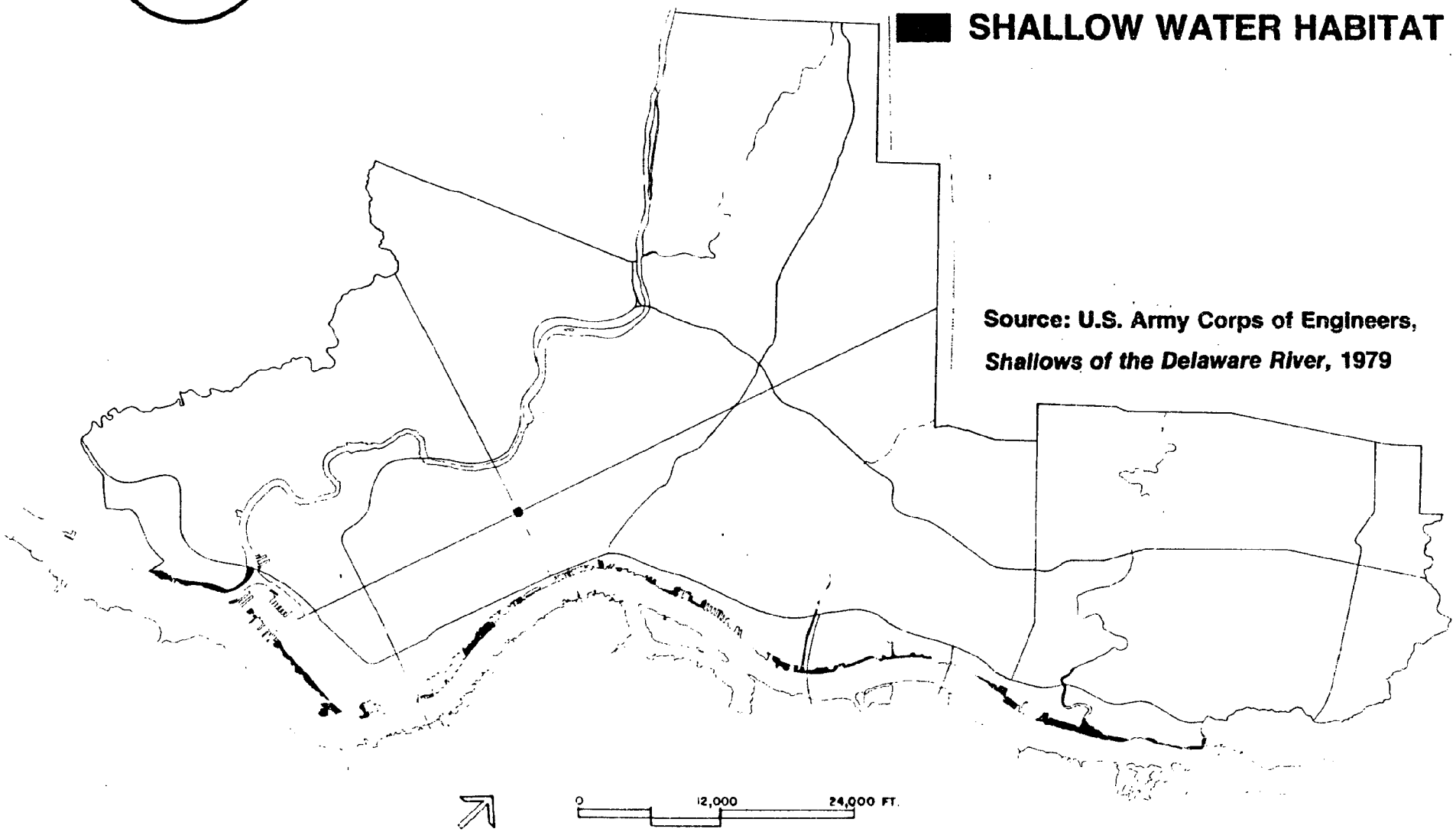
The Philadelphia's portion of the Delaware River does not have extensive shallow water habitats. The U. S. Army Corps of Engineers prepared the Shallows of the Delaware River, a study which mapped shallow areas and which provided a technical basis for regulations restricting future disturbance of shallow water habitats. The maps in the Corps' study show approximately 500 acres of shallow water areas along the Philadelphia riverfront (see Shallow Water Areas map). The survey identified in all about 4500 acres of shallows in the 54 mile stretch of estuary from the Delaware State line north to the falls at Trenton, on both the Pennsylvania and New Jersey sides of the river, and about 7500 acres in the lower estuary extending 20 miles downriver of the Delaware State line. On both sides of the river there has been a substantial loss of shallows over the last two centuries from bulkheading, dredging and pier construction. In Philadelphia alone there may have been between 5000 and 7000 acres of shallows at the time the settlers first arrived, but only about 10 percent of the original extent of shallows exists today.

Shallows in the Philadelphia area are principally in the stretch of riverfront north of the Betsy Ross Bridge. In this area, there is not extensive shipping activity churning up river bottom sediments, and there has never been extensive pier construction characteristic of the river closer to Central Philadelphia. The most extensive shallows today are at the mouth of Pennypack and Frankford Creeks, at the bend in the river at the Navy Yard and below the mouth of the Schuylkill River. Shallows have also become established between inactive piers, for example between Piers 56 and 76 South, along the South Philadelphia riverfront, and between Piers 69 to 96 North.

There have not been detailed studies of the ecology of Philadelphia's shallows. The only specific study was a survey of shallows and tidal flatlands prepared in connection with an application by the Port Corporation for a Section 10/404 permit from the U.S. Army Corps of Engineers to fill in 17 acres of submerged land as an extension of Tioga Marine Terminal. Even though this site is downstream of the Northeast Treatment Plant and is polluted, an aquatic biologist, Tom Lloyd, noted a high density of clams and worms, important food for many fish species, and a good population of killifish, a minnow-like, vegetarian fish which is a key species in the cycling of food in aquatic ecosystems. Many ducks were observed feeding on the dense worm population in this shallow area. Although the game fish populations were depressed in the Tioga Terminal area by low dissolved oxygen, improved water quality in the future will allow for a much greater fish population in this portion of the river.

Philadelphia's remaining shallow water habitat area will become increasingly important as water quality in the Delaware River improves. At present, low dissolved oxygen concentration is by far the principal reason for poor fish population characteristics along Philadelphia's riverfront. Projected improvements in dissolved oxygen during summer, from the current seasonal

SHALLOW WATER AREAS



average of 1.0 mg/l at the lowest point in the "sag" in significant areas of the river to a projected 2.3 mg/l, will permit the population of many game fish to rebound. By the late 1980s, the availability of suitable shallow water habitats may become the limiting factor in game fish populations in the Philadelphia area north of Penn Treaty Park. While several important species are migratory, like herring, shad and striped bass, and are not dependent on shallows areas, other game fish such as white and yellow perch, sunfish, largemouth bass and catfish, are dependent on shallows. These fish grow and breed close to where they hatch. In the future, when oxygen levels remain above critical concentrations year round, shallow water areas will become far better recreational fisheries than they are now through much of Philadelphia.

PROJECTIONS OF FUTURE FISHERY IMPROVEMENTS

The City's pollution abatement program have important effects on the Delaware Estuary fisheries. Although the federal Clean Water Act established in 1972 a national goal for fishable and swimmable waters for all waterways, swimming is not a viable goal for all of the Delaware Estuary. The principal objective set forth by regional and state agencies for the Philadelphia portion of the Delaware is to foster a healty resident fish population and to eliminate the block to the migration of anadromous fish. For Philadelphia residents, a greatly improved recreational fishery will be the primary benefit of the City's pollution abatement program. But commercial fisheries, over the long run, might also substantially improve, with the harvesting potential of shad, herring, spot, Atlantic menhaden, eel and blue crab being enhanced in the Delaware Bay and Estuary as a result of Philadelphia's pollution abatement.

Projections of future fish production and fishing opportunities can be made in very general terms for several sections of Philadelphia's Delaware River in part based on projections of future dissolved oxygen concentrations.

The water quality in the stretch between the Navy Yard and Penn Treaty Park may never reach DRBC's water quality objectives, and will not support a viable resident fish population. Even after pollution abatement projects have been completed, summer dissolved oxygen levels occasionally may fall close to zero, and the seasonal average may be below 2.5. These are not suitable oxygen levels for resident game fish. As a rule of thumb, the summer season dissolved oxygen concentrations should remain above 3.5 mg/l to support resident fish populations.

In the area between the Penn Treaty Park and the Tacony-Palmyra Bridge, fish populations should greatly improve (compare the map of Areas of Recreational Fishing to the map of Future Recreational Fishing Areas). While this area is polluted today, in the future water quality objectives for dissolved oxygen will be achieved during much of the year. The summer average dissolved oxygen will average between 3.5 mg/l and 6.0 mg/l, and only rarely will dissolved oxygen levels sink to 1.0 mg/l. Even though there will be periods of low oxygen stress during summer, resident fish population should increase several fold. Sunfish, catfish and white perch should occur in sufficient numbers to permit recreational fishing.

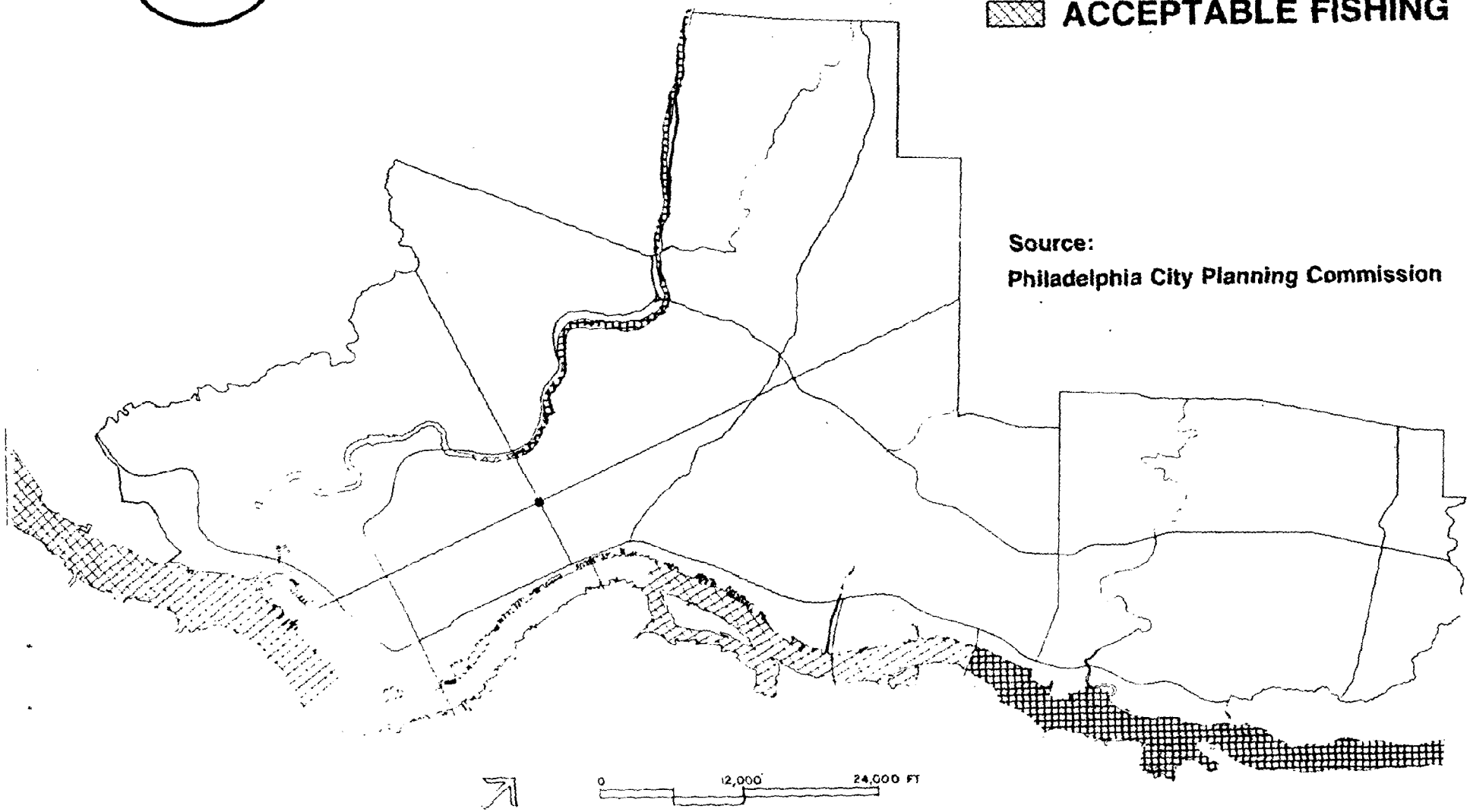
North of Tacony-Palmyra Bridge, recreational fishing will be exceptionally good. Summer average dissolved oxygen concentrations will exceed 6.0 mg/l and at no time during the year will dissolved oxygen concentrations fall to levels which are stressful to game fish. Fishing pressure by anglers far greater than now experienced in this portion of the riverfront can be sustained.

The U. S. Fish and Wildlife Service anticipates a several fold increase in the shad run in the Delaware River during spring. At present, a shad run during a season with favorable water quality conditions is 200,000 shad. The run, however, is shortened by the onset of low dissolved oxygen. A vigorous shad run is also impeded by high mortality of young shad during their migration to the ocean in fall. By the early 1990s, a shad run of one-half million is projected. This is the combined effect of improved water quality, and a concomitant breakdown of the oxygen block, and the establishment of vigorous shad spawning in the upstream reaches of the river. An

FUTURE RECREATIONAL FISHING AREAS

GOOD FISHING

ACCEPTABLE FISHING



Source:
Philadelphia City Planning Commission

improved shad fishery can be of economic importance by the turn of the century, as commercial catches could be sustained at levels a hundred times higher than present. Recreational fishing for shad could also be promoted in the Philadelphia area, even in those stretches of the river in which summer oxygen levels do not sustain game fish.

Several other game fish species may return to the Delaware Estuary when the pollution abatement program is completed. One popular fish is the walleye, a fish which averages about 2 pounds. This fish requires, as do shad, waters with high oxygen concentrations. The Pennsylvania Fish Commission recently recognized that water quality in the upper estuary had improved sufficiently to justify the stocking of walleye. The Commission has also stocked tiger muskellunge as a trophy fish; this species reaches 20 pounds when mature. The ultimate goal of fishery managers is the return of striped bass, a prime game fish averaging 20 pounds in weight in the Chesapeake and Lower Delaware Estuaries. These fish are rare in the Philadelphia portion of the estuary due to pollution, although they were once caught in the Philadelphia area. The attractiveness of the upper estuary as a game fishery will expand several fold when striped bass return. Finally, Atlantic sturgeon is a game and commercial fish which is the largest of fresh water fishes, averaging 5 to 10 feet in length and 100 to 300 pounds in weight when mature. Improved water conditions and low fishing pressure may lead to a return of the Delaware sturgeon fishery which was so prosperous in the 1880s and early 1890s.

WATER RESOURCE MANAGEMENT

Water resource managment of the Delaware and Schuylkill River consists of principally pollution control and fishery enhancement. The network of agencies and organizations involved with pollution abatement is complex and extensive because the responsibility for pollution control and water quality regulation is divided among many groups at local, regional, state and federal levels. Fishery management is principally a state responsibility, with the federal interest in the nation's fisheries represented by the U.S. Fish and Wildlife Service. These two areas of management concern, pollution abatement and fishery enhancement, are interconnected because the major driving force for improved recreational and commercial fisheries in the Delaware Estury is the basin's pollution abatement efforts.

POLLUTION ABATEMENT

Reduction of organic waste loads from municipally owned treatment plants is the single most important means of improving water quality in metropolitan areas. For the Delaware River near Philadelphia, four agencies are involved in pollution control: the federal Environmental Protection Agency (EPA), the Delaware River Basin Commission (DRBC), the Pennsylvania Department of Environmental Resources (DER) and the Philadelphia Water Department (PWD). In general terms, the DRBC established in the 1960s the amount of waste load reductions which the PWD had to achieve at the City's three sewage treatment plants through upgrading and expansion. The EPA, using funds appropriated by Congress in the federal Clean Water Act, awards construction grants to the DER, which in turn awards

grants to PWD and other municipalities to cover 75% of the cost of treatment plant construction. Both PWD and DRBC monitor water quality through regular sampling of the Delaware Estuary, PWD confining their samples mostly to the Philadelphia vicinity, while DRBC samples throughout the estuary.

The PWD is progressing with the upgrading and expansion of sewage treatment facilities. The Southwest Sewage Treatment Plant, located near the Philadelphia International Airport, was largely completed in June 1979 and is close to achieving mandated reductions in organic waste discharges. Site preparation is still underway at Southeast and Northeast Sewage Treatment Plants, with major portions of the Northeast facility under construction in 1981. The expected completion date for the Northeast facility is 1984. The Southeast's completion date is likely to be 1986. Full reductions in organic loads at Southeast will probably not be achieved until 1987 or 1988, as there is a year or longer lag between construction completion and optimum performance of waste treatment systems. Improvements to water quality are immediately observed when waste load reductions are accomplished.

Federal budget constraints are not likely to seriously disrupt the City's pollution abatement program. Federal priorities for pollution abatement are being directed to those water bodies in urban centers such as the Delaware River which are grossly polluted and to providing grants to those jurisdictions under which EPA is legally obligated to provide funds. It is likely that the 1979 consent decree signed by EPA and PWD will be modified to allow construction of the treatment facilities to proceed on a schedule compatible with the availability of EPA construction funds.

There is at present no expectation that the City's pollution abatement program will be terminated short of its completion nor that the City will be expected to bear a larger share of total project costs than the 25% for which it is currently responsible.

The pollution abatement program is expensive and will continue to cause major water and sewer rate increases for Philadelphia families. By the end of fiscal year 1981, $540 million in funds for pollution control will have been spent or obligated by the Water Department, and by 1987 an additional $300 to $400 million will be committed (75% of these funds are federal grants). The capital improvement program at the sewage treatment plants has been a major factor in water and sewer rate increases. In 1978, residential customers paid about $90 per year for water and sewer service. In 1980, this service cost $145 per year, and rates proposed for fiscal year 1982 would cause typical residential rates to increase to $210. It is possible that, by the conclusion of the $900 million pollution abatement program, residential customers will be paying $400 annually, a more than four-fold increase over rates prior to the pollution abatement program. The extraordinary increase in this utility bill could meet serious customer resistance and might constitute a significant burden on poor families and persons on fixed incomes. Unfortunately, these rate increases are not readily linked to noticeable improvements in water and sewer service, as the palatability of drinking water will not change perceptibly and river water quality improvements at present remotely benefit most water customers.

Despite the expensive pollution abatement program, water quality objectives are not likely to be achieved throughout Philadelphia's

Delaware Estuary. Dissolved oxygen levels in a six mile stretch of the Delaware River from the Navy Yard to Penn Treaty Park are likely to violate the DRBC's 3.5 mg/l minimum daily average standard during summer even after the City's pollution abatement program has been completed. Both north and south of the zone, the objective should be met consistently. The Schuylkill River from South Street to its confluence with the Delaware will probably continue to violate dissolved oxygen standards even if sewer overflow chambers are properly maintained.

In response to the inadequacy of earlier waste load allocations to achieve water quality objectives, the Delaware River Basin Commission has refined a water quality model of the Delaware Estuary which will permit them to assign new waste load allocations to dischargers in the estuary. This model will be validated in 1982 to produce profiles of dissolved oxygen which accurately reflect current conditions and then to generate predictions of future dissolved oxygen assuming compliance with existing waste load allocations. Upon the recommendations of advisory groups, DRBC staff have been directed to then study three alternatives: 1) reallocation to dischargers of waste loads necessary to meet existing dissolved oxygen standards, 2) reduction of waste loads necessary to achieve a higher objective of 4.0 mg/l minimum daily average dissolved oxygen in Zones 3 and 4, and 3) even further reduction in waste loads which would achieve the objective of never having dissolved oxygen concentrations fall below 4.0 mg/l, which is approximately equivalent to a minimum daily average concentration of 6.0 mg/l. The DRBC will not be considering the alternative of reducing the dissolved oxygen objective for that section of the Delaware River near Center City Philadelphia which is likely to continue violating standards after pollution abatement is completed.

