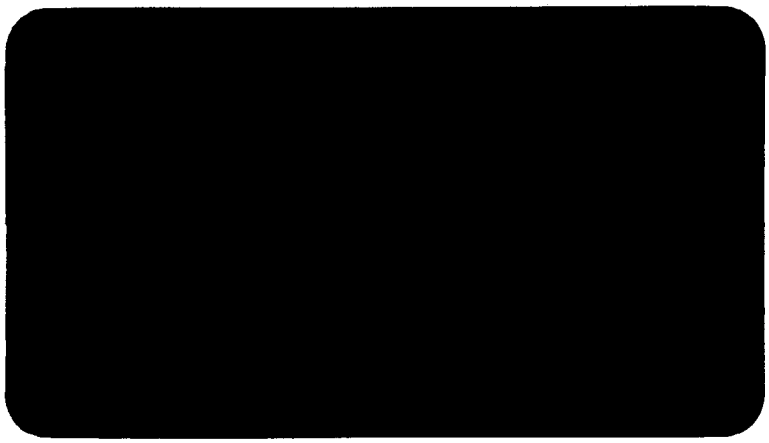

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FINAL

BALTIMORE COUNTY
WATER DEPENDENT FACILITY PLAN

Prepared for

Baltimore County, Maryland
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CONTENTS

1. INTRODUCTION

2. DEVELOPMENT REVIEW PROCESS FOR WATER DEPENDENT FACILITIES

   2.1 Approach
   2.2 Project Review Steps
   2.3 Expanded Outline

3. PRELIMINARY SITE SCREENING EVALUATION

   3.1 Screening Factors
   3.2 Aquatic Concerns
   3.3 Terrestrial Concerns
   3.4 Informational Requirements for Applicant Submittal

4. DETAILED ENVIRONMENTAL ASSESSMENT

   4.1 Water Quality Concerns
   4.2 Best Management Practices
   4.3 Rating System

5. STATE AND FEDERAL REGULATORY PROGRAMS

   5.1 Summary
   5.2 Agency Responsibilities and Guidelines

      5.2.1 Federal Agencies
      5.2.2 State Agencies

6. IMPLEMENTATION RECOMMENDATIONS

APPENDIX A: MARYLAND RECEIVING WATER STANDARDS
APPENDIX B: FEDERAL SURFACE WATER QUALITY
APPENDIX C: EPA ANALYTICAL METHODS
APPENDIX D: FLUSHING RATES AND STEADY STATE CALCULATIONS
APPENDIX E: SIMPLE ONE DEMENSIONAL KINEMATIC MODEL RESULTS FOR THE BUSH RIVER AND ROMNEY CREEK

1. INTRODUCTION

The 1984 session of the Maryland State Legislature enacted the Chesapeake Bay Critical Area Law in recognition that land uses near the water's edge have important water quality and habitat consequences. This landmark legislation designated the Criteria Area, required interim findings, established a Chesapeake Bay Critical Area Commission, and mandated the Commission to promulgate Criteria that would guide tidewater jurisdications in the development of local Critical Area Plans. The Criteria, with minor amendments, were adopted as regulations under COMAR 14.15.01 through 14.15.09 in 1986.

Section 14.15.03 requires that local jurisdictions develop a process for approving new or expanded water-dependent facilities within the Critical Area. Water-dependent facilities are defined as those structures or works associated with industrial, maritime, recreational, educational or fisheries activities that require location at or near the water's edge. Water-dependent activities, by definition, cannot exist outside the Buffer and are dependent on the water owing to the intrinsic nature of their operations.

This report presents Baltimore County's response to the local plan requirements for water-dependent facilities. It provides a comprehensive and integrated decision-making system for the review of water-dependent facility construction within the County. The plan includes an objective review process, integrates state and federal regulatory guidelines applicable to water-related development activity and recommends elements of an implementation program.

Development pressure along Baltimore County's shoreline has been very intense. One method to assess the intensity of development along the shoreline is to review Army Corps of Engineer's (ACOE) activity under their Section 10/404 permit authority. A survey of over 7,000 Corps permits granted in the Chesapeake Bay region between 1773 and 1979 provides valuable insights into the nature of water-related development activity in Baltimore County (Eberhart and Dolan, 1979). The Baltimore District granted 577 permits in Baltimore County during that six-year period which translates to a density index of 3.22 permits per mile of shoreline, second only to Anne Arundel County. Most other jurisdications showed a range of permit activity between .5 and 2.0 permits per mile of shoreline. The high density of projects approved along Baltimore County's waterways is especially significant when one considers that most development activities occurred in Middle River and Back River.

An earlier study on the development pressures along the Chesapeake Bay Shoreline stated that Anne Arundel, Talbot, and Baltimore Counties were under the greatest pressure for alterations of their shorelines. Between them they accounted for 55.2 percent of the total number of 1983 Maryland Corps applications (Eberhart 1974). Clearly, the need is present to implement a water-dependent facility plan for Baltimore County which will

ensure that future activities will minimize the individual and cumulative impacts on water quality and the remaining natural habitat in the Critical Area.

This report is intended to provide a planning tool to County staff responsible for the review of applications for new or expanded water-dependent Facilities. It may, however, also provide guidance to developers on the initial selection and evaluation of potential sites for water-dependent uses. The proper selection of a site is clearly one of most important aspects of developing a water-dependent facility in an environmentally sound manner.

2. DEVELOPMENT REVIEW PROCESS FOR WATER-DEPENDENT FACILITIES

2.1 APPROACH

One of the major objectives of this report is to delineate a review process for water-dependent facilities which is objective and one which permits a thorough evaluation of the major community planning and environmental issues. Section 2.2 describes, in an expanded outline format, the basic steps involved in evaluating a specific proposal for a water-dependent facility. It incorporates the many definitions, conditions, conservation and performance requirements of the Chesapeake Bay Critical Area Criteria that are applicable to water-dependent facilities. By proceeding through the decision matrix steps, I through VI, the reviewer is able to determine: whether this review process applies to the proposed activity; the class of water-dependent facility proposed; whether the activity is permitted, regulated, or prohibited, and, identifies conditions and conservation requirements that apply to the proposed activity. Once the requirements have been identified, Section 3.0 describes a preliminary evaluation process that is used to determine the sites overall suitability for a proposed water-dependent facility.

The Water-Dependent Facilities Review Process is structured to facilitate two levels of review: a preliminary site screening evaluation; and, a detailed environmental assessment. The first level of review identifies the major community planning issues and environmental concerns associated with the proposed activity and is consistent with the level of detail necessary for the County to determine it's position at the special exception hearing. The detailed environmental assessment would follow special exception approval and provides sufficient information for the County to prepare a findings of fact for the County Review Group (CRG). In instances where a special exception is not required for a particular use, the two-tier system is still useful in identifying issues and evaluating solutions or mitigation.

The preliminary evaluation is a means to screen out proposals which will generate unacceptable impacts to the natural resources or water quality of the Chesapeake Bay. Many of the factors listed in the preliminary site screening evaluation reflect permit issues considered in the Army Corp of Engineers (ACOE) permitting process. Others reflect issues of special concern to Baltimore County or to the State of Maryland and represent unique problems associated with the Chesapeake Bay. In addition, the preliminary evaluation flags those issues which are suitable for resolution or mitigation during the second level of review.

This approach assumes that not every environmental impact can be resolved or mitigated and, we believe, provides a realistic perspective on the complex of local, state and federal regulations which affect permitting decisions for water-dependent facilities. In order for the County to make a findings of fact required by the Chesapeake Bay Critical Area Law, requires an intensive review of environmental baseline data, site plan

and Proposed Best Management Practices (BMPs). Without a two-phased review, these requirements place a significant financial burden on the applicant who has little idea whether his proposal will be approved. The preliminary evaluation can inform applicants early in the review process that it is highly unlikely that his or her project will receive local approval or that the applicant has some assurance that the additional expense of time and funds will lead to an approvable project.

The key step in the preliminary evaluation requires the reviewer to determine the intensity of impact of the proposed project in twelve environmental issue areas. The reviewer must then choose, in most cases, between three levels of impact: unacceptable; moderate/undetermined; or minimal/resource not present. Where feasible, definable parameters for determining severity of impact are incorporated into the review process.

The information required of the applicant for the preliminary evaluation includes the applicant's response to these twelve environmental issue areas, in addition to the conceptual site plan, existing conditions map and a regional context map. The applicant is required to submit an environmental assessment report describing the plant and wildlife habitats identified on the existing conditions map and incorporating the analysis of potential environmental impacts to the natural resources and water quality of the Chesapeake Bay. A complete list of information required at the first level review can be found in Table XX. Sections 3.2 and 3.3 describe aquatic and terrestrial concerns associated with water-related development activity, identifies informational sources and clarifies the ecological inventory requirements listed in Table XX.

The natural features information should include a description of the existing conditions for both the upland portion of the site and the adjacent aquatic system. In order for this two-stage review process to be effective, requires the bulk of the natural features inventory to be compiled during the first level review. A site investigation which includes identification of dominant plant species and verification of any potential rare and endangered species is mandatory.

The second level of review is a more detailed environmental assessment of the major issues that have been flagged at the first level of review. Projects reaching the second level of review are generally assumed to be viable projects unless particular environmental impacts or a combination of factors are found to be unresolvable through best management practices or mitigation. The Phase II review builds on the environmental baseline data that was provided during the preliminary evaluation. In instances where the environmental impact could not be adequately addressed during the preliminary evaluation more detailed field information may be required.

Stormwater management practices provide an example of the differences in the type of information required during the first and second levels of review. During the preliminary site evaluation, the requirements for stormwater management are conceptual. The applicant must show the

proposed location for the stormwater management facility, must determine whether infiltration is appropriate, or whether a retention/detention structures will be utilized. Information required for the second level of review would include: projected non-point source loadings; final engineering specifications; sediment control practices.

The key step in the detailed environmental assessment involves the application of an objective and consistent rating system to each proposal that comes before the County Review Group. The rating system addresses the cumulative impacts of a water-related project on the environment by assigning points to the entire set of natural resources of concern to Baltimore County.

Much of the review conducted for the County Review Group is technical in nature and involves an evaluation of the engineering alternatives to mitigate adverse impacts associated with the construction and operation of water-dependent facilities. Section 4.2 describes BMPs for upland and water-related development activities. The rating system also attempts to address the cumulative impacts of additional water-dependent facilities by assigning a weighted factor for poor existing water quality and a similarly weighted factor for poor flushing characteristics in the adjacent estuarine subarea. The latter acknowledges the importance of flushing characteristics in concentrating pollutants from a number of water-related development activities.

Currently there are 78 marinas, boat yards, or yacht clubs located along Baltimore County's waterways. These facilities alone contain over 5,000 boat slips. Many of the water-dependent applications that Baltimore County will receive will be for expansion of existing facilities. This is especially true when one considers the restrictions on new water-dependent facilities in the Resource Conservation Area. For significant expansions of water-dependent facilities, the two-level review described herein is certainly applicable, however, the County may wish to abbreviate the review process for minor expansion proposals.

2.2 PROJECT REVIEW STEPS

I. Is proposed activity located within the Chesapeake Bay Critical Area?

II. Determine if activity proposed is water dependent.

III. Determine type of water-dependent facility.

IV. Locate proposed site, determine Critical Area designation. Is the proposed activity permitted, regulated or prohibited by Critical Area designations?

V. Evaluate whether water-dependent Critical Area requirements have been met.

A. Community Piers

B. Marinas

C. Industrial/Port-Related

D. Waterfront Recreation

E. All Water-Dependent Facilities

VI. Additional upland requirements determined by Critical Areas designation.

A. Intensely Developed Area.

B. Limited Developed Area.

C. Resource Conservation Area.

VII. Preliminary Site Screening Evaluation

A. Environmental Issues

B. Community Planning Issues

VIII. Detailed Environmental Assessment

2.3 EXPANDED OUTLINE

I. Is proposed activity located within the Chesapeake Bay Critical Area?

If affirmative - proceed to II

If not - activity does not fall under this review process.

II. Determine if activity proposed is Water-Dependent.

Does the proposed activity require location at or near the shoreline? If the proposed activity can exist outside the Buffer and is not dependent on the water intrinsically than it is not a water dependent facility and is not permitted in the Buffer.

If activity is water dependent - proceed to III.

If activity is not water dependent - it is prohibited in the Buffer unless Buffer exemption pursued (see COMAR 14.15.09)

III. Determine Type of Water Dependent Facility.

A. Private Piers

Is activity an individual pier, privately owned or maintained by riparian landowner and not part of subdivision providing community piers.

If activity is individual pier - than exempt from water-dependent facilities approval process.

If activity is not a individual pier - continue to B.

B. Community Piers

The definition of community piers and other related non-commercial boat docking and storage facilities requires that the facility be under community ownership by residents of a record plat subdivision. Community piers would include boat docking facilities associated with condominium, apartment and other multiple-family dwelling units. Yacht clubs, although sometimes structured to benefit members, will generally fall under C.

If community pier - proceed to IV.

If not community pier - continue to C.

C. Marinas, or Other Commercial Maritime Facilities.

Marinas, by Criteria definition, refer to any facility for the moring, berthing, storing of watercraft excluding community piers. Boat building, repair and storage facilities would also be included in this class of water-dependent facilities.

If activity proposed is a marina or related maritime facility-proceed to IV.

If not - continue to D.

D. Industrial and Port-Related Water-Dependent Facilities.

Ports, according to Criteria definition, refers specifically to areas established or designated by Baltimore County or the state to promote water-borne commerce, excluding fisheries activities. Any industrial land use activity requiring water access or use such as intake/outfall structures would fall under this category.

If activity industrial or port-related - proceed to IV.

If not - continue to E.

E. Waterfront Recreation or Education.

The operative determinant for this category is the term public. Includes public beaches, publicly-owned boat launching and docking facilities, fishing piers, and, waterfront passive recreational uses.

If activity is a public waterfront use - proceed to IV.

If not, continue to F.

F. Water-Dependent Research Facilities.

Includes County, State and federal research agencies or private educational institutions.

If activity is a research facility, the criteria allows activities in the buffer under all three categories (RCA, LDA, IDA). Only requirement is that non-water-dependent structures associated with research activities be located, to the extent possible, outside of the buffer.

If not - continue to G.

G. Fisheries Related Activities.

Commercial water-dependent fisheries facilities would fall into this class and include, fish off-loading docks, crab shedding structures, shellfish culture operations. These fisheries activities may be permitted in the buffer in all three categories (RCA, LDA, IDA). Land and water areas with high aquacultural potential are recommended for protection from water quality degradation by adjacent land and water uses.

IV. Locate proposed water dependent facility and determine Critical Area designation.

Determine whether the activity is permitted as of right, regulated or prohibited by Chesapeake Bay critical area requirements (see Table 2-1).

If activity proposed is prohibited in the Critical Areas designation determined for the site, does the applicant wish:

TABLE 2-1 LOCATIONAL REQUIRMENTS FOR WATER-DEPENDENT FACILITIES

Type of Facility	RCA	LDA	IDA
Private Piers	P	P	P
Community Piers[a] (new and expanded)	C	C	C
New Marinas and Other Commercial Maritime Facilities	X	C	C
Expanded Marinas and Maritime Facilities	C[b]	C	C
Industrial and Port-Related Facilities[c] (new, expanded or redeveloped)	X	X	C
Public Beaches and Other Water-Oriented Recreation Areas (new)	C	C	P
Research Areas (new)[d]	P	P	P
Fisheries Facilities	P	P	P

Key

P = proposed activity permitted as-of-right
C = allowed if conservation requirements can be met
X = Prohibited in specific Critical Area designation

(a) Subject to limitations on slip density.
(b) Permitted in RCA only if net improvement in water quality can be achieved.
(c) Non-water dependent activities may be allowed in the Buffer only in shoreline areas exempted from the the Buffer requirement.
(d) Provided that non-water dependent features are located outside of Buffer.

1. Amend application so that it is in conformance with the Critical Area designation (for example changing site plan from commercial marina to a community pier which may be permitted in RCA).

2. Request change of Critical Area designation which may allow proposed use (if growth allocation permits).

If activity is permitted providing specific conditions or conservation requirements are met - proceed to next section.

V. Evaluate whether the water-dependent Critical Area requirements have been met.

A. Community pier and non-commercial marina (new or expanded facility).

1. Facility may not offer food, fuel, or other goods and services or sale.

2. Sanitary facilities must be shown.

3. Community piers must be part of an existing or proposed riparian subdivision.

4. Disturbance to the Buffer is restricted to the minimum necessary to provide a single point of access to the water dependent facility.*

5. Applicants for riparian subdivisions are strongly urged to utilize community piers for residents over the option of private piers. Incentives should be utilized by the County to discourage private piers. If the applicant proposes community piers - no individual piers would be allowed.

6. The number of slips, piers or moring buoys shown on the site plan cannot exceed the lesser of the following two means of determining the number of slips allowed; 1. One

* It is important to note that the Buffer is a "floating buffer" and includes areas adjacent to the minimum 100' Buffer which contain hydric soils, highly erodible soils, and significant habitats. In addition, if step slopes are present in the Buffer, then the Buffer shall be increased 4 feet for each 1% increase in slope greater than 15% or to the top of slope, whichever is greater. For facilities proposed in the RCA designation, the Buffer shall be increased to 300 feet for non-water-dependent facilities.

slip for each 50 feet of shoreline in the subdivision in the Intense and Limited Development Areas and one slip for each 300 feet of shoreline in the subdivision in the Resource Conservation Area; or 2. Density of slips, piers or moring buoys to platted lots or dwellings within the subdivision in the Critical Area according to the followed schedule:

Platted Lots or Dwellings in the Critical Area	Slips and Morings
1 to 15	One for each lot
16 to 40	15 or 75%, whichever is greater
41 to 100	30 or 50%, whichever is greater
101 to 300	50 or 25%, whichever is greater
Over 300	75 or 15%, whichever is greater

7. Are non-water-dependent improvements, insofar as possible, located outside the buffer? Is there any justification for a waiver from the buffer requirements?

B. Marinas and Maritime Facilities.

1. Expansion of existing marinas within Resource Conservation Areas can only be allowed if they can show a 10% reduction in pollutant loadings from the marina site.

2. Applications for new marinas must show a means for minimizing the discharge of bottom-wash waters into tidal waters.

C. Industrial and Port-Related Water-Dependent Facilities.

1. Each new, expanded, or redeveloped industrial application will be unique and no set of guidelines could be expected to cover the range of potential uses and impacts. Each application will have to be evaluated on the basis of general design criteria found in COMAR 14.15.09 (Habitat Protection requirements) and Section E, described below.

D. Public recreational or educational facilities may be located in the Buffer provided that:

1. Adequate sanitary facilities exist;

2. Service facilities, to the extent possible located outside the buffer;

3. Permeable surfaces to the extent practical, if no degradation of groundwater would result;

4. Disturbance to natural vegetation is minimized;

5. Areas for passive recreation such as nature study, and hunting and trapping and for education, may be permitted in the Buffer within Resource Conservation areas, if service facilities for these uses are located outside of the Buffer.

E. All applications for water-dependent facilities must show:

1. That they are water-dependent.

2. That the project meets a recognized private right or public need;

3. That, insofar as possible, non-water-dependent structures or operations associated with water-dependent projects or activities are located outside the Buffer;

4. That adverse effects on water quality, and fish, plant, and wildlife habitat are minimized. This finding will be based on the following factors:

a. That the activities will not significantly alter existing water circulation patterns or salinity regimes;

b. That the water body upon which these activities are proposed has adequate flushing characteristics in the area;

c. That disturbance to wetlands, submerged aquatic plant beds, or other areas of important aquatic habitats will be minimized;

d. Mitigation of pollutant loadings from: upland surface runoff; sewage discharge from landslide or boating activity; bottom-wash and maintenance operations;

e. Activities proposed not adversely impact shellfish beds;

f. The timing and method of dredging cause the least disturbance to water quality and natural habitat;

g. The activities proposed minimize interference with prevailing pattern of littoral drift;

h. The activities proposed will not generate a volume of dredged spoils that cannot be handled in an environmentally sound manner. Of special concern here is

whether the location of the proposed facility will require extensive maintenance dredging over the life of the facility and, if so, the applicant should include a long-term plan for the disposal of periodic maintenance dredge spoil. Dredge spoil should not be placed within habitat protection areas or within the minimum 100 foot buffer except under the following conditions: when backfill has been permitted as a shoreline erosion control measure; when dredged spoil is used in an approved vegetative shore erosion project; when placed in an existing or previously approved spoil disposal area.

The determination as to whether each application meets policy objectives described above will be made both at first level review and in some circumstances at second level review when more detailed information is needed.

For Preliminary Site Screening Evaluation - See Section VII

For Detailed Environmental Assessment - See Section VIII

VI. Additional upland requirements determined by Critical Areas designation (RCA, LDA, IDA).

Site plan review of a water dependent facility must, in addition to evaluating the requirements above, address the upland aspects of the Critical Area requirements which vary according to the sites' designation as Intensely Developed (COMAR 14.15.02.03), Limited Development (.04) and Resource Conservation Areas (0.5). For some water-dependent facility applications such as a community pier, these concerns will most likely be addressed as part of the Critical Areas review for the associated residential development and, hence, can be omitted from this review. However, in the example of a commercial marina application, Critical Area Criteria applicable to landside impacts may play an important role in the approval process. This is particularly true for the area of the site outside the Buffer. The following policies and requirements for evaluating landside impacts are not meant to be comprehensive but do address the major concerns that may arise during site plan review of landside activity related to a water-dependent facility applications.