DRBC's waste load reallocation process raises two serious questions for Philadelphia. First is whether Philadelphia can afford to upgrade the three sewage treatment plants to an even greater extent than is now planned. Although the City is committed to the current abatement program, public officials are likely to resist more restrictive effluent criteria requiring still further upgrading of sewage treatment plants. One of the major objections is that higher water and sewer rates would be burdensome to customers and, as service costs increase, they may make Philadelphia less economically competitive with other cities. Another reason is that the pollution abatement program has drawn needed capital away from improvements to drinking water filtration plants and the water supply distribution system. Many Water Department officials consider the drinking water supply component of the City's infrastructure to be in greater need of improvements to sustain acceptable service levels than water pollution control facilities.

The second question is whether the water chemistry and biology of the Delaware River is sufficiently well understood to justify pollution abatement beyond the current waste load allocations. DRBC's water quality models contain a significant amount of subjectivity. Because there are major gaps in scientific understanding of estuarine systems, professional judgments have had to be relied upon. One poorly understood aspect of water chemistry involves the conversion of ammonia nitrogen and organically-bound nitrogen to nitrate nitrogen in oxygenated waters. Water resource engineers have made some estimates of the ways

in which these nitrogen compounds create a demand for dissolved oxygen downstream of effluent discharges. Their expectation is that there will be quick chemical reactions which will create a serious sag in dissolved oxygen in the Philadelphia vicinity when microbes convert the several nitrogen compounds to nitrate. To reduce these nitrogen reactions and the oxygen sag that ensues, the City's pollution control plants would have to be outfitted with nitrification facilities for transforming ammonia to nitrate. While the cost of such facilities cannot be estimated precisely, they would probably cost several hundred million dollars. Water Department engineers argue that serious discussions about sewage treatment levels higher than those for which the facilities are currently designed should not occur until after the reaction of nitrogen in the Delaware Estuary can be studied with the current pollution abatement program complete. The DRBC, on the other hand, is already several years behind in refinements to waste load allocations mandated by federal regulations. The DRBC is expected to continue proceeding with their reallocation studies utilizing their best estimates of nitrogen chemistry.

The other scientific area not well understood is the projected response of the fisheries to improvements in water quality. There have not been sufficient surveys of the Delaware River fisheries in the vicinity of Philadelphia to establish fish population characteristics in the river. There are wide variations in dissolved oxygen from season to season, from day to day and even during the day. The DRBC models cannot yet predict these fluctuations with accuracy, nor can aquatic biologists predict how fish populations might react to these fluctuations. How fish respond to a minimum daily average of 3.5 mg/l in contrast to a "better" 4.0 mg/l or a "worse" 3.0 mg/l is not known for the estuary, yet the cost of achieving these standards may differ by hundreds of millions of dollars. On one hand, significant improvements to fish populations may prove to be accomplishable only by a degree of waste treatment which cannot be practicably applied to Philadelphia for technological and financial reasons. But instead it might be the case that a fish population can be maintained satisfactorily for much of the year even in those sections of Philadelphia's Central and South Delaware riverfront areas which are not expected to meet DRBC objectives after pollution abatement. A study of fishery response to the current pollution abatement program would be prudent before further abatement efforts are prescribed by regulatory agencies.

Besides conventional organic wasteloads from municipal facilities, other materials affecting water quality may be discharged to the rivers. The Pennsylvania DER and federal EPA have worked to control discharge of industrial wastewater to rivers and streams. All Philadelphia industries and utilities are apparently in compliance with applicable regulations. There has been some public concern that existing regulations do not adequately control discharge of organic chemicals and heavy metals. Although EPA is considering measures to improve industrial effluent regulations, the current climate of federal regulatory reform does not make additional controls likely in the near future.

There is, however, an elaborated and effective system for responding to accidential chemical spills at the riverfront. Within Philadelphia's port, oil, gas and chemical stocks arrive for processing and leave as export commodities, and it is the handling of these substances

near the riverfront which gives rise to the greatest potential for spills. For the Delaware and Schuylkill Estuaries, the U.S. Coast Guard has responsibility for coordinating emergency response efforts to clean up chemical spills. All coastal oil and chemical firms are associated in a cooperative effort to pool resources to respond with qualified personnel and proper equipment when spills occur in the rivers. The Coast Guard has a Chemical Hazard Response Information System (CHRIS) which provides information on proper techniques for safely handling and removing spilled chemicals.

As water quality in the Delaware River improves, a variety of new opportunities will be open to Philadelphians. Each of the Water Department's residential customers will be paying approximately a $250 premium annually for a cleaner Delaware River. There are, however, very few points along the river that residents may go to fish, boat or simply walk along the river. For much of the riverfront, the existing land use and ownership patterns reflect historic environmental conditions -- a foul smelling, unappealing place to live and play, suitable only for water-dependent utilities, maritime trade facilities and noxious industries. Pollution abatement in the early 1950s, however, eliminated the worst of the environmental problems, thereby contributing to opportunities for public urban renewal and private reinvestment in Society Hill, Old City and Queen Village.

The current round of pollution abatement signals fundamentally new opportunities for utilization of the riverfront. Opportunities to develop boat launches and fishing piers and to convert commercial piers to residential uses are widened dramatically by improvements to recreational fisheries, water quality and the river's aesthetic appeal. Because all residents of Philadelphia help pay for this relatively clean and attractive resource, recreational and residential access to the river should be developed to the maximum practicable extent and in a way which serves to expand the tax ratables affordable by riverfront properties. Along the northern stretch of riverfront, where there has already been significant improvements in water quality and where water quality objectives will be consistently met, recreational opportunities are particularly strong.

RIVER FLOW MANAGEMENT

Another important water resource management program in the Delaware River is the management of river flows as a way of achieving chloride standards. The Delaware River Basin Commission (DRBC) is responsible for managing the water resources of the Delaware River basin in a way which controls the salt line in the estuary. The principal reason for controlling the salt line is to prevent contamination of municipal and industrial water supplies by sea salts. In the 1960s, the DRBC determined that the chloride level should not exceed 250 milligrams per liter in the river above the Navy Yard. They further determined that this could be accomplished by ensuring a flow of 3000 cubic feet per second (or 1950 million gallons per day) at Trenton. Achieving the standard prevents contamination of groundwater aquifers and surface waters which serve Camden and several industries in this stretch of riverfront, and it also keeps chloride levels from exceeding 50 mg/l further upstream at Torresdale. A system of reservoirs in the Delaware Basin releases water during low flows in order to supplement normal flows. Unfortunately,

these reservoirs do not have sufficient capacity to release water at a rate necessary to achieve at all times the flow objective at Trenton. During drought periods, reservoirs must be heavily tapped to supply drinking water to New York City and northern New Jersey, and there is insufficient additional storage to help maintain flows.

A major finding of the DRBC "Level B" study is that the current chloride standard is more restrictive than need be to protect New Jersey water supplies. Relaxing the chloride standard would reduce the need to provide additional storage in the upper basin to supplement water flows. But the study further demonstrated that achieving the current chloride standard would require the maintenance of a flow much higher than the existing 3000 cfs objective. These two findings in effect cancel each other; even a relaxed chloride standard could only be achieved by a flow at or slightly exceeding the existing flow objective. The recommendations in the Level B study are that 5 dams with over 220,000 acre-feet of storage and a yield of about 750 cfs be built in the upper basin, enabling a minimum flow of 3,100 cfs be achieved at Trenton, and that the chloride standard be relaxed to 121 mg/l at river mile 98 (this is about 70% more chlorides than the current standard). These recommendations have not yet been adopted by the DRBC, in part because of ongoing, complex interstate discussions known as the "Good Faith" negotiations. The negotiations will one day lead to new, formal understandings among the parties concerned with the management of the basin's water supply as to maximum allowable diversions of water to New York City and to Northern New Jersey under different weather conditions -- normal, drought warning and drought. Chloride standards and flow objectives are an integral component of the negotiations. The Level B study also leaves open several other issues, most notably the construction of the controversial Tocks Island Dam after the turn of the next century and the modification of water quality standards to "maximize the fishery potential."

FISHERY ENHANCEMENT

In the Delaware Estuary, fishery management programs have been very limited, even though Pennsylvania, New Jersey, DRBC and the federal government each have had a role to play. There are currently no restrictions on the quantity of fish which can be harvested nor are there any fish stocking programs. The Pennsylvania Fish Commission has been the most active agency in the estuary. The estuary and the Schuylkill River are under the jurisdiction of the Area 6 Fishery Manager of the Pennsylvania Fish Commission. Although the Fish Commission has not performed current assessments of estuarine fisheries, there have been recent planning efforts, funded in part by Pennsylvania's Coastal Zone Mangement Program, recommending that three species be stocked in the estuary between the Tacony-Palmyra Bridge and Trenton Falls. These fish are the tiger muskellunge, walleye and striped bass. Recent improvements in water quality in this zone of the Delaware Estuary make the establishment of these game fish a good possibility. The Fish Commission has also been designing and programming for future construction boat launching facilities in Philadelphia and vicinity to permit greater access to the Delaware River for boaters and fishermen.

The other two fish management agencies, New Jersey's Bureau of Freshwater Fisheries and the U. S. Fish and Wildlife Service, are

involved in a joint Anadromous Fish Project. This project is principally the tagging and recapturing of shad during their spring migration up the Delaware River; this provides an annual shad count. Several research efforts are underway in conjunction with the shad count to determine the environmental requirements for successful shad restoration in the estuary. Also, the Bureau of Freshwater Fisheries will soon begin a study of the feasibility of introducing into the estuary the steelhead rainbow trout, a Pacific Coast anadromous fish, with an eye toward the development of a commercial fishery. At present, the only commercial fishery in the upper estuary is a small channel catfish operation in Riverside, New Jersey. (Several thousand shad are also taken in Lambertville, New Jersey, in the non-tidal portion of the Delaware.) If these trout were to become well established, they would offer an attractive recreational fishery as well as a commercial fishery.

Fisheries management on the Schuylkill River is more active than on the Delaware River. The Pennsylvania Fish Commission's Area 6 Fish Manager has prepared a management plan for Section 15, the stretch of river between Flat Rock Dam in Upper Roxborough and Fairmount Dam in Center City. The Commission has also begun work on a plan for Section 16, from Fairmount Dam downstream to the Delaware River. The most important recommendations in the plan for Section 15 are for: 1) the construction of a fish ladder at Flat Rock Dam, 2) the continued stocking of tiger muskellunge and walleye on a biannual basis, 3) periodic surveys of fish populations and tissue analyses to check for unacceptable levels of toxic substances, and 4) a prohibition on harvesting of shad, herring and alewife until their populations are better established.

The most significant fishery management project on Philadelphia's Schuylkill River to date is the Fairmount Fishway. The Pennsylvania Fish Commission conducted a 4-1/2 year feasibility study, completed in 1976, which concluded that shad, herring and and alewife could be successfully restored to the Schuylkill River if fishways were built at three dams along the Schuylkill River and if two unnecessary dams were removed. In November 1977, under the auspices of the City's Fairmount Park Commission, the $565,000 construction project for the Fairmount Fishway was begun. Dedicated in the spring of 1979, this fishway passed about 10 fish per hour during spring migration in 1979 and 1980. The fishway in 1981 apparently passed fish at even greater rates. Electrofishing surveys conducted by the Fish Commission in the fall of 1979 indicated a noticeably more diverse population of fish in the pool behind the Fairmount Dam than had been previously encountered, attributable to the success of this fishway.

The most significant fish management project planned for the Schuylkill will be a fish ladder at Flat Rock Dam. The Fish Commission has been urging strongly for DER to program funds for a fishway at the state-owned dam in Upper Roxborough. The proposed $800,000 fishway apparently has not been given high priority by DER in their capital program. But the value of the existing Fairmount Fishway cannot be fully realized until after the Flat Rock project is completed and modifications are made to the several other upstream dams.

The Fish Commission is currently working on a plan for the Schuylkill River downstream of Fairmount Dam. In August 1981, fish surveys were conducted in this stretch of the river. Serious pollution and low dissolved

oxygen were encountered which severely restrict fish populations downstream of Market Street Bridge. The correction of malfunctioning sewer overflow chambers and their regular maintenance would be an important contribution to reducing pollution. This source of contamination was highly visible to the Fishery Manager during his survey work.

The value of Philadelphia's fishery as a food source for the families of fishermen has not been assessed because of a lack of information on the edibility of the fish. Because the Delaware and Schuylkill rivers are widely regarded as industrialized rivers, there is a widespread presumption that fish in these waters are tainted by heavy metals and organic compounds. There have been, however, no regular analyses of fish flesh for concentrations of exotic substances in excess of standards set by EPA and the Food and Drug Administration. A study has been recently completed by the U.S. Geologic Survey of the presence of pesticides and other organic substances in Schuylkill River fish, but the results of this study were not yet available as of fall 1981. Water quality standards for aluminum, nickel, zinc and copper have not been set by the state DER because elaborate bioassay studies have not been performed to determine the toxicity of these metals to fish. The acceptability of fish for human consumption as well as the viability of the fishery may prove dependent on compliance with these standards. For these reasons, bioassay studies and fish flesh analyses are necessary to evaluate the potential of the Delaware and Schuylkill Rivers to be "harvested" as a food source.

SHALLOW AREA PROTECTION AND MANAGEMENT

Protection of shallow water habitats from unwarranted disturbance is a major objective of federal environmental laws and regulations. The Federal Clean Water Act established shallows protection as a means of preserving important aquatic habitats. This law established the Section 404 permit program, administered by the U.S. Army Corps of Engineers, to regulate fill activities and the discharge of dredge material in navigable waters. The protection of shallows is presumed to be in the nation's interest and to take priority over most filling and dredging activity. The kinds of activities for which fill in shallows is acceptable are those which serve a broad public interest and which support water-dependent uses requiring a riverfront location. Most marine commerce activities fit these criteria; residential development would not generally be acceptable if it were to require fill within shallow areas. Reuse or reconstruction of piers, as long as a substantial modification of the river bottom is not proposed, is not considered to be a fill activity requiring a Section 404 permit.

Not all shallows along Philadelphia's riverfront are of equal importance as aquatic habitats. Currently, those shallows downriver of the Tacony-Palymra Bridge probably do not function to their full potential as aquatic habitats because during much of the summer dissolved oxgen concentrations are too low to support a viable resident fish population. The City's pollution abatement program at the three sewage treatment plants will alleviate the dissolved oxygen "sag" to a great degree. But seriously low oxygen concentrations will exist even after the sewage treatment plants are upgraded for that stretch of the Delaware between Penn Treaty Park at river mile 101

downriver to the Navy Yard at river mile 95. Disturbance of shallows in this portion of the river would not have as serious an environmental impact as would disturbance in less polluted sections of the river which do sustain resident fish. For this reason, protection of shallows along stretches of riverfront projected to remain polluted in the future should not be accorded as high priority as protection of shallows where the water will sustain viable fisheries.

Crea tion of artifical shallows could benefit fisheries in the Philadelphia area. There are several long stretches of riverfront north of Tacony-Palymra Bridge in which there are no substantial shallows areas. These areas could benefit from the creation of shallow water habitats which would serve as nursery and feeding area for many kinds of fish. Creation of shallows, as explained later in the recommendations chapter, does not entail unusual or expensive kinds of engineering work. A submerged bulkhead could be installed several hundred feet off shore, backfilled with material dredged from the river bottom and planted with native aquatic vegetation. Corps of Engineers staff are available to assist in the design and implementation of projects to create artifical shallows.

Shallow creation may be of importance to applicants for Section 404 permits. The U.S. Army Corp of Engineers, along with the federal Environmental Protection Agency, the U.S. Fish and Wildlife Service and Pennsylvania Fish Commission, have begun to reach a concensus that an unavoidable loss of shallows at one location could be mitigated through replacement with artificially created shallows elsewhere, perhaps with a 1.5 acre replacement shallows for each acre of original shallows lost. If replacement shallows in zones of good water quality are substituted for shallows in polluted waters, the value of the artificially created shallows may prove to be substantially greater than that of the original shallows. If this policy were adopted by the regulatory and review agencies, shallows creation could become an important management technique by which Section 404 permit applicants can successfully obtain permits for fill activities.

TABLE 10: SUMMARY OF DRINKING WATER QUALITY, 1979 (1)

Parameter	Standard (2)	Belmont Plant Effluent	Queen Lane Plant Effluent	Torresdale Plant Effluent
Arsenic	0.05	0.003	0.001	0.002
Barium	1.0	0.06	0.08	0.06
Cadmium	0.010	0.001	0.001	0.001
Chromium	0.05	0.001	0.003	0.002
Lead	0.05	0.001	0.001	0.001
Mercury	0.002	0.0002	0.0001	0.0005
Nitrate (as N)	10.00	1.94	2.20	0.75
Selenium	0.01	0.001	0.001	0.001
Silver	0.05	0.001	0.001	0.001
Fluoride	1.8	0.95	0.85	1.05
Pesticides				
Endrin	0.0002	0.00001	0.00001	0.00001
Lindane	0.004	0.00001	0.00001	0.00001
Methoxychlor	0.1	0.00001	0.00001	0.00001
Toxaphene	0.005	0.001	0.001	0.001
2, 4-D	0.1	0.00006	0.00068	0.00002
2, 4, 5-TP	0.01	0.00003	0.00011	0.000005
Turbidity Units (Formazin)	1.000 T.U.	0.34	0.24	0.31
Coliform Colonies Bacterial/100 ml	0.01	0.00	0.00	0.01
Gross Beta Activity Pico Curies/Liter	50 pC/l	8.4	9.4	9.9
Strontium 90	8 pC/l	2.7	1.6	1.4
Tritium	20,000 pCl	880.0	880.0	563.0

NOTES:

(1) USEPA, Safe Drinking Water Act, Public Law 93-523.

(2) All units are in milligrams per liter (mg/l) unless otherwise specified.

SOURCE: Philadelphia Water Department, in Water and Sewer Revenue Bonds, Sixth Series, April 1980.

TABLE 11: COMPARISON OF DELAWARE ESTUARY STANDARDS TO WATER QUALITY CONDITIONS (1)

STANDARD	CRITERION (2)	Average Concentration (Standard Deviation) Minimum - Maximum Values		
		ZONE 2	ZONE 3	ZONE 4
Aluminum	Not to exceed 0.1 mg/l of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	.36 (.20) .14-.90	.32(.18) .07-.90	No Data
Alkalinity	Equal to or greater than 20 mg/l as $CaCO_3$, except where natural conditions are less. Where discharges are to waters with 20 mg/l or less alkalinity, the discharge should not further reduce the alkalinity of the receiving waters.	32(10) 12-52	33(10) 11-58	31(8) 14-51
Arsenic	Not exceed 0.05 mg/l.	No Data	No Data	No Data
Bacteria (3)	During the swimming season (May 1 through September 30), the fecal coliform level shall not exceed a geometric mean of 200 per 100 milliliters (ml) based on five consecutive samples, each sample collected on different days; for the remainder of the year, the fecal coliform level shall not exceed a geometric mean of 2000 per 100 ml based on five consecutive samples collected on different days.	238 6-10,000	4619 20-200,000	10,809 800-900,000
Chloride	Zone 2 - Maximum 15 day mean 50 mg/l Zone 3 - Not more than 200 mg/l Zone 4 - Not more than 250 mg/l	13(4) 4-23	15(6) 4-62	23(14) 7-124
Chromium	Not to exceed 0.05 mg/l as hexavalent chromium.	.004(.002) .000-.013	.003(.002) .000-.012	.012(.006) .005-.016

TABLE 11 (Continued)

STANDARD	CRITERION	Average Concentration (Standard Deviation) Minimum - Maximum Values		
		ZONE 2	ZONE 3	ZONE 4
Copper	Not to exceed 0.1 mg/l.	.014(.007) .003-.039	.017(.015) .002-.175	.037(.027) .011-.065
Cyanide	Not to exceed 0.005 mg/l as free cyanide (HCN+CN-)	No Data	No Data	No Data
Dissolved Oxygen	Zone 2 - Minimum daily average not less than 5.0 mg/l; Zones 3 & 4 - minimum daily average not less than 3.5 mg/l.	6.1 (1.2) 3.7-8.5	3.3(2.2) .1-8.1	1.2(.6) .3-2.7
	During periods 4/1-6/15 and 9/16-12/31 not less than 6.5 mg/l as a seasonal average.	9.3 4.5-13.5	7.9 .2-13.9	5.4 .2-11.8
Fluoride (4)	Not to exceed 2.0 mg/l.	No Data	No Data	.14 .05-.24
Iron	Not to exceed 1.5 mg/l as total iron; not to exceed 0.3 mg/l as dissolved iron.	.63(.65) .16-5.00	.63(.55) .12-4.39	No Data
Lead	Not to exceed the lesser of 0.05 mg/l or 0.01 of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	.007(.005) .001-.037	.008(.009) .000-.117	.005(.002) .004-.008
Manganese	Not to exceed 1.0 mg/l.	.09(.07) .02-.44	.09(.05) .02-.41	No Data
Nickel	Not to exceed 0.01 of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	.01(.00) .00-.02	.01(.00) .00-.05	No Data

TABLE 11 (Continued)

STANDARD	CRITERION	Average Concentration (Standard Deviation) Minimum - Maximum Values		
		ZONE 2	ZONE 3	ZONE 4
Nitrite Plus Nitrate	Not to exceed 10 mg/l as nitrogen.	1.11(.38) .03-2.07	1.11(.36) .02-2.40	1.19(.37) .02-2.31
pH	Not less than 6.5 and not more than 8.5.	7.1 6.0-7.8	6.9 5.7-7.8	6.6 6.2-7.2
Phenolics	Zone 2 & 3 - Not to exceed 0.005 mg/l Zone 4 - Maximum 0.02 mg/l.	.001(.002) .000-.015	.003(.004) .000-.050	.002(.002) .000-.015
Sulfates (4)	Not to exceed 250 mg/l.	No Data	No Data	20 10-34
Threshold Odor Number (4)	Not more than 24 at 60°C.	No Data	No Data	18 14-25
Total Dissolved Solids (4)	Zone 2 & 3 - Not to exceed 133% of ambient stream concentrations or 500 mg/l, whichever is less. Zone 4 - Not to exceed 133% of ambient stream concentrations.	No Data	No Data	111 54-179
Turbidity	Maximum monthly mean of 40 NTU, maximum value not more than 150 NTU.	9(16) 2-205	8(12) 1-220	31(8) 14-51
Zinc	Not to exceed 0.01 of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	.04(.04) .00-.30	.04(.02) .00-.17	.05(.02) .03-.07

TABLE 11 (Continued)

NOTES

1 Data is from Philadelphia Water Department boat runs January 1, 1976 to December 31, 1980; only those sampling sites from within Philadelphia are included in the statistics. All concentrations. except for pH, turbidity, threshold odor number and fecal coliform are in milligrams per liter, which is the same as parts per million.

2 SOURCE: Pennsylvania Department of Envioronmental Resources. "Rules and Regulations - Title 25; Sub-part C - Protection of Natural Resources: Article II - Water Resources; Chapter 93 - Water Quality Criteria," revised, March 4, 1978, Harrisburg, PA.

3 Fecal Coliform values in this table are for the period 6-16 to 9-15, rather than the 5-1 to 9-30 period specified in the regulations.

4 Data for fluoride, sulfate and total dissolved solids was obtained from the Philadelphia Water Department, Torresdale Quality Control Laboratory's raw water quality report for fiscal 1980. Threshold Odor Number was supplied by the plant engineer at Torresdale filter plant and is the annual average of monthly averages for calendar year 1980 and the average of monthy maximum and minimum values.

TABLE 12: COMPARISON OF SCHUYLKILL RIVER STANDARDS TO WATER QUALITY CONDITIONS

STANDARD	CRITERION (1)	AVERAGE (Range) (2) (milligrams/liter)
Aluminum	Not to exceed 0.1 mg/1 of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	0.15 (.06-.25) (filterable aluminum)
Alkalinity	Equal to or greater than 20 mg/1 as $CaCO_3$, except where natural conditions are less. Where discharges are to waters with 20 mg/1 or less alkalinity, the discharge should not further reduce the alkalinity of the receiving waters.	81 (41-125)
Arsenic	Not exceed 0.05 mg/1.	No Data
Bacteria	During the swimming season (May 1 through September 30), the fecal coliform level shall not exceed a geometric mean of 200 per 100 milliliters (ml) based on five consecutive samples, each sample collected on different days; for the remainder of the year, the fecal coliform level shall not exceed a geometric mean of 2000 per 100 ml based on five consecutive samples collected on different days.	No Data
Chromium	Not to exceed 0.05 mg/1 as hexavalent chromium.	.003 (.001-.006)
Copper	Not to exceed 0.1 mg/1.	.015 (.000-.040)
Cyanide	Not to exceed 0.005 mg/1 as free cyanide (HCN+CN-)	.0005 (.000-.0010)

TABLE 12 (Continued)

STANDARD	CRITERION	AVERAGE (Range)(2)
Dissolved Oxygen	Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l. For the epilimnion of lakes, ponds and impoundments, minimum daily average of 5.0 mg/l., no value less than 4.0 mg/l.	10.2 (5.5-15.5)
Fluoride	Not to exceed 2.0 mg/l.	.25 (.16-.38)
Iron	Not to exceed 1.5 mg/l as tota iron; not to exceed 0.3 mg/l as dissolved iron.	.36 (.06-1.46) total .10 (.00-.14) filterable
Lead	Not to exceed the lesser of 0.05 mg/l or 0.01 of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	.01 (.003-.029)
Manganese	Not to exceed 1.0 mg/l.	.08 (.00-.19) filterable
Nickel	Not to exceed 0.01 of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	No Data
Nitrite Plus Nitrate	Not to exceed 10 mg/l as nitrogen.	3.1 (1.53-4.41)
pH	Not less than 6.0 and not more than 9.0	7.7 (7.0-8.4)
Phenolics	Not to exceed 0.005 mg/l.	.002 (.000-.008)

TABLE 12 (Continued)

STANDARD	CRITERION	AVERAGE (Range)(2)
Total Dissolved Solids	Not more than 500 mg/l as a monthly average value; not more than 750 mg/l at any time.	300 (164-434)
Zinc	Not to exceed 0.01 of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	.09 (.00-.30)
Temperature	No rise when ambient temperature is 87°For above; not more than a 5°F above ambient temperature until stream temperature reaches 87°F; not to be changed by more than 2°F during any one-hour period.	No Data

NOTES: (1) Pennsylvania Department of Environmental Resources. "Rules and Regulations-Title 25; Sub-part C-Protection of Natural Resources; Article II-Water Resources; Chapter 93-Water Quality Criteria," September 2, 1974, Harrisburg, PA.

(2) Philadelphia Water Department, Treatment Section, Quality Control and Research Division, Samples for July 1980 to March 1981, Belmont and Queen Lane Treatment Plants. The average given above are the mean of monthly average concentrations in milligrams per liter; the range is the minimum and maximum values of all samples reported for this 9 month period.

TABLE 13: CHARACTERISTICS OF FISH IN THE DELAWARE AND SCHUYLKILL RIVERS

Fish Classification	Size	Anadromous	Pollution Tolerance	Game Fish	Shallows Dependency	ABUNDANCE			
						Schuylkill	Delaware-Zone 2	Delaware-Zone 3	Delaware-Zone 4
Family-Freshwater Catfish									
White Catfish	2	No	H	Yes*	H	C	C	C	U
Yellow Bullhead	1	No	H	Yes	H	U	U	R	R
Brown Bullhead	1	No	H	Yes	H	A	A	C	C
Channel Catfish	2	No	H	Yes*	H	C	C	C	U
Family-Killifish									
Banded Killifish	.2	No	H	No	H	U	A	A	A
Mummichog	.2	No	H	No	H	U	A	A	A
Family-Silverside									
Tidewater Silverside	.2	No	L	No	H	R	U	U	U
Family-Stickleback									
Threespine Stickleback	.5	No	L	No	H	R	R	R	R
Fourspine Stickleback	.5	No	L	No	H	R	R	R	R
Family-Temperate Bass									
White Perch	1	Semi-	M	Yes*	M	A	A	C	C
Striped Bass	2	Yes	L	Yes*	M	R	U	R	R
Family-Sunfish									
Redbreast Sunfish	.5	No	M	Yes	H	A	U	U	U
Green Sunfish	.5	No	M	Yes	H	C	U	U	U
Pumpkinseed	.5	No	M	Yes*	H	A	C	C	C
Bluegill	.5	No	M	Yes	H	A	C	C	C
Smallmouth Bass	1	No	L	Yes*	H	A	U	R	R

TABLE 13 (Continued)

Fish Classification	Size	Anadromous	Pollution Tolerance	Game Fish	Shallows Dependency	ABUNDANCE			
						Schuylkill	Delaware-Zone 2	Delaware-Zone 3	Delaware-Zone 4
Family-Sunfish (cont.)									
Largemouth Bass	1	No	L	Yes	H	A	C	U	U
White Crappie	.5	No	L	Yes*	M	U	U	U	R
Black Crappie	.5	No	L	Yes*	M	C	U	U	R
Family-Freshwater Eel									
American Eel	2	No	M	No	M	U	C	C	C
Family-Herring									
Blueback Herring	1	Yes	L	Yes/No	L	C (tidal)	A	C	C
Alewife	1	Yes	L	Yes/No	L	C	A	C	C
American Shad	2	Yes	L	Yes*	L	U	C	U	U
Gizzard Shad	1	Yes	L	Yes	L	C	C	U	U
Family-Pike									
Muskellunge	3	No	L	Yes*	L	U	R	R	R
Chain Pickerel	3	No	L	Yes	L	R	U	R	R
Family-Minnow									
Goldfish	1	No	M	No	M	A	C	U	U
Carp	1	No	M	Yes/No	M	A	C	C	C
Silvery Minnow	.3	No	H	No	H	U	A	A	A
Golden Shiner	.3	No	L	No	H	A	C	U	U
Comely Shiner	.3	No	L	No	H	U	U	U	U
Satinfin Shiner	.3	No	L	No	H	C	C	C	C
Common Shiner	.3	No	L	No	H	R	U	U	U
Spottail Shiner	.3	No	M	No	H	A	A	C	C
Swallowtail Shiner	.3	No	L	No	H	U	U	U	U
Spotfin Shiner	.3	No	M	No	H	C	U	U	U
Fathead Minnow	.3	No	L	No	H	R	U	U	U

TABLE 13 (Continued)

Fish Classification	Size	Anadromous	Pollution Tolerance	Game Fish	Shallows Dependency	ABUNDANCE			
						Schuylkill	Delaware-Zone 2	Delaware-Zone 3	Delaware-Zone 4
Family-Sucker									
White Sucker	2	No	H	Yes/No	M	A	C	U	U
Family-Perch									
Yellow Perch	1	No	L	Yes	M	C	U	R	R
Walleye	2	No	L	Yes*	M	U	R	R	R
Tessellated Darter	1	No	L	Yes	M	U	C	R	R

KEY:

Size - size, in feet, of adult fish

Andromous - Yes, means fish migrate from salt to freshwater to spawn. The American eel is catadromous in that it migrates to the ocean to spawn.

Pollution Tolerance - H - High Tolerance;
M - Moderate Tolerance
L - Low Pollution Tolerance

Game Fish - Yes, fish species is commonly sought for sport. Yes* indicates a particularly desirable sport fish. No, fish is not a sport fish.

Shallows Dependency - High - fish spends most of life in shallows;
Moderate - a portion of the fish's life is spent in shallows or fish feeds frequently in shallows;
Low - Fish is seldom encountered in shallows area.

Abundance - Based on fish surveys, a comparison of relative proportion of total fish population represented by each species. A - Abundant; C - Common; U - Uncommon; R - Rare.

SOURCES: John Tyrawski, Shallows of the Delaware River, March 1979. Paul Harmon, "Abundance and Distribution of fish in the Schuylkill River," Proceedings of the Schuylkill River Symposium, September 24 and 25, 1980, pp. 90-91. Interview with Michael Kaufman, Area 6 Fishery Managager, Pennsylvania Fish Commission.

TABLE 14: SUMMARY OF DELAWARE RIVER FISH SURVEY, 1973

Location River Mile	Trenton RM 127-131	Bristol RM 114-118	Bridesburg RM 104-108	Philadelphia RM 88-97	Chester RM 81-86	Total All Stations	Percentage each Species of Total Catch	Rank
No. Species	13	16	13	10	14	21		
No. Specimens	3899	7920	2217	365	642	15043		
No. Collections	156	159	180	180	171	843		
Species								
Blueback Herring	678	3670	1425	158	427	6358	42.3	1
White Perch	1533	2578	367	43	71	4592	30.5	2
Spottail Shiner	1032	132	27	4	1	1196	8.0	3
Channel Catfish	53	862	40	0	0	955	6.3	4
White Catfish	420	275	82	1	2	780	5.2	5
Alewife	66	241	85	57	2	451	3.0	6
Silvery Minnow	19	34	6	85	110	254	1.9	7
American Eeel	8	14	176	8	5	211	1.4	8
Brown Bullhead	73	13	1	1	12	100	0.7	9
Bluegill	0	74	0	0	4	78	0.5	10
Johnny Darter	11	10	1	0	0	22	0.1	11
American Shad	4	9	0	2	0	15	*	12
Striped Bass	0	1	3	0	4	8	*	13
Mummichog	0	0	0	6	1	7	*	14
White Sucker	0	5	0	0	0	5	*	15
Gizzard Shad	1	0	2	0	1	4	*	16
Banded Killifish	0	0	2	0	1	3	*	17
Largemouth Bass	0	1	0	0	0	1	*	18
Fallfish	1	0	0	0	0	1	*	18
Carp	0	0	0	0	1	1	*	18
Golden Shiner	0	1	0	0	0	1	*	18

* - Less than one-tenth percent

SOURCE: From U. S. Fish and Wildlife Service, Anadromous Fish Project, "Progress Report: 1973, (Mimeo)."

TABLE 15: COMPARISON OF FISH SURVEYS AT TWO DIFFERENT SAMPLING AREAS

	Poor Water Quality River Mile 82.0-87.5 Chester-Little Tinicum Island			Good Water Quality - River Mile 115-120 Croydon-Bristol Area		
	Total	Rank	% Total Catch	Total	Rank	Total Catch
No. Species	36	-	-	36	-	-
No. Specimens	7484	-	-	17,686	-	-
No. Collections	181	-	-	901	-	-
Blueback Herring	72	6	1.0	3,782	1	21.38
White Perch	33	10	0.4	3,349	2	18.93
Spottail Shiner	35	10	0.4	3,182	3	17.98
Mummichog	3220	1	43.0	2,186	4	12.35
Silvery Minnow	1527	3	20.4	1,569	5	8.87
Banded Killifish	1597	2	21.3	1,277	6	7.21
River Herrings	-		0	597	7	3.37
Alewife	41	10	0.5	597	8	3.37
Satinfin Shiner	104	5	1.4	283	9	1.59
Channel Catfish	0		0	240	10	1.35
White Catfish	20	1	0.3	92	11	.50
White Sucker	1	14	+	90	12	.50
Golder Shiner	10	13	0.1	72	13	.40
American Eel	33	10	0.4	76	14	.40
Bluegill	36	10	0.4	67	15	.30
Brown Bullhead	59	7	0.1	48	16	.27
Tassellated Darter	0		0	44	17	.20
Swallowtail Shiner	31	10	0.4	26	18	.10
Carp	37	9	0.5	17	19	.10
Pumpkinseed	493	4	6.6	16	20	.09
American Shad	0		0	13	21	.07
Spotfin Shiner	11	13	0.1	11	22	.06
Striped Bass	0		0	10	23	.05
Gizzard Shad	1	14	+	8	24	.04
Largemouth Bass	42	8	0.6	7	25	.03
Goldfish	14	12	0.2	4	26	.02
Black Crappie	10	13	0.1	4	26	.

TABLE 15: (Continued)

	Poor Water Quality River Mile 82.0-87.5			Good Water Quality - River Mile 115-120		
		Rank	% Total Catch	Total	Rank	Total Catch
White Crappie	2	14	+	3	27	0.01
Comely Shiner	0		0	2	28	0.01
Redbreast Sunfish	3	14	+	2	28	0.01
Sea Lamprey	0	-	0	1	29	*
Chain Pickerel	0	-	0	1	29	*
Fallfish	1	14	+	1	29	*
Creek Chubsucker	1	14	+	1	29	*
Tidewater Silverside	15	12	0.2	1	29	*
Fourspine Stickleback	2	14	+	1	29	*
Green Sunfish	14	12	0.2	1	29	*
Smallmouth Bass	1	12	+	0	-	-
Spotfin Shiner	11	13	0.1	0	-	-
Fathead Minnow	6	13	0.1	0	-	-

* Less than 0.005%

SOURCE: Army Corps of Engineers, "Shallows of the Delaware River," March, 1979; River Mile 82.0-87.5 is from Potter, et. al. 1974, Jan.-Dec. 1973 sampling; River Mile 115 -120 is from Chase, 1974, collection from 1972.

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MAP NOTES (CHAPTER IV)

Water Withdrawers

SOURCE: Commonwealth of Pennsylvania. 1978. Pennsylvania Coastal Zone Management Program Technical Record. Harrisburg: Office of Resources Management, Department of Environmental Resources. (Updated 1981 through phone interview with Norristown regional office of Department of Environmental Resources.)

Wastewater Dischargers

SOURCE: Delaware Valley Regional Planning Commission. 1978. COWAMP/208 Water Quality Management Plant, Southeastern Pennsylvania. Philadelphia: Delaware Valley Regional Planning Commission.

Riverfront Recreation

SOURCE: Philadelphia City Planning Commission survey, 1981.

DRBC Zones and River Mile Index

SOURCE: U. S. Army Corps of Engineers. 1979. Shallows of the Delaware River.

Dissolved Oxygen Violations, 1970-1974

SOURCE: Pence, Michael. 1981. Computer-generated summaries of Philadelphia Water Department's water quality data base.

Dissolved Oxygen Violations, 1980

SOURCE: Pence, Michael. 1981. Computer-generated summaries of Philadelphia Water Department's water quality data base.

Projected Dissolved Oxygen Violations

SOURCE: Philadelphia City Planning Commission interpretation of Environmental Protection Agency's 1973 study of dissolved oxygen in the Delaware Estuary.

Areas of Recreational Fishing

"Good Fishing" areas are those water bodies in which summer average dissolved oxygen concentrations exceed 6.0 milligrams per liter.

"Acceptable Fishing" areas have summer average disolved oxygen concentrations between 3.5 to 6.0 milligrams per liter. The best fishing would be in spring and fall; low dissolved oxygen may interfere with fishing in summer.

SOURCE: These areas are Planning Commission interpretations of water quality data provided by the Philadelphia Water Department.

Shallow Water Areas

SOURCE: Tyrawski, John M. 1979. Shallows of the Delaware River. Trenton, New Jersey to Reedy Point, Delaware. Philadelphia: Philadelphia District, U. S. Army Corps of Engineers.

Future Recreational Fishing Area

(See Notes and SOURCE on back of Areas of Recreational Fishing map.)

ENVIRONMENTAL FEATURES AND AMENITIES

The tidal Delaware and Schuylkill riverfronts have few areas with natural, vegetative cover, while in contrast the non-tidal Schuylkill riverfront is predominantly devoted to parkland. The Delaware and lower Schuylkill have been subject to three centuries of bulkheading, filling, pier construction and other kinds of shoreline modifications. There are no lands along the rivers which retain shoreline characteristics which originally existed in pre-Colonial times. The character of today's riverfront lands is reviewed below, working northward along the Delaware Estuary to Poquessing Creek and then along the Schuylkill River from Upper Roxborough downriver to Fairmount Dam.

LOWER SCHUYLKILL RIVERFRONT

The Lower Schuylkill riverfront consists of lands in the vicinity of the tidal Schuylkill River and along the Delaware River south of the Walt Whitman Bridge. This area includes Tinicum Marsh, the Eastwick Neighborhood Improvement Area, Philadelphia International Airport, the U.S. Navy Yard and the future Schuylkill River Park.

There are vast contrasts in land conditions in the lower estuary area. This stretch of riverfront contains some of the most environmentally significant areas of Philadelphia's riverfront. There are hundreds of acres of open fields and wetlands which provide diverse and productive habitats for small mammals and a wide variety of birds. Yet there are many activities serving essential regional functions such as the International Airport, auto junkyards, a landfill, dredge spoil disposal areas, refineries, petroleum storage areas, industrial parks and a sewage treatment plant. Some of these uses have the potential for causing serious environmental impacts.