A. Intensely Developed Areas.

1. Conserve, to the extent possible, plant and wildlife habitat. Development or redevelopment is subject to habitat protection area criteria (COMAR 14.15.09).

2. For redevelopment, reduce pollutant loadings by at least 10% below the level of pollution on the site prior to redevelopment, or seek offsets.

3. For new development, reduce pollutant loadings from predevelopment levels by 10%.

4. Where feasible, promote public access to the shoreline.

5. Minimize removal of forest and woodland vegetation.

B. Limited Development Areas.

1. Maintain, to the extent practical, existing areas of natural habitat.

2. Maintain the ecological integrity of surface hydrologic features on the site.

3. Incorporate a wildlife corridor system into the site plan which provides continuity of existing wildlife and plant habitats with offsite habitats.

4. If the site has forested areas or developed woodlands and the plan proposes clearing these forests, the following requirements apply:

   a. Only 20% of the woodland can be cleared. Restrictive covenants are required to protect the remaining woodland.

   b. The applicant may clear up to 30% of the forested lands, however, he must replace any forest greater than 20% at 1.5 times the surface acreage disturbed. Alternative provisions may include fees-in-lieu.

5. If no forest exist on the site, 15% of the land area shall be aforested.

6. Impervious areas cannot exceed 15% of the site.

7. Development is precluded on slopes greater than 15%, unless the slopes are actively eroding and the development is the only effective way to improve this stability of the slope.

8. Protect Habitat Protection Areas described in COMAR 14.15.09.

C. Resource Conservation Areas

1. Expansion or new development is subject to habitat protection criteria (COMAR 14.15.09).

2. Overall acreage of forest and woodland in the RCA may not decrease. Applicants must show how areas of cleared forest can be replaced on or offsite or contribute offset payment.

3. Conservation requirements for LDA shall apply to any development activity permitted in RCA.

VII. Preliminary Site Screening Evaluation

A. Environmental Issues

In order for the County to make a findings of fact that the proposed use will minimize adverse effects on water quality and natural resources, a two-level review is proposed. This step represents the first level review and reflects most of the environmental policy objectives described previously in Step V-E. Some of these objectives can be better evaluated during the second level of review, because more detailed information will be available i.e., the timing and method of dredging and mitigation of upland pollutant loadings. This first level review will generally correspond to the special exception phase of the development review process.

1. Reviewer must evaluate the adequacy of information provided by applicant for first level review (see Table 3.4).

2. Determine the intensity of impact for the 12 environmental factors listed below. The Preliminary Site Screening Evaluation procedure is more fully described in Section 3.0.

Submerged aquatic vegetation
Tidal wetlands
Shellfish beds
Rare, threatened, or endangered species
Spawning/nursery areas for anadromous fish
Shallow water habitat
Dredging requirements
Filling
Dredge spoil disposal
Navigation issues
Flushing characteristics
Existing water quality conditions

B. Community Planning Issues

The special exception hearing before the Hearing Commissioner is the proper forum for addressing community planning issues. The issues which should be addressed at this stage of development review include:

Availability of public water and sewer.
Present zoning and land use.
Proximity to population.
Public access to marina and water.
Long-term plan for site (identify potential conflicts concerning future expansion of marina)
Proximity to existing marinas.
Aesthetics of area.
Offsite traffic impacts.
Historical/archeological sites.
Local opinion.
Relationship of marina to adjacent land uses.
Secondary impacts of marina development.

VIII. Detailed Environmental Assessment

Subsequent to conceptual approval of the special exception for a water-dependent facility, the applicant will be informed of any additional information requirements needed for the detailed environmental assessment. Issues flagged during the preliminary evaluation may require additional fieldwork or research. One additional requirement might be for a flushing dye study, requested because the desktop calculations used in the preliminary evaluation were not conclusive enough to predict the severity of impact under moderate flushing conditions. Depending on the type of water-dependent facility proposed, the second level of review may also require: engineering specifications for stormwater management and sediment control structures, grading plan; design specifications for bottom wash facility; the Best Management Practices. Section 4.0 describes the informational requirements and methods for conducting the detailed environmental assessment.

Apply rating system described in Section 4.3. The maximum number of points is 100 and higher scores represent an increasing severity of impact to natural resources and water quality. Scores less than 50 are considered to have an acceptable level of impact. Scores ranging from 50 to 70, inclusive, must reduce predevelopment loadings by 20 percent. This can be accomplished onsite or, if not feasible, offsite yet within the drainage basin of the estuarine subarea. Scores of 75 or greater are considered unacceptable and will be denied. Very few proposals are anticipated to receive scores requiring denial at the CRG stage of review.

3. PRELIMINARY SITE SCREENING EVALUATION

The types of facilities and land use activities applicable to the water-dependent review process are potentially quite diverse and may range from a passive waterfront recreational park to commercial marinas and may also include more intensive industrial operations such as off-loading facilities or intake-outfall structures. Table 3-1 illustrates the diversity and frequency of ACOE permit activity in the Chesapeake Bay Region from 1973 to 1979. The majority of permit applications in Baltimore County will be for commercial marinas or community piers associated with upland residential development. A full service marina may provide a wide array of services and incorporate a number of separate facilities in the site plan. For example, water-related facilities may include a boat launching ramp, a crane travel lift or marine railway and a fueling pier. Land-related facilities may include a restaurant, convenience store, camping area, or marina supply store to name a few. Table 3-2 illustrates the range of marina services and facilities that may be included in a conceptual site plan.

The major environmental impacts associated with the siting and design of marinas are loss of habitat from dredging and construction of shoreline structures, and the effects of stormwater runoff and boat discharges on water quality. Marinas require safe, protected moorings for boats and so are generally located in calm water on protected shorelines. These sheltered areas, however, also often support habitat for wetlands and submerged aquatic vegetation. Thus, marina construction often leads to habitat loss or alteration. These calm, sheltered areas may have poor flushing characteristics which tend to concentrate pollutants from upland and water-related sources. In general, the most appropriate marina site would be one that requires as little modification to the nearby environs as possible. The types of activities associated with marina construction and operation can lead to multiple environmental impacts to water quality and to the ecology system. The range of environmental impact considerations is illustrated in Table 3-3.

The proper siting of a commercial marina is certainly the single most important aspect of developing a marina in an environmentally sound manner. From the developer's perspective, a properly sited marina will reduce construction and operating costs and will likely receive the quickest approval by regulators. Table 3.4 lists the desirable and undesirable site characteristics of marina siting.

The tables referenced above are included in the report to provide review staff who may be unfamiliar with the range of water-related facilities and the nature of their environmental impacts. Section 3.1 presents the preliminary site screening evaluation procedure which requires the reviewer to determine the severity of impact to natural resources and water quality considerations. Sections 3.2 and 3.3 expand on the aquatic and terrestrial concerns related to shoreline developments and identifies

TABLE 3-1 PERMIT ACTIVITY BY STRUCTURE/ALTERATION TYPE IN THE CHESAPEAKE BAY, 1973-1979

Structure/ Alteration Type	Total Number of Permits Granted	Total Number of Structure/ Alternations Approved
Pile	2,988	20,686
Pier	3,933	6,040
Bulkhead	1,869	1,962
Fill	1,848	1,848
Buoy	433	1,810
Jetty or Groin	472	1,698
Riprap	822	1,005
Dredging (New)	888	888
Spoil Disposal	610	610
Dolphin	68	406
Building	236	251
Boat Ramp	206	210
Discharge Pipe	105	169
Maintenance Dredging	115	115
Aerial Crossing	61	109
Bridge	89	89
Pipeline	65	75
Channelization	71	71
Submerged Cable	53	69
Crab Impoundment	38	38
Marine Railroad	25	34
Intake Pipe	20	32
Dam	17	17
Fence	14	14
Tunnel	5	10
Intake Structure	5	5
Artificial Reef	3	3
Wave Gauge	1	1
Duck Blind	1	1
New Structure Subtotals	15,061	38,266
Repair Activities	628	672
Temporary Structures	89	99
TOTALS	15,778	39,037

Source: Eberhart 1980.

TABLE 3-2 MARINA SERVICES AND FACILITIES

Water Related	Land Related
MARINA SERVICES	
Boat launching	Boat sales
Mooring service	Boat repairs
Water taxi service	Marina supply sales
Transient boat service	General supply sales
Waste collection	Trailer storage
Fueling	Parking
Boat towing	Overnight accomodations
Fire and rescue services	Food service
Navigation and weather information	Concessions
	Utility service
	Recreational services
MARINA FACILITIES	
Open and covered mooring	Boat building and repair
Boat launch ramp	Boat dry storage
Marine railway	Trailer storage
Crane lift	Restaurant
Drydock	Motel
Fueling pier	Picnic areas
Sanitary pump-out facility	Convenience store
Anchorage areas	Boat washing
Marine service station	Parking
Entrance and exit channels	Swimming pool
Swimming area	Camping
Water skiing course	Beach area
Basin flushing system	Club room
Storm and wave protection	Marine supply store
	Public toilets and showers
	Recreational facilities
	Bait shop
	Seafood sales

Source: EPA 1985.

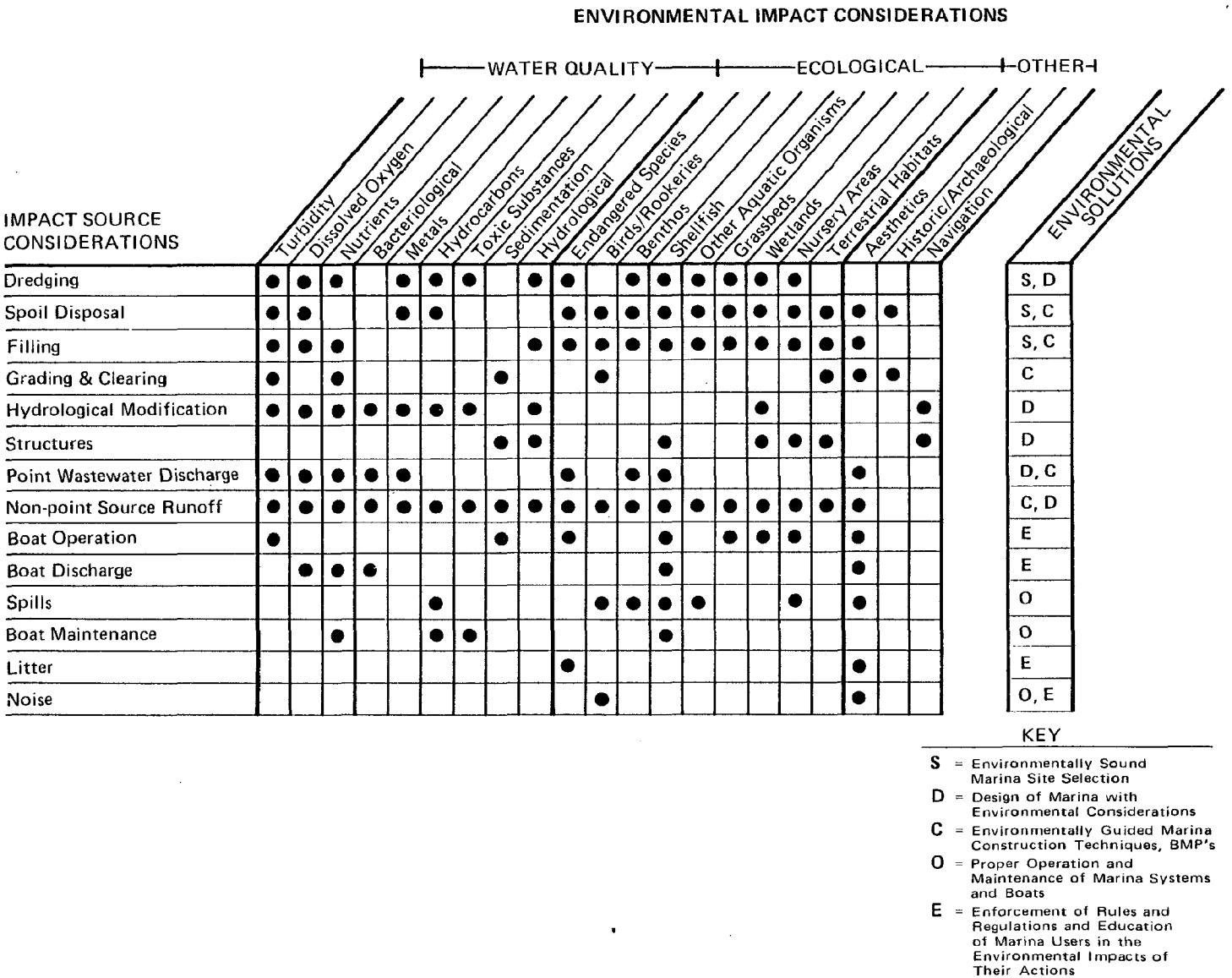


TABLE 3-3 ENVIRONMENTAL IMPACTS, SOURCES AND PRIMARY SOLUTIONS (EPA, 1985)

TABLE 3-4 MARINA SITING CHARACTERISTICS

Desirable Site Characteristics

- Easy access to open water, population centers, utilities, public sewer and water lines
- Accessible from existing roads and waterways
- On sheltered waters providing adequate storm protection with deep waters close to shore
- Near existing state of federally maintained channels
- Near currently permitted public areas for disposal of dredged material
- High tidal range or flow and high flushing rates, such as near the mouths of estuaries or tidal creeks, near inlets or on convex shorelines
- Compatibility with existing land and water uses
- Away from shellfish beds used for harvesting for human consumption

Undesirable Site Characteristics

- Shallow water habitat present (<3' in depth) or with inadequate water or land area for intended use, requiring extensive dredging or filling
- Low tidal range or flow and low flushing rates, such as dead-end channels or canals or the upper reaches of tidal creeks
- In a location with poor water quality, marginally meeting of failing to meet state water quality standards
- Near specially designated fish or wildlife protection areas or near shellfish beds or submerged aquatic vegetation beds.
- Location where rare, threatened, endangered or otherwise designated unique or outstanding aquatic or terrestrial species or habitats are found
- In an area of recognized historic, archaeological or scenic value

Source: EPA 1985.

pertinent informational sources and requirements. Section 3.4 lists the informational requirements required for the ecological inventory and assessment of the site.

3.1 PRELIMINARY SITE SCREENING EVALUATION FACTORS

Natural Resource Impacts

1. Submerged aquatic vegetation
2. Tidal wetlands
3. Shellfish beds
4. Rare, threatened, or endangered species
5. Spawning/nursery areas for anadromous fish
6. Shallow water habitat

Physical Alterations

7. Dredging requirements
8. Filling issues
9. Dredged material disposal
10. Navigation issues

Water Quality Impacts

11. Flushing characteristics
12. Existing water quality conditions

Natural Resource Impacts

1. Submerged Aquatic Vegetation (SAV)

   The dramatic decline of SAV throughout the Chesapeake Bay estuary over the past two decades places a high priority on protecting existing SAV beds. State and federal permitting agencies will, in most cases deny an application which will lead to the destruction of an existing SAV bed. An application having direct impacts to SAV beds is considered to have a fatal flaw.

Severity of Impact

a. Unacceptable

Any application which involves the dredging, filling or physical removal of an existing SAV bed, as identified by the most current DNR SAV quad-sheet maps or field investigations, is considered an unacceptable level of impact.

b. Significant

If review of baseline data and field evaluation required for the preliminary evaluation reveals potential SAV habitat, a more detailed evaluation should be conducted for second level review.

c. SAV Habitat not Present

Loss of existing SAV within the limits of construction shall not be an issue at CRG review.

2. Tidal Wetlands

Tidal wetlands have long been recognized as an important natural resource in the Chesapeake Bay. The Maryland Wetlands Act of 1972 severely limits the destruction or physical alteration of tidal wetlands. Tidal marshes can be classified into three wetland types (Queen, 1979). An embayed marsh is one which occupies a drowned stream valley as it enters the estuarine system. Extensive marshes cover large areas projecting into an estuary or river. For the purposes of this exercise, extensive marshes are greater than 100 ft in width. A fringe marsh runs in a band parallel to shore and is less than 100 ft in width.

Severity of Impact

a. Unacceptable

Any proposed site which has extensive or embayed marshes within the limits of construction is considered to have an unacceptable level of impact.

b. Moderate

Fringe marshes have less value as a transporter of detritus and most likely have maximum value as a buffer to wave erosion of the fastland. Any proposal having fringe marshes within the limits of construction should be "flagged" for more detailed evaluation of mitigation alternatives at the second level of review.

c. Resource not present

Tidal wetlands are not an issue at CRG review.

3. Shellfish Beds

Significant permitting issues may arise from potential impacts to shellfish resources. These impacts are considered as part of the Section 10/Section 404 permit review process and in state permitting programs (EPA 1985). Although bacterial contamination is the major concern, siltation and turbidity also have the potential to impede shellfish growth.

Marina developments are restricted from viable shellfish beds and adjacent areas in Maryland based upon the size of marina and survival time of coliform bacterial. These requirements will not generally, if at all, apply to Baltimore County project reviews owing to the historical loss of shellfish beds in the mid-bay region. However, more stringent water quality requirements may be applied in Class II waters.

Severity of Impact

a. Significant

Viable shellfish beds located in or adjacent to construction limits. Marinas that have less than 50, 51 to 100, and greater than 100 slips may not be located closer than 660, 1320 and 2640 ft, respectively, to shellfish beds.

b. Moderate

Projects proposed in Class II water should be flagged for consideration of water quality restrictions related to protecting potential shellfish habitat.

c. Resource not present

Shellfish beds are not an issue at CRG review.

4. Rare, Threatened or Endangered Species

The presence of a federally or state rare/endangered species on a particular site is not necessarily a fatal flaw. The screening procedure focuses on whether the proposed use will either directly or indirectly affect the species and its habitat requirements. At the preliminary evaluation stage, the applicant must show that a FWS determination has been requested and an onsite survey for potential/observed presence of rare or endangered species has been conducted. Hence, the presence of a

federal or state designated rare or endangered species is potentially a fatal flaw only when the proposed land use activities adversely affect the species or its habitat requirements.

Severity of Impact

a. Unacceptable

The presence of a rare, threatened or endangered species listed by FWS or under the Maryland Nongame and Endangered Species regulations must be documented at the first level review. In addition, an assessment must be made of the potential direct and indirect impacts of the development proposal to the listed species. If the applicant cannot show that the species and its habitat can be protected to the greatest extent possible, then the proposed water-dependent facility is considered to have an unacceptable level of impact.

b. Moderate

Any species of fish, wildlife or plants designated by the secretary of DNR as species in need of conservation, threatened or endangered, should be identified. The assessment of state rare or endangered species should be conducted prior to first level review, and should include the potential for rare and endangered vacular plants of Maryland (Natural Heritage A and B ranked species) and Maryland's federal candidate endangered plants. The presence of, or potential for, these species within the project boundaries will require a more extensive evaluation of the species' habitat requirements at CRG review. Where appropriate, the CRG review should address the designation of habitat protection areas, conservation easements, or cooperative agreements between property owner and public agencies.

c. Resource not present:

Rare, threatened or endangered species are not an issue at CRG review.

5. Spawning and/or Nursery Areas for Important Anadromous Fish

The Chesapeake Bay Critical Area Criteria requires that local jurisdictions adopt the following policies with regard to anadromous fish: protect the instream and streambank habitat of anadromous fish propagation waters and provide for the unobstructed movement of spawning and larval forms of anadromous fish in streams. Propagation refers specifically to spawning which occurs at the interface of tidal/freshwater in the uppermost reaches of estuaries. Spawning areas for anadromous

fish have been designated by DNR. Nursery areas are generally synonymous with shallow water habitat and are dealt with in the next section.

Severity of Impact

a. Unacceptable

Any proposal for a water-dependent facility which generates adverse impacts on anadromous fish spawning areas is considered an unacceptable level of impact. The physical and chemical water quality impacts associated with marinas located in an anadromous fish spawning area would have a high probability of reducing spawning success and fry survival.

b. Moderate

Community piers located in anadromous fish spawning areas may have less of an impact than the corresponding number of individual piers. The location of a community pier can be selected to minimize the amount of dredging and disturbance to the instream and streambank habitat. The identification of current or historical anadromous fish spawning within the construction limits or adjacent to the site would not lead to a negative recommendation at first level review for community piers. However the timing and methods of construction will need to be carefully evaluated at CRG review. In all cases, every means to minimize the volume and area coverage of dredging should be undertaken.

c. Resource not present

Anadromous fish spawning/nursery areas are not an issue at CRG review.

6. Shallow Water Habitat

Water depths of less than four feet are generally considered to be shallow water habitat. These areas are considered valuable fish nursery and potential SAV habitat. Shallow water areas also provide valuable edge habitat for wading birds and small mammals. Sites with little topographic relief along the shoreline are an indication that shallow water habitat may be located offshore. Mudflats and sandflats are characteristic shallow water habitats.

Severity of Impact

a. Significant

For dredging projects	Area coverage less than 3 feet depth
from 200 to 1,999 cubic yards	greater than 50%
between 2,000 and 19,999 cy	greater than 40%
greater than 20,000 cy	greater than 30%

b. Minimal

If the percent of shallow water habitat within the dredging disturbance limits is less than listed above, the site is considered to have minimal impact to shallow water habitat.