The lower Schuylkill area provides several unique habitats for birds. Some are well known, like Tinicum Marsh, while others are not usually regarded as bird habitats, such as dredge spoil disposal areas and sludge lagoons. One of the most significant habitats is Tinicum Marsh, one of the two areas in the lower estuary listed in the recently published book Birding in the Delaware Valley. Virtually every bird identified in the Delaware Valley at one time or another has been spotted at Tinicum, and the bird list for this site contains 271 species. The Tinicum National Environmental Center is a wildlife habitat of special importance to the northeastern United States. There has been extensive loss of freshwater wetlands throughout this corner of the United States. This loss has depressed the populations of waterfowl favoring freshwater wetlands. At one time, most of the Eastwick area was habitat for these birds. But over the years, landfilling with garbage and construction debris has decimated freshwater wetlands. Tinicum remains as one of the critical freshwater wetlands in this section of the country.

The second most important bird habitat, also listed in Birding in the Delaware Valley, is the Philadelphia International Airport area. The airport, because of its wet grassland condition and its security from unauthorized human intrusion, attracts a variety of unusual birds which are rarely seen in the Delaware Valley. These rare birds, which are regular winter residents of the airport, are the short-eared owl, snowy owl, upland plover, snowy bunting and lapland longspur.

Near the airport are the sludge lagoons of the City's Southwest Sewage Treatment Plant and the U.S. Army Corps of Engineer's spoil disposal basins. Both of these facilities are unintentional but important bird habitats. With the permission of the City's Water Department, a birdwatcher has been regularly surveying bird species utilizing the lagoons. Although a bird list has not yet been compiled for the lagoons, birds uncommon to the Delaware Valley have been spotted, including the European little gull and the Hudsonian godwit. Although the Corps' spoil disposal basin is a freshwater basin, the cycles of inundation and desiccation in the basin arising from the periodic nature of dredging activities make the basin an unstable habitat subject to wide fluctuations in waterfowl populations.

There are major land areas which provide upland bird habitats. Many areas of former marshland have been filled and have become covered with weeds, shrubs and trees which are habitats for upland ground and song birds. These kinds of habitats are common to parklands in Philadelphia and suburban areas of the Delaware Valley and are not as unique as those wetland habitats attracting waterfowl.

The expansive areas of fields and wetlands also support a variety of wildlife. Mice, rabbits and muskrat are probably the most abundant mammals, but opossum, skunk and raccoon are also probably numerous. Snapper turtles are known to inhabit the dredge spoil basins. A field between the dredge basins and the City's sludge disposal area is an apiary for commercial honey production.

The lower Schuylkill River has a variety of social resources. The Tinicum National Environmental Center is a wetland managed by the federal Department of Interior as an education center and wildlife reserve. Bartram's Garden Park on the Schuylkill River is a national historic landmark consisting of the homestead of naturalist John Bartram, with an herb and flower garden and an arboretum surrounding the several colonial buildings. The John Bartram Association sponsors an environmental education program for neighboring communities. Fort Mifflin, the fort which protected the port of Philadelphia during Colonial times, is an historical landmark open to the public and offering a beautiful view of the Delaware River. Commercial honey production and intensively-cultivated community gardens are two unusual uses of natural resources in the waterfront area. A private boat launch along Hog Island Road, although just outside of Center City, is one of the very few access points to the Delaware River south of Center City. Near Center City, the City has completed a six acre park at a cost $850,000, which will be the southern terminus of the multi-million dollar Schuylkill River Park, a linear park which will one day extend from Lombard Street one mile northward to the Art Museum.

The visual appearance of the lower Schuylkill River area has tremendous variability. Auto junkyards along the Schuylkill River and the Police Department's abandoned car impoundment

yard under the Penrose Avenue Bridge provide the bleakest visual appearance. Passyunk Avenue and 61st Street, in the midst of the auto junkyard areas, are two streets among the most bleak in appearance in the City. Open fields between the dredge disposal fields and the airport, however, offer some of the most secluded natural vistas in the City. International Airport provides exciting visual experiences, especially in the vicinity of Fort Mifflin along the path of incoming flights. There has been considerable recent commercial, industrial and residential development in the Eastwick area which, when combined with highway and airport terminal improvements, give the impression of a new and vital hub of activity. There are large areas of vacant, cleared land in the Eastwick Industrial Park which seem incongruent with the wide roadways and dense development in surrounding areas, but which give a sense of impending development. The Gulf and Arco refineries along the Schuylkill River create odors and a generally unappealing appearance which detracts from the attractiveness of the Eastwick area in general, as the flaming vents, large storage tanks and processing facilities are visible for many miles, even from new residential areas. Tinicum Marsh, despite its proximity to the airport and oil storage facilities, is a refuge from urban scenery.

There are several unique vantage points which provide interesting perpectives on the urban environment. A particularly powerful view of the Arco refineries on the east side of the Schuylkill River can be seen at the end of 67th Street on the west side of the river. The Girard Point Bridge, which carries I-95 across the Schuylkill River, is another dramatic, man-made structure along the lower estuary offering a view of the aircraft carrier Saratoga which is being rehabilitated at the Navy Yard. From a point beneath the George C. Platt Bridge, the arching bridge superstructure seems to soar over the oil refinery. At the Delaware River's edge near Fort Mifflin or behind the airport, large oil tankers may be viewed at berth in the Delaware River; oil is siphoned from these tankers through pipes under the Delaware River to on-shore storage tanks.

CENTRAL RIVERFRONT AND SOUTH DELAWARE WATERFRONT

The Central Riverfront and South Delaware Waterfront constitute one of the most heavily urbanized stretches of shoreline in the Delaware Estuary. There are virtually no land areas sustaining productive animal and plant communities. The waterfront edge in this area is completely bulkheaded, although abandonment of some piers has resulted in invasion by plants and siltation between piers. This has restored, to a small degree, natural aquatic and terrestrial ecological processes. Industrial processing and port activities dominate, but there has been recent land use changes north of Washington Avenue, such as redevelopment of some land to residential uses at Christian Street and recreation development at Penn's Landing. This suggests that landscaped plantings will one day be more dominant than is now the case along the waterfront north of Washington Avenue.

There is no vegetative cover in this area which contains quality, productive plant communities. Vacant, open fields consist typically of the more drought resistant weeds such as bristlegrass, prickly lettuce, goosefoot, wormwood and sweet clover. Several sites support the weed-like Ailanthus (Tree-of-Heaven). Several railyards have been unutilized over the last couple of years and

have been invaded by weeds, as has a pier at the Kerr-McGee property, an abandoned fertilizer factory.

Because of the severe lack of vegetative cover, wildlife habitats are extremely scarce. In one field trip, only two kinds of birds were noted, a catbird and a flock of mourning doves. The catbird, a bird well adapted to the urban environment, is notable for its exceptionally fine singing which can penetrate the noise of an industrial area. The Kerr-McGee site's weedy pier area was found to be a resting area for mourning doves, a federally protected bird. On an earlier visit, a duck nest was observed at this location. The attractiveness of this site to birds is attributable to its isolation in contrast to many other weedy sites. The other kinds of birds which would be likely found on vacant lots in this zone are the hardy urban birds, namely the starling, pigeon, robin and house sparrow.

The river's edge in this stretch of riverfront is completely bulkheaded. There are no natural shore edges, nor are there rocky, rubble edges, as can be observed along much of the riverfront both north and south on the river. Of the approximately 17,000 feet of riverfront in this area, about 3,500 feet contains piers and structures which appear blighted from the river and are in a deteriorated or abandoned condition.

This heavily industrialized zone has a landscape mostly unrelieved by trees, shrubs, grass and similar plant cover. Grass cover is unusually sparse; grass in the landscaped lawns of Penn's Landing and along one section of the Delaware Expressway are the principal grass areas. Just outside the study area, a good grass cover has been established at the I-95 Expressway connections with Walt Whitman Bridge. Because these grassed areas are so scarce, they are significant for their enhancement of the waterfront's appearance, affording relief from the visual bleakness of industrial buildings and roadways. A unique example of landscape plantings used to relieve a stark urban appearance is the planting of trees, shrubs and lawns at the entrance to the Philadelphia Electric Company's Southwark Generating Station. Most other industries have made no effort to provide landscaping.

The visual appearance of this area is also affected by the poor condition of many of the buildings and vacant lots. While several major structures have been renovated, many buildings are deteriorated and some are vacant. There are many vacant lots in the area south of Washington Avenue. Illegal dumping of trash and debris, especially along Weccacoe Street, has been a problem. The roads in this area, both the collectors and Delaware Avenue, are not well paved. All of these various factors combine to create a negative visual appearance.

Visual access to the Delaware River along the Central Riverfront and South Delaware Waterfront is good between the Fairmount Avenue and Washington Avenue but poor south of Washington Avenue. North of Washington Avenue, Delaware Avenue is close to the river, and water can be seen between the piers and their warehouse structures. Penn's Landing is a major cultural facility which draws visitors to the riverfront, and there are also several informal places where drivers may stop and view the Delaware. There are no parks or landscaped sitting areas south of Washington Avenue to serve workers in this industrialized area, nor can the river be viewed from public streets. While there are several lunch stops

along Delaware Avenue which serve truckers and workers, no outdoor eating or resting was observed during a site visit on a pleasant spring day.

There are several facilities in this stretch of riverfront which are cultural resources. The most significant is Penn's Landing which, besides the promenade along the river, attracts visitors to historical ships, the Moshulu restaurant and a sculpture garden. Major industrial, residential, commercial and hotel development is expected over the next decade. At the south end of Penn's Landing, Rainbow Tours departs for tours of the Delaware River. A private tennis club has been developed at Pier 30, and along the north side of this pier the Heritage Ship Guild is headquartered. The Ralph Rizzo Ice Rink and recreation center is a neighborhood recreation facility situated under I-95 Expressway at Washington Avenue. As part of I-95 Expressway construction, the Pennsylvania Department of Transportation installed covers over depressed sections of highway a half block wide at Chestnut Street and a full block wide between Lombard and Spruce Streets. These covers are urban parks linking Penn's Landing with Society Hill. The Old Swedes' Church at Washington Avenue, managed by the National Park Service, is a very distinctive historical landmark. This church is an oasis amidst the hard, urban scenery and is also the southern end of the area in which there is a diverse mixture of land uses. To the south, land uses are almost solely industrial and commercial.

NORTH DELAWARE RIVERFRONT

The North Delaware Riverfront, for the purpose of this environmental study, is divided into two parts. Although the upper portion near Mayfair and Torresdale neighborhoods has significant industries, there are still important environmental resources. The lower portion of the North Delaware Riverfront, from Fairmount Avenue north to Frankford Arsenal, is heavily urbanized. In the discussion below, the lower section of the North Delaware is discussed first.

Like its counterpart to the south, the lower North Delaware Riverfront is heavily urbanized. Over three-quarters of the 6 mile stretch of shoreline is bulkheaded, although abandonment of some piers has permitted recent invasion by weeds, shrubs and shrubby trees. The Tioga Marine Terminal is the major marine commerce facility in the northern half of Philadelphia's riverfront, and most of the other piers are no longer actively utilized for shipping activities. The underutilization of vast areas of riverfront land, along with accessibility to Center City and major transportation systems, suggests that there are significant redevelopment opportunities in the north riverfront area.

There is no vegetative cover in the north riverfront area which consists of high quality plant communities. The only mature trees are at Penn Treaty Park, a small park at the foot of Columbia Avenue on the Delaware River. This park commemorates the establishment of Philadelphia by William Penn.

There are, however, several areas with significant ground cover. Piers C and D at Port Richmond have lain idle long enough to have developed a cover of young trees, shrubs,

herbs and grasses which attract doves, pigeons, sparrows and catbirds.

Another significant area consists of lands bordering the mouth of Frankford Creek and beneath Betsy Ross Bridge. These have become areas of green amidst predominantly heavy industry. The Delaware River Port Authority maintains grassy fields underneath the Betsy Ross Bridge which are apparently used by nearby communities for recreational activities. Under the bridge, trails leading to the river's edge have been well worn amidst head-high grasses and shrubs and twenty-foot tall trees. The small promontory at the mouth of Frankford Creek affords a spectacular view of the Delaware which is enhanced by the soaring superstructure of the Betsy Ross Bridge. At low tide, sandy deposits along the creek and river give the appearance of a beach. Access to this area is not well defined, as gaps in cyclone security fences and an abandoned railroad bridge are the principal means of entrance.

Three quarters of the lower North Delaware Riverfront have bulkheading and piers. The second half of the 1800s saw major growth in marine commerce which caused the initial development of the river edge. The configuration of the river edge has changed considerably over the past hundred years, as piers were extended and deepened to accommodate larger vessels. One-third of the edge has been modified over just the last fifteen years. The 3,000 foot long Tioga Marine Terminal was created by new bulkheading and fill, and about 7,000 feet of old, unutilized pier areas have been filled in with rubble and dirt in order to create developable lands. The configuration of the river edge may continue to change over the next decades as redevelopment of available land takes place.

The visual appearance of most of the properties in the lower North Delaware Riverfront is bleak and unappealing. In part this is attributable to the preponderance of utilities and large industries. The Northeast Trash Transfer Station, PECO's Delaware and Richmond Stations, the PGW Richmond Plant and the Northeast Sewage Treatment Plant are facilities which tend to emit air pollutants and odors and to have imposing, stark appearances. Several large land areas are rubbly and barren, notably the Cramp Shipyards and filled land adjacent to Penn Treaty Park. Some other riverfront properties are storage areas for bulk material, such as the coal piles at Port Richmond and paving material piles just north of the Betsy Ross Bridge. Several other properties, such as Metal Bank of America, serve as storage yards for scrap materials.

Public access to the River is exceptionally limited in the lower North Delaware Riverfront area. There are only two park facilities in this six mile stretch of riverfront, Penn Treaty Park and Pulaski Pier Park. Both are small, less than an acre of fast land. They both serve low to middle income, row home neighborhoods. Pulaski Pier is close to the Richmond community, and Penn Treaty serves Fishtown. Land has been recently acquired to provide for expansion of Penn Treaty Park so that it may better serve as a site for the City's Century Four celebration in 1982. The City also has applied for $210,000 from the Pennsylvania Coastal Zone Management Program for improvements to Pulaski Pier Park. The only other cultural resource in this riverfront area is the privately owned Riverfront Dinner Theater, near the foot of Poplar Street about 150 feet north of the Benjamin Franklin Bridge. This theater is situated at the end of a pier at the concave bend in the Delaware, affording a magnificent view of the river.

While not typically considered appealing vistas, several facilities in the lower North Delaware Riverfront are of such a scale as to be attractive. Port Richmond contains enormously large relics of its heyday as a terminus for the export of coal, grain and other commodities. The scale of this facility and its current desolateness are striking. The Tioga Marine Terminal provides a sharp contrast to Port Richmond. Here the immense scale of the cranes, cargo vessels and staging areas and the hustle and bustle of truck traffic produce an atmosphere of great energy and vitality. Within these two facilities lies a complex and interesting history of Philadelphia as one of the major industrial and port cities in the world.

In strong contrast to the lower North Delaware Riverfront to the south, lands along the upper portion of Philadelphia's estuary have a residential and institutional character. Here also is the preponderance of public and private river access points, corresponding to the relatively clean and appealing condition of the water. The upper North Delaware Riverfront is about 5-1/2 miles long, extending from the original mouth of the Frankford Creek at the Frankford Arsenal, north to the City boundary at Poquessing Creek.

There are several areas of significant vegetative cover along the upper North Delaware Riverfront. Most notable is the approximately 200 acres of land at the mouth of the Pennypack Creek. This area until several years ago was used by the Sanitation Division of the City's Streets Department as an emergency dump and ash residue disposal area. The dump has been closed, and the land has rapidly returned to a field condition suitable for a wide variety of birds and mammals. Rabbits and mice are abundant, attracting several fox to the site. There are several dozen pheasant in the grassy areas, and the heavy thistle and sunflower vegetation attracts goldfinch. The tidal flat at the mouth of the Pennypack is an attractive resting area for both migrating and resident waterfowl and is probably home also for muskrats. Plans have been prepared for park development at this site, including a boat launch, marina, ballfields and play areas.

Another area with a significant vegative cover is the Foerd Estate overlooking the mouth of the Poquessing Creek. This estate is an arboretum of specimen exotic trees and shrubs, and the grounds and flower beds have been well maintained. The estate's mansion is used as a conference center by the Lutheran Church.

There are public lands in the upper North Delaware Riverfront which afford good wildlife habitat and diverse ground cover. These include Pleasant Hill Park, Linden Street boat launch and nearby fish ponds and the Water Department's Torresdale Filtration Plant facilities. Together they constitute a major riverfront open space resource. Pleasant Hill Park, a narrow, tree covered park along the River, is programmed for improvements by the City. The Linden Street boat launch is a heavily used access point with a five acre parking lot which fills to capacity on summer weekends. Adjacent ponds, which were once a state owned fishery, have been refurbished with landscaping and walkways and are open to fishing by children. The Water Department's 100 acres of concrete clear water basin are covered by six feet of earth supporting field vegetation which is home for rodents, rabbits, pheasant, and perhaps woodcock and fox. The adjacent raw water basin attracts migrating waterfowl, and muskrats are suspected of inhabiting the Water Department's sludge basin

on the north bank of the mouth of Pennypack Creek.

There are several private lands which provide green open space or tree cover. Saint Vincent's Orphanage is on about eight acres of landscaped grounds with an expansive lawn area. The Baker Bay condominium complex has retained wooded areas along the Delaware River, providing a park-like setting for their residents. The grounds at the approaches to the Tacony-Palmyra Bridge are well landscaped and maintained.

Recreational access to the Delaware River in the riverfront north of Frankford Arsenal is better than in any other section of Philadelphia's Delaware Riverfront. The City's only public boat launch is located in the upper estuary at Linden Street. There are also four yacht clubs with launches and docks in the Delaware.

1) Wissinoming Yacht Club, at Devereaux Street,

2) Quaker City Yacht Club, at Princeton Avenue,

3) Columbia Yacht Club, adjacent to the Linden Street access ramp, and

4) Delaware River Yacht Club, at the foot of Grant Avenue.

In addition, Pekora's Marina near the Tacony-Palmyra Bridge services and stores recreational boats, although their marina has been closed. There is also an active boat club in this area, the Bridesburg Boat Club.

The Pennsylvania Fish Commission has determined that there is a tremendous demand for additional boating access to the Delaware River. They will have under construction soon a boat launch facility at the foot of Princeton Avenue on surplus federal lands adjacent to the Quaker City Yacht Club. This facility, projected to cost $300,000, will have spaces for 76 cars and trailers and for nine or ten single cars. This is considered by the Fish Commission to be a small-scale access area. A much larger facility is under design for the 22 acres assigned to the Fish Commission for a boat launch at Frankford Arsenal. Projected to cost over a million dollars and to be built in three phases from 1982 through 1985, this facility will be able to serve over 300 cars and trailers. In addition, the City plans to incorporate a boat launch and marina in designs for the park at the mouth of Pennypack Creek.

The development of these boat launches and associated recreational activities serves to capitalize on the significant improvements in water quality that have occurred in the last decade. In the early 1970s, dissolved oxygen levels averaged 4.5 milligrams per liter (mg/l) during the summer, while in 1980 the average was in excess of 6.0 mg/l. This increased concentration of dissolved oxygen should substantially improve fish populations, providing suitable conditions for such game fish as walleye, bass, white perch and sunfish. This water quality improvement is attributable to the completion of pollution abatement facilities by upstream municipal and industrial waste dischargers. When the Northeast Sewage Treatment Plant is in full operation in 1985, good sports fisheries should be encountered down to the Frankford Creek.

UPPER SCHUYLKILL RIVERFRONT

The Upper Schuylkill River is a major recreational resource for Philadelphians. For the four and a half miles above the Fairmount Dam, parklands border the Schuylkill River. Although access to the four miles above the river's confluence with the Wissahickon Creek is somewhat limited, further upstream the river sustains significant recreational usage and holds the promise for greatly increased recreation.

The Upper Schuylkill Riverfront can be divided into three segments. The upper segment is a mile and a half long from the City boundary in Upper Roxborough downstream to the Flat Rock Dam. Development in this stretch is low density residential, consisting of small houses and mobile homes within the river's floodplain. Some of these homes are summer cottages which have been converted to permanent homes. These homes occur on both the Montgomery County and Philadelphia sides of the river, and typically include docks and motorboats set within a well-treed landscape. There is a park in Merion Township with public access to the river for their township's residents. Although the hiking and biking trail in Manayunk extends upstream to the Shawmont Station, there is no access point in the pool above Flat Rock Dam from which Philadelphia residents may launch motorboats or sailboats.

Within this upper Schuylkill area, there are substantial woodlands and fields close to the river. The Schuylkill Valley Nature Center and some other private lands managed by the Center stretch for about three quarters of a mile from the City boundary to Port Royal Avenue. Three tree-lined rights-of-way contribute to the natural apearance of the valley. Closest to the river is the Reading Norristown railline, and further uphill there is an abandoned Penn Central right-of-way. The Penn Central line has been developed to a bicycle path from Port Royal Avenue to Spring Mill near Conshohocken. The Penn Central line and bike path is set against the wooded Schuylkill Valley Nature Center property and provides an overlook to the Schuylkill River. The third right-of-way further uphill is for Philadelphia Electric Company's overhead electric transmission lines. In this right-of-way, the land is maintained as fields and is heavily traversed with paths for trail bikes.

The Schuylkill Valley is fairly steeply sloped, rising about 100 feet in elevation within 150 to 250 feet inland of the railroad rights-of-way. Throughout this valley, the sound of the Schuylkill Expressway can be distinctly heard as a constant drone, even where trees along the highway hide it from view.

The woods and fields in this upper stretch of the Schuylkill River contain some of the most important wildlife habitats remaining in the City, as well as some of the City's most beautiful and appealing landscapes. There are several herds of deer within the forested stream corridors which drain to the Schuylkill River. Birdwatchers encounter bird species which are not commonly encountered elsewhere within City limits, such as the phoebe and the warbling vireo. Waterfowl, particularly Canada geese and mallards, are permanent residents along this stretch of the river.

The second portion of the Upper Schuylkill Riverfront is between the Flat Rock Dam and the Schuylkill's confluence with the Wissahickon Creek. The dominant feature along this

section of the River is the Manayunk Canal. This canal was built in the 1830s to serve as an industrial power supply and as a lock system permitting river-borne commerce. Although at one time there were over a dozen paper and fabric mills on the canal, there are now two paper processers and a food processing plant. These firms no longer utilize the canal, the lock system of which has been long in disrepair.

The Manayunk Canal was recently refurbished at a cost of $2.2 million. A towpath has been built along the canal, in parts cantilevered over the water. The path extends for nearly two miles from Lock Street in Manayunk upstream to the Shawmont train station. This serves as a major link in a bicycle trail system proposed to one day extend from the Art Museum in Center City Philadelphia to the Valley Forge National Park. The canal has also served to focus attention on the revitalization of the Main Street commercial corridor.

Despite the Manayunk Canal project, access to the Schuylkill River is not good in this stretch of the river. Below Flat Rock Dam, the Schuylkill River has a white water rapids attractive to canoeists. The industries on Venice Island, however, have largely blocked the river from boating access, although Connelly Container Corporation has permitted, on an informal basis, canoe launchings from their property. A recreation center on Venice Island is headquarters for a canoe club, but this club does not have good access to the river from the island, as there is an approximately 20 foot drop to the river at this point.

There is open land at the downstream end of Venice Island near the lower lock which could provide riverfront recreation opportunities. The only unobstructed view of the Schuylkill River within the Manayunk area is at this lower lock parcel. Because this site is also the southern terminus of the Manayunk towpath, there is apparently a demand for parking for park visitors. The attractive setting at the river edge is appropriate for picknicking and sitting areas. Because this land is within the floodway of the Schuylkill River, City ordinances forbid the reuse of this property, which was formerly a warehouse and later a restaurant, for new commercial or residential structures. For these several reasons, recreation development is an appropriate use for this area.

Between the mouth of Wissahickon Creek and the lower lock of the canal, the Schuylkill River has a distinctly urban appearance, with retaining walls at its edge supporting industrial buildings, most notably Container Corporation of America. Because there are only two small industrial wastewater dischargers, the water in the Schuylkill is not significantly impacted by this industrial zone. It is also within this industrial zone that the bicycle trail from Conshohocken to Center City must share with cars and trucks about 1-1/2 miles of Main Street. Main Street at this point becomes narrow between rock outcrops on the northeast side of the street and industrial property to the southwest. The bicycle trail is picked up at the mouth of the Wissahickon Creek, where trails from Forbidden Drive along the Wissahickon Creek connect with trails along the Schuylkill River in Fairmount Park. It is also at the mouth of the Wissahickon Creek that the Philadelphia Canoe Club is situated.

The third segment of the Upper Schuylkill Riverfront is from Wissahickon Creek downstream to the Fairmount Dam. Fairmount Park borders both sides of the Schuylkill River. In this section, the Schuylkill River forms a pool behind the dam. The pool supports sculling by the Schuylkill Navy rowing clubs and also boating, sailing and fishing by the general public. The landscaped parklands and convenient pathways attract bikers, joggers and picknickers who enjoy the river scenery.

A major element in this section of the Schuylkill River is its rich historical and cultural character. Thirteen historic mansions are within East and West sections of Fairmount Park in close proximity to the Schuylkill River. These were estates of prominent, eighteenth and nineteenth century Philadelphians who were attracted to the scenic, rolling landscape overlooking the Schuylkill River. Many of these mansions were acquired in the second half of the 1800s when Fairmount Park was assembled. The Laurel Hill Cemetery overlooks the Schuylkill. Established in 1836 and designed by noted architect John Notman, this cemetery was once a favorite public promenade and picnic area. Fairmount's West Park was the site of the nation's Centennial Exposition of 1876. Memorial Hall, the main pavillion of the Exposition, now serving as administrative offices for the Fairmount Park Commission, is one of the only structures in West Park which remains from the Centennial Exposition. The Philadelphia Zoological Gardens, situated on a plateau overlooking the west bank of the Schuylkill River, was established in 1875 as the first zoo in America. The Fairmount Waterworks at the east end of Fairmount Dam is significant both as a symbol of major engineering advances in public water supply systems in the early 1800s and as an architectural feature. The Waterwork's Greek revival type structure has served as a major public garden area from the 1800s to the present.

The good water quality of the Schuylkill River contributes significantly to the recreational value of Fairmount Park. The good appearance and odor of the river is compatible with boating activities. High dissolved oxygen in the water sustains an abundant fish population attractive to fishermen. The Pennsylvania Fish Commission and Fairmount Park Commission jointly sponsor annual fishing contests on the Schuylkill to promote the river's good recreational fishery. Fecal coliform levels are low enough to allow contact recreation activities. To help foster the image of the Schuylkill as a safe and clean river, the Park Commission in 1980 sponsored a river float race in which thousands of participants created rafts, boats and other devices on which to float down the river.

The lower stretch of the Upper Schuylkill River is impacted by transportation arterials near its banks. Two major arterials, East and West River Drives, wind along the river. These drives carry motorists to and from Center City, but also provide access to the riverside park areas. The Schuylkill Expressway is on the west side of the river, and its heavy volume, high speed traffic creates a constant drone which is noticeable along the full length of Philadelphia's Schuylkill riverfront. Long freight trains, consisting principally of coal hoppers, move occasionally along trackage paralleling the expressway on the west side of the river.

The quality of the wildlife habitat in this section of the Schuylkill River is mixed. Grassy areas immediately adjacent to the river do not attract foraging mammals or their

predators. But beyond the river, the land rises steeply and is wooded, and still further uphill there are open fields. These woodland and fields are some of the most productive wildlife habitats in the City. Squirrels, rabbits, raccoon, opossum, skunk and mice are probably plentiful, but because of the area's closeness to dense development, deer are absent.

The Upper Schuylkill Riverfront has important habitats for waterfowl and other birds. The most abundant waterfowl are the Canada geese which are permanent residents in the Fairmount Park portion of the Schuylkill River. Mallard ducks are also permanent residents. Several kinds of gulls, notably the herring and ring-necked gull and less commonly the glaucous and Iceland gull, are occasional visitors along the Schuylkill. Herons and egrets wander up the Schuylkill River during late summer before the fall migration to the south begins. There are also a variety of summer resident birds which favor river edge habitats. These include several species of swallows, flycatcher, orioles and sandpipers, the yellow warbler, the warbling vireo and belted kingfisher. During winter several hawks inhabit the woodlands in Fairmount Park near the river. These hawks include the red-tailed, rough-legged, Cooper's and kestrel hawks.

ENHANCEMENT AND PROTECTION OF RIVERFRONT LAND RESOURCES

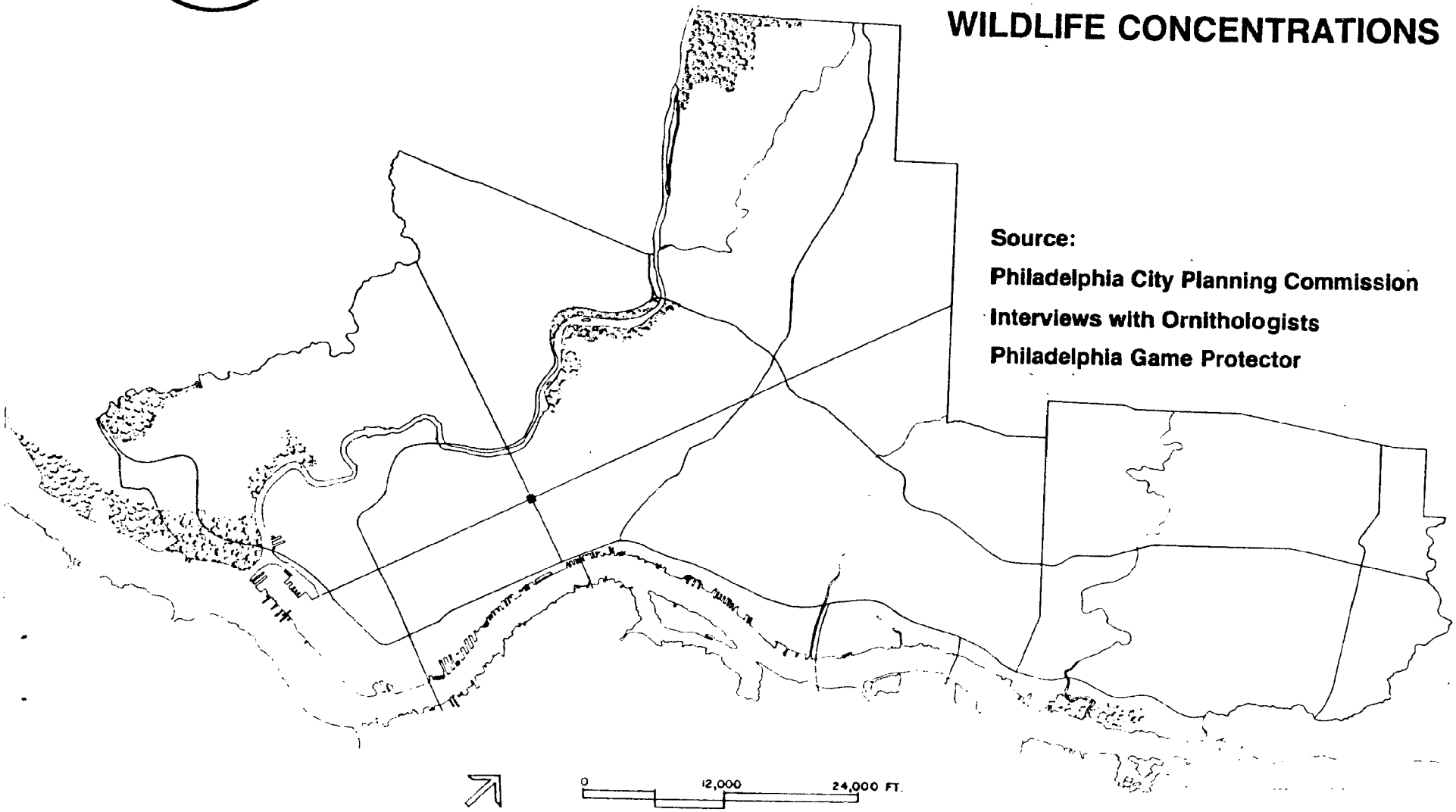
Highly productive wildlife habitats can exist along the river because natural river edges provide diverse "ecological niches." Each animal has a set of requirements for food, cover, climate and other environmental conditions which together characterize the niche requirements for that species. Along an undeveloped riverfront, environmental conditions vary greatly over a short distance, such that the niche requirements for a large number of different animals are met within the confines of a small area. In from the river, land may grade from wetlands, to lowlands and then to uplands, just as out from the river's edge the water may deepen from tidal flatlands, to shallow water areas and then to deep water. On land, open fields may give way to shrubby thickets and to woodlands. This diversity in vegetative cover, land wetness and water depth creates an enormous potential for diverse wildlife populations.

Wildlife habitats are not abundant along Philadelphia's riverfront (see Riverfront Wildlife Areas map). Only about 3.5 miles of the 22 mile portion of Philadelphia's Delaware Estuary has significant concentrations of birds and mammals. The Schuylkill River offers a considerably larger proportion of habitats, with 6.0 miles of the 15 mile riverfront bordering parklands, fields or wooded areas.

Wildlife enhancement and protection can be pursued along the Delaware and Schuylkill Rivers through a number of different management techniques. The major strategy should be to encourage growth of a natural vegetative cover along as much of the riverfront as practicable. This strategy does not preclude urban uses, because even intensive development of riverfront properties may include a planted riverfront buffer of shrubbery and trees. On lands where new development will disrupt existing habitats, a natural cover could be retained as a buffer along the river. Where barren, vacant lands devoid of ground cover are redeveloped, plans could call for a landscaped edge designed to enhance wildlife

RIVERFRONT WILDLIFE AREAS

AREAS OF SIGNIFICANT WILDLIFE CONCENTRATIONS



Source:

Philadelphia City Planning Commission

Interviews with Ornithologists

Philadelphia Game Protector

habitats. Existing firms with unutilized river frontage could make plantings at the river's edge, not only benefitting wildlife but also enhancing the riverfront's appearance from the water.

The major, long-range opportunity for wildlife protection is in the Corps' Fort Mifflin Reservation. The 300 acre Fort Mifflin disposal area has habitats consisting of both upland fields, which have become established on completed spoil basins, and freshwater wetlands within active spoil basins. Fort Mifflin will be filled by 1998 and is likely to become surplus federal property. Although it could be developed to industrial or other urban uses, it could instead be developed as parkland and as a wildlife refuge. Its use as open space would complement the public uses at the nearby historic Fort Mifflin and the Fish Commission's proposed boat launch to be developed within the clear zone of International Airport.

A second opportunity for wildlife protection is at the mouth of Pennypack Creek. About 100 acres of former garbage dump and ash piles have returned to field conditions which are rich in pheasant, rabbits and goldfinch and other animals common to meadow habitats. Tidal flats at the mouth of the Pennypack, in addition, are attractive to waterfowl. Although preliminary plans for park development at this location call for extensive playfields, less intensive recreational development of this site would accommodate a 50 or 75 acre wildlife reguge with nature trails, while also allowing development of several ballfields.

For both the mouth of Pennypack Creek and Fort Mifflin, very little intervention by man is necessary to encourage wildlife. A succession of plant communities on idle land has already permitted the natural restoration of wildlife. The only useful improvement would be low-cost plantings of evergreens and fruit-bearing trees to help improve the habitat for songbirds and the visual attractiveness of the open fields.

Existing vegetated river edges can be retained as a wildlife protection measure. Along the west bank of the tidal Schuylkill River there are about 4,500 feet of shrubby and tree-covered lands which provide wildlife habitat. These are portions of unutilized industrial lands, apparently associated with oil storage and refining operations. About 4,000 feet of this river frontage is within the Schuylkill's floodway. Because City ordinances restrict construction of new structures within the floodway, permanent open space may prove to be the highest use to which lands immediately along the river could be put.

A substantial number of parcels in the upper Delaware Estuary and tidal Schuylkill River are rubbly, underutilized industrial lands which could be treated in a way beneficial to wildlife. There are about 2.5 miles of industrial riverfrontage on the Delaware which existing firms do not utilize. These edges could be planted with a 50 foot wide vegetated buffer. This buffer might consist of medium height grasses with plantings of such fruit and nut bearing shrubs and trees as oak, hawthorn, roses, blackberries and apples, to grasses such as fescue, bristle grass and brome and to such evergreens as scotch pine and cedar.

Many riverfront lands may not provide satisfactory soil for plantings. Rubble has been used as fill in many riverfront areas, and an infertile dirt has been applied to the

rubble. A good ground cover can be best established where the soil is fertile and sufficiently deep as to provide a good root zone. Therefore, a clean soil fill may have to be applied to riverfront lands planted as a buffer. The Water Department's composted sewage sludge, combined with dredged river bottom silt, would create an excellent soil medium for planted buffers.

Restoration of the river edge would have the added benefit of improving the appearance of the riverfront. Pleasure boating is expected to increase several fold within Philadelphia's portion of the Delaware Estuary. An attractive riverfront contributes to boating enjoyment. As recreational boating traffic increases on the river, industrial firms may become increasingly aware that their public image is affected by the appearance of their river edge. Storage areas and scrap piles can be screened with vegetation to improve their appearance and security.

A considerable number of underutilized, vacant parcels are likely to be developed over the next several decades. Some of these properties contain derelict structures, while others are rubbly lands which seem to attract illegal dumping of demolition debris and trash. The Kerr-McGee property on the riverfront south of Center City is an example of a large parcel with many large, decrepit structures. The Cramp Shipyard, just south of Port Richmond, is a large rubble and trash strewn parcel. Both of these properties will one day be redeveloped to industrial or possibly residential use. A significant element of redevelopment plans should be landscape design, recognizing that the Delaware River, as a public thoroughfare, exposes the river edge to view. Almost any landscape planting provides refuge for songbirds, a positive environmental feature in a development.

Tree plantings provide advantages which extend beyond wildlife habitats and visual effects. Trees serve as windbreaks and help to sift out particles and dust suspended by winds. By providing shade, they make an area appealing and comfortable to workers and residents.

There are opportunities for publicly sponsored environmental improvements. Delaware Avenue, which has been principally a truck and through-traffic corridor, may one day be serving a substantial residential population. The creation of a landscaped boulevard for a major portion of Delaware Avenue could enhance the image of the riverfront as a cultural attraction and as a desirable residential location. Such improvements need not be confined to the area north of Washington Avenue where residential development is occurring. In the industrial corridor south of Washington Avenue, Delaware Avenue appears wide enough to accommodate landscape plantings. Presently, workers and truckers have no outdoor parks or sitting areas offering shade and benches at which lunch may be comfortably enjoyed. A City-initiated tree planting program in an area such as the South Delaware Waterfront could help to support industrial redevelopment efforts because it would serve to improve the quality of the work place environment.