Physical Alterations

7. Dredging

Dredging activities may impact water quality, aquatic and wetland resources by altering water circulation patterns, increasing turbidity and siltation, decreasing dissolved oxygen, releasing nutrients or other pollutants from sediments and increasing erosion or shoaling rates (EPA 1985). County review of marina applications must consider both the dredging in the marina basin and any associated dredging to gain access to a navigable channel. Areas with high shoaling and sedimentation rates should be avoided owing to the periodic maintenance dredging required. Marina sites proposed on long, winding channels or with shallow bottom characteristics should be avoided. The degree of impacts associated with dredging activities will depend on existing water quality, habitat quality, and the aquatic resources present, adjacent land use patterns, and the manner in which dredging and disposal is conducted. Section 4.4, Best Management Practices, describes practices applicable to dredging.

Severity of Impact

a. Significant

Dredging does not represent a fatal flaw at first level review. The types and scales of water-dependent facility applications which may come before the County for review precludes selecting a threshold volume. The significance of dredging is its potential to adversely impact the natural resources described above. The applicant must, at a minimum, provide estimates of the volume of dredge spoil and delineate the area extent of dredging. Marina sites proposed in an

upper estuary near the river influx or near a tidal nodal point, will require a more detailed evaluation. Sedimentation will be greater because velocity decreases at these two points and a large percentage of the suspended particles will settle out. Marinas located in these areas may require extensive maintenance dredging. Available records should be reviewed to determine historic sedimentation rates. Nearby marinas could be contacted to get an understanding of maintenance dredging requirements. If maintenance dredging has been identified as a significant issue during first level review, the applicant should provide an assessment of future maintenance dredging requirements.

b. Moderate

Applications falling into this class are determined qualitatively; however, they will generally range from 2,000 cy to 20,000 cy. Considerations during second level review revolve around the methods and timing of dredging work and the area extent of shallow water habitat dredged.

c. Minimal

Preferred marina sites would be those requiring little or no dredging. Such sites include those located on existing channels or upland areas located adjacent to deep water (6-8 ft).

8. Filling

Filling activities often cause temporary impacts to nearby aquatic habitat resources through increased siltation and turbidity, decreased dissolved oxygen, or release of pollutants from fill material. More important, however, is the modification or loss of shallow water habitat or wetlands. A Section 404 permit, administered by ACOE, which has jurisdiction over discharges of dredged or fill material, and a Section 401 water quality certification, are required for filling activities in navigable waters of the United States, including wetlands. As is most often the case, if filling is associated with dredging or other construction activities, a Section 10 permit is also required. Filling of open water or shallow water areas is generally considered unacceptable by state and federal regulatory agencies. Exceptions include lack of any viable alternative, and instances when fill is necessary to resolve an existing shoreline erosion problem.

Severity of Impact

a. Significant

This screening factor is included in this preliminary evaluation to flag potential state and federal permitting issues. In most cases, filling of open water, shallow water, or wetlands is not permitted. The applicant should be notified as early as possible in the review process of this permitting issue.

b. Minimal/no filling proposed

Filling associated with shoreline erosion control structures is not considered a significant impact.

9. Dredged Material Disposal

With regard to disposal of dredged material, a preferred marina site would be located near a currently permitted upland disposal site. Adequate disposal areas for initial and maintenance dredging should be secured and designated for the life of the project (EPA 1985). Early consultation with the District Engineer, Baltimore ACOE, is advised. Clean dredged material may be suitable for beach nourishment or non-structural shoreline erosion control, where appropriate. Innovative uses for dredged material should be encouraged and should be viewed as a positive factor in the development review process. Theoretically, a safe disposal site can be found either onsite or offsite for every dredging project. If no appropriate location exists onsite, dredged material can be transported to an existing permitted site. The decision on whether dredge spoil can be accommodated from a particular dredging project is primarily economic. The cost of disposal of dredged material may or may not be justified by the expected return from the development proposed.

Severity of Impact

a. Significant

Significant development review issues include:

- Volume of initial dredging greater than 2,000 cy
- No means of disposing dredged material is identified in project proposal.
- The proposed disposal site is located within the Buffer, including habitat protection areas as defined in COMAR 14.15.09 unless material is utilized in erosion control or habitat enhancement effort.

- There is documented evidence that the dredged material may be contaminated by heavy metals, pesticides, or other potentially hazardous organic compounds.

- Preliminary evaluation of sedimentation and shoaling rates indicates that maintenance dredging will be an important consideration in sizing the dredge spoil area.

- Overboard disposal is proposed.

Any significant issues raised during the preliminary site screening evaluation will require detailed assessment prior to CRG review.

b. Minimal

Instances where a detailed assessment and second level review is not required include:

- Disposal of dredged material in a currently permitted disposal site.

- There is minimal volume of dredge spoil in upland location onsite (less than 2,000 cubic yards). Dredge spoil site is located outside of Buffer or spoils are incorporated into shoreline erosion control program.

- No dredging is proposed.

10. Navigation Issues

The inclusion of navigation issues in the preliminary site screening evaluation serves to identify, early in development review process, potential state and federal permitting issues. Construction or placement of any structure in navigable waters requires a Section 10 permit from ACOE. If marina development requires placing structures closer than 30 m (100 ft) to a federally-maintained channel or basin, the permit application may be denied or require design modifications before approval, if the structure is determined to pose a hazard to safe navigation. ACOE guidelines will not allow pier and platform structures to encroach further than one-third of the distance to the opposite shoreline.

Severity of Impact

Significant:

If the proposed water-dependent facility infringes on any state or federal channel, appropriate agencies should be

contacted. In general, design modifications can remove navigation obstructions as a potential permitting issue.

No Impact:

No infringement on a federal, state, or Maryland Port Authority channel is proposed.

WATER QUALITY IMPACTS

11. Flushing Characteristics

The flushing characteristics of the site have been identified as a key factor in determining overall suitability from an environmental perspective. Pollutants enter marina waters by discharges from marine sanitation devices, hull antifoulants, and bilges. In addition upland land use activities may contribute to pollutant loadings in the marina basin via surface runoff. The potential for water quality problems is higher in the upper reaches of estuaries or tidal creeks which are characterized by low tidal range or low net flow. Preferred sites are those on open water or near the mouth of an estuary. For open water sites, convex shorelines are preferable to concave shorelines (EPA 1985).

Various design strategies can be utilized to maximize natural circulation to reduce sedimentation and maximize dispersion of pollutants. Some of these options are identified in the Section 4.2 Best Management Practices.

Severity of Impact

Unacceptable:

Prior to the special exception hearing, the applicant is required to develop the flushing model described in Appendix 6.2.3. Assumptions made in calculating residence time need to be clearly stated. Flushing times estimated to be five days or longer are considered unacceptable. The inherent limitations of these models, however, argue for the opportunity of proceeding to in-situ dye studies in an effort to more accurately determine the flushing characteristics. The applicant should be made fully-aware that if more detailed field studies confirm the desk top model, the application will be denied at CRG review.

Moderate/Undetermined:

Marina sites with flushing times of 3 or 4 days will require a dye study to more accurately determine flushing characteristics. Also, in those instances, where no estimate of return flow or freshwater inflow can be reasonably made, instream data will be required.

Minimal:

If the flushing model indicates a flushing time of less than three days, the site is considered to have adequate flushing and no additional assessment is required for CRG review.

12. Existing Water Quality

The existing water quality of the water body at the site of the proposed water-dependent facility is considered to be a key factor in determining the overall environmental suitability of the project. Since water-dependent facilities are expected to have some impact upon the quality of the receiving waters, the applicant will be required to determine the existing water quality at the proposed site. The County, however, may waive any water quality monitoring requirements if their determination indicates little or no water quality impacts are anticipated. In addition, the applicant will be required to estimate the expected impacts the project will have upon the site and the methods by which such impacts will be minimized.

Existing water quality may be determined from existing data if such data are current and if there are sufficient samples and appropriate variables with which to define the site. In most cases, however, the applicant will be required to obtain original data according to the procedures and analytical methodologies defined in Appendix C. A minimum of five samples must be taken, one every three weeks between June and October. Following completion of the analysis, the results shall be averaged and compared 1) to Maryland receiving water standards and 2) to the Nielson Classification scheme.

Following comparison to these two, the applicant must define the expected impacts to water quality which may be expected from the project. This is a two step approach, and involves 1) calculation of flushing rates and 2) calculations of expected steady state conditions following completion of the proposed project.

Severity of Impact

Unacceptable/Poor Water Quality:

If water quality data indicate that the water body fails to meet State Water Quality Standards and if the results of total nitrogen and total phosphorous testing indicate that the Neilson index is less than 6, then the applicant will be required to complete detailed analyses of stormwater loadings, run the Steady State Model, and define appropriate stormwater management strategies. If the results of these efforts indicate that there will be a net improvement in water quality related to project loadings following project completion, then the applicant may proceed. If such improvement cannot be shown to be achievable, the project will be considered unacceptable.

Moderate/Fair Water Quality:

If the water quality data indicate that the water body presently does not meet state water quality standards, but if the Neilson index is less than 6, then the applicant must calculate the expected post-construction, managed stormwater loadings and show that a net reduction in overall loadings will result from the project.

Minimal/Good Water Quality:

The applicant must show that the existing water quality meets the state water quality standards and the Nielson index is less than 6. If these criteria are met, then the applicant must show that the project will not result in significant degradation and that appropriate stormwater management plans will result in the minimization of impacts.

SECTION 3.2 AQUATIC CONCERNS RELATED TO WATER-DEPENDENT FACILITY DEVELOPMENT

Issue	Description	Information Required for Review Process
Submerged Aquatic Vegetation (SAV)		
a. Existing SAV	SAV is currently considered a Category 1 resource by the Fish and Wildlife Service (FWS) and, as such, is highly protected under policies set forth in NEPA and the Fish and Wildlife Coordination Act. According to FWS policy, no loss of existing SAV habitat is permitted.	The results of a survey based on DNR wetland maps, aerial photographs from Baltimore County National Wetlands Inventory (NWI) Maps and a field examination characterizing the community should be provided . The presence of SAV in the vicinity of the site and/or evidence of SAV on the shore should be noted. The area of habitat to be directly impacted by the planned development should be shown.
b. Potential SAV habitat	Any low energy shallow water area characterized by fine substrate conditions may have the potential to support SAV. The FWS has considered all shallow water habitat as a Category 2 resource. According to FWS policy, no net loss of in-kind habitat will be permitted.	A qualitative examination of substrate composition with a description of its suitability for SAV colonization should be required. This evaluation should include wave energy, proximity to existing SAV beds, etc. Photo interpretation using a historical series of aerials available from Baltimore County may indicate the potential of SAV habitat.
Shallow Water Habitat	In addition to the SAV issue, shallow water habitat is viewed as a nursery area for fish, a valuable edge habitat for wading birds and small mammals, as well as providing innumerable other benefits. The FWS policy requires no net loss of this habitat type. In developments requiring extensive dredging, the 'no net loss' requirement may present a fatal flaw problem since an attempt at mitigation may require filling deeper state waters, which is generally not permitted by the Army Corps of Engineers (ACOE). The potential to make shallow water habitat from an upland area may be considered a feasible mitigation for dredged shallow water habitat.	An accurate estimate (based on field survey or bathometric chart) of the amount of dredging required (volume and area) in shallow water habitat (<3 feet deep) and the availability and location of a suitable site for mitigation (conversion of upland to shallow water habitat - not shoreline habitat) are minimum requirements. Every effort to reduce the amount of dredging required for the plan should be discussed.

SECTION 3.2 AQUATIC CONCERNS RELATED TO WATER-DEPENDENT FACILITY DEVELOPMENT

Issue	Description	Information Required for Review Process
Wetlands		
a. Tidal Wetlands	Tidal wetlands are protected by the State of Maryland and the ACOE. As a result of the long-term, cumulative loss of tidal wetlands in Maryland, any project requiring tidal wetland impact is seriously flawed. Prior to permit denial however, the County may wish to examine the quality and quantity of the affected wetland in light of tidal wetlands creation technology. It is not inadvisable to require an improvement in quality and an increase in quantity of wetland as part of the negotiation process, i.e., a developer could replace a one acre partially degraded marsh with a larger wetland designed with habitat value in mind. In most cases, mitigation will only be considered for fringe marshes.	Results of a survey based on DNR wetland maps, NWI wetland maps, aerial photographs from Baltimore County, Areas of Critical State Concern and a site visit characterizing the community type and quality should be presented. The area and extent of direct impact to the tidal wetland should also be noted. The presence and location of a suitable mitigation site could be indicated if the developer is willing to mitigate.
b. Non-tidal Wetlands	Non-tidal wetlands are the subject of increased protection form the ACOE, State, and County. For this reason, development requiring alteration of these wetlands should be discouraged. In some cases, however, non-tidal wetlands can be improved upon by mitigation techniques. The County may wish to review a particular wetland prior to rejecting an application or initiating the mitigation negotiation process.	Results of a survey based on NWI maps, Baltimore County Soil Survey and field examination characterizing the community type and quality should be presented. The extent and area to be directly impacted by the development and a potential site for wetland creation/mitigation should be identified.

SECTION 3.2 AQUATIC CONCERNS RELATED TO WATER-DEPENDENT FACILITY DEVELOPMENT

Issue	Description	Information Required for Review Process
Rare and Endangered Plants and Animals		
a. Federal Level Protection Under Endangered Species Act of 1973	The documented presence of a rare, threatened or endangered species listed by the FWS on the property is an issue of great concern. The FWS requires that the planned development have no detrimental effect on the species and habitat of concern. This is not to say that the presence of a species of concern is a fatal flaw in and of itself. However, if the species is in an area to be filled, dredged or otherwise altered, then a fatal flaw situation exists.	The minimum acceptable effort includes a letter from the FWS identifying species and habitats of concern in the study area in conjunction with a survey specifically addressing the potential/observed presence of the identified species/habitats identified in the FWS letter. In addition, when present, potential impacts from the developmentust be discussed and a mechanism to ensure the protection of the critical species habitat should be identified.
b. State Level Protection Under Maryland Nongame and Endangered Species Act	The group of species protected under the legislation is largely a subset of species on the federal list with several additional species of local concern. The presence of a species listed on the Maryland Nongame and Endangered Species List presents a situation similar to a federally listed species occurrence. A DNR sponsored bill is before the 1987 State Legislature which is enacted would greatly expand the number of species, especially plants, protected by the Nongame and Endangered Species regulations.	Developers should request letters from the Maryland Forest, Park and Wildlife Service and the Maryland Natural Heritage Program identifying any species or habitats of concern in the study area. The letters, in conjunction with a survey specifically addressing the potential/observed presence of the identified species/habitats identified in the letters, should be included in the report. In addition, when present, potential impacts resulting from the development must be discussed.
c. Species in Need of Conservation	The level of protection afforded these species is not clear in the Critical Area Criteria. This larger collection of species of state concern is the product of the Maryland Natural Heritage Program. Within the large set of species of concern, several subcodes designate the degree and extent of the species existence in Maryland.	

SECTION 3.2 AQUATIC CONCERNS RELATED TO WATER-DEPENDENT FACILITY DEVELOPMENT

Issue	Description	Information Required for Review Process
Spawning/Nursery Areas	Generally, any shallow water habitat could be considered as a spawning and/or nursery area. Specifically, this category may only apply to those areas identified by DNR and contained in the Aquatic Resources Areas Handbook or other data base. Marina placement in designated spawning areas should be strongly discouraged. Due to the nature of inventory surveys (age and scale of mapping) an area identified as a spawning or nursery area may never have been or may no longer be a spawning or nursery area. Once designated as a spawning or nursery area, however, the burden of demonstrating that the area is not a spawning or nursery area should be on the developer and subject to DNR review.	The results of a review of the DNR database identifying the presence of the nearest spawning/nursery area in conjunction with a discussion of the direct impact of the development on the identified area should be provided by the applicant.
Shellfish Beds	The presence of shellfish beds in areas to be dredged is of concern because of habitat loss. A commercial shellfish bed in the vicinity of the marina may have to be closed to fishing as a result of its proximity to the development and increased loadings of certain constituents (microbial, antifouling compounds, hydrocarbons, etc.).	Class II waterbodies are the only waterbodies with harvestable shellfish beds. The results of a review of the DNR database identifying the presence of the nearest shellfish beds relative to the location of the development, a discussion of the direct impact of the development on the identified area, and the type of shellfish bed (commercial, species, etc.) should be provided. Few, if any, viable shellfish beds occur in Baltimore County waterways, however, stricter water quality standards will apply in Class II waterbodies.
Use by Populations of Geese, Ducks, and Wading Birds	On the decline as a result of habitat loss, populations of migratory ducks, geese and wading birds may be protected by federal law as items of interstate commerce. Although marina development may reduce habitat for some of these species, other species appear able to coexist in marina areas (mallards). For this reason, the presence of migratory waterfowl should not be viewed as sufficient cause for permit denial.	Discussion of the potential use of the area by waterfowl (based on field observation and DNR information) and the potential direct impact to the resource resulting from the development should be presented. A list of the particular species known or suspected to use the area should also be provided with species of particular state concern identified as such (e.g., black rail, black duck). Special emphasis should be given to habitat suitable for rookeries.

SECTION 3.2 AQUATIC CONCERNS RELATED TO WATER-DEPENDENT FACILITY DEVELOPMENT

Issue	Description	Information Required for Review Process
Aquatic Vertebrates and Invertebrates	While the dredging of an area will alter benthic habitat and invertebrate communities, the resulting altered habitat and marina pilings will be colonized by other invertebrates. Some concern for the susceptibility of certain invertebrate groups to antifouling compounds should be considered as a detriment of the project. Aquatic vertebrates (fish, turtles, snakes, etc.) will also undergo habitat loss and/or alteration as a result of dredging and marina construction.	A discussion of the habitat present in terms of invertebrate and vertebrate use should be presented. Presence or evidence of turtles, snakes, etc. should be noted.
Substrate Conditions	Substrate size composition ranges from coarse (cobble and gravel) to fine (sand, silt and clay). Generally, the coarser substrates are indicative of an area with a net loss of material while the finer substrates occur in areas with a net accretion of material. Other environmental site characteristics which are related to these different substrate conditions are flushing rate, tidal/wave energy levels, and countless others. Generally, an area with a coarser substrate will present fewer environmental problems to marina development than will a finer substrate.	Provide a qualitative description of the substrate composition (muck, sandy silt, gravelly sand, etc.) for the waterfront portion of the property. Discuss limitations on dredge spoil disposal resulting from the composition of the material drains or dries rapidly, fine material cannot be piled deeper than 3 foot if it is expected to dry).
Existing Water Depth	The existing depth is related to the amount of dredging necessary to permit marina development. Other concerns with shallow water areas are discussed elsewhere. Deeper water areas are more easily developed into marinas (all other factors being equal).	The results of a depth survey normalized to mean high and low water for the entire shoreline of the property should be presented.

SECTION 3.2 AQUATIC CONCERNS RELATED TO WATER-DEPENDENT FACILITY DEVELOPMENT

Issue	Description	Information Required for Review Process
Wave Action	Wave action is important from several perspectives. From the view of environmental degradation, an area with greater wave action will have coarser sediments and a greater flushing rate. From the boat owners perspective, an area with greater wave action presents more trouble for docking and a higher probability of damage to the boats. From the marina owner/engineers point of view, bulkheading, shoreline stabilization and construction are more difficult and expensive.	A discussion of fetch from the waterward compass directions coupled with shoreline depth characteristics addressing the relative wave action in the project area are the minimum requirements.
Tidal Range	Tidal range is another environmental variable which is important. From the perspective of environmental degradation, a large tidal range increases the rate of the flushing and reduces the build up of fine materials and contaminants.	Present the mean and spring tidal ranges for the area based on information contained in NA Tide Tables. Some assumptions will usually be necessary (reference station used, etc.) and these assumptions should be stated.
Flushing Potential	Tidal range and freshwater discharge are the two major components of flushing in tidal estuarine areas. Clearly, an embayment of a tidal water body is predominantly influenced by tidal flushing, while a riverine tidal water body has the additional freshwater discharge component to consider. The basin shape and size greatly influences the volume of tidal waters entering the system as well as the exchange rate. A poorly mixed system could have a large tidal influx but a lower than expected (based on volume calculations) true exchange rate because of the poor mixing with the flood tide waters and the proportionately larger retention of the original waters. For this reason a detailed dye study is often necessary to accurately estimate flushing rate. In a well mixed system this scenario would be unlikely to occur. A high flushing rate is desirable because it removes materials from a waterbody and increases the assimilative capacity of the system.	For detailed information on identifying the flushing characteristics see Section XX.

SECTION 3.3 DRAFT TERRESTRIAL CONCERNS RELATED TO WATER DEPENDENT FACILITIES DEVELOPMENT

Issues	Description	Information Required for Review P rocess
Soil Types	Certain soils have been identified as hydric and likely to support wetland plants. Where these soils are identified it is necessary to perform a wetlands survey. In addition, certain soils are identified by the SCS as prone to erosion. This characteristic should also be considered in light of the upland portion of the marina development. Permeability rates are an important feature for success of some stormwater infiltration plans.	The results of an examination of the soil types and their location relative to planned upland development (including SWM facilities) should be presented. The presence of soils listed by Baltimore County as either hydric or secondary hydric soils should be noted. A table providing the permeability and capability of soils onsite should be included. All this information is available in the County Soil Survey.
Habitat Quality	Although not specifically addressed in the Critical Areas legislation, habitat quality (as a result of disturbance or poor management) may be considered a more appropriate candidate for development than an area of higher habitat quality, everything else being equal. In this way, the better habitat remains protected while environmentally compatible growth is permitted.	As a part of the required environmental inventory of the site, observations on habitat quality should be reported. The presence of trash/debris, large diameter trees, etc. should be noted. Habitat quality is a relative issue, however, so the presence/absence and extent of anthropogenic influence should be stressed.
Plant Communities	The type of plant community present at a site is closely tied with habitat quality. A more mature woodland is currently valued because of their relatively low stormwater nutrient loadings to the Bay and its tributaries. In addition to this attribute, a woodland producing mast (nuts/acorns) provides a valuable food for wildlife. Contrasted with a stand of tulip poplar or sweet gum, a stand of oak, hickory or cherry provides a greater variety of function and should be preferentially protected, all else being equal. Similarly, an older stand of trees indicates an area which has had a longer time for intricate patterns of use to develop, as compared to a 15-to-15-year old second growth woodland.	The description of habitat contained in the environmental inventory should be of sufficient detail to permit an assessment of the existing plant communities. The area covered by each different community type should be estimated.

SECTION 3.3 DRAFT TERRESTRIAL CONCERNS RELATED TO WATER DEPENDENT FACILITIES DEVELOPMENT

Issues	Description	Information Required for Review P rocess
Animals Expected and Observed	An analysis of the habitats present can be used to make a list of animals expected to use the habitat. Presumably, a greater animal use (number of species) expected for a habitat, the more valuable the habitat. Certain animals are present in all but the most degraded of habitats, however. So unless a unique or valuable animal uses the area in question, this category should not be overemphasized.	The report should present a list of animals which may occur on the site based on the different types of habitat present. Footnotes indicating species or species sign (e.g., pellets, tracks) observed should be included.
Rare and Endangered Plants and Animals	See Section in "Aquatic Concerns"	See Section in "Aquatic Concerns"
Unique and/or Valuable Habitat Types	An area may be of such a development history that the resulting habitat is unique for the portion of the state in which it occurs. Similarly, a particular set of environmental conditions may exist at a site which give rise to an unusual community of plants and animals (e.g., limestone outcrop). Often microhabitats of this type are considered valuable and worthy of protection. Since the occurrence of these habitats is rare, great emphasis should be given to their protection.	A detailed environmental inventory should note the presence of unusual habitat and/or plant assembly.
Surface Waters	Rivers, streams, and ponded water are protected by an assortment of County, State, and Federal regulations. These regulations generally require little or no impact to the surface water body. In addition, the presence of surface waters is usually an indication of the presence of wetlands. Neither of these features are fatal flaws, but the presence of surface waters will require a more detailed examination of potential impacts.	The identification and classification of the stream should be provided in the environmental inventory. Other characteristics which may be requested by the County are the fish species and relative numbers present, invertebrate species present and their relative abundance, and a chemical analysis of water quality.
Non-tidal Wetlands	See Section in "Aquatic Concerns"	See Section in "Aquatic Concerns"

SECTION 3.3 DRAFT TERRESTRIAL CONCERNS RELATED TO WATER DEPENDENT FACILITIES DEVELOPMENT

Issues	Description	Information Required for Review P rocess
Floodplain Area	Construction in floodplain areas is restricted by NEPA and E011988. All federal agencies must ensure floodplains are being managed according to the goals of avoiding short and long-term impacts, to promote preservation of floodplains, and where possible, restore floodplains to their natural and beneficial values/ functions. County floodplain regulations may restrict development potential. Alterations within the 100-year floodplain may require a waterway construction permit.	The location of the 100-year floodplains should be shown relative to the limits of disturbance from development.
Presence/Absence of Disturbance	The development of an undisturbed tract of land should be discouraged while the rehabilitation of a disturbed area should be viewed as a form of mitigation for a project with other minor impacts.	See "Habitat Quality" discussion in this section.
Steep Slopes development),	The Critical Area Criteria contains specific conservation requirements affording protection of steep slopes. The minimum 100' buffer must be expanded to include contiguous areas of slope greater than 15% by the following formula (4 feet for each 1% increase in slope greater than 15% or to the top of slope, whichever is greater). Generally, outside of the buffer slopes greater than 15% must be left undisturbed unless the area is actively eroding and the proposed development would improve the stability of the slope. Essential road and utilities may cross areas of steep slopes.	Discussions of the development's use of the area of steep slope (total area of steep slope and area to be used by the soil types and erosive potential, existing conditions (photographs) as well as any mitigative plan proposed to reduce concern for past, present, and future erosion should be required. Slope map with minimum slope classes of: 0-15%; 15-25%; greater than 25%.

SECTION 3.3 DRAFT TERRESTRIAL CONCERNS RELATED TO WATER DEPENDENT FACILITIES DEVELOPMENT

Issues	Description	Information Required for Review P rocess
Areas of Severe Erosion	Areas of existing severe erosion should be rehabilitated as part of the development process. The rehabilitation concept should be required to address the likelihood of its long-term success. Improvement of severe erosion problems aides the development in attaining the goals of an environmentally compatible development as set forth in the Critical Area Legislation. Actively eroding areas should receive priority attention in attaining the 10% net improvement in stormwater loadings.	A drawing illustrating the location of the problem area(s) relative to the planned development with a discussion of a plan to reduce/eliminate the severe erosion (or other problem) as well as quantitative and qualitative estimates of the benefits to be realized from the plan (e.g., stormwater loadings, habitat quality).

3.4 INFORMATIONAL REQUIREMENTS FOR APPLICANT SUBMITTAL

Mapped Information

1. Regional Context Map

   Presented at an appropriate scale to incorporate the following features:

   - Parcel boundaries
   - Drainage basin which includes entire parcel
   - Regional road system providing access to site
   - Adjacent significant natural resources within 1,320' (1.4 mile) of project construction limits (SAV beds, tidal wetlands, shellfish beds, rare or endangered species, spawning/nursery areas)

2. Existing Condition Map(s)

   For larger and more complex sites, a series of ecological inventory maps at the same scale is recommended.

Natural Features	Comments
. Soil types	
. Topography	Include bathymetric data
. Slope	Slope classes 0-15%, 15-25%, greater 25%
. Non-tidal wetlands	
. Surface hydrologic features	
. Drainage subareas	
. Location of critical species sitings	
. Major plant communities	
. Aquatic resources	

3. Conceptual Site Plan

   - Limits of upland, shoreline, and waterway construction
   - Footprints of upland and waterway structures and/or improvements
   - Proposed SWM facilities
   - Habitat Protection Areas as defined in COMAR 14.15.09
   - Floating Buffer (100' minimum and contiguous sensitive areas)

Site Evaluation Report

At a minimum, the supporting documentation shall include:

- The applicant's response to the 12 preliminary site screening evaluation factors
- Description of plant communities identified on project site

- Description of adjacent estuarine system including existing and potential SAV habitat, bottom characteristics, condition of shoreline, spawning/nursery areas
- Observed and expected species lists
- Evaluation of soil development constraints (drainage, erodibility, potential foundation, and road problems)
- Wildlife habitat value of existing site conditions
- Evaluation of storm water management approaches

4. DETAILED ENVIRONMENTAL ASSESSMENT

4.1 WATER QUALITY

The single area which receives the greatest attention in the permitting review process is the impact of water dependent facilities upon water quality of adjacent estuarine ecosystem. Under the Chesapeake Bay Critical Areas legislation, water quality impacts must be minimized in the development and operation of water dependent facilities. Facility impacts with respect to water quality can be divided into two basic components:

1. in-water and operational impacts,
2. upland water quality impacts related to non-point source loading and stormwater runoff.

As part of the guidelines for Baltimore County's water dependent facilities program, the applicant must show the impacts which would be expected from the construction and operation of the proposed project and the applicant must further show the reductions in pollutant loadings achieved through best management practices and stormwater management facilities. In order for the review process to be conducted effectively, the applicant must provide information either from existing sources or through original studies on the existing water quality of the water body adjacent to the proposed activity.

The list of proposed or suggested parameters that must be provided is given in Table 4-1. This list was developed, utilizing information from both EPA, and EPA. The information provided in the Chesapeake Bay Program (EPA, 1982) indicates that for the upper bay the most critical problems relate to nutrient enrichment. Since the stresses which have resulted in reduction in biological activity in the upper bay are related primarily to phosphorus, this pollutant would be viewed as the keystone pollutant for identifying both impacts and minimization of loadings. The other parameters, however, allow for an assessment of the relative stress of the existing water body under predevelopment conditions. Average values for total nitrogen and total phosphorous are used in a general model to define the relative trophic condition of the adjacent water body. This approach has been developed by Neilson (1981) and reviewed by D'Elia in the Chesapeake Bay Program Summary Report (EPA, 1982). This approach allows the comparison of total nitrogen and total phosphorus to a simple scale of 0 10, given in Table 4-2. This scale is used in conjunction with Table 4-3 to define the relative conditions of the water body.

In utilizing Neilson's classification scheme, values must be obtained for total nitrogen which is defined as the sum of TKN, NH_3-N and NO_2/NO_3, and the calculation of Total Phosphorus. Using these two values for in-situ average summer conditions, a numerical value can be obtained from the scale given in Table 4-2. This value is then located in Table 4-3 where, under the marine aquatic life column, the acceptability or unacceptability of the existing water body can be estimated. While this is

TABLE 4-1 PRELIMINARY LIST OF WATER QUALITY PARAMETERS REQUIRED FOR WATER DEPENDENT FACILITIES PERMIT APPLICATION REVIEW

	Bottle Type	Preservative	Sample Size (ml)	Holding Time (at 4 C)	Method Number	Detection Limit
ORGANICS						
Chlorophyll a	Plastic	None	500	30 days[a]	APHA 1002G	1 µg/L
BOD	Plastic	None	500	48 hours	EPA 405.1	1 mg/L
COD	Plastic	0.5 ml H_2SO_4	500	28 days	EPA 410.4	10 mg/L
TOC	Plastic	0.5 ml H_2SO_4	500	28 days	EPA 415.1	0.3 mg/L
Phenols	Glass	1 ml H_3PO_4	250	28 days	EPA 420.2	0.05 mg/L
METALS						
Copper	Plastic	1 ml HNO_3	500	6 months	EPA 220.2	0.002 mg/L[b]
Lead	Plastic	1 ml HNO_3	500	6 months	EPA 239.2	0.002 mg/L[b]
NONMETALS						
TKN	Plastic	0.5 ml H_2SO_4	500	28 days	EPA 351.2	0.2 mg/L
NH_3-N	Plastic	0.5 ml H_2SO_4	500	28 days	EPA 350.1	0.1 mg/L
Nitrate-nitrite	Plastic	0.5 ml H_2SO_4	500	28 days	EPA 353.2	0.1 mg/L
Total phosphorus	Plastic	0.5 ml H_2SO_4	500	28 days	EPA 365.4	0.1 mg/L
Orthophosphorus	Plastic	None	500	48 hours	EPA 365.1	0.01 mg/L

(a) After filtration; filters must be kept frozen in dessicators.
(b) Using furnace method--Atomic Absorbtion spectrometry.
(c) Mean probable number.

TABLE 4-1 (Cont.)

	Bottle Type	Preservative	Sample Size (ml)	Holding Time (at 4 C)	Method Number	Detection Limit
PLASTIC						
Total nonfilterable residue	Plastic	None	500	7 days	EPA 160.2	5 mg/L (based on 100-ml sample size)
BACTERIOLOGICAL						
Total coliforms	Plastic	Sterile	125	6 hours	APHA 908A	0 MPN[(c)]
Fecal coliforms	Plastic	Sterile	125	6 hours	APHA 908C	0 MPN[(c)]
Fecal streptococci	Plastic	Sterile	125	6 hours	APHA 910A	0 MPN[(c)]

TABLE 4-2 CLASSIFICATION SCHEME FOR NUTRIENT ENRICHMENT IN ESTUARIES (FROM NEILSON 1981)

Level of Nutrient Enrichment	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
0	0.003	0.0004
1	0.010	0.001
2	0.032	0.004
3	0.100	0.014
4	0.320	0.044
5	1.000	0.140
6	3.200	0.440
7	10.000	1.400
8	32.000	4.400
9	100.000	13.800
10	320.000	44.000

Source: EPA 1983.

TABLE 4-3 NEILSON'S (1981) CHART SHOWING IMPACTS OF NUTRIENT ENRICHMENT ON WATER USES

Level of Nutrient Enrichment	Public Drinking Water Supply	Livestock Drinking	Irrigation	Freshwater Aquatic Life	Marine Aquatic Life	Recreation and Aesthetics	Industry	Commercial Shipping
0		A					A	
	Acceptable		Acceptable	Acceptable				
		C		(oligotrophic)	Acceptable		C	A
1					(oligotrophic)	Acceptable		
		C					C	C
	Minor							
	Purification	E					E	C
2	Required		Increased	(mesotrophic)				
		P	Nutrient	Problems	Problems arise	Infrequent	P	E
			Levels	Arise	Infrequently	Episodes		
		T	Could	Periodically	or due to	when	T	P
3	More		Enhance		Local	not		
	Extensive	A	Usefulness		Conditions	Acceptable	A	T
	Treatment							
	Needed	B		(eutrophic)			B	A
4				Marginally				
		L		Acceptable	(mesotrophic)	Frequent	L	B
					Marginally	Episodes		
		E			Acceptable	when	E	L
5						not		
	Marginally	Algae	Generally		(eutrophic)	Acceptable		E
	Acceptable	May	Acceptable		Marginally		Algae	
	and	Clog	But		Acceptable		May	
6	Sometimes	Intake	Algae				Clog	
	not	Pipes	Could				Intake	
	Acceptable		Clog				Pipes	
			Pipes and					
7			Pumps	Generally				
			and	not				
		Marginally	There	Acceptable	Generally			Problems
		Acceptable	Could be		Not	Not		May
8			Nitrate		Acceptable	Acceptable		Arise
	Not		Build-up					
	Acceptable		in				Not	Hydrogen
			Ground				Acceptable	Sulfide
9			Water				for some	
		Not					Purposes	
		Acceptable						
10								

Source: EPA 1983.

admittedly a simplistic system, in relative terms, it provides a first cut at determining those conditions against which impacts can be compared.

A second component which is important for additional comparison and definition of existing conditions is chlorophyll a. As noted in the Chesapeake Bay Studies by D'Elia (EPA, 1982) nutrient enrichment problems were found in low salinity areas (less than 8 to 12 PPT), where chlorophyll a concentrations were equal to or greater than 60 micrograms per liter. In general, preenrichment concentrations of chlorophyll a would be expected to be less than 30 micrograms per liter. Values between 30 and 60 micrograms per liter in summer would indicate moderate enrichment, while concentrations in excess of 60 micrograms per liter would indicate high enrichment. These ranges of values would be applicable to Baltimore County waters. A combination of the chlorophyll a concentrations and the Neilson Index utilizing total nitrogen and total phosphorus form the basis for definition of relative water quality and stress within the water body adjacent to any given proposed water dependent facility.

In addition to the nutrients recommended for analyses, biochemical oxygen demand, chemical oxygen demand and trace metals are also recommended. Also fecal coliform bacteria and fecal streptococal bacteria are also recommended so as to define the presence of human sewage impacts which are common in many areas of Baltimore County waters.

The following variables are recommended to accompany every permit application:

Chlorophyll a
Biochemical Oxygen Demand
Copper
Lead
Total kjeldahl nitrogen
Ammonia nitrogen
Nitrate/nitrite/nitrogen
Total Phosphorus
Orthophosphorus
Total Suspended Solids
Fecal coliform bacteria
Fecal streptococal bacteria

As a first step comparison, it will be necessary to determine whether or not the data indicate a failure to meet existing surface water criteria. This will give an initial overview beyond the Neilson comparison of the relative conditions of the water body. Table 4-4 gives the State of Maryland receiving water quality criteria for estuarine waters as applicable to Baltimore County. The complete statement of the receiving water quality standards is given in Appendix A. Appendix B gives the federal surface water criteria which would be applicable to estuarine waters in Baltimore County. While there are many compounds which are listed in the federal criteria, this information is primarily included for future reference. The coliform concentrations can be compared with the State of Maryland Surface Water Quality Standards for total and fecal

TABLE 4-4 STATE OF MARYLAND, RECEIVING WATER QUALITY CRITERIA FOR ESTUARINE WATERS IN BALTIMORE COUNTY (SEE APPENDIX A FOR COMPLETE MARYLAND RECEIVING WATER QUALITY STANDARDS)

Toxic Materials Criteria - Applicable to all State Waters

Aldrin-Dieldrin	0.003 microgram/liter
Benzidine	0.1
DDT	0.001
Endrin	0.004
PCB	0.001
Toxaphene	0.005

CLASS I - Recreational Waters

Fecal Coliform	Not to exceed 200 mpn/100 ml - 5 sample average - 30 day period
Dissolved Oxygen	$\geq$ 5.0 mg/liter
Temperature	$\leq$ 90F (32C) outside mixing zone Thermal barriers may not be established
pH	$\geq$ 6.5; $\leq$ 8.5
Turbidity	May not exceed levels detrimental to aquatic life. $\leq$ 150 ntu at any time $\leq$ 50 ntu monthly average

CLASS II - Shellfish Harvesting Waters

Fecal Coliform	Not to exceed 14 mpn/100 ml
Dissolved Oxygen	$\geq$ 5.0 mg/liter
Temperature	$\leq$ 90F (32C) outside mixing zone Thermal barriers may not be established
pH	$\geq$ 6.5; $\leq$ 8.5
Turbidity	May not exceed levels detrimental to aquatic life. $\leq$ 150 ntu at any time $\leq$ 50 ntu monthly average

coliform. Total streptococal bacteria are not included in the state standards but their presence is a direct indication that the coliform are human in origin.

Appendix C provides a statement of the procedures for collecting water samples for original data and the EPA approved methodologies required for analyzing these variables.

Constituent Modeling

The final step in comparing the proposed facility to existing water quality conditions and for defining relative impacts is to combine the results of the water quality data and the flushing studies and to compare these to expected pollutant loadings which may be attributable both to operations and upland runoff conditions following completion of the project. It should be remembered that this is relatively simplistic approach and is intended to be used as a guideline with which to judge the relative impacts of the application. The parameters which would be most effective in predicting the relative impacts and indicating the effectiveness of best management practices and stormwater runoff control are as follows:

A - Inwater Pollutant Additions

Copper
Lead
Fecal coliform
Biochemical Oxygen Demand

B - Stormwater Loadings

Total Phosphorus
Total Nitrogen
Biochemical Oxygen Demand
Lead
Zinc
and Sediment as expressed by Total Suspended Solids

For the first order estimations, phosphorus alone may be used as a keystone pollutant. For the in-water calculations, it is possible to utilize existing information and models developed and included in EPA, 1985 to define maximum expected steady state conditions for Copper, BOD, and coliform. The approach would be to assume the worst case conditions and make the calculations necessary to predict the additional loadings from operations for copper, lead, BOD and fecal coliform. These can then be applied to the flushing and steady state models given in Appendix D to define the relative impacts.

4.2 BEST MANAGEMENT PRACTICES

ACTIVITY: BOAT MAINTENANCE

Impact	BMP	Information Required for Review Process
Discharge of toxic chemicals such as copper or tin based antifoulant paints or battery acids may impact aquatic fauna. The bottom paint used on boats is designed to reduce fouling and, as such contains toxic compounds. These compounds may include copper or tributyltin. Data on the effects of chronic low level release of these compounds is lacking (EPA 1985). Antifoulant compounds enter marina waters while boats are docked and as a result of washing the hull. In addition, marine organisms are also affected by detergents from boat washing. Detergents, including oil dispersants, may be divided into two categories; water-based compounds, which are highly toxic to fish and shellfish but not to crustaceans, and solvent-based compounds for which the reverse is true. Other potential impacts due to boat maintainance involve discharge of chemicals due to improper storage or use, such as painting while the boat is in the water.	Measures which reduce the potential for discharge of toxic chemicals into marina waters include: . Use of antifouling paints restricted to boat hulls only; piers and other in-water structures should not be painted. . Restriction of the number of boats in-water with copper-base painted hulls . Encouragement to use dry dock facilities which may minimize exposure times of marina waters to antifoulants. . Systems designed to retain and dispose of paint flakes and fine particles from hull cleaning and repainting should be included among boat maintenance facilities. . All previously opened containers of miscellaneous chemicals, boat paints, and paint vehicles should be stored in designated facilities. . Waste chemicals should be disposed offsite by contract with a private waste handling firm. . No explosive chemicals should be stored onsite. . Waste motor parts and old batteries should be disposed to closed containers before removal offsite. . Painting of boats in-water should be prohibited.	. Description of inwater structures, materials and preservatives. . Describe dry dock facility in terms of availability, i.e., capacity and cost of use. . Show structures or design features of boat washing facility which prevent discharge of antifoulants, oil/grease and detergents to marina waters. These include drainage and filtration systems which may be incorporated in the overall storm water management plant. . Describe of boat maintanance facilities indicating storage locations of paint, solvent and other potential toxicants and methods insuring proper storage and disposal of toxicants and emptied toxicant containers. . Outline plans for increasing boater awareness of potential release of toxicants to marina waters and penalties for disreguard of marina rules concerning such.