ENVIRONMENTAL NUISANCES AND CONSTRAINTS AND THEIR MANAGEMENT

FLOODPLAINS

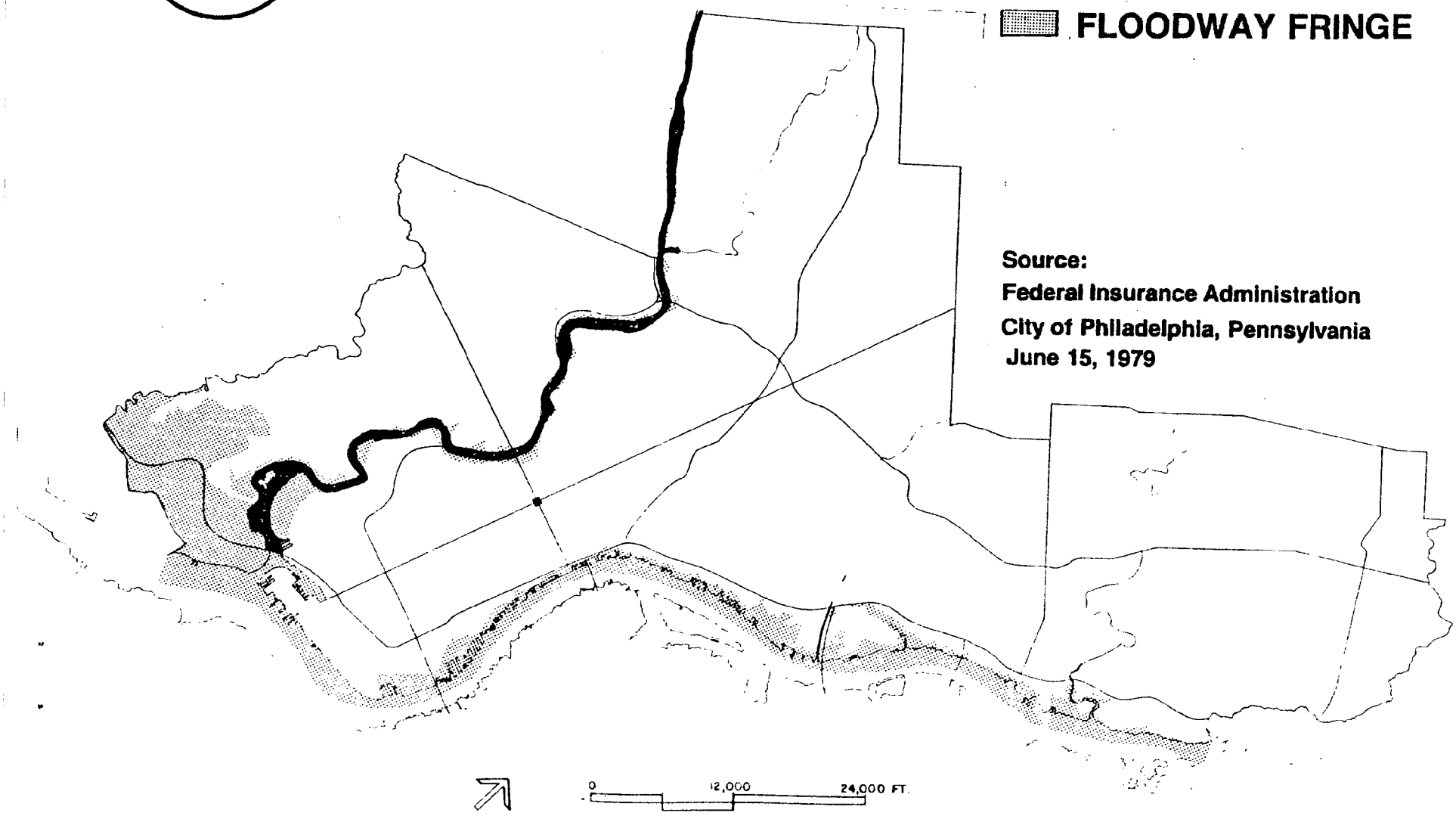
The most significant environmental constraint on riverfront development is potential flooding and the damage it can do. Floodplains are flat, low lying areas adjacent to streams or rivers which are temporarily inundated during periods of unusually heavy stream flow. Floodplains have been identified for the City in a report prepared by the U.S. Army Corps of Engineers for the Federal Insurance Agency, the agency administering the Federal Flood Insurance Program. In June 1979, the City adopted amendments to the Philadelphia Code to regulate activities within floodplains. These regulations apply to activities within areas which would be inundated by flood events having a probability of occurring, on the average, once in a hundred years, or expressed in different terms, the area with a 1% probability of being flooded in any given year.

For the purpose of regulating development, floodplains are divided into two zones. These two zones are the floodway and the floodway fringe. The floodway, in general terms, is the central portion of the floodway which during a flood event carries most of the flooding waters. The fringe is a backwater area in which floodwaters are comparatively shallow and move at low velocities. The Corps, however, utilizes a more precise definition for the floodway. The floodway is the stream channel and the adjacent floodplain area which must be kept free of additional encroachments in order that a flood with a 100 year recurrence interval can be carried without unacceptable increases in flood heights. The Federal Insurance Administration has established, as a standard, 1.0 feet as an acceptable increase in flood heights. Conceptually, if the floodplain were compressed at the edge by structures and fill, floodwaters could be only carried by the remaining floodplain if flood heights are increased. The U. S. Army Corps of Engineers has identified as the floodway fringe those areas of the floodplain which if completely filled would not cause floodwaters to increase by more than one foot in elevation in the remainder of the floodplain.

To implement these floodplain management principles, the City adopted codes which permit no new obstructions or encroachment within the floodway. Construction is permitted in the floodway fringe so long as livable spaces and utilities are installed at least one foot above the elevation of 100 year flood waters; this is known as the regulatory flood elevation. The regulatory flood elevation is the maximum elevation which floodwaters will reach, even should development completely obstruct upstream floodway fringe areas.

The concept of floodways and floodway fringe areas cannot be applied to the Delaware River. The floodway concept applies only to "fluvial flooding." Flooding in the Delaware Estuary is caused by tidal flooding, which occurs when heavy flows from the upper basin collide with the upriver movement of water associated with high tides. Regulatory flood elevations in the Delaware River were determined by the

FLOODPLAINS



U.S. Army Corps of Engineers from tidal elevation frequency curves prepared for several points along the river. The elevation of the 100 year tidal flood event is 10.5 feet above mean sea level at the northern City limits at Poquessing Creek and 9.7 feet above mean sea level at the City boundary 22 miles downstream near Fort Mifflin. Elevation measurements on City drainage and street maps do not utilize mean sea level as a datum elevation. When expressed in terms of City datum, flood elevations are 4.79 feet at Poquessing Creek and 3.99 feet at Fort Mifflin.

At the regulatory flood elevation, most piers and riverfront lands along the Delaware River are submerged. This is illustrated in the Floodplains map. These flooded areas are delineated by the Corps as within the floodway fringe, so there are no local prohibitions on construction of new structures. The floodplain of the 100 year flood is generally between 250 and 1000 feet wide inland from the pierhead line, and only occasionally is it as wide as 2000 feet. Areas where the floodplain is particularly wide are in the vicinity of the Tioga and Packer Avenue Marine Terminals and at the Frankford Arsenal. The area of most severe Delaware tidal flooding, however, is in the Eastwick area of Southwest Philadelphia, where the floodplain extends 1-1/2 to 2 miles inland from the river. Flooding from a 100 year event would inundate Philadelphia International Airport, the Southwest Sewage Treatment Plant and roughly two-thirds of the residential portion of the Eastwick Neighborhood Improvement Area. Flooding hazards were factored into the design of the Southwest Sewage Treatment Plant so that treatment units will not be disrupted by flooding.

The floodplain of the Schuylkill River includes both the floodway and floodway fringe areas because the Schuylkill River is subject to fluvial flooding upstream of the I-95 Girard Point Bridge. The floodway typically extends inland between 100 to 300 feet from the shoreline. The floodway fringe is also generally narrow, about 100 to 500 feet beyond the floodway. But there is considerable variability in the extent of flooding. Near Center City, the floodway fringe extends 1000 feet eastward toward 21st Street, between Market and Arch Streets. A little further downstream, in the vicinity of South Street Bridge, the floodway is 500 feet wide on both sides of the riverfront, and the floodway fringe is an additional 500 feet wide. The floodway is widest near the mouth of the river. In the vicinity of Penrose Avenue Bridge, the floodway extends 1500 feet westward from the shoreline, while on the eastern bank, bulkheads on oil refinery property keep floodwaters confined to the edge of the river.

Several key areas and facilities are prone to flooding along the Schuylkill River. Two residential areas are within the floodway fringe, homes along River Road in Upper Roxborough and the neighborhood in the vicinity of Reed Street to Arch Street, from 24th to 21st Streets. Industrial firms are also prone to flooding. On Venice Island in Manayunk, paper and food processing firms are within the floodway of a 100 year flood, and in the industrial corridor downstream of University Avenue Bridge approximately one dozen industrial structures are also within the floodway. Main Street in Manayunk is within the Schuylkill floodway for 1400 feet from Levering Street to a point 250 north of Green Lane Bridge. The U.S. Army Corps of Engineer's Flood Insurance Study reported that during the June 1973 flood in the Schuylkill Basin homes and stores along Manayunk's Main Street

"were so deeply flooded that they had to be evacuated and guarded against looting."

Transportation is disrupted on the Schuylkill during severe flooding. East and West River Drives are completely within the floodplain of a 100 year flood. During the 1973 flood, the Vine Street extension of the Schuylkill Expressway was inundated between 30th Street and 16th Street. Trackage of Amtrak's Northeast Corridor is within the Schuylkill's floodway in the vicinity of 30th Street Station, and B & O freight lines paralleling the east bank of the Schuylkill are also within the Schuylkill's floodway in vicinity of Center City.

Development within the floodplain of the 100 year flood event is controlled by the Philadelphia Code. On June 11, 1979, an ordinance was signed into law amending three sections of the Philadelphia Code: Title 4, Building Code; Title 10, Regulation of Individual Conduct and Activity; and, Title 14, Zoning and Planning. Zoning Code amendments established the floodway and floodway fringe zones. This code prohibits new encroachments in floodways. In the floodway fringes, dwellings are permitted if the lowest floor elevation is one foot above the elevation of the regulatory flood, and non-residential structures are permitted if the structure is floodproofed. Building Code amendments require all new construction and substantial improvements be at a minimum one foot above the regulatory flood elevation, or, in the case of non-residential structures, floodproofed to this elevation. The Building Code also requires anchoring to prevent flotation or movement of structures and engineering evidence that the structure can withstand hydrodynamic loads created by floodwaters. It also prohibits storage of bouyant, flammable or explosive materials below an elevation one foot above the regulatory flood elevation. Title 10 requires that a permit be obtained from the Department of Licenses and Inspection prior to any construction, reconstruction, modifications, placement of fill, material storage, land clearing, land improvement or any other development-related activity in floodplains. Title 10 also serves notice to residents that the State has regulations on activities within floodplains.

The State control over floodplain development is exercised by the Pennsylvania Department of Environmental Resources, as authorized by the Dam Safety and Encroachment Act of 1978, P. L. 1375, No. 325, as amended by Act 70. For any development activity, including construction and placement of fill, an application must be made to DER for a permit. The principal State concern is that the passage of floodwaters not be significantly obstructed by floodplain development and that there are no other unacceptable impacts on social, economic or environmental conditions in the vicinity of the stream. In particular, the DER attempts to ensure preparation of adequate soil and erosion control plans and to guarantee minimal disturbance of aquatic habitats. Although the U.S. Army Corps of Engineers also requires submission of permit applications for development of properties adjoining the Schuylkill and Delaware River, they largely depend on State and City reviews for compliance with floodplain controls.

One way in which compliance with the City's floodplain ordinance is obtained is through the National Flood Insurance Program. Any development project receiving federal assistance, insurance or guarantees must obtain flood insurance if situated in a floodplain.

Similarly, mortgage insurance companies require flood insurance for buildings within a flood-plain of a 100 year flood event. The City supplies written notices to mortgage or loan insurance companies as to whether residential, commercial or industrial structures are within flood prone areas, based on maps prepared for the City by the U.S. Army Corps of Engineers. Similarly, no federal funds may be spent on any public project, such as sewage treatment plants or public housing projects, without flood insurance being purchased for those structures identified within flood plains.

AIR POLLUTION

Riverfront lands contain major sources of air pollutant emissions. Approximately 91,500 tons of air pollutants are emitted from industries and utilities annually, about 17 percent of the total pollutants emitted within the City. About 84 percent of these industrial and utility emissions are from firms located in the vicinity of the Schuylkill and Delaware Rivers. These emissions can be classified into four groups:

1) oil processing facilities, accounting for 30,000 tons per year;

2) electric utilities, discharging 17,000 tons per year;

3) municipal incinerators, emitting 7,000 tons per year; and

4) industrial firms, discharging 23,000 tons per year.

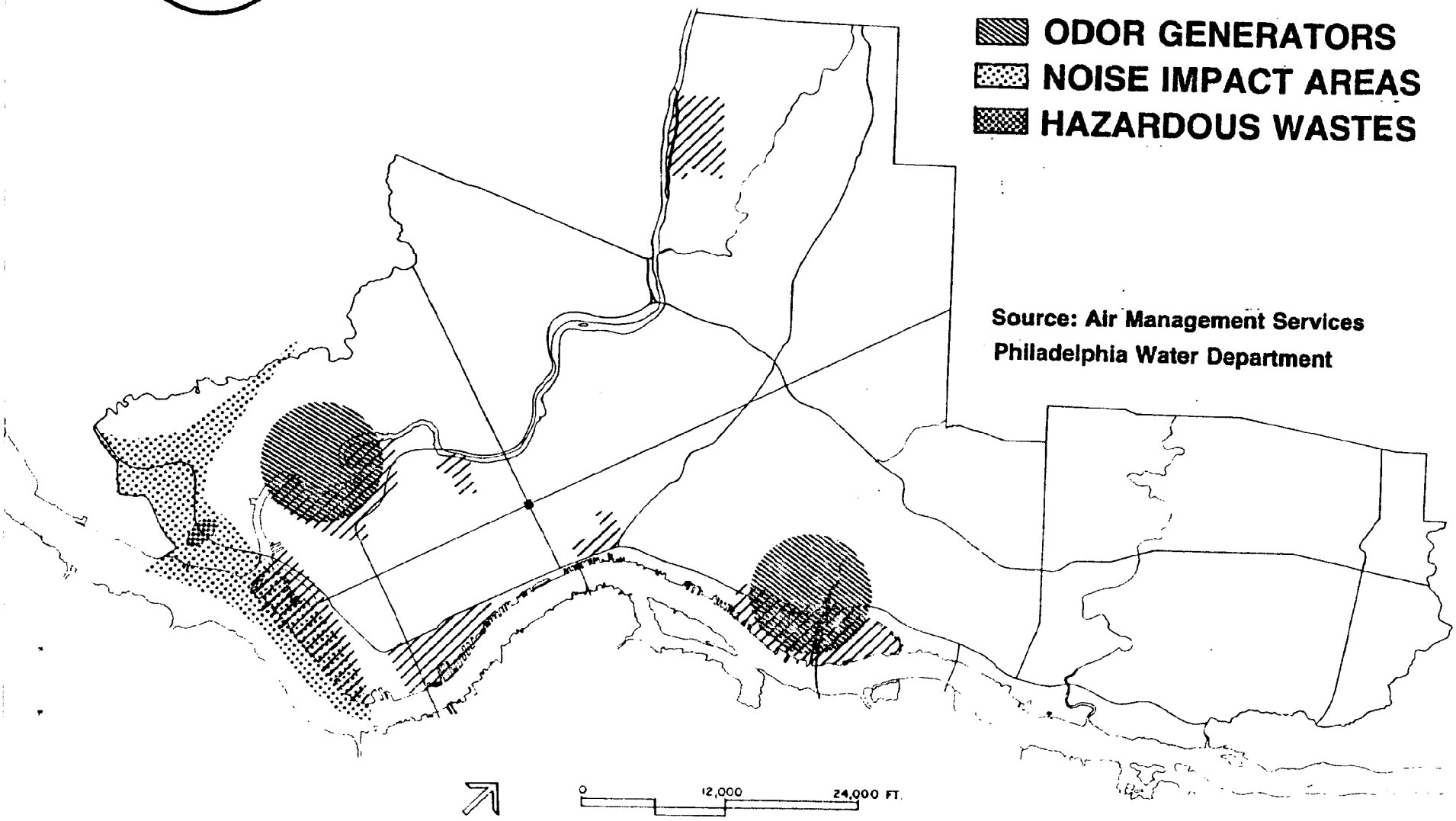
These point sources of pollution are generally situated in six localities: 1) Richmond/ Bridesburg, 2) North Bridge/Lower North Delaware, 3) South Delaware, 4) Lower Schuylkill, 5) Central Schuylkill and 6) Upper Schuylkill. The Environmental Nuisances map indicates those riverfront census tracts in which over 1,000 tons per year of air pollutants are emitted annually; these census tracts correspond to the six localities.

The Lower Schuylkilll River area has, by far, the largest concentration of air pollutant emissions. The Arco and Gulf refineries discharge 30,000 tons per year. These facilities are located on the east bank of the tidal Schuylkill River, along a three mile stretch north of Penrose Avenue. Half of these emissions are sulfur oxides, which prevailing winds carry in the direction of Center City and which in the past would cause occasional violations in air quality standards.

The area north of Benjamin Franklin Bridge and below Columbia Avenue contain several large facilities, notably National Sugar, PECO's Delaware Generating Station and the City's East Central Incinerator. Approximately 10,000 tons per year of pollutants are emitted within this area. Pollutants are generally carried out over the Delaware River and do not affect residential areas.

The South Delaware Waterfront has several industries which emit air pollutants. One of the largest is the Amstar Corporation which is near areas being considered for redevelopment to residential uses. Publicker Industries is another major industrial point source, and two smaller ones are Inolex Corporation and Crown Paper Board. PECO's Southwark Generating Station is currently operating at only 20% capacity and apparently

ENVIRONMENTAL NUISANCES



emits over 500 tons per year, a significant level of emissions.

A significant concentration of industries in the Richmond/Bridesburg area release about 9,000 tons of pollutants per year. Rohm and Haas, Allied Chemical, Aldan Rubber, Franklin Smelting and Refining Co., A. P. Green & Co., and Atlantic Metals are the principal industrial sources in this area.

Beside the refinery area, there are several other pockets of industrial activity responsible for air pollutant emissions along the Schuylkill River. On the upper tidal portion of the Schuylkill, there are several significant air pollution sources which together produce over 6000 tons per year -- Celotex, U. S. Gypsum and PECO's Schuylkill Generating Station. The E. I. duPont de Nemours facility on the tidal Schuylkill River, although once a significant source, has closed recently. In Manayunk and Roxborough along the upper Schuylkill River, industries on Venice Island and the City's Northwest Incinerator are major stationary pollution sources, responsible for about 6,000 tons of pollutants annually.

Although there are many significant sources of air pollutant emissions along the riverfront, air quality is generally acceptable. Air pollution emissions from riverfront industries and utilities are not generally responsible for violations of air quality standards at the ground level. The possible exception to this is air quality violations in vicinity of the oil refinery complex. The City's Air Management Services, in their 1980 report on air quality, shows that the City's air quality generally achieves the national ambient air quality standard for total suspended particulates, sulfur dioxide, carbon monoxide and nitrogen dioxide. AMS detected occasional violations of the particulates standards at several monitoring stations, but revisions to the standard under consideration by the federal EPA may eliminate these violations. The occasional violations of nitrogen dioxide standards occur at heavily trafficked intersections where automobile-generated nitrogen dioxide accumulates. Further controls on this pollutant through the Federal Motor Vehicle Control Program should achieve the standard consistently in the future.

The one ambient air quality standard which is consistently violated city-wide is the pollutant class called photochemical oxidants, principally composed of ozone. This is a warm-weather pollutant formed by the reaction of hydrocarbons and nitrogen dioxide under intense sunlight. The principal ozone control strategy is the further reduction of hydrocarbons, which in Philadelphia are generated largely by motor vehicles. Although air quality specialists have considered techniques for decreasing car traffic as a way of reducing hydrocarbon emissions, further controls on automobilies emissions will be the principal mechanism by which hydrocarbons can be reduced. Traffic controls can be used to reduce hydrocarbon by only 5 to 10 percent, and these controls can be implemented only at very high costs. Even the complete implementation of additional hydrocarbon controls through the Federal Motor Vehicle Control Program is not projected to correct all violations of photochemical oxidant standards which now occur.

The Air Managment Services has recently begun a thorough review of air-borne toxic substances. With a $437,000 grant from the federal Environmental Protection Agency, AMS will be evaluating community exposure to toxic air-borne substances in the vicinity of two riverfront industrial areas, the Gulf and

Arco refinery complex and three Bridesburg firms, Philadelphia Coke, Allied Chemical and Rohm and Haas. This grant will equip AMS with the facilities and staff to implement portions of recent "right-to-know" legislation. This legislation consists of amendments to the Philadelphia Code giving citizens the "right-to-know" the nature of toxic materials handled by local industries and giving the City the legal and institutional means to protect public health and safety with regard to such materials. Although unacceptable levels of air-borne substances are not expected to be encountered in either of these areas, the technical capabilities being developed by AMS will allow them to adequately handle pollution incidences which may occcur in the future.

One of the important analytical tools that AMS has developed is a diffusion model. This is a computer-assisted analysis of the way air pollutants are carred within plumes away from exhaust stacks and become dispersed downwind. An analysis was performed by an AMS meteorologist of the Amstar Corporation sugar refinery to predict sulfur dioxide concentrations at proposed residential areas in the vicinity of the refinery. This analysis showed that for high-rise apartment buildings in the vicinity of Amstar, air pollutant plumes are generally carried over such structures. Should the air be so unstable as to cause plumes to blow down onto an apartment building, there would be sufficient dilution and dispersion of sulfur dioxide such that concentrations would be barely 10% higher than ambient conditions and not in violation of air quality standards.

Two City facilities at the riverfront will receive improvements to air pollution controls over the next several years. The electrostatic precipitators at the City's two incinerators, the East Central and Northwest incinerators, will be replaced at a cost of close to $3 million. In the case of the East Central Incinerator at Delaware Avenue and Spring Garden Street, this will eliminate smoke which has recently become a chronic problem. Even after replacement of the precipitators, however, the East Central plant will emit 1,000 pounds daily of particulates, and there will be occasional discharges of flyash. Those emissions may cause some nuisances should nearby land be developed to residential uses.

ODORS

Odor is not a widespread problem on the riverfront. Odors are confined to principally two localities, the Richmond/Bridesburg area and the oil refinery area. These two areas are identified on the Environmental Nuisances map.

Gulf and Arco Refineries are sources of persistent and continual odors. The processing facilities at these refineries are complex, and the chemicals they handle are highly odiferous. Even with a high level of pollution control, odors may be released. In addition, these companies, along with Philadelphia Gas Works, handle odorants, such as mercaptan, which give natural gas and propane, which are otherwise odorless, their identifying smell. The odors released from the refinery area affect South Philadelphia and occasionally Southwest and West Philadelphia.

The riverfront industrial area of Richmond and Bridesburg, once known as the stink belt, has a number of industries and utilities which

generate odors. The facilities which are principally responsible for odor problems, according to Air Managmeent Services, are: Unitank Terminal Services, Franklin Smelting and Refining Company, the City's Northeast Sewage Treatment Plant, Keystone Mutual/Shoemaker and Sons, Co., Philadelphia Coke, Allied Chemical and Rohm and Haas. During fieldwork by Planning Commission staff, a variety of smaller firms were also identified as sources of odors.

Under the Air Management Code, Title 3 of the Philadelphia Code, odors are an air pollution nuisance. An air pollution nuisance is defined as any substance discharged to the air which is "offensive, or objectionable, or both, to persons because of inherent chemical or physical properties (3-102)(5)(b)(.6)" or which "causes severe annoyance and disturbance (3-102)(5)(b)(.2)." When the Health Department's Air Management Services receives an odor complaint, an inspector responds by visiting the complainant, and if the odor is not just fleeting, he tracks the odor to its source and issues a violation notice to a responsible party. If on a return inspection an odor is still detected, a second violation is served. Although AMS does not have authority to impose administrative penalties for violations of the Air Management Code, several procedures may be initiated to compel correction of the odor problem. Frequently, AMS staff will meet with a violating industry to advise them on techniques to correct chronic odor problems. A compliance schedule may be agreed upon by AMS and the industry under which the industry will correct their odor problems without further violations being issued. A fine, a schedule for which is set forth in the Air Management Code, may be incorporated into the compliance agreement. Should a firm not enter into negotiations with AMS, the department may choose to have the City's Law Department seek a court order in Municipal Court for an injunction against the firm to cease and desist discharging odors and for issuance of a fine. This procedure typically results in compliance agreements between the City and industries.

Odor problems are occasionally very difficult to solve. Corrective measures might require extensive capital equipment investments. Compliance with the Air Management Code, however, may be linked usefully with achieving occupational exposure standards for workers, standards which are also promulgated by the City's Health Department.

The Air Management Code has provisions for keeping residential areas separated from industrial uses as a way of avoiding odor and air pollution nuisances. AMS rarely receives odor complaints from neighboring businesses; the vast majority of complaints are made by residents in close proximity to industries. The Air Management Code gives the Department of Public Health the authority to prohibit residential construction in areas prone to air pollution nuisances. Conversely, it may prohibit industries from entering residential areas if air pollution nuisances have a reasonable probability of occurring. The code also gives the department the authority to limit the density of emissions of contaminants in an area which is already in violation of air quality standards.

Redevelopment of riverfront properties may create situations where odor complaints might arise. The riverfront in vicinity of Central Philadelphia is experiencing redevelopment pressures as former industrial and commercial properties are converted to residential uses. Although the Amstar and National Sugar

refineries are not significant odor generators, they do give off occasional odors, particularly during the delivery of raw sugar. Historically, industries south of Washington Avenue have been sources of noxious odors, notably Kerr-McGee and Publicker Industries, although neither facility is a current odor source. Should odor-causing industrial processes resume at these or other nearby locations, the presence of new, high cost dwellings in proximity to Washington and Delaware Avenues may give rise to complaints that would not have been filed when the area was solely industrial.

The City's pollution abatement program will help reduce a serious odor problem for Richmond area residents. The Northeast Sewage Treatment Plant is overloaded, and a strong sewage odor emanates from the facility, particularly in summer. The $350 million construction program for this facility will enlarge and upgrade treatment units, which should largely end odor emissions.

NOISE

Noise is not a very significant environmental nuisance within riverfront areas. This is due to three conditions. First, there are only two major noise generators in the riverfront, I-95 expressway and Philadelphia International Airport. Secondly, background noise levels are generally high enough to mask the noise contribution of most riverfront industrial and commercial activities. Finally, because there are so few residential areas in proximity to the riverfront, the population exposed to noise generators is very small.

The Philadelphia International Airport, located in the southwestern section of the riverfront, straddling Delaware and Philadelphia counties, is a major source of noise. In a report prepared by the Federal Department of Transportation and the Environmental Protection Agency, the effect of airport noise on residential communities was evaluated and recommendations for future noise control were made. This study reveals that, with the exception of a few households in the Eastwick area, Philadelphia residents are not greatly affected by airport noise. Residents of Essington, Delaware County, and Gloucester County, New Jersey, are more directly impacted than Philadelphians because the principal landing and take off patterns are in an east-west direction.

This study also shows that in many areas of South and Southwest Philadelphia "indigenous" noise levels in industrial areas are sufficiently high as to mask airport noise. Noise levels are measured in terms of Ldn, a scale which ranges from 45, representing farmland noise levels, to 90, the noise level at the edge of a highway. The 65 Ldn is generally considered to be the delineation between acceptable and unacceptable noise levels for residential areas. In maps presented in the study, noise levels in South Philadelphia were estimated at 71 to 75 Ldn and in Southwest Philadelphia at 66 to 70 Ldn. Because noise levels attributable to airport operations over lands outside the airport limits are generally less than 75 Ldn, indigenous noise masks airport noise. The Environmental Nuisances map illustrates the zone where airport noise exceeds 65 Ldn.

Another noise source is the I-95 expressway. High speed car and truck traffic can generate high noise levels in the 80 to 90 Ldn range. These levels are generally unacceptable for residential communities adjacent to

expressways. The particular impact is dependent, however, on the elevation of the expressway in relation to nearby homes. The most disruptive noise occurs in situations where the road level is at the same elevation as second floor bedrooms in homes situated within 100 feet of the highway. Where the road level is either depressed below groundfloor elevations or above roof level, the noise impact is greatly lessened.

I-95 impacts residential communities in generally two locations, in Central City and in Bridesburg. Most of I-95 is near industrial areas or is raised above the roof line of residential areas. Through Center City, houses in Society Hill, Queen Village and Old City are close enough to be impacted by noise. To mitigate this noise, the Pennsylvania Department of Transportation has depressed roadway levels and has erected sound barrier walls. In Bridesburg, there are several residential blocks for which no sound barriers have been built and in which neighbors apparently find expressway noise a nuisance.

Noise along Delaware Avenue may become a greater nuisance than it is now as more homes are built along it. Delaware Avenue does not have a smooth paved surface, and within the roadway are several rail tracks. Delaware Avenue also serves as a major truck route. These factors cause noise associated with Delaware Avenue to be higher than would be the case for normal arterial roadways. New homes have been built adjacent to Delaware Avenue, and although they probably include ample sound proofing, indigenous noise levels in the external environment are likely to be intrusive. This situation may improve when Delaware Avenue is reconstructed.

The City does not have strong regulatory controls over noise. In Title 10, Regulation of Individual Conduct and Activity, Chapter 10-400 deals with noise. Provisions in the code deal with noise from garbage collection, street vendors, construction activity and motor vehicles. There is also a general provision for "all other loud and unnecessary noises upon or near to the streets and other public places." Air Management Services has drafted noise regulations which were reviewed in a public hearing in April 1981. These hearings prompted AMS to consider more restrictive noise regulations if they can get the Police Department to assume greater enforcement responsibility than has been the case to date. These new regulations are not expected to greatly affect riverfront areas because most of the regulations would deal with activities within residential areas.

ENVIRONMENTAL HAZARDS ALONG THE RIVERFRONT

The concentration of petroleum, chemical and metal processing activities along the riverfront is an indication that potential environmental hazards exist, such as from fire, explosion and release of toxic substances. While the risk of major fires, explosions and spills are not great, elaborate precautions have been designed to prevent accidents, and equally elaborate institutional arrangements have been set up to deal with accidents that might occur.

The City's Fire Department is the principal agency responding to land-based chemical accidents. Each of the Fire Department's companies prepare "pre-plans" for responding to emergencies at industrial and commercial sites within their jurisdiction. When a fire or an emergency spill occurs which involves

hazardous materials, one of the City's three, specially-trained hazardous material/chemical units responds. All fire companies and the three special units have access, through the Fire Communications System, to the Coast Guard's CHRIS for supplementary information. CHRIS is an acronym for Chemical Hazard Response Information System, a system which provides information on proper techniques for safely handling and removing spilled chemicals. Firemen can also receive information through a national, 24 hour, toll-free telephone line to Chemtrec, the Chemical Transportation Emergency Center, established by the Chemical Manufacturers Association in Washington, D.C. Chemtrec can provide guidance for proper response techniques for chemical spills. Where the emergency involves a chemical freight train or a truck, Chemtrec also automatically contacts the shipper whose material is involved in accident, as the shipper is ultimately responsible for emergency control. Shippers may also be able to supply additional emergency material handling information. Providing a third source of emergency information, the federal Department of Transportation has published an updated Hazardous Material Emergency Response Handbook. This document is used by the Fire Department as a primary source of emergency response information.

Recent amendments to the Philadelphia Fire Code gives the Departments of Fire and Licenses and Inspections additional responsibilities for industrial hazardous substances control. The amendments require these departments to establish siting and storage requirements for hazardous materials and to collect reports from industries on the nature of chemical substances with which they work. Reports on chemicals used by industries are available for inspection by the public through "right-to-know" provisions in the code. All industrial or commercial firms must obtain permits from L & I if they generate, store, handle, transport or use hazardous chemicals. With these amendments, the Philadelphia Code provides greater authority for control of hazardous materials than is available to any other municipal government in the nation.

The movement and disposal of hazardous waste materials is subject to federal and state laws. The federal Resource Conservation and Recovery Act and Pennsylvania's new Solid Waste Management Act have established a set of procedures for issuing permits for hazardous waste facilities and for monitoring the movement of hazardous wastes from their origin to their final disposal places. Permit applications made to the State's Department of Environmental Resources for waste facilities in the City are reviewed by a host of City agencies, including the Departments of Water and Licenses and Inspections and the Planning Commission, with the Health Department coordinating the City's review for the State.

The hazardous waste management system is still new to the State and City. Only several permit applications have been reviewed for new disposal facilities in the City. One important proposed disposal facility was reviewed and rejected by the City. Near Allegheny Avenue at the Delaware River, the Unitank Company proposed storing toxic organic substances for transfer to the Vulcanis, an incinerator ship that would burn the wastes over the ocean. The City objected to this project because an accidental spill could affect the quality of drinking water supplies at the Torresdale Filtration Plant. In November 1981, the City received 18 applications from existing industrial facilities within Philadelphia that are required, under

state law, to apply for permits, even though there may be no change to the nature of their operations. Of the 18, half are facilities in the vicinity of the riverfront. It is likely that in the future additional existing firms will apply for state hazardous waste disposal permits.

There is one site in the vicinity of the riverfront at which industrial wastes were illegally dumped and which is a serious environmental hazard (see Environmental Nuisances map). At a closed City dump along Enterprise Avenue, near the airport in Southwest Philadelphia, about 10,000 drums of industrial liquid chemicals were illegally dumped. The leakage from these drums could contaminate the Delaware River and aquifers which supply water to New Jersey communties. These drums are largely waste organic solvents, mostly from Delaware Valley industries. Many drums have corroded and are leaking, contaminating surrounding soil.

Because the dump is under the jurisdiction of the City's Water Department (as the site was to be used for a sludge compost facility) and because they have the technical capability to handle the situation, the Water Department has taken responsibility for clean-up operations at the site. The Water Department hired Roy F. Weston, Inc. to survey the dump and to offer several reclamation strategies. Following review by Federal and State environmental agencies, a strategy was selected which will involve the removal and containerization of all drums and surrounding soil for permanent disposal at a permitted landfill in New York State. The estimated cost for this clean-up procedure is $8 million. The City has exacted contributions of $2 million from some of the industries whose drums were discovered at the dump. The Law Department is preparing to sue the other firms who have chosen not to contribute to the clean up effort. Clean-up will begin in 1982.

There are probably industrial waste sites along the riverfront which remain unidentified. There has been long history of metal, chemical and petroleum handling along the riverfront. Outdoor areas typically have served as storage areas for raw material stockpiles and chemical drums. Wastes may have been buried by industries on their property as a convenient disposal method. There may have been, and may continue to be, undetected leaks in chemical and fuel storage tanks which contaminate the soil and groundwater in vicinity of such industries. Contamination of groundwater may affect the Schuylkill and Delaware River or their tributary streams when groundwater discharges to surface waters.

The detection of buried industrial hazards is extraordinarily difficult. Unless contamination appears in a sewer or in well water, it is likely to remain undetected. A study of Philadelphia's groundwater resources prepared by the U.S. Geological Survey for the Water Department indicates widespread contamination of the groundwater. Where these substances are oily, decontamination of the site might be necessary before land can be reused. Where gasoline or other highly volatile liquids contaminate the ground, an explosion potential exists and the ground must be pumped to siphon off the organic liquids. This situation has arisen at several City fuel tanks along the riverfront where groundwater has hastened the corrosion of underground metal tanks.

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MAP NOTES (CHAPTER V)

Riverfront Wildlife

This is a generalized map of those fields and woodlands which are likely to have significant concentrations of mammals and birds.

SOURCE: Interpretation of 1980 aerial photographs and field surveys.

Floodplains

This map does not show floodplains of tributary streams. Because the Delaware River is subject to tidal flooding, there is no floodway on the river. Maps of City floodplains do not depict flooding along the New Jersey riverfront. For this reason, the City boundary in the middle of the river is the limit of flooding shown on this map.

SOURCE: Federal Insurance Administration. 6/15/79. "Floodway Flood Boundary and Floodway Map, City of Philadelphia, Community-Panel Numbers 420757-005, 15, 20, 25, 30, 35, 40 and 45." Washington, D.C.: Federal Emergency Management Agency.

Environmental Nuisances

Air Pollutants. This category refers to census tracts within which air pollutant emissions from point sources exceed 1000 tons per year.

Odor Generators. The generalized circles show the areas which are regarded by Air Management Services as having major odor sources.

Noise Impact Areas. This is the land area in which noise from Philadelphia International Airport exceeds 65 Ldn, a level above which is generally regarded unacceptable for residents.

Hazardous Wastes. This map unit is the Enterprise landfill at which many thousands of drums of industrial liquid wastes were dumped illegally.

SOURCE: Interviews with Air Managment Services and Philadelphia Water Department.

RECOMMENDATIONS FOR MANAGEMENT OF RIVER RESOURCES

MANAGEMENT AND STUDY OF WATER QUALITY

DISSOLVED OXYGEN RESEARCH

A critical need in management of the water resources of the Delaware River is basic research into the river's water chemistry. The chemistry of dissolved oxygen and other substances is enormously complex, and although substantial amounts of data have been collected in the estuary, even basic reactions which govern dissolved oxygen concentrations are not well understood. What is known about dissolved oxygen has been incorporated into computer models by the Delaware River Basin Commission. DRBC is using these models to forecast dissolved oxygen for that future date when the estuary's billion dollar investment in pollution control equipment is completed. There are, however, significant questions about the reliability of the forecasts. The response of dissolved oxyen to reduced waste-loads and to high levels of nitrogen compounds is difficult to predict and may prove quite different from that which is forecast by DRBC models.

The questionable reliability of DRBC's computer models is very significant for Philadelphia. The models will be utilized to reallocate permissible organic waste loads to wastewater dischargers in the estuary. The model may indicate that existing waste load allocations are too high to meet DRBC's objective for minimum daily average dissolved oxygen concentrations in the vicinity of Philadelphia. Reduced waste loads consistent with achieving the oxygen standard may then be allocated to Philadelphia. The current allocations, however, have been the basis for the design of Philadelphia's sewage treatment facilities which will cost $900 million, and reduced waste load allocations could significantly increase the cost of new treatment facilities. If there is indeed risk that the model is predicting waste load reductions in excess of that needed to achieve dissolved oxygen standards, then any increased costs for pollution abatement at this time is unwarranted. The City should not be allocated lower waste loads over those presently assigned to the City until after improvements to dissolved oxygen arising from the current pollution abatement program can be full evaluated.

Poorly understood water chemistry also affects the credibility of DRBC's dissolved oxygen standards. The DRBC dissolved oxygen standards for Zone 3 and 4 is for not less than 3.5 mg/l during summer, expressed as a "minimum daily average." Because dissolved oxygen concentrations fluctuate considerably during the day, water with a daily average concentration of 3.5 mg/l actually has a much lower concentration, referred to as the "instantaneous low," at some point during the day. In addition, because the Delaware is sampled only infrequently, generally on a weekly basis, water quality data compiled by DRBC and the Philadelphia Water Department cannot provide a direct indication of compliance with the dissolved oxygen standard. This data, instead, provides seasonal average concentrations, not

daily averages. As a consequence, water quality experts have derived "rule-of-thumb" comparisons between their measured seasonal average and the daily average on which the standard is based. This "rule-of-thumb" is that when the seasonal average concentration is 4.0 mg/l, the minimum daily average is 3.5 mg/l, and the instantaneous low concentration is 1.5 mg/l. But 10 samples from near the mouth of Frankford Creek in 1980, which averaged 4.2 mg/l over the summer, had a minimum value of 0.4 mg/l, substantially below the estimated "instantaneous low derived from the "rule-of-thumb". Considerable effort, therefore, should be devoted to better establishing the nature of daily and seasonal dissolved oxygen fluctuations so that the significance of the standard may be better understood.

FISH POPULATION SURVEYS

Although DRBC's dissolved oxygen standard was established for the maintenance of a resident fish population, whether the adopted standards are high enough to sustain a fishery is a debate which remain unresolved. There are no on-going fish survey programs in the Delaware River near Philadelphia which can correlate fish population characteristics with dissolved oxygen concentrations. There are no data by which the failure to meet dissolved oxygen standards can be linked to effects on fish in the river. During DRBC's waste load reallocation process, there is apt to be debate over the adequacy of current waste load allocations to meet the 3.5 mg/l standard in the Philadelphia area. This debate cannot be meaningful unless the relative affects on the fishery of achieving this standard or meeting alternative standards, either lower or higher, can be described. At present there cannot even be an assurance that additional waste treatment would have measurable improvements for fish populations. Because the fundamental objective of the dissolved oxygen standard for summer is to maintain a resident fish population, it is important that the relationship between fish and dissolved oxygen be established in order to avoid unnecessary pollution control expenditures.