BEST MANAGEMENT PRACTICES

ACTIVITY: CONTROL OF STORMWATER RUNOFF (post-construction)

Impact	BMP	Information Required for Review Process
Water quality in the marina basin and adjacent waters can be impacted by pollutants in stormwater runoff. These pollutants include sediments nutrients, salts, petroleum hydrocarbons, metals, and bacteria. Of primary concern is the potential for increased turbidities due directly to suspended sediments and indirectly to increased algal growth. Sediment derived turbidity as well as decreased light penetration due to algal blooms can affect the growth of SAV. Other suspended or dissolved pollutants may be accumulated in fish and shellfish affecting the health of those organisms and the organisms which consume them.	Features which minimize stormwater discharge of pollutants act to contral runoff velocity and volume, and retain pollutants before these waters enter the Bay system. These features include: . Use of retention and detention basins to handle the first one inch of rainfall, and effect the removal of a minimum of 10% percent of pollutant loadings, especially sediments, total nitrogen, biochemical oxygen demand total phosphorous, lead, and zinc. . Use of bulkheads as runoff filtering devices by directing runoff through porous surface to bulkheads lined with filter cloth. . Use of porous surfaces (crushed stone, shell) wherever possible, particularly in parking lots . Direction of runoff from impervious surfaces to porous surfaces to improve infiltration capacity. . Minimal clearing of vegetation onsite . Retention and creation of vegetative buffers (especially wetlands) onsite between potential sources of pollutants and discharge areas. . Location outfalls for extremely high runoff levels to discharge into waters with high flushing rates (Boozer 1979). . Conservative use of fertilizers onsite . Use of non-phosphorous detergents for washing boats.	. Maps of the are proposed for development must indicate: 1. Post-construction drainage patterns, especially of runoff coming off of nonvegetated area (urban runoff). 2. Type and pervious nature of all surfaces on marina property. 3. Design and location of detention/retention systems. 4. Post-construction vegetation patterns. . Description of stormwater managment plant must include: 1. Estimates of pre-and post construction loadings of major pollutants (sediment, N.P. lead and zinc, and biological oxygen demand in marina waters) with all assumptions of controlling conditions detailed. 2. Mixing and flushing rates in marina waters. 3. Total acreage of major land cover types and infiltration potentials. 4. Maintainance schedule for stormwater management structures.

BEST MANAGEMENT PRACTICES

ACTIVITY: SITE LOCATION

Impact	BMP	Information Required for Review Process
1. Dredging, construction, and increased boat traffic may disturb aquatic resources such as shellfish beds, submerged aquatic vegetation, and fish nurseries.	Plans and construction designs must list and locate aquatic resources potentially impacted and demonstrate minimal impact (see Description of Aquatic Concerns with Water Dependent Facility Development).	. Maps of the area proposed for development must show aquatic resources within one mile by surface water connection. These resources must include (but are not limited to: shellfish beds, SAV, and wetlands.
2. The activities listed above may interfere with navigation.	Section 10 permit must be obtained from COE indicating the nature and extent of interference with a navigable waterway.	. Maps and construction plans which indicate locations of navigated waterways and potential interference and expected length of time involved for construction of marina.
3. May interfere with circulation or salinity regimes.	404 Permit must be obtained for all dredging and dredged material disposal.	. Information required for 404 permits: 1. Evaluation of economic, social environmental costs vs benefits. 2. Extent of private and public need. 3. Desirability of alternate locations. 4. Effects on wetlands. 5. Impacts on navigation. 6. Effects on flood control. 7. Compliance with applicable effluent and water quality standards and management practices. 8. Interference with adjacent properties or water resource projects. 9. Consistancy with state, regional or local land use classification. 10. Compliance with Coastal Zone management programs. 11. Enhancement, preservation or rehabilitation. 12. Cumulative impacts.

BEST MANAGEMENT PRACTICES

ACTIVITY: DREDGING (Initial Construction and Periodic Maintenance)

Impact	BMP	Information Required for Review Process
Dredging temporarily degrades water quality onsite and in the direction of waterflow by increasing turbidity through the resuspension of the bottom sediments. These resuspended sediments can affect filter feeding organisms such as shellfish by reducing feeding rates, suffocate organisms by clogging gills, reduce primary productivity by reducing light penetration, and bury benthic organisms through siltation. Resuspended bottom sediments can contain trace metals, toxic substances, nutrients, and organic debris that can be released into the water column. Resulting water quality problems can include lowered dissolved oxygen concentrations and promotion of algal blooms.	Water quality impacts may be avoided or minimized by (Maloney et al. 1980a; Ervin et al. 1980; Bednarz 1983): . Planning dredged channels that follow the course of natural channels . Building slips for boats with deep drafts in naturally deep water . Extending piers and docks as far as possible into naturally deep water . Providing upland storage for smaller boats and using boat lifts to transport them to the water. Dredging Method When dredging is required, water quality impacts due to increased turbidity may be reduced by: . Choice of dredging method . Use of silt screens or similar containment methods. Other Mitigative Measures Other mitigative measures for dredging impacts include: . Dredging during colder months when DO levels are higher (cold water has a greater capacity for DO than does warm water) would help mitigate dredging-related DO and BOD problems. Time of year restrictions generally do not permit dredging between 15 March and 1 June. . Dredging dead-end (Venetian) finger canals can be sloped, as opposed to being at right angles with the bottom, to reduce stagnant, low DO pocket areas. Sloped banks can be stabilized with rip-rap to prevent erosion . Water circulation can be ensured by using properly designed culverts, pilings, and bridge spans, and by using discontinuous mounds for open water discharge.	. Maps of areas proposed for dredging must indicate: 1. Depths and contours of basin, channel(s) and adjacent waters within a 1/2 mile radius before and after development. 2. Location of dredged area and depth of material removed. 3. Location and design of turbidity control structures. . Conceptual plans must include description of: 1. Dredging schedule indicating no interference with fish spawing season (15 March - 1 June). 2. Method and equipment used for dredging. 3. Design features of turbidity control structures. 4. Best use of naturally deep waters.

ACTIVITY: DREDGE SPOIL PLACEMENT

Impact	BMP	Information Required for Review Process
Dredged material may be disposed of in open water, wetlands, or upland sites. Open water disposal is seldom a viable option for marine projects and disposal on wetlands is unacceptable because of environmental reasons. Environmental solutions for potential disposal problems were compiled from NMFS (1983), Van Dolah et al. (1979), Wright (1978), Johnston (1981), and Reimold et al. (1978). Maryland regulations currently so severely restrict any open waters disposal that only upland disposal is allowed.	BEST MANAGEMENT PRACTICES Mitigative measures for dredged material disposal include: . Productive use of suitable dredged material for beach replenishment, construction, sanitary landfill, and agricultural soil improvements . Confining discharges to the smallest practicable deposition zone to protect adjacent substrates . Dedicating permanent upland disposal sites as part of the marina specifications would help eliminate future problems related to disposal of maintenance dredging material. These permanent sites can be sites that have been previously used or represent an environmentally satisfactory alternative . The carrying capacity at existing disposal areas could be increased by raising the height of containment embankments . Disposing of toxic and organic materials in impervious containment basins (settling of contaminated suspended particles may be enhanced by the addition of a cationic polyelectrolyte with further treatment using sand filters and activated charcoal before discharge). Currently, only Hart and Miller Islands Disposal site will accept significantly contaminated dredged materials. . Upland retention or treatment of runoff from the discharged material to remove dissolved pollutants before they reach the aquatic environment (a simple treatment such as ozonation or aeration can be adequate for reduction of BOD and COD before the discharge of supernatant liquid from spoil areas enters into receiving waters) . Controlling erosion at diked areas by shaping the dike and using stabilization measures, such as revegetation. Positioning outfalls to empty back into the dredged area . Characterizing the sediments to be dredged and considering the potential odor problems during the selection of the disposal site and site preparation.	. Conceptual plans must detail: 1. Location and design of disposal site. 2. Treatment for removal of pollutants before discharge of supernatent liquid. 3. Use of spoil after dewatering. When upland disposal is not possible and open water disposal is considered environmentally acceptable, measures that can minimize problems or impacts include: . Using several sites to provide a more even distribution of dredged material overburden . Maintaining the same elevation as marshes and other continguous areas to promote natural tidal flooding and flushing . Situating spoil islands on the windward side of the dredged channel. . Using materials for approved tidal wetland development.

ACTIVITY: BASIN DESIGN

BEST MANAGEMENT PRACTICES

Impact	BMP	Information Required for Review Process
Basin and entrance channel design affect flushing and sedimentation patterns. Adequate flushing of a marina is necessary for maintaining the water quality of the marina basin and adjacent waterway. Natural circulation near the site should be maintained whenever possible. Poorly flushed marinas can become stagnant and permit the concentration of pollutants from the marine facility and boats. The settling and accumulation of organic material and fine sediments can result in decreased dissolved oxygen levels and shoaling within the marina basin. Inadequate flushing and subsequent stagnation may lead to water quality degradation, affecting dissolved oxygen, water temperature, and pollutant concentrations.	Design features that promote flushing are: . Basin depths that are not deeper than the open water or channels to which the basin is connected and never deeper than the marina access channel . Basin and channel depths that gradually increase toward open water . Two openings at opposite ends of the marine to establish flow-through currents . Single entrances that are centered in rectangular basins rather than at one corner . Basins with few vertical walls and gently rounded corners or oval shaped . Even bottom contours, gently sloping toward the entrance with no pockets or depressions . Areas where tidal exchange may not adequately flush the marina, tide gates or one-way valves may be used to enhance the flushing rate . For harbor-locked marinas dredged from uplands, flushing may be induced by creating a tidal prism with the basin. The basin is flooded on incoming tide and the water flows out smaller diameter pipes on the ebb tide . Entrance channels designed with openings as wide as possible and with increasing depth away from the marina basin promote flushing (Boozer 1979) . Flushing may also be enhanced when entrance channels are located in the direction of prevailing winds as wind-generated currents can facilitate circulation between the basin and the adjacent waterway. . Placement of breakwaters may impede shoaling in channels and basin, and help to maintain good flushing.	. Maps of area proposed for development must indicate pre-and post-development features such as: 1. Depth of basin, entrance channel(s) and adjacent waters with 1/2 mile radius. 2. Bottom contours of basin. 3. Location and design of mechanical flusing enhancement structures and breakwaters. 4. Sedimentation patterns. . Description of pre-and post-development conditions, must include. 1. Flushing potentials in basin and channel(s). 2. Estimates of sedimentation rates.

BEST MANAGEMENT PRACTICES

ACTIVITY: CONSTRUCTION IN WATER

Impact	BMP	Information Required for Review Process
A direct water quality impact during construction of bulkheads, revetments, pilings, piers, docks, and breakwaters is a temporary increase in turbidity.	. Impact on water quality may be minimized by use of pile-driving rather than jetting. . See Dredging for Turbidity Control	. Description of construction methods and type of equipment to be used for building of in water structures.
All structures may impede water and sediment movements.	. All structures should be designed and placed for minimal restriction of water circulation or mixing within the marina basin, and for reduction of shoaling . Avoid solid structures . Elevate docks and piers as high as possible, orient in north-south rather than east-west direction, and minimize structure width to allow for maximum sunlight penetration	. Show structures on conceptual plans with depths before and after indicated.
Mooring structures can impact water quality within the marina basin through leaching of wood preservatives. References on environmental solutions to potential impacts on shoreline structures include Bara et al. (1977), Chmura and Ross (1978), Mulvihill et al. (1980), and NMFS (1983).	These impacts may be reduced by: . Using alternative materials such as concrete-filled, steel-reinforced PVC, plastics, or other non-conventional materials . Using highly refined (grade one) creosote that contains less tar or alternative preservatives such as chromated copper arsenate (CCA salt) to minimize chemical leaching	. Describe types of structure and materials to be used. . Give mean life expectancy of structures. . As above, and state type of material and preservatives.

BEST MANAGEMENT PRACTICES

ACTIVITY: BOAT FUELING AND OPERATION, CONTROL OF PETROLEUM PRODUCT POLLUTION

Impact	BMP	Information Required for Review Process
Pollutants discharged to waters in association with the fueling and operation of boats include carbon monoxide, carbon dioxide, oil, gasoline, and other hydrocarbons resulting from combustion of fuels and lubricants, and lead. Data on the impact of chronic low level discharges of the remaining pollutants on coastal organisms and ecosystems are lacking. Most studies concerning the effects of hydrocarbons on marine fauna have been after major oil spills, where the amount of hydrocarbon pollutants is considerably greater than would occur from outboard exhausts. These studies (included in Hart and Fuller 1979) showed that the areas of concern regarding oil pollution were direct lethal toxicity, sublethal disruption of physiological or behavioral responses (of which extremely little is known), persistence and accumulation of oil in invertebrates that is passed up the food web chain, destruction of habitat, and damage to fishery resources through tainted shellfish or finfish meat (Moore and Dwyer 1974; Dawson 1979; Williams and Duke 1979). Outboard motor exhaust and bilge discharge lead to marine waters. Lead also enters the aquatic environment in surface emissions, atmospheric fallout, and surface runoff. Almost all of the lead that is discharged eventually reaches bottom sediments (Kuzminski and Mulcahy 1974). Lead is very toxic to most plants and is moderately toxic to mammals where it acts as a cumulative poison (Bowen 1966). Fish are most sensitive to lead among aquatic organisms (Mathis and Kevern 1975). Lead bioaccumulates and is passed through the food web.	Measures which prevent discharge of petroleum products to the aquatic environment include: . Location and construction of fuel storage tanks which minimize potential of accidental puncture . Tanks should be EPA-approved and filled using approved safety equipment and procedures . Fuel pumps should be fitted with automatic shut-off of the feeder line if the pump is knocked off vertical alignment. Fueling nozzles should be fitted with back-pressure shut-off valves. Locking fuel fills should not be utilized, requiring the operator to manually hold the on-position during the fueling procedure. . Filling of fuel tanks from containers should be prohibited while boats are in marina. Fueling should be supervised by marina personnel who should be trained to prevent and cleanup any fuel spills. Only low-lead gas and diesel fuel should be sold onsite. Facilities for fueling of ramp-launched boats before launching would help prevent spills directly into the water. . Discharge of oil and gas with bilge water should be controlled by use of oil filtration devices on bilge pumps or soil absorbant pads (sponges) placed in the bilge and recovered prior to bilge water discharge (Chmura and Ross 1978). . Maintenance services provided by the marina may help improve combustion efficiency of resident boats. . Removal of engines to an upland shop for major maintenance and repair may also help reduce petroleum product losses to the water.	. Conceptual plans must include: 1. Location and construction of fuel storage tanks. 2. Location and design of fuel pumps. 3. Types of fuel distrubuted at marina. 4. Details of maintenance/shop facilities at marina. 5. Desing of bilge disposal system with emphasis on control of petroleum products. 6. Marina personnel training which covers prevention and cleanup of oil or fuel spills.

BEST MANAGEMENT PRACTICES

ACTIVITY: CONTROL OF TRASH

Impact	BMP	Information Required for Review Process
Litter is a form of pollution associated with increased boating activity that has an aesthetic as well as an ecological impact. During the peak boating season, approximately one-half to one cubic yard of uncompacted garbage per day can be expected for every 100 boats in a marina (Olsen and Burd 1982). Plastics are the chief concern. To date, 15 percent of the world's 280 species of sea birds are known to have ingested plastic (Wehle and Coleman 1983). Plastic has been found in the stomachs of four of the seven species of marine turtles, in at least eight species of fish, in marine mammals including whales, dolphins, and manatees, and in invertebrates. Lost or discarded fish netting, monofilament line, plastic beverage yokes are materials that may lead to strangulation, drowning, or starvation.	Measures which prevent loss of trash to marina waters and upland facilities include: . Provision of equipment carts on all piers for conveyance of refuse to conveniently placed dumpsters. . Strict enforcement by marina personnel of proper disposal of trash by boaters, with potential fines for improper disposal.	. Plans should indicate loction and type of trash collecting facilties. . Plans for training of marina personnel and enforcement of proper trash disposal should be outlined.

BEST MANAGEMENT PRACTICES

ACTIVITY: CONTROL OF SEWAGE DISCHARGES

Impact	BMP	Information Required for Review Process
Raw sewage from boats and filtered discharges from ineffective upland septic systems may impact water quality and aesthetics. Boat sewage can be visually repulsive. Increased nutrient loadings from sewage may contribute to increased biological demand (BOD) in receiving waters (OCZM 1976). The most serious effect of discharging fresh fecal material is the potential for introducing disease-causing viruses and bacteria (pathogens). Problems may occur if boat sewage is released in the vicinity of shellfish (clam or oyster) beds or into enclosed waterways with limited flushing. Shellfish require clean water to be microbiologically safe for human consumption, regardless of whether they are eaten raw or partially cooked. Fecal coliform bacteria, other bacterial pathogens, and viruses found in water and sediments are concentrated by shellfish, depending upon temperature, density of pathogens, salinity, currents, depth, water chemistry, and shellfish feeding activity (Van Donsel and Geldreich 1971; Metcalf and Stiles 1968). Once concentration of pathogens has occurred, microorganisms will not necessarily be flushed at the same rate (Janssen 1974; Kelly and Arcisy 1954). Known enteric pathogens associated with feces-contaminated shellfish include typhoid fever, dysentery, gastroenteritis, and infectious hepatitis (NSSP 1965).	Marina features which reduce the potential of sewage discharge include: . Newly constructed and renovated marina facilities should be connected to the municipal sewage system for disposal of sewage from boats and shore-based facilities. . Ample and conveniently located toilet facilities and showers should be provided onshore. . Pump-out facilities for holding tanks and portable heads should be provided by the marina at the fueling dock. . Cost of pump-out service should be included in slip rental fees and provided on an unlimited basis. . Marina stores should supply Coast Guard approved marine heads, marine sanitation devices, and related supplies. . Boaters should be notified of the prohibition against sewage dumping in marina waters, the pollution levels which result from discharges, and the penalties imposed for violations, by posting prominant signs at points of access to piers and other frequented areas, and in conjunction with slip rental agreements. . Individuals leasing slip space should be held responsible for sewage disposal violations by written contract agreements which specify: "Head discharge overboard will result in voiding this contract immediately and expulsion from the marina with forfeiture of rental fees. Heads are to be pumped out without a per-service fee at marina as often as requested."	. Conceptual plans must detail: 1. Sewage holding and disposal systems for onshore and boat-pump facilities which are connected to municipal systems. 2. Location and design of pump-out facilities. 3. Location and design of onshore toilet and shower facilities. 4. Training of marina personnel concerning the importance of prevention of sewage pollution in marina waters and enforcement of marina rules regarding unlawful discharges.

BEST MANAGEMENT PRACTICES

ACTIVITY: PROTECTION OF SHORELINE

Impact	BMP	Information Required for Review Process
Modification of shoreline by removal of wetland vegetation, construction, and increased wave action due to boat wake may encourage erosion at a marina site. Loss of shoreline area and degraded water quality may result.	Shorelines may be protected against erosion by employing: . Creation and protection and maintenance of existing marshes. . Rip-rap stabilization of eroding banks. Armor stone placed near high tide line. . Bulkhead and revetment stabilization of marina basin. Bulkheading may be appropriate along shoreline if placed at or above MHW. . 5 mph speed limit enforcing a "No Wake" zone in marina basin and entrance channel. . Basin depth designs which minimize turbidity due to prop wash and scour. . Designated slips for boats of different drafts. . Breakwaters near entrance channel or marina mouth.	. Maps of area proposed for development must indicate pre and post development shoreline features such as: 1. Location, extent and quality of wetlands. 2. Slopes of shoreline. 3. Mean high and mean low water lines. 4. Bulkheads, revetments, rip-rap, and breakwaters. 5. Depths of basin, channel and all adjacent waters. 6. Sedimentation patterns, acretion and depletion. 7. "No wake" zone in marina basin and entrance channel. 8. Areas of erodable soils. . Outline measures of boater awareness and compliance with"no Wake' rules including description of penalties for non-compliance.

4.3 DETAILED ENVIRONMENTAL ASSESSMENT RATING SYSTEM

The intent of the detailed environmental assessment is to provide sufficient information for the County Review Group (CRG) to prepare a findings of fact, required by the Critical Area Legislation. This second level of review builds on the environmental baseline data that was provided during the preliminary evaluation. Issues flagged during the preliminary evaluation may require more detailed field information.

During the development of the water-dependent facilities review process, it became apparent that a means to address the cumulative impacts of numerous facilities in an estuarine subarea was essential to protect water quality and the natural resources of the Chesapeake Bay. The rating system attempts to address this concern by assigning weighted factors to these areas of the County's waterways where cumulative impacts of numerous water-dependent facilities would lead to water quality and habitat degradation.

Estuarine subareas with poor flushing characteristics and poor water quality receive the most points. This weighting acknowledges the importance of flushing characteristics in concentrating pollutants from a number of water-related development activities. If a proposed facility receives enough points, the developer would be required to show an improvement in expected stormwater loadings above the ten percent rule. This additional requirement may be satisfied onsite or, in some cases, it may have to be provided offsite yet within this same watershed.

Much of the review conducted by the CRG is technical in nature and will require the presentation of engineering plans and specifications for the construction and operation of the proposed water-dependent facility. Section 4.2 describes a range of BMPs for upland and water-related development activities. Estimations of point and non-point source loadings to the estuary must be included in the environmental assessment accompanying the site plan.

County planning staff has the responsibility for assigning points to the thirteen rating categories. Most of the information should be available from the preliminary evaluation and additional assessment. It should be noted that because several of the rating factors require information that is not currently available on a county-wide basis, it is not possible to thoroughly evaluate the outcome of the rating system at this time. Numerous scenarios involving development, redevelopment, or expansion were evaluated according to the rating system proposed, however, there may need to be revisions to the rating system after it has been applied to a number of actual water-dependent facility applications.

RATING SYSTEM

Natural Resources

1. **Offsite Aquatic Resources.** Includes: SAV beds, viable shellfish beds, extensive or embayed tidal wetlands greater than two acres, anadromous fish spawning area (as identified on current DNR aquatic resource maps).

   If the waterside construction limit is within 1320 feet of a designated aquatic resource area:

   Project receives 5 points

2. **Shallow Water Habitat.** This factor considers adverse impacts on potential SAV habitat, anadromous fish nursery area and other wildlife benefits of preserving shallow water habitat.

   a. dredging is estimated to produce less than 199 cubic yards (cy) of spoil — 0 points

   b. 200 to 1,999 cy spoil: if greater than 50% of area extent of disturbance is shallow water habitat (less than 3' deep), project receives 10 points.

   c. 2,000 to 19,999 cy spoil: if greater than 40% of the area of disturbance is shallow water habitat, project receives 10 points

   d. greater than 20,000 cy: if greater than 30% the area extent of disturbance is shallow water habitat, project receives 10 points.

3. **Tidal Wetlands.** Project requires mitigation for impacts to fringe tidal wetlands.

   Project receives 5 points

4. **Rare and Endangered Species.** The presence of any species designated by Baltimore County as a Critical species (includes Federal and State listed rare, threatened and endangered species, and those of local significance).

   Project receives 5 points

5. **Habitat Protection Area.** Calculate percentage of upland area of site identified on the existing conditions map to be Habitat Protection Area, as defined by Chesapeake Bay Critical Area Criteria.

a. less than 10% of site is designated as Habitat Protection Area:

Project receives 0 points

b. greater than 10% and less than 40%:

Project receives 5 points

c. greater than 40% of site:

Project receive 10 points

Physical Alteration

6. Proposal involves structures that would significantly alter natural **littoral drift movement.**

Project receives 5 points

7. Proposal would alter **salinity** regime in vicinity of project site.

Project receives 5 points

8. Proposal would significantly alter **water circulation** patterns in vicinity of project site.

Project receives 5 points

9. **Dredging.** Proposal does not incorporate Best Available Technology for minimizing adverse impacts of dredging.

Project receives 5 points

10. **Dredged Material.** Project site is located in an area where extensive and frequent maintenance dredging will be required.

Project receives 5 points

Water Quality Impacts

11. **Flushing Characteristics.** If the application of the flushing model or an in-situ dye study reveals a flushing rate between two and four days:

Project receives 15 points

12. **Water Quality.** Existing baseline water quality data or required water quality sampling data provides the basis for classifying receiving tidal waters as poor, fair or good (see Section 4.1 and Appendices for methodology).

a. poor water quality: project receives 15 points
b. fair water quality: project receives 10 points
c. good water quality: project receives 0 points

13. **Sewage Disposal.** If project proposes onsite sewage disposal.

Project receives 5 points

RATING SYSTEM CHECKLIST

FACTOR	WEIGHTING	POINTS
1. Offsite Aquatic Resources	2X	10
2. Shallow Water Habitat	2X	10
3. Tidal Wetlands	1X	5
4. Rare & Endangered Species	1X	5
5. Habitat Protection Area		
a. less than 10% of site		0
b. greater than 10%, less than 40%	1X	5
c. greater than 40%	2X	10
6. Littoral Drift	1X	5
7. Salinity	1X	5
8. Water Circulation	1X	5
9. Dredging Impacts	1X	5
10. Dredge Spoil	1X	5
11. Flushing Characteristics	3X	15
12. Water Quality		
a. Good		0
b. Fair	2X	10
c. Poor	3X	15
13. Sewage Disposal	1X	5
MAXIMUM TOTAL SCORE	(1X=5)	100

Scores ranging from 50 to 70, inclusive, must reduce predevelopment pollutant loadings by 20%.

Scores of 75 or greater are considered unacceptable and will be denied.

5. STATE AND FEDERAL REGULATORY PROGRAMS

5.1 SUMMARY

A comprehensive discussion of all potentially applicable federal and state regulations would require many pages of analyses, and is not the goal of this section. Instead, an attempt has been made to distill a complex array of regulations into an orderly and understandable description of the permitting process.

The Army Corps of Engineers (Corps) is the lead federal agency in the permitting of water-dependent facilities and their role includes coordination of input from the state and local agencies, special interest groups, and the general public. This permitting authority has been delegated to the Corps by Section 404 of the Clean Water Act and Sections 9 and 10 of the Rivers and Harbors Act. Section 404 of the Clean Water Act authorizes the Corps to regulate discharge of dredged or fill materials into the waters of the United States.

Section 9 of the Rivers and Harbors Act requires a Corps permit for the construction of dams or dikes and will not be a factor in most County water-dependent facility applications. Section 10, however, of the same Act authorizes Corps regulation of essentially all construction in, over and under navigable waters of the United States. Finally, the Corps is required by Section 7 of the Endangered Species Act to ensure that permitted actions are compatible with the protection of federally listed endangered and threatened species.

The Corps considers comments from a variety of federal, state and local agencies throughout the permitting process, and shares denial authority with the Environmental Protection Agency (EPA). The Corps has a memorandum of cooperation with the U.S. Fish and Wildlife Service (FWS) for water-related permitting. In addition, the Corps seeks comments from other federal agencies which may include: the National Marine Fisheries Service, the U.S. Coast Guard, and the National Park Service. The Corps 404 permitting process also solicits comments, or may require prior permitting/licensing from: the Maryland Board of Public Works; Maryland Department of Natural Resources (DNR) Watershed Permits Division, Wetland Permits Division, Coastal Resources Division, and Tidal Fisheries Division; Maryland Office of Environmental Programs; Maryland Historical Trust; the Regional Planning Council; and Baltimore County. All comments from these agencies are given serious consideration before the granting or denial of the permit.

Concurrently with the Corps permit application, it is also necessary to submit similar applications to the following two State agencies: the Maryland Office of Environmental Programs (OEP); and to the Wetlands Permits Division of DNR. All projects which have the potential to significantly impact coastal resources must also receive a determination of Coastal Zone Consistency from the Coastal Resources Division of DNR. Projects which involve dredging of state wetlands require a Wetlands License from the Maryland Board of Public Works. Finally, projects which

involve construction in state waters, specifically the Port of Baltimore, require a Construction Permit from the Maryland Port Administration.

Water Quality Certification must be obtained from OEP (of Maryland Department of Health and Mental Hygiene) before the Corps will permit a water-dependent project. Section 401 of the Clean Water Act authorizes the state water quality certification process to regulate activities which may result in discharge into navigable waters. OEP determines whether the discharge will comply with applicable water quality standards. This applies to discharges during construction and to those associated with the subsequent operation of the facility. OEP circulates the water quality certificate application to other state and federal agencies for comment before granting or denying the certificate.

Dredging projects in wetlands require permit from either or both the Wetland Permits Division of DNR, Water Resources Administration, and Maryland Board of Public Works. Maryland DNR is authorized by Titles 8 and 9 of the Natural Resources Article to regulate dredging and filling within tidal wetlands (state or private). Tidal wetlands below the mean tide line are state wetlands. Dredge and fill activities of state wetlands must be approved by the Maryland Board of Public Works. The Board derives its authority to license dredge and fill operations on State wetlands from Section 9-202 of Title 9. Both applications must demonstrate that the project has been developed to incur the least environmental impact to the wetlands. Corps permits are generally not issued until a Board license is issued if state wetlands are involved. Again, permit applications are circulated to several state and federal agencies prior to granting or denying the permit.

All projects which require construction, dredging and spoil disposal within the Port of Baltimore are regulated by the Maryland Port Administration (MPA). MPA derives its authority for issuance of construction permits from Title 6 of the Annotated Code of Maryland. Applications for construction permits are circulated among the Corps, and DNR which cooperates with MPA under the direction of a Memorandum of Understanding.

Table 5-1 provides a summary of state and federal regulatory authority and actions involving ACOE Section 10/404 permit applications.

5.2 AGENCY RESPONSIBILITIES AND GUIDELINES

This section provides a synopsis of the responsibilities and guidelines of respective state and federal agencies who are involved with approving or commenting on water-related development activities. State and federal guidelines have been adapted from several sources; however, the primary sources are the Maryland Dredge and Fill Handbook (Coastal Resources Division, DNR, 1983) and the Coastal Marina Assessment Handbook (EPA, 1985). It is important to note that several of the agency guidelines incorporated into this section are informal policy guidance or draft guidelines and that in many instances state and federal regulatory decisions are made on the individual merits of the application.

TABLE 5-1 SUMMARY OF STATE AND FEDERAL REGULATORY PROGRAMS

Agency	Action	Remarks
Corps of Engineers	Corps Permit	Required for all dredging operations in Maryland coastal waters.
Maryland Board of Public Works	Wetlands License	Required for all dredging projects involving state wetlands. Corps permit generally not issued until license is issued.
Wetland Permits Division Water Resources Administration DNR	Wetlands Permit	Required for all dredging projects in private wetlands.
Coastal Resources Division Tidewater Administration DNR	Coastal Zone Consistency Determination	Required for all dredging projects. A positive determination is a prerequisite for issuance of a Corps permit.
Office of Environmental Programs/Department of Health and Mental Hygiene	Water Quality Certification	Required for all dredging projects. This certification is a prerequisite for issuance of a Corps permit.
Maryland Port Administration/Dept. of Transportation	Construction Permit	Required for all port-related construction activity in state waters. Usually limited to Port of Baltimore.
Environmental Protection Agency	Review and approval comments	Required for all dredging projects.
U.S. Fish and Wildlife Service [DOI]	Review comments	Required for all dredging projects.
National Marine Fisheries Service [DOC]	Review comments	Required for all dredging projects.
U.S. Coast Guard	Review and approval comments	Required only when a bridge or causeway is involved in the project.

TABLE 5-1 (Cont.)

Agency	Action	Remarks
National Park Service [DOI]	Review comments	Required only when National Park lands are involved or impacted.
Tidal Fisheries Division Tidewater Administration DNR	Review comments	Comments solicited by and submitted to Wetland Permits Division.
Watershed Permits Division Water Resources Administration/DNR	Review comments	Comments usually solicited by and submitted through Wetland Permits Division
Maryland Historical Trust	Review comments	Required on all projects.

5.2.1 Federal Agencies

U.S. Army Corps of Engineers

A Corps permit is required to locate a structure; to fill, excavate, or discharge dredged or fill material in waters of the United States; or to transport dredged material for the purpose of dumping it into ocean waters. Every activity may not require a separate individual permit application. Certain activities and work have been authorized by nationwide permits and general permits.

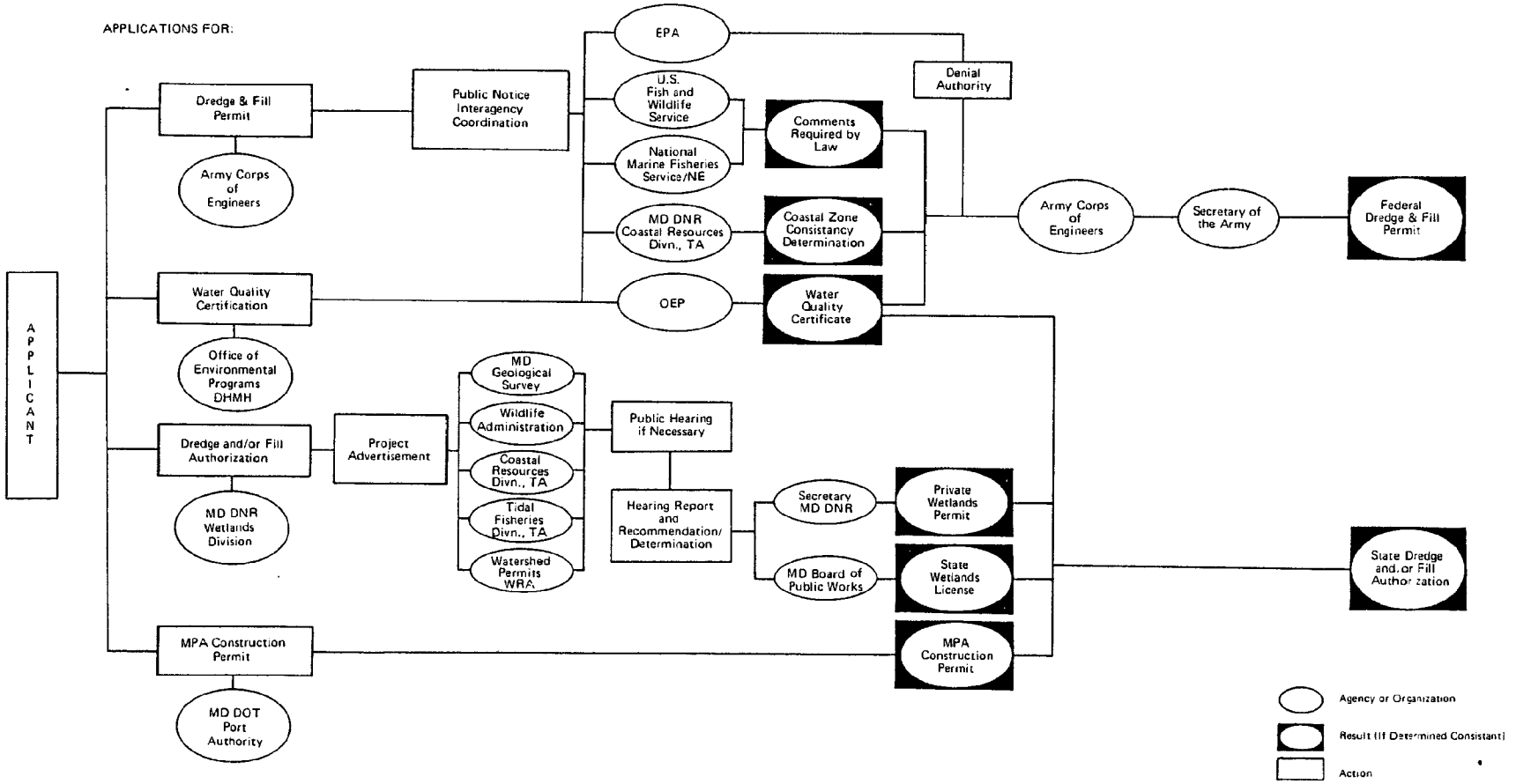
Nationwide permits have been issued for discharges of dredged or fill material into certain smaller or minor waters of the United States. Nationwide permits have also been issued for certain types of activities in all waters of the United States. These permits and their conditions are published in Section 330.4 and 330.5 of Title 33 of the Code of Federal Regulations. If any activity is covered by a nationwide permit and the applicable conditions will be met, there is no need to apply for an individual permit. In effect, activities authorized by the nationwide permits in the regulation are permitted in advance. No paperwork or delay is required.

General permits are issued by the District Engineer. They are similar to the nationwide permits, but are limited to specified regions and may require some notification or reporting procedures. The District Engineer is authorized to determine those categories of activities in specified geographical regions that will cause only a minimal adverse environmental impact and to permit them with general permits. These will reduce delays by eliminating the need to process many individual applications.

The overall process followed by the Corps in reviewing permit applications, including marina development is shown on Figure 5.1. This diagram illustrates overall Corps responsibilities and decision points. The procedure shown would apply in general, to Corps reviews under any area of authority. Typically, when a Corps application form is utilized by an applicant, only one form is submitted for both Section 10 and 404 approval and adequate information for both reviews is required. This general process has been modified to some extent based on memoranda of agreement signed by the Corps and state permit agencies.

The Corps' permit review process provides a clearinghouse for the collection and review of comments from public agencies at all levels of government, private groups and individuals. It also brings together comments representing the entire range of social, economic and environmental factors affected by marina development.

Following receipt of the permit application, the Corps undertakes a preliminary assessment to determine the type of environmental review required. This environmental review may range from a categorical exclusion to a full Environmental Impact Statement (EIS) procedure based upon the potential extent of adverse impact on the natural and man-made environment. A proposed activity is categorically excluded from further



Flow chart of the fill/dredge permitting process in Maryland.

Figure 5-1. Flow chart of the fill/dredge permitting process in Maryland.

environmental review if the Corps finds that the project will have minimal or no individual or cumulative effect on environmental quality and that it will not cause an environmentally controversial change to existing environmental conditions.

When a categorical exclusion is not made, the next step in the permit process is for public notice to be given. This notice goes out to all interested parties along with those agencies with a required review or regulatory role in the process. The finding of the preliminary assessment may be included as part of the public notice.

A public hearing is held when it is determined necessary. This is based on review of comments from individuals, special interest groups, other Corps offices and public agencies. The permit application is then evaluated and the necessary environmental reviews, as determined in the preliminary assessment, are conducted. Following the completion of the environmental review, the permit decision is made and the permit is either issued or denied.

Review Guidelines

Impact Category	ACOE Concerns
Water Quality	1. Compliance with applicable effluent limitations, water quality standards and management practices during construction, operation and maintenance.
Aquatic Resources	1. Potential direct and indirect loss of or damage to fish resources.
Terrestrial Resources	1. Potential direct and indirect loss of and damage to wildlife resources.
Wetland Resources	1. Unnecessary alteration or destruction of wetlands will be discouraged as contrary to the public interest. 2. Determine whether the coast line or base line might be altered.
Socioeconomic Resources	1. Probable impact of marina and associated activities on the public interest, including nearby properties. 2. Extent of public or private need. 3. Effect on the enhancement, preservation or development of historical, scenic and recreational values.
Navigation Resources	1. Interference with public access to, or use of navigable waters. 2. Interference with a Federal project in navigable waters.

Aesthetic Resources	1. Impact on public interest with respect to scenic values and Wild and Scenic Rivers.
Ground-water Resources	1. Potential impacts to wetland recharge areas and potable water supplies.

U.S. Environmental Protection Agency

The Environmental Protection Agency (EPA) participates in the review of permit applications to conduct dredging operations as a review and commenting agency. In this capacity, EPA makes recommendations to the Corps on whether a proposed permit should be approved or denied. EPA's authority goes beyond that of the other review agencies because it has legal authority to deny a proposed permit for environmental reasons. In the event of a disagreement between EPA and the Corps on the issuance of a permit, EPA can challenge the Corps decision.

Review Guidelines

These criteria identify EPA guidelines for projects proposing discharge of dredged or fill material under Section 404(b)(1) of the Clean Water Act.

No discharge of dredged or fill material is permitted:

- Where practicable alternatives with less adverse impacts on the aquatic ecosystem and no other significant adverse impacts exist; such alternatives include:
  - activities resulting in no discharge
  - alternative discharge locations
- If water quality standards would be violated
- If toxic effluent standards would be violated
- If the continued existence of endangered species would be violated
- Where requirements to protect marine sanctuaries would be violated
- Unless considerations of the economic impacts on navigations are overriding, where there are:
  - significant adverse effects on human health or welfare, municipal water supplies, plankton, fish, shellfish, wildlife and special aquatic sites
  - significant adverse effects on aquatic life and other aquatic-dependent wildlife
  - significant adverse effects on aquatic ecosystem diversity, productivity and stability

- The marina should be sited so that dredging of access channels is kept to a minimum. Access channels should not be dredged through submerged grass or shellfish beds

- The use of elevated boat lifts instead of dredged basins should be considered in areas where smaller boats are to be docked and deep water is accessible without dredging through sensitive habitats

- The entrance channel should be well marked and boaters should be required to stay within the designated channel to reduce the possibility of boat traffic tearing up nearby submerged grass beds or causing siltation problems

- The entrance to the marina should be at least 1,000 ft from shellfish harvesting areas to reduce the possibility of polluting or silting these areas.

National Marine Fisheries Service

The National Marine Fisheries Service is one of three federal agencies required by federal law to comment on ACOE Section 10/404 permit applications. The basic goal or purpose of the National Marine Fisheries Service (NMFS) is to maintain a viable commercial and recreational marine fishery for the benefit of all present and future U.S. citizens. To achieve this goal, the NMFS has established a variety of programs to deal with the different needs of managing these fisheries. One basic need is to improve management of the habitat on which marine fish depend for spawning, nursery, and feeding. To achieve this, the branch of the NMFS which is responsible for maintaining environmental integrity uses existing legislation to ensure that all decisions regarding actions taken in the coastal zone give full consideration to potential effects on fish habitat.

The Northeast Region of the National Marine Fisheries Service generally recommends permit denial for the following conditions:

- Filling of wetlands or open water to create fastland

- Bulkheads located channelward of the mean high water line, unless special circumstances require such placement

- Marinas located in or near productive shellfish beds or in areas where tidal circulation of water is minimal

- Dredging of marsh, shellfish, and sea grass beds

- Dead-end canals

- Dredging for fill or borrow material

- Structures, such as tide gates or dikes, which impede circulation of tidal water over wetlands.

- significant adverse effects on recreational, aesthetic and economic values

Specific procedures for making these determinations have been set forth in Subparts C through F of 40 CFR 230.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) participates in the review of permit applications to conduct dredging operations as a commenting agency. The FWS assesses the impacts on fish and wildlife of all water and related land resource development projects which are federally funded or are constructed under a federal permit or license. The FWS provides reports to federal construction or regulatory agencies and to permit applicants. Many of these projects occur in or affect wetland areas. Federal permits for water-related development are reviewed by the FWS to determine the existence of adverse impacts on fish and wildlife and their habitats, particularly in wetland areas.