A major fish population study is recommended for the Upper Delaware Estuary. A variety of sampling methods, such as trawling, gill netting, seine collection and electrofishing, is necessary to eliminate the tendency of different techniques to catch different kinds of fish. The sampling sites should be throughout the upper estuary and be in the vicinity of Water Department sampling stations so that water quality conditions may be correlated to fish populations. Some sampling should be in deep water, while other sampling sites should be in shallow water habitat areas to establish the importance of shallows. Dissolved oxygen measurements should be made at the time of sampling. Sampling should be made at several times during the day and for each season of the year, and the survey should be conducted for three years to allow for the effect of varying rainfall and runoff conditions on water quality and fish populations.

DRBC has a charter-mandated responsibility, but probably not the funds, to carry out this fish survey. The DRBC should not reallocate waste loads to the estuary's wastewater dischargers until after such a survey of fish is completed so that it can be utilized to assess the adequacy of existing water quality objectives.

FISH FLESH AND BIOASSAY STUDIES

In conjunction with the fish survey, there should be two additional studies to establish the influence on fish of metals and other substances in trace amounts. One study should consist of bioassay texts establishing the water quality standards for aluminum, lead, nickel and zinc. The current standards for these four metals are expressed in state regulations as a proportion of the concentration at which 50 percent of specimens of a representative fish species die after 96 hours of exposure. Because these bioassay tests have not been done, these four water quality standards do not have any meaning. The second test which should be performed is an analysis of fish flesh from fish caught in the Delaware and Schuylkill Rivers to determine whether the fish are acceptable for human consumption. Together these two tests could establish whether Philadelphia's rivers can be safely harvested for food.

FISHERY MANAGEMENT

FISH STOCKING IN THE DELAWARE

The Delaware Estuary's billion dollar pollution abatement effort should greatly improve recreational and commercial fishing opportunities. When sewage treatment plants are fully operational in 1987, agencies responsible for fishery management should be ready to promote the optimal utilization of the river. The Pennsylvania Fish Commission has proposed stocking the estuary upstream of the Tacony-Palmyra Bridge with tiger muskellunge, walleye and striped bass, three favorite game fish. This proposal should be carried out in order to hasten the improvement of the river as a recreational resource. New Jersey's program for assessing the potential viability of a steel-head rainbow trout stocking program and the U. S. Fish and Wildlife Service's Anadromous Fish Project are two programs which may help foster new commercial fishery enterprises in the Delaware River. Other commercially oriented management projects should be identified. The Pennsylvania Fish Commission should also continue their annual boating and angling use survey. This survey can provide measures of the increased utilization of the Delaware River arising from improved water quality.

FISH LADDER AT FLAT ROCK DAM

For the Schuylkill River, the construction of a fish ladder at the state-owned Flat Rock Dam should be accorded high priority. The State has delayed funds for a fish ladder at this dam, even though the full value of the City's Fairmount Fishway will not be realized until this second ladder is built. Local environmental groups and political representatives should work together to urge the inclusion of this project in the Department of Environmental Resources' capital program.

SCHUYLKILL FISHERIES MANAGEMENT

The Pennsylvania Fish Commission has recommended several fishery management programs for the Schuylkill River between Flat Rock and Fairmount Dams. The Fish Commission plans to continue its stocking program for walleye and tiger muskellunge on a biannual basis. They have also recommended regulations prohibiting the harvesting of shad, herring and alewife from the Schuylkill until after the population of these migratory fish have been reestablished. The Fish Commission has also been encouraging the City's Fairmount Park

Commission to develop a maintenance program for the upkeep of the Fairmount Fishway, a facility which is under City ownership. The most important step is to keep the fishway clear of debris, but repairing vandalism and cutting weeds are also needed. These recommendations should be implemented.

A very significant fishery management project for the tidal Schuylkill River is the control of pollution discharge. A large proportion of sewer overflow chambers are apparently regularly malfunctioning, causing raw sewage to be discharged in the Schuylkill River below Fairmount Dam during dry weather. This sewage discharge has caused dissolved oxygen to decline to levels incapable of sustaining fish life or the passage of migrating fish. During the spring migrating season in particular, it is essential that all overflow chambers be functioning properly to avoid an oxygen block which would interfere with the full use of the fishway at Fairmount Dam. The City's Water Department is responsible for the maintenance of these chambers. Their maintenance crews should be directed to daily inspect each overflow point during the March through June migrating season so that they may make timely repairs.

MANAGEMENT OF SHALLOWS

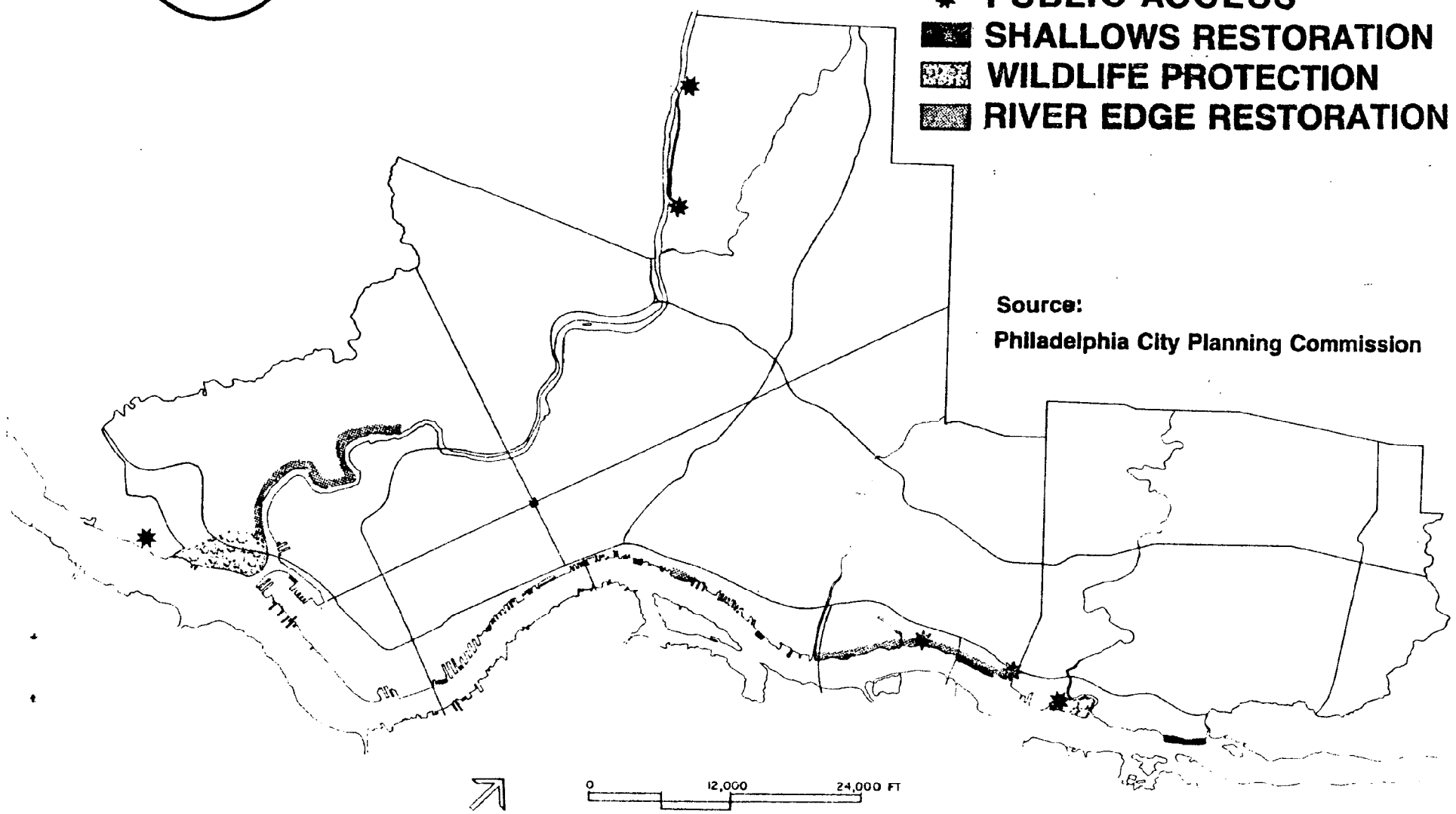
PROTECTION OF EXISTING SHALLOWS

Although the City's $900 million pollution abatement program will create major improvements to the water quality in the Delaware Estuary, the future of Philadelphia's game fishery is in part dependent on the condition of the shallow water habitats. Federal regulations on dredge and filling activity are being strongly enforced in order to achieve the national objective of shallow waters protection. Federal and State agencies, moreover, are recommending that shallow areas be restored in areas like Philaldelphia where the historical use of the shoreline has largely eliminated the original shallows.

SHALLOWS CREATION

New shallows should be created along Philadelphia's riverfront to compensate for future loss of shallows and to improve recreational fisheries. Shallows creation, although not an activity which has been undertaken elsewhere in the estuary, is apparently not a difficult task. The Operations Division of the Army Corps of Engineers has undertaken shallows area creation as a means of dredge spoil disposal within the Delaware Bay. For the estuary in the vicinity of Philadelphia, the most appropriate method would consist of the placement of pre-cast concrete blocks to serve as a bulkhead about 500 to 1000 feet off shore, backfilled with dredge spoil pumped from the channel. While a City agency or the Port Corporation would have to take responsibility for testing the river bottom, designing the structure and placing the bulkhead, the Corps of Engineers could probably supply the backfill. To avoid creating hazards for boaters, the shallow would have to slope gradually from 8 feet below mean sea level to about 4 feet deep at the shore. There are several horticultural firms which are able to supply seed and root stocks for vegetation native to shallow areas. This vegetation could be planted to aid rapid habitat restoration. The Corps staff says that shallows restoration does not require unusual or difficult engineering or construction techniques, and they are available to give technical information on shallow restoration techniques and general cost estimates.

RECOMMENDATIONS



A program for shallows protection and enhancement should be based on the following objectives and guidelines:

1. Shallows which are in areas of high water quality are relatively more important than those in areas of poor water quality.

2. Shallows in close proximity to areas of public access for boating and fishing are more important than those without good access.

3. Protection and enhancement measures should not interfere with development of marine commerce facilities and with the use of the river for pleasure boating.

4. Shallows should not be disturbed as a result of development activity which is not in support water dependent uses.

5. Shallows lost to development should be replaced by artifically created shallows.

Shallow habitat restoration is recommended for the following locations (see Recommendations map):

Torresdale area. There are no extensive shallow habitats in the Torresdale Area between Linden Street Access Ramp and the City boundary at Poquessing Creek. This portion of the Delaware River has the cleanest water within City boundaries, and there is good public access for boating and fishing. Shallows restoration could significantly benefit the fisheries in this area.

Tacony-Palmyra Bridge area. Shallows should be restored in the area of river from the Tacony-Palymra Bridge to a point one-half mile upstream, extending from the shore to approximately 750 feet offshore. This stretch of riverfront has no shallows. Within a mile of this portion of the river there are two private yacht clubs, and two new public boat launch facilities are proposed. Major improvements to water quality will occur after the Northeast Sewage Treatment Plant has been upgraded. A feasibility study is needed to determine whether the artificially created shallows would be stable within this stretch of the estuary.

Pulaski Pier. Although there is a tidal flat at this small park facility, the submerged area closest to Pulaski Pier is generally deeper than 10 feet. Because this park will be rehabilitated and made more suitable for fishing, and because water quality should significantly improve in this portion of the river, creation of a shallow water habitat could substantially increase the attractiveness of the park for fishing.

Penn Treaty Park. Penn Treaty Park will be expanded over the next several years for the City's tercentenary celebration. It will also be one of the only public access points to the river for Fishtown residents. When water quality improves, there will be a concomitant improvement to the fisheries. Shallows restoration could aid this fishery improvement and, by providing a good fishing opportunity, serve to make Penn Treaty Park a more interesting recreation facility.

PUBLIC ACCESS DEVELOPMENT

ACCESS TO THE DELAWARE

Access to the Delaware River for Philadelphia residents should be a high priority in river-front planning. The enormous capital and operating costs for pollution abatement will have created by 1987 a premium of about $250 annually for each of the Water Department's residential customers. The primary benefit derived from this premium is cleaner water and improved fisheries. Boating and fishing access to the river should be developed to meet the maximum demand which can be expected for water-based recreation. The Pennsylvania Fish Commission has budgeted several million dollars over the next five years to build three public boat launches which will serve primarily Philadelphia residents at the foot of Princeton Avenue, at the Frankford Arsenal and at Hog Island. The City has supported the Fish Commission, but should also continue developing boating and fishing access on its own at the mouth of Pennypack Creek, Penn Treaty Park and other publicly-owned riverfront locations.

Because water quality will be particularly good upstream of the Tacony-Palmyra Bridge, the City should consider acquiring access to properties with substantial unused lands at the river's edge for future park development in this northeastern section of Philadelphia.

ACCESS TO THE SCHUYLKILL RIVER

On the Schuylkill River, new river-oriented recreation could be developed. The Schuylkill is not fished nor enjoyed by boaters to its full potential, and in the pool above Fairmount Dam two projects are proposed. Fishermen are presently limited to river-bank fishing beause of the lack of suitable launches for low powered motor boats in the Fairmount pool. The Fish Commission in 1980 proposed to assist in the construction of a launch in Fairmount Park upriver of Girard Avenue bridge, and they have also proposed a set of boating regulations to ensure minimal conflict with the scullers of the Schuylkill Navy. Although not supported then by the City, this project should be reconsidered. Because much of the Schuylkill River banks in the Manayunk area is owned by industries, there is presently limited public access to the scenic and productive stretch of the river above the mouth of Wissahickon Creek. Park and launch development might be practicable, for example, at the southern end of Venice Island.

One of the best opportunities for enhanced river-oriented recreation for City residents is in the pool above Flat Rock Dam. The City has completed a trail from Manayunk to the Shawmont Station on the Norristown raillines. This parkland, however, is not equipped for the launching of power and non-power boats for fishermen and boaters. Because this pool is underutilized and the river is rich in scenic qualities and fish, the opportunity for additional recreational development is great on existing, City-owned parkland.

WILDLIFE HABITAT MANAGEMENT

HABITAT PRESERVATION

There are only a few opportunities for protecting wildlife habitats along the river-front. The two principal areas which are recommended for wildlife protection are the mouth of Pennypack Creek and the Fort Mifflin

spoil disposal areas. These areas provide most of the only significant wildlife habitats along Philadelphia's portion of the Delaware Estuary. Minimal efforts would be necessary to maintain these areas as wildlife preserves. In addition, several areas along the tidal Schuylkill have shrubby or tree covered riverfronts which could be developed in a way which maintains a vegetated buffer. These potential buffers extend along 4500 feet of the west bank of the Schuylkill River.

RIVERFRONT RESTORATION

There are major opportunities to restore a vegetated buffer at the riverfront to enhance both the wildlife habitats and the visual appearance of the riverfront (see Recommendations map). The principal zone in which a planted buffer could be created is from the Betsy Ross Bridge to a point three miles upstream at Northern Shipping. In this zone, the river edge is mostly rubble, rather than bulkheaded, and riverfront industries generally do not utilize their river frontage for marine dependent activities. This is also the zone within which the greatest increase in recreational boating will occur.

Another important riverfront area for restoration is the west bank of the Schuylkill River from Bartram's Gardens south to the river's confluence with the Delaware River. With the exception of U.S. Gypsum and one oil storage facility, the west bank consists of lands which can be planted to an attractive and productive vegetative buffer. Because this area is largely within the Schuylkill's floodway, a buffer would not be creating restrictions on future development. A planted buffer would serve also to visually link the several tree-covered parcels which already exist on the west bank. In one case, the creation of a buffer would require the removal of junked automobiles which now fall at the edge of the river.

MITIGATION OF ENVIRONMENTAL NUISANCES

For the most part, public controls over flood plains, air quality, noise, odors and hazardous materials are adequate to protect the safety and well-being of City residents and workers. There are only several issues which are not well covered by laws, regulations or administrative procedures.

HAZARDOUS MATERIALS CONTROL

The State in 1981 began implementing regulations governing the transport, storage and disposal of hazardous waste materials; and recent amendments to City codes have resulted in new efforts by City agencies to protect the community and workers from exposure to toxic substances. There are several issues facing the City with regard to hazardous materials and wastes which will be addressed over the next several years.

The City is charged in the amended codes with establishing siting regulations for industrial firms handling hazardous materials. But there are only a few particularly toxic substances for which siting criteria have been promulgated nationwide. The City is concerned that local regulations may not be technically justifiable and that they may injure the economic competitiveness of Philadelphia industries. Residential communities in the City are quite concerned that standards be set

which specify acceptable distances from which homes must be separated from industries handling hazardous materials. But if this were applied to existing firms, there could be dislocation of industry from the City. The City has not yet adopted siting criteria because of these dilemmas.

The City is still formulating procedures to guarantee its own conformance with the State's hazardous waste handling and disposal regulations. The City's laboratories have small quantities of substances that must be disposed of in a controlled manner, and occasionally the Fire Department's emergency treatment of chemical spills leaves it with large amounts of contaminated absorbents with which it must deal. A number of departments may have old transformers containing polychlorinated biphenyls (PCBs), the disposal of which is controlled by the Environmental Protection Agency.

Although the City would like to assist Philadelphia industries with hazardous waste disposal problems, it is not clear how it can do so. There are no sites within the City for the treatment or permanent disposal of hazardous industrial wastes, and some firms must export wastes considerable distances at high cost. Some businessmen have urged the City to accommodate such facilities within the City because it could possibly give Philadelphia a competitive edge for attracting industries needing such treatment and disposal services. On the other hand, City codes and regulations are sufficiently cautious and restrictive as to make the development of such a facility enormously difficult to achieve. The riverfront, which contains many of the sites most remote from residential communities and closest to existing industries, is not a clearly desirable location for an industrial waste plant because of the potential for spills to the river. This was the basis for rejecting the proposed Vulcanic incinerator ship. The balance of economic benefits against environmental risks is likely to be exceptionally difficult in the siting of hazardous waste disposal facilities.

ODOR CONTROL

Although there are City ordinances regulating odors, many odor problem are not amenable to easy solutions. Air Management Services is conducting a study in the two areas where odors are particularly bad in order to evaluate community exposure to air-borne hazardous substances. As part of this study, five industrial firms will be surveyed, and all present and potential emission points will be examined. These in-depth surveys may serve to identify control measures which could be applied to odors as well as to hazardous substances. A diffusion model recently developed by AMS meterologists to predict the movement of air-borne substances can be used for odors as well as conventional pollutants. The analytical equipment being purchased by AMS under EPA grants will give the City the technical capacity to identify and measure odor-causing substances. The net result of these steps should be to equip the City to better control odors in these two riverfront areas in the future.

FLOODPLAIN CONTROLS

There are a substantial number of industrial building within the floodway of the Schuylkill River, both in the tidal portion of the river and on Venice Island in Manayunk. Should they make substantial improvements, these

industries are required by City codes to floodproof up to at least the regulatory flood elevation. City codes also permit no new structures to be built in the floodway without the creation of additional flood carrying capability in the floodplain. Technically, outdoor storage of material or accessory buildings in floodplains are required to have L & I permits. These several constraints on floodway development may cause, over the long term, the displacement of industries from within the floodway. If this were to happen, these lands could be reutilized for open space, perhaps the most appropriate use for floodway areas. This process has already occurred on the southern end of Venice Land, where a fire damaged building was demolished and cannot be replaced with a new structure because of floodplain restrictions. This land could be acquired for parkland and become a significant access point to the Schuylkill River from Manayunk.

SEPARATION OF LAND USES

One technique for mitigating environmental nuisances is separation of land uses, but this control measure has generally not been used. Complaints received by AMS regarding noise, odors and air pollution are most typically from residents objecting to nearby industrial activities, utilities or heavy traffic. The Air Management Code provides the Public Health Department with the authority to compel separation of uses where a nuisance may be created by inappropriately clustered land uses. Redevelopment of the Central Riverfront District, an area which at one time was devoted solely to industrial and commercial enterprises, will create an increasingly mixed land use pattern. While over the long-term residential land uses may fully replace industry and utilities from Spring Garden Street south to Washington Avenue, in the near term conflicts may arise from noise, odors, air pollution and traffic impact from existing uses on new residents. These conflicts could be lessened by not encouraging residential development in advance of the closing of industries or utilities or, conversely, by encouraging relocation of undesirable activities to new industrial locations. The East Central Incinerator is one example of an air-polluting utility which may be eventually closed but which is likely to create occasional nuisances if new homeowners are built nearby in the near future.