The U.S. Fish and Wildlife Service will generally recommend permit denial under the following conditions:

- Projects which needlessly degrade or destroy wetlands
- Projects not designed to prevent or minimize significant fish, wildlife, and environmental damages
- Projects which do not utilize practicable, suitable, and available upland sites as alternatives to wetland areas
- Projects located on uplands which do not assure the protection of adjacent wetland areas.
- Projects not designed to use current technology
- Projects where applicant uses a "piecemeal" approach to obtaining permits.

Review Guidelines

- Marinas with docks and piers that extend out from the shoreline far enough not to require dredging of the shallow shoreline would be preferable as a means of gaining access to deep water. These docks could either be floating or elevated on piles. The marina breakwater should either be a floating type or should allow for adequate circulation within the enclosure in other ways (e.g., leaving the bottom of the breakwater open, leaving openings every few inches along the breakwater, leaving the area near shore open)
- In areas where extending the dock into deep water is not possible, excavation of basins in uplands would be the next choice

Review Guidelines

General Considerations - In assessing the potential impacts of proposed projects, the NMFS is guided by the following seven considerations:

- The extent of precedent setting and existing or potential cumulative impacts of similar or other developments in the project area
- The extent to which the activity would directly affect the production of fishery resources (e.g., dredging, filling marshland, reduced access, etc.)
- The extent to which the activity would indirectly affect the production of fishery resources (e.g., alteration of circulation, salinity regimes, and detrital export)
- The extent of any adverse impact that can be avoided through project modification or other safeguards (e.g., piers in lieu of channel dredging)
- The extent of alternative sites available to reduce unavoidable project impacts
- The extent to which the activity requires a waterfront location if dredging or filling wetlands is involved
- The extent to which mitigation is possible to offset unavoidable habitat losses associated with a water-dependent project that clearly is in the public interest.

All marinas affect aquatic habitats to some degree, but adverse effects can be minimized with proper location and design. In addition to guidelines for bulkheads and seawalls, the following apply:

- Marinas should be located in areas where maximum physical advantages exist (e.g., where the least initial and maintenance dredging will be required)
- Design should be located at least 1,000 ft from shellfish harbesting areas, unless state regulations state otherwise
- Open dockage extending to deep water is a preferable alternative to the excavation of boat basins; where not possible, excavation of basins in uplands is generally preferred
- The turning basins and navigation channels should not be designed to create a sump that would result in long-term degradation of water quality. For example, the depth of the boat basin and access channel should not exceed that of the receiving body of water, and should not be located in areas of poor water circulation

- The depth of the basin should not exceed the depth of light penetration through the water column. If greater depths are necessary for deeper draft boats, these boats should be docked near the entrance to the basin so that the basin depth could be reduced sloping upward from the receiving body of water

- The design should not disrupt currents or restrict the tidal flow. Often a flushing channel would be a beneficial addition to the design to provide another entrance for tidal waters

- Permanent spoil disposal sites should be set aside in non-wetland areas for use in initial construction and future maintenance dredging. The site should be designed to contain the material in such a manner so as to prevent dispersal into adjacent wetland areas. All effluent from the disposal area should be directed back into the basin being dredged and should be monitored to ensure that it meets all water quality standards

- At the entrance and within the basin, sloping riprap, gabions, or vegetation should be used as stabilization rather than vertical seawalls. Where bulkheads are essential, a shallow zone should be maintained against the bulkheads with not more than a 3:1 slope starting at least 10 ft from the bulkhead

- Sharp angles and turns that may collect debris or cause shoaling or flushing problems should be avoided within the basin

- Project proposals should include facilities for the proper handling of petroleum products, sewage, litter, and other refuse. Current federal regulations regarding holding tanks should be enforced

- For marinas dredged into upland sites, the basin should be dredged and the shoreline stabilized before the "plug" is removed connecting the basin with open water in order to reduce the detrimental effects or turbidity and siltation produced during excavation. In other areas, designs for the excavation projects should include protective measures such as silt curtains, diapers, or weirs

- Berms and swales should be made part of the marine design so that there is a gradual slope away from the edge of the basin. This will help prevent introduction of contaminants into adjacent open water and wetland areas

- All development near the marina should be on a central wastewater treatment facility as opposed to septic systems which could leach polluted ground water into the marina

- Filling or dredging of vegetated wetlands for marine construction is unacceptable

- Marinas should not be sited in areas of known high siltation and shoaling rates

- Permanent spoil disposal sites should be set aside in non-wetland areas for use in initial construction and future maintenance dredging

- Marinas should be designed to ensure adequate flushing and should not create a sump; they should be no deeper than the parent body of water and aligned with prevailing summer winds to take advantage of wind-driven circulation

- When marinas are built in proximity to grassbeds, channel routes should be clearly marked to avoid damage to the grassbeds by propellers and propwash.

Bulkheads are retaining structures used to protect adjacent shorelines from the action of currents or waves, or to make waterfront more accessible. A common practice has been to erect vertical seawalls in the water and then place fill material on the landward side of the structure. This technique has often been ineffective in terms of protection and is disruptive to marine productivity. To mitigate these environmental losses, the following criteria apply:

- Except under special circumstances such as severely eroding shorelines from a recent storm, structures should be aligned no further waterward than the existing shoreline (upland boundary) and constructed so the reflective wave energy does not destroy adjacent fishery habitat or wetlands

- Where possible, sloping (3:1) riprap, gabions, or vegetation should be used rather than vertical seawalls

5.2.2 State Agencies

Wetlands Permits Division (DNR)

The Wetland Permits Division of the Water Resources Administration is responsible for wetland resource management, monitoring of overboard dredge material deposition, and the management/information system supporting these efforts. Priorities include review and processing of wetland permits and approvals for dredging and filling privately-owned wetland licenses for dredging and filling in state wetlands; performing the administrative tasks associated with the above (i.e., wetland hearing, etc.); administering the State's effort regarding environmental monitoring of dredge spoil deposition projects with particular emphasis on research contracts and identification of funding associated with the monitoring.

Title 9, Wetlands and Riparian Rights, contains two sections which address the licensing and permitting of dredging operations. Section 202, License for Dredging or Filling of State Wetlands, specifies that a person may not dredge or fill on state wetlands without a license. Section 306, Permit to Conduct Activity not Permitted by Rules and Regulations, specifies that a person proposing to conduct dredge and fill operations on any private wetland must obtain a permit from the Secretary of the Department of Natural Resources.

County reviewers should be cognizant of the fact that a Wetlands License may be required by the Wetland Permits Division for direct stormwater discharge to State tidal wetlands regardless of whether the project proposal involves any dredging or filling of wetlands. The determination of "direct discharge" is made on a case-by-case basis by the Wetlands Division.

Review Guidelines

The public policy of the State is to preserve wetlands while providing for the rights of the riparian land owner for access to navigable waters. Sections 9-202 and 9-306 describe procedures for obtaining state permission for making permanent changes to wetlands. The intent of the Act is carried out by the use of the following policy criteria in evaluating project plans:

1. In cases where reasonable access for a riparian property owner can be provided directly from fast land, such an alternative shall be taken as opposed to the creation of a channel through the vegetated wetlands or filling for access.

2. In those cases where access is to be provided to a Subdivision or other multi-home development or community, creation of one common access channel or pier is encouraged; thus, a centralized boating facility is preferable. In the case of isolated single family dwellings a pier from fast land to open water shall normally fulfill the right of reasonable riparian access.

3. The ownership of land bordering upon tidal waters does not carry with it the right to extend boat access inland by means of artificial channels.

4. Canals, channels, ponds or lagoons may not be excavated without the plans also being approved by the appropriate Soil Conservation District. The Soil Conservation District shall verify the existence of such permit prior to their approval of the Sediment Control Plan. Ponds or other excavations within 100 feet of an existing shoreline may not be approved by the Soil Conservation Districts without the written approval of the Water Resources Administration.

5. The authorization by the state for any person to dredge a navigation channel through wetlands should be coordinated to the maximum possible extent with the approval of such work by federal and local agencies.

The owner of the land bounding on navigable or tidal waters is entitled to protect his shore against erosion as described in Title 9 of the Natural Resources Article. To ensure this right, the Water Resources Administration uses the following criteria to review proposed projects in carrying out the state policy to preserve the wetlands while allowing the exercise of the right of a riparian owner to protect his shore against erosion.

6. The construction of bulkheads or other shore protection measures shall include only such filling as necessary for effective use of such measures and shall generally be located at the mean high water line or no further channelward than needed for proper tie-back emplacement, or in cases of a steep bank or cliff, no further channelward than needed to obtain a stable slope.

7. Where shore protection is needed and a marsh exists in front of an applicant's land, the shore protection structure shall be placed behind the marsh or low profile protection (preferably riprap) placed channelward of the marsh so that normal tidal flow into the marsh will be maintained.

8. Bulkheads shall be constructed with adequate returns to fastland or connected to adjacent shore erosion control structures, as may be applicable.

9. Because of their possible detrimental effect, shoreline protective structures may not be approved or recommended for approval in the following cases, except where there is no alternative means to achieve a necessary public benefit whose need significantly outweighs the harm done by the proposed work:

    a. Marshland will be filled or otherwise destroyed.
    b. Surface drainage channels will be filled or occluded.
    c. Navigation will be adversely affected.

    d. Unique or rare and endangered flora or fauna will be affected.
    e. Important historical or archeological sites will be adversely affected.
    f. Private oyster leases or natural oyster bars in adjacent open water will be affected.

10. In those cases where the best public interest justified approval of the work, such projects involving the filling of Private or State wetlands including those involving

the creation of fast land, approval of such project may be considered if the following conditions are satisfied:

a. The project cannot feasibly be undertaken on an adjacent or nearby fast land location.

b. It is not feasible to provide the service the project is intended to provide by an alternative means not involving the filling of wetlands.

c. The creation of fast land shall occur only in those areas adjoining existing fast lands.

d. No significant ecologically productive submerged wetlands, such as major finfish and shellfish spawning and habitat areas, shall be destroyed.

e. Fill utilized for the creation of fast land shall be obtained from a land-based source and not dredged from adjacent Private or State wetlands.

f. The creation of fast land shall not obstruct navigational channels, adversely affect the public's use of the waters of the state including the public's right to navigation and fisheries, significantly affect major current patterns, or significantly alter the existing contour of the shoreline.

g. In all projects involving the filling of State wetlands, compensation for fast land created in the public domain shall generally be provided to the State in an amount determined by the State Board of Public Works.

11. Title 9, Natural Resources Article, requires that in granting denying or limiting any permit, the Department of Natural Resources shall consider the effect of the proposed work with reference to the public health and welfare, marine fisheries, shellfisheries, wildlife, economic benefits, the protection of wildlife and property from flood, hurricane and other natural disasters, and the public policy set forth in Section 9-102 of that Article. In granting a permit or license, limitations or conditions may be imposed to carry out this public policy.

Watershed Permits Division (DNR)

The Watershed Permits Division reviews all plans and specifications submitted with proposed dredge and fill projects, in particular those with dredge spoil disposal areas. The review focuses on sediment and erosion control plans as required for proposed land clearing, soil moving or construction activities associated with the dredge and fill operation. The project review entails verifying the design adequacy of the sediment control measures as well as the basic containment areas structures; ascertaining that all necessary measures have been identified and

specified; and that adequate standard details and specifications are incorporated into the construction documents. Recommendations may be made to correct any perceived deficiencies in the plans including the containment area size or configuration, dike size, construction methods, and outfall erosion protection. In addition, standard specifications for sediment and erosion control as well as innovative ideas proposed are checked for field efficiency.

Coastal Resources Division (DNR)

The Coastal Resources Division (CRD) has the responsibility to review and comment on all proposed projects that have the potential to significantly impact coastal resources. This primarily consists of Corps of Engineers and DNR (Water Resources Administration) permit applications, and federally funded projects through the State Clearinghouse process. The Division's major responsibilities in this regard are to (1) provide data and information relevant to the project; and (2) determine the project's consistency with the objectives and policies of the Coastal Zone Management Program. For any project in which there is a federal action involved, the Division must issue a Federal Consistency determination to the appropriate federal agency. This requirement is mandated by the Federal Consistency clause of the Coastal Zone Management Act of 1972 which states that any federal action in the coastal zone must be consistent to the extent practicable, with a State's approved Coastal Zone Management Program.

Army Corps of Engineers Permits constitutes approximately 80 percent of the Federal Consistency review made by the State. The Department is notified of all Corps permits through the Public Notices issued by the regional office. There are two State approvals necessary before the Corps may issue a permit: (1) water quality certification from the Department of Health and Mental Hygiene; and (2) consistency with the Coastal Zone Management Program from the Department of Natural Resources.

In the review procedures described below, close coordination is maintained during the review with personnel handling the water quality certification. When a State permit/license is involved, water quality certification will not be issued until the Water Resources Administration has made a decision (in the case of a wetland permit) or recommended a decision to the State Board of Public Works (in the case of a wetlands license). Regardless of the review procedure, all projects for which the Corps of Engineers have not received comments, either verbal or written, from the Coastal Resources Division by the deadline date on the Public Notice are to be considered consistent with the Coastal Zone Management Program assuming that:

- There are no major issues associated with the issuance of Water Quality Certification;
- There are no major issues resulting in the delay of issuance of a license and/or permit from the Water Resources Administration; and

- The applicant has not revised the project plans such that the resultant impacts differ significantly from the plan(s) associated with the initial public notice.

There are two review procedures dependent upon the nature of the proposed action. If dredging or filling is involved, a State license and/or permit is required from the Water Resources Administration. In these cases, the Coastal Resources Division has the responsibility to document to the Water Resources Administration any inconsistencies between a permit application and the Costal Zone Management Program. If the Coastal Resources Division does not submit comments on a permit application, it is assumed by the Water Resources Administration that the proposal is not inconsistent. In the case involving a State license and/or permit, the Federal Consistency determination is inherent in the permit decision.

The second review procedure involves those Corps permit applications in which there is no dredging or filling involved. In these cases, the Coastal Resources Division becomes the lead agency in the Department of Natural Resources for the review. Upon consultation with all relevant agencies in the Department, comments are sent directly to the Corps. The comments include a consistency determination.

Tidal Fisheries Division (DNR)

The Tidal Fisheries Division participates in the review of permit applications to conduct dredging operations as a State technical review and commenting agency. Responsibilities applicable to the dredge and fill permit process include: review of permit applications and environmental impact assessment documents, preparation of position papers; providing technical information to other agencies. The agency responses to dredging issues are primarily concerned with the maintenance of aquatic biota populations. Review of proposed physical changes are examined for their ecological impacts according to theory, past experience, and pertinent literature. Evaluation of the possible effects of the proposed projects are made and forwarded to the appropriate lead agency.

Review Guidelines

1. Dredging in shallow water, low salinity areas. These projects impact spawning grounds and nursery areas for finfish, such as to present hazards to their well being. This response is applied to dredging projects removing more than 500 cubic yards of material. The usually recommended no-dredging period for protection of spawning fish populations is March 1 through June 15.

2. Channel dredging in close proximity to natural oyster bars. If dredging is proposed within a charted oyster bar, it is recommended that dredging be restricted to the period October 1 to December 15. If dredging is proposed within 500 yards of natural oyster bars, the usually recommended dredging period is October 1 and December 15 and/or March 1 to May 31 of any year. The rational behind this

recommendation is that dredging operations should avoid the summer spawning and spat setting periods and the colder periods of reduced adult activity.

3. Dredging for bulkhead and fill projects. These project proposals usually receive a recommendation to limit bulkheading with accompanying dredged fill to the mean high water line. If allowed to project past the high water line these projects would convert shallow water habitat into fast land, thus degrading important habitat for aquatic organisms.

4. Dredging for bulkhead and fill projects on dead end canals. These proposals usually are recommended to be denied on the grounds that the project would further degrade the water quality and fishery habitat on an already ecologically stressed system. Dead end canals have generally poor circulation and relatively vertical banks. A suggested alternative to bulkheading and dredging in these cases is the placement of riprap on the banks and no fill allowed.

5. Dredging projects which would fill a marsh. These projects usually are recommended to be denied. TFDs position is that the marsh protects the general water quality of the receiving waters adjacent to the project from the effects of stormwater runoff and septic field seepage. Waste assimilative capacity of marshland is significant as is the marsh's contribution of detritus to the aquatic food chain.

Office of Environmental Programs (DHMH)

The Office of Environmental Programs of the Department of Health and Mental Hygiene must by law evaluate all proposed dredging projects that may involve changes or alterations in all State waters (tidal land non-tidal) for the purpose of issuing or denying a Water Quality Certification.

Under Section 401 of the Federal Water Pollution Control Act (PL 92-500; 86 Stat. 816, 33 USC 1411), any applicant for a federal permit to conduct an activity which may result in a discharge into navigable waters is required to obtain a certification from the State that the discharge will comply with the applicable water quality standards. The certification also pertains to the subsequent operation of the facility.

In cases where the Crops of Engineers or U.S. Coast Guard has stated that a water quality certificate is required, the Office of Environmental Programs issues or denies the water quality certificate, or places certain conditions on the activity. Even in public notices that do not state that a water quality certificate is required, but it is felt that the construction or use of the facility will create a discharge to the waters of the State, the Office reviews the proposed activity and issues or denies the water quality certificate, providing appropriate recommendations to the Corps of Engineers to implement water quality protection measures. The Office may solicit comments from interested parties and may schedule a public hearing on the project.

Review Guidelines

1. Hydrological evaluation: All data which reflect current water quality standards should be evaluated. When a particular parameter is in violation or shows deterioration toward a violation of standards, additional requirements to prevent further degradation may be needed.

2. Hydraulic Dredging Impact Evaluation: Hydraulic dredging operations necessitate the provision of diked disposal areas from which discharges to waters of this State occur. Effluent quality is a function of the character of the sediments that have been removed and their treatment at the disposal facility. When sediments are known or suspected to be contaminated, additional treatment may be required to protect the receiving water quality. Anticipated dredging impact on aquatic resources shall be minimized, eliminated or mitigated.

3. Geological evaluation: In order to minimize the need for future maintenance dredging and its associated impacts, the site development plan and natural topography shall be evaluated. Measures to minimize or eliminate sediment transport to the marina basin may be required.

4. Toxics evaluation: The discharge of paints, solvents, fuels and other toxic materials to the waters of this State is not permitted by the Water Quality Certification. In order to prevent accidental discharges of these pollutants from occurring, marina operations and their proximity to the waterway shall be evaluated.

6. IMPLEMENTATION RECOMMENDATIONS

The Chesapeake Bay Critical Area Criteria requires an intensive environmental assessment for water-dependent facilities including flushing characteristics, circulation patterns, salinity, and water quality impacts. The baseline information needed to address these concerns is not currently available. Hence, the process described in this report requires the applicant to generate this information, and then evaluate the proposed development in light of these site-specific factors. It is recommended that the County undertake an opportunity/constraint analysis of the County's estuarine subareas with the objective of identifying areas which are suitable or unsuitable for various classes of water-dependent facilities. This analysis would require an assessment of current water quality, existing or potential aquatic resource habitat, a determination of flushing characteristics, and bathometic data. An overly mapping technique can be used to compile and evaluate the physical and natural resource information. The completion of this inventory would reduce the burden placed on the applicant and could lead to waterfront zoning classifications for various water-dependent facilities. At that point, the review process for water-related development activities could be greatly abbreviated.

In the interim, it is recommended that the Water-Dependent Facility Plan be formally incorporated as one part of Baltimore County's Chesapeake Bay Critical Area Plan.

The current development regulations for each type of water-dependent facility needs to be evaluated in context of the review process proposed in this document. The development regulations should be amended so that all significant water-dependent facilities are handled administratively, as special exceptions. This will allow the two-level review process proposed herein to be applied to each water-dependent facility application. Specifically, marinas should not be permitted as-of-right in any zoning districts.

As part of the larger Local Critical Area Plan, incentives and/or disincentives need to be proposed for community piers. Wherever reasonable and feasible, private piers should be actively discouraged. Private piers, although not specifically addressed in COMAR 14.15.03, have a significant potential for cumulative impacts to water quality and aquatic resources.

APPENDIX A

MARYLAND RECEIVING WATER STANDARDS

MARYLAND RECEIVING WATER QUALITY STANDARDS

(Code of Maryland Regulations, Title 10 — Health and Mental Hygiene, Subtitle 50 — Water Management, Chapter 1 — Water Pollution Control, Section .02; Adopted July 11, 1980; Amended June 6, 1983; December 19, 1983; November 8, 1984)

A. Introduction.

(1) The surface water quality standards consist of two parts:

(a) Designated uses of waters, and

(b) Water quality criteria for the waters based upon designated uses.

(2) Sections B-I of this regulation:

(a) Define specific water use classes for the surface waters of this State,

(b) Designate water quality criteria for each class;

(c) Define the anti-degradation policy of this State;

(d) Define other policies which apply to water quality standards; and

(e) Designate a water use class for all surface waters of this State.

B. Water Uses and Classes.

(1) Beneficial Water Uses.

The Department shall manage and regulate the waters of this State to protect the following beneficial water uses:

(a) (text unchanged)

(b) Fish, other aquatic life, and wildlife;

(c) Shellfish harvesting;

(d) Public water supply;

(e) Agricultural water supply; and

(f) Industrial water supply.

(2) Basic Water Use.

(a) All waters of this State shall be protected for the basic uses of water contact recreation, fish, other aquatic life, wildlife, and water supply.

(b) These uses comprise Class I.

(c) Criteria for Class I Waters shall apply to all waters of this State unless the designated classification imposes more restrictive criteria.

(3) Specific Surface Water Use Classes.

(a) General. Water use classes are established for the waters of this State. The concepts of suitability and capability for a water use as expressed in these classes include:

(i) Existing conditions; and

(ii) Water uses which will be made possible by anticipated improvements in water quality.

(b) The actual uses of surface water are not limited to those designated in this regulation. Any reasonable and lawful use is permitted provided that the surface water quality is not adversely affected by the use.

(c) Class I: Water Contact Recreation. Aquatic Life, and Water Supply. This classification includes waters which are suitable for:

(i) Water contact sports;

(ii) Play and leisure time activities where individuals may come in direct contact with the surface water;

(iii) The growth and propagation of fish (other than trout), other aquatic life, and wildlife;

(iv) Public water supply;

(v) Agricultural water supply; and

(vi) Industrial water supply.

(d) Class II: Shellfish Harvesting Waters. This classification includes waters where:

(i) Shellfish are propagated, stored, or gathered for marketing purposes; and

(ii) Actual or potential areas for the harvesting of oysters, softshell clams, hardshell clams, and brackish water clams.

(e) Class III: Natural Trout Waters. This classification includes waters which have the potential for or are:

(i) Suitable for the growth and propagation of trout; and

(ii) Capable of supporting natural trout populations and their associated food organisms.

(f) Class IV: Recreational Trout Waters. This classification includes cold or warm waters which have the potential for or are:

(i) Capable of holding or supporting adult trout for put-and-take fishing; and

(ii) Managed as a special fishery by periodic stocking and seasonable catching.

C. General Water Quality Criteria.

The waters of this State may not be polluted by:

(1) Substances attributed to sewage, industrial waste, or other waste that will settle to form sludge deposits that:

(a) Are unsightly, putrescent, or odorous; and

(b) Create a nuisance; or

(c) Interfere directly or indirectly with water uses;

(2) Any material including floating debris, oil grease, scum, sludge and other floating materials, attributable to sewage, industrial waste, or other waste in amounts sufficient to:

(a) Be unsightly and create a nuisance;

(b) Produce taste or odor;

(c) Change the existing color;

(d) Change other chemical or physical conditions in the surface waters;

(e) Create a nuisance; or

(f) Interfere directly or indirectly with water uses; and

(3) High-temperature, toxic, corrosive or other deleterious substances attributable to sewage, industrial waste, or other waste in concentrations or combinations which:

(a) Interfere directly or indirectly with water uses; or

(b) Are harmful to human, animal, plant, or aquatic life.

D. Specific Water Quality Criteria.

(1) Applicability.

(a) The following surface water quality criteria are established for the classes indicated. These criteria shall apply:

(i) In freshwater streams and rivers during periods of flow greater than or equal to the design stream flow;

(ii) In tidal waters at all times; and

(iii) Outside of any mixing zones which may be designated by the Department.

(b) If the natural water quality of a stream segment is not consistent with the criteria established for the stream then:

(i) The natural conditions do not constitute a violation of the water quality standards; and

(ii) The water quality to be maintained and achieved is not required to be substantially different from that which would occur naturally.

(c) A discharge may not cause a violation of the specific water quality criteria.

(2) Toxic Materials Criteria. Toxic materials criteria are established to protect freshwater aquatic life, saltwater aquatic life or human health. The toxic materials listed below may not exceed these designated limits in any waters of this State:

(a) Aldrin-Dieldrin — .003 micrograms/liter;

(b) Benzidine — 0.1 micrograms/liter;

(c) DDT — .001 micrograms/liter;

(d) Endrin — .004 micrograms/liter;

(e) Polychlorinated Biphenyls (PCB's) — .001 micrograms/liter;

(f) Toxaphene — .005 micrograms/liter.

(3) Criteria for Class I Waters: Water Contact Recreation, Aquatic Life, and Water Supply.

(a) Bacteriological. There may not be any sources of pathogenic or harmful organisms in sufficient quantities to constitute a public health hazard. A public health hazard will be presumed:

(i) If the fecal coliform density exceeds a log mean of 200 per 100 ml, based on a minimum of not less than five samples taken over any 30-day period; or

(ii) If 10 percent of the total number of samples taken during any 30-day period exceed 400 per 100 ml; or

(iii) Except when a sanitary survey approved by the Department of Health and Mental Hygiene discloses no significant health hazard. §D(3)(a)(i) and (ii) does not apply.

(b) Dissolved Oxygen. The dissolved oxygen concentration may not be less than 5.0 mg/liter at any time.

(c) Temperature.

(i) The maximum temperature outside the mixing zone determined in accordance with §F of this regulation or with Regulation .13 may not exceed 90°F (32°C) or the ambient temperature of the surface waters, whichever is greater.

(ii) A thermal barrier that adversely affects aquatic life may not be established.

(d) pH. Normal pH values may not be less than 6.5 or greater than 8.5.

(e) Turbidity.

(i) Turbidity may not exceed levels detrimental to aquatic life.

(ii) Turbidity in the surface water resulting from any discharge may not exceed 150 units at any time or 50 units as a monthly average. Units may be measured in Nephelometer Turbidity Units, Formazin Turbidity Units or Jackson Turbidity Units.

(4) Criteria for Class II Waters: Shellfish Harvesting.

(a) Bacteriological: There may not be any pathogenic or harmful organisms in sufficient quantities to constitute a public health hazard in the use of waters for shellfish harvesting. A public health hazard will be presumed.

(i) If the most probable number (MPN) of fecal coliform organisms exceeds a median concentration of 14 MPN per 100 ml;

(ii) If more than 10 percent of samples taken exceed 43 MPN per 100 ml for a 5-tube decimal dilution test or 49 per 100 ml for a 3-tube decimal dilution test;

(iii) Except when a sanitary survey approved by the Department of Health and Mental Hygiene discloses no

significant health hazard. §D(4)(a)(i) and (ii) does not apply.

(b) Dissolved oxygen same as Class I waters.

(c) Temperature — same as Class I waters.

(d) pH — same as Class I waters.

(e) Turbidity — same as Class I waters.

(5) Bacteriological — same as Class I waters.

(a) Bacteriological — same as Class I waters.

(b) Dissolved Oxygen. The dissolved oxygen concentration may not be less than 5.0 mg/liter at any time, with a minimum daily average of not less than 6.0 mg/liter.

(c) Temperature.

(i) The maximum temperature outside the mixing zone determined in accordance with §F of this regulation or with Regulation .13 may not exceed 68°F (20°C) or the ambient temperature of the surface water, whichever is greater.

(ii) A thermal barrier that adversely affects aquatic life may not be established.

(d) pH — same as Class I waters.

(e) Turbidity — same as Class I waters.

(f) Total Residual Chlorine (TRC). The use of chlorine or chlorine compounds is prohibited in the treatment of wastewaters discharged into the waters of this State designated as Class III unless:

(i) The volume of treated sewage discharged from the sewage treatment facilities is less than 1 percent of the 7 day, 10 year low flow; or

(ii) Matching federal funds are not available to convert existing publicly owned treatment works from chlorine to another disinfectant.

(iii) When an exception occurs, the total residual chlorine shall be less than .002 mg/liter in the surface waters.

(6) Criteria for Class IV Waters: Recreational Trout Waters.

(a) Bacteriological — same as Class I waters.

(b) Dissolved oxygen — same as Class I waters.

(c) Temperature.

(i) The maximum temperature outside the mixing zone determined in accordance with §F of this regulation or with Regulation .13 may not exceed 75°F (23.9°C) or the ambient temperature of the surface water, whichever is greater.

(ii) A thermal barrier that adversely affects aquatic life may not be established.

(d) pH — same as Class I waters.

(e) Turbidity — same as Class I waters.

(f) Total Residual Chlorine Total residual chlorine concentrations shall be less than .002 mg/liter in the surface waters.

E. Anti-Degradation Policy.

(1) Certain waters of this State possess an existing quality which is better than the water quality standards established for them. The quality of these waters shall be maintained unless:

(a) The Department determines a change is justifiable as a result of necessary economic or social development; and

(b) A change will not diminish uses made of, or presently possible, in these waters.

(2) To accomplish the objective of maintaining existing water quality, all new or increased sources of pollution are required to provide the degree of waste treatment necessary to maintain these waters at this higher quality.

(3) The Department will discourage downgrading any stream from a water use class with more stringent criteria to one with less stringent criteria.

(a) Downgrading may only be considered if:

(i) The designated use is not attainable because of natural causes;

(ii) The designated use is not attainable because of irretrievable man-induced conditions; or

(iii) Substantial and widespread adverse social and economic impacts will result from maintaining the designated use.

(b) Before downgrading any stream, the Department will provide public notice and opportunity for a public hearing on the proposed change.

(4) Water which does not meet the standards established for it shall be improved to meet the standards.

F. Mixing Zone Policy.

(1) Effluents may be mixed with surface waters in the mixing zone.

(2) Effluents may not be treated in the mixing zone.

(3) Surface waters outside the mixing zones shall meet the water quality standards for that particular body of water.

(4) The Department may designate mixing zones subject to the following requirements:

(a) There shall be no interference with biological communities or populations of indiginous species to a degree which is damaging to the aquatic life or ecosystem;

(b) There shall be no diminishing of other legitimate beneficial uses;

(c) Mixing zones may not form barriers to the migratory routes of aquatic life;

(d) Mixing zones shall be designated and located to protect surface waters and shallow water shoreline areas.

(e) The general water quality criteria set out in §C of this regulation apply within the mixing zones.

(5) A mixing zone is not permitted for toxic materials identified in §D(2) of this regulation.

(6) Except for thermal mixing zones established by Regulation .13, mixing zones may not exceed the following maximum limits.

(a) In freshwater streams and rivers, a mixing zone width may not exceed one-third of the width of the surface water body.

(b) In lakes, the combined area of all mixing zones may not exceed 10 percent of the lake surface area.

(c) In estuarine areas, the maximum cross-sectional area of the mixing zone may not exceed 10 percent of the cross-sectional area of the surface water body.

G. Intermittent Stream Policy.

(1) Discharges to intermittent streams are not permitted when feasible alternatives are available.

(2) Effluent limitations for discharges to specific intermittent streams may be determined by the Department on a case-by-case basis.

(3) Effluent limitations may not be less stringent than:

(a) The minimum national effluent guidelines established under the Federal Act; or

(b) Those levels necessary to maintain the water quality standards of downstream segments; or

(c) Those levels necessary to protect the biological community of the intermittent stream.

(d) Those levels necessary to protect public health.

H. Review and Revision.

(1) Procedure. Under State law and §303(c) of the Federal Act, the Department shall review and revise its water quality standards as appropriate. Changes shall be transmitted to the EPA.

(2) Hearing Transcripts. Transcripts of public hearings on proposed standards revisions shall be available for public inspection in the main office of the Department. Transcripts shall be furnished to the EPA upon request.

I. Classification of the Surface Waters of this State.

(1) All surface waters of this State shall be protected for Class I use in water contact recreation, for fish, other aquatic life and wildlife.

(2) For interstate waters, these classifications apply only to those waters within this State.

(3) A stream segment is a distinct portion of a sub-basin.

(4) If the stream segment limits are specified as beginning at a specific point, streams terminating downstream of this point are not included in the same segment. For example "Deer Creek and all tributaries above Eden Mill Dam" does not include Little Deer Creek.

(5) Stream segments, listed below in §I(7) in tabular form, shall be given additional protection required for:

(a) Shellfish harvesting waters (Class II Waters);

(b) Natural trout waters (Class III Waters; and

(c) Recreational trout waters (Class IV Waters).

(6) For each sub-basin in §I(7), information is arranged under the following headings:

(a) Class — Refers to water classification;

(b) Waters — exact name of stream segment or segments;

(c) MCGS — Most downstream point or line for each stream segment using the Maryland Coordinate Grid System (East/North).

(d) Limits — Written description of boundary of stream segment established by MCGS.

(e) Any stream segment not listed in §I(7) is Class I Water.

(7) Stream segment classification for each sub-basin are:

(a) SUB-BASIN 02-12-02: LOWER SUSQUEHANNA RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II: None			
Class III:			
	(i) Deer Creek and all tributaries	965/671	Above Eden Mill Dam
	(ii) Basin Run and all tributaries	1040/667	
	(iii) Kellogg Branch and all tributaries	966/655.5	
	(iv) North Stirrup Run and all tributaries	969/650.2	
	(v) South Stirrup Run and all tributaries	968.3/649	
	(vi) Deep Run and all tributaries	1008.2/677.8	
	(vii) Gladden Branch and all tributaries	967/658	
	(viii) Rock Hollow Branch and all tributaries	958/663	
	(ix) Love Run and all tributaries	1046/678	
	(x) Stone Run and all tributaries	1050.5/682.5	
Class IV:			
	(i) Deer Creek and all tributaries	1040/649.3	From mouth to Eden Mill Dam
	(ii) Octoraro Creek	1036.7/665	Mainstem only

Most downstream point or line for the segment using the Maryland Coordinate Grid System (MCGS) (East North)

(b) SUB-BASIN 02-12-01: COASTAL AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All portions of the territorial seas and estuarine portions of bays and tributaries except:			
	(i) Bishopville Prong and tributaries	1321.7/216.4	Above confluence with St. Martins River
	(ii) Shingle Landing Prong and its tributaries	1323/214	Above confluence with St. Martins River at Piney Island
	(iii) Herring Creek and tributaries	1336.4/189.9	Above Route #50
	(iv) Ocean City Harbor	1345/185.5	Above entrance to West Ocean City Harbor
Class III: None			
Class IV: None			

(c) SUB-BASIN 02-13-02: POCOMOKE RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
	(i) Manokin River and tributaries	1174/137.9	Above Route #363
	(ii) Big Annemessex River and tributaries	1160/8/95.2	Above River Road
	(iii) Jenkins Creek	From 1127/48 To 1127.3/45.7	Above mouth
	(iv) Fair Island Canal	From 1177.6/51 To 1187.7/50.1	
	(v) Pocomoke River	1196/62	Above Maryland/Virginia Line
Class III: None			
Class IV: None			

(d) SUB-BASIN 02-13-03: NANTICOKE RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
	(i) Blackwater River and tributaries	From 1083.1/192 To 1084.2/191.6	Above mouth
	(ii) Transquaking R. and tributaries	From 1085.2/196.3 To 1088/197	Above mouth
	(iii) Nanticoke River and tributaries	From 1126/194 To 1128.2/191.2	Above line from Runaway Pt. to Long Pt.
	(iv) Wicomico River and tributaries	1147.9/160.5	Above ferry crossing at White Haven
	(v) Monie Creek	1138.7/146.7	Above mouth
Class III: None			
Class IV: None			

(e) SUB-BASIN 02-13-04: CHOPTANK RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
	(i) Choptank River and tributaries	From 1099.3/308 To 1101/306.5	Above line from Bow Knee Pt. to Wright Wharf
	(ii) Tred Avon River and tributaries	1057.6/341.6	Above Easton Pt.
Class III: None			
Class IV: None			

(f) SUB-BASIN 02-13-05: CHESTER RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
(i)	Chester River and tributaries	1066.5/502	Above Route #213
(ii)	Corsica River	1060.4/448.4	Above Earl Cove
(iii)	Piney Creek	From 1010.7/419.9 To 1012/418.8	Above Route #50
(iv)	Winchester Creek	1026.5/416.1	Above mouth
(v)	St. Michaels Harbor	1023/348.7	
Class III: None			
Class IV: None			

(g) SUB-BASIN 02-13-06: ELK RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
(i)	Elk River and tributaries	From 1112.8/617 To 1114.8/613.9	Above line from Bull Minnow Pt. to Courthouse Pt.
(ii)	Bohemia River and tributaries	From 1108/603.7 To 1109/600	Above line from Rich Pt. to Baltery Pt.
(iii)	Sassafras River and tributaries	1088.6/561.5	Above Ordinary Pt.
(iv)	Stillpond Creek and tributaries (Still Pond)	1044/547	Above Kinnaird Pt.
(v)	Worton Creek	From 1031.4/532 To 1032.5/534.7	Above mouth
(vi)	Fairlee Creek	From 1023.6/524 To 1026/527.5	Above mouth
(vii)	Northeast R.	From 1081.3/623.3 To 1087.6/619.1	Above mouth
Class III:			
	Principio Creek and all tributaries	1073/634.5	
Class IV: None			

(h) SUB-BASIN 02-13-07: BUSH RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
(i)	Bush River and tributaries	From 1010.5/576 To 1014.1/574.1	Above line from Fairview Pt. to Chilbury Pt.
(ii)	Romney Creek	1022.3/567.5	Above Briar Pt.
(iii)	Swan Creek and tributaries	From 1050/603.5 To 1047.5/604.2	Above mouth
Class III:			
	Bynum Run and all tributaries	1088.9/597.4	
Class IV:			
	Winters Run and tributaries	982.2/604.8	Above Atkisson Reservoir

(i) SUB-BASIN 02-13-08: GUNPOWDER RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
(i)	Gunpowder R. and all tributaries	From 987/561.5 To 991.2/555.5	Above line from Oliver Pt. to Maxwell Pt.
(ii)	Middle River	From 972/536.1 To 970/532.5	Above line from Log Pt. to Turkey Pt.
Class III:			
(i)	Little Gunpowder Falls and all tributaries	976.8/578.8	Above B&O railroad bridge ¼ mile south of Rt. 7 (Old Philadelphia Road)
(ii)	Gunpowder Falls and all tributaries	930.8/578.9	Above Loch Raven Dam
(iii)	Long Green Run and all tributaries	950/584	
(iv)	Sweathouse Branch and all tributaries	950/584	
Class IV:			
	Whitemarsh Run and all tributaries	964/564	

(j) SUB-BASIN 02-13-09: PATAPSCO RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II: None			
Class III:			
(i)	Brice Run and all tributaries	850/540	
(ii)	Piney Run and all tributaries	828/554	
(iii)	Jones Falls and all tributaries	897.7/565.6	Above Lake Roland
(iv)	Morgan Run and all tributaries	813.8/589.6	
(v)	Norris Run and all tributaries	835.1/592.6	
(vi)	Cooks Branch and all tributaries	836.2/584.4	
(vii)	Red Run and all tributaries	863/572.4	
(viii)	Keysers Run and all tributaries	833.8/596.8	
(ix)	Beaver Run and all tributaries	828.3/602.1	
(x)	Gwynns Falls and all tributaries	861.5/578.5	Above Reisterstown Road
(xi)	Gillis Falls and all tributaries	782/557	
(xii)	South Branch Patapsco River and all tributaries	782/557	Above Confluence with Gillis falls
Class IV:			
(i)	South Branch Patapsco River	833.4/552.2	Mainstem only
(ii)	North Branch Patapsco River	833.4/552.2	Mainstem only above Liberty Reservoir
(iii)	East Branch Patapsco River	830.1/620.3	Mainstem only
(iv)	West Branch Patapsco River	830.1/620.3	Mainstem only
(v)	Jones Falls	908/538.5 to 901/563	From North Avenue to Lake Roland Dam
(vi)	Herring Run and all tributaries	929.5/537	Above Interstate 95
(vii)	Stony Run and all tributaries	905/541	
(viii)	Dead Run and all tributaries	888/536.5	
(ix)	Stemmers Run and all tributaries	946/542.5	

(k) SUB-BASIN 02-13-10: WEST CHESAPEAKE BAY AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
(i)	Magothy River and tributaries	936.9/455	Above Henderson Pt.
(ii)	Severn River and tributaries	920.6/451	Above mouth of Forked Creek
(iii)	South River and tributaries	918.8/410.1	Above Porter Pt.
(iv)	Rockhold Creek and tributaries	925.7/315.8	Above Mason Beach Road
(v)	Tracys Creek	924.5/344.2	Above Route #256
Class III:			
	Jabez Branch and all tributaries	905/455	
Class IV:			
	Severn Run and all tributaries	907.3/454.1	Above Route #3

(l) SUB-BASIN 02-13-11: PATUXENT RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
	Patuxent River and tributaries	886.8/316.3	Above Ferry Landing
Class III:			
	Patuxent River and tributaries	787.2/510.7	Above Triadelphia Reservoir
Class IV:			
	Patuxent River and all tributaries	813.2/476.8	Between Rocky Gorge Reservoir and Triadelphia Reservoir, and including Triadelphia Reservoir

(m) SUB-BASIN 02-14-01: LOWER POTOMAC RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II:			
All estuarine portions of tributaries except:			
	Potomac River and tributaries	From 723.8/211.8 To 710.9/205.3	Above line from Smith Pt. to Simms Pt.
Class III: None			
Class IV: None			

(n) SUB-BASIN 02-14-02: WASHINGTON METROPOLITAN AREA

Class	*Waters*	*MCGS*	*Limits*
Class II: None			
Class III:			
(i)	Paint Branch and all tributaries	815.2/433.2	Above Capital Beltway, I-495
(ii)	Rock Creek and all tributaries	764/475	Above Muncaster Mill Road
(iii)	North Branch Rock Creek and all tributaries	771.5/468	Above Muncaster Mill Road
Class IV:			
(i)	Little Seneca Ck. and all tributaries	719/492.9	
(ii)	Rock Ck. and all tributaries	From 769.2/451.1 to 764/475	From Route #28 to Muncaster Mill Road
(iii)	Northwest Branch and all tributaries	809/413	Above East-West Highway (Md. Rt. 410)

(o) SUB-BASIN 02-14-03: MIDDLE POTOMAC AREA

Class	*Waters*	*MCGS*	*Limits*
Class II: None			
Class III:			
(i)	Tuscarora Creek and all tributaries	694/592	
(ii)	Carroll Creek and all tributaries	678.5/579.5	Above Route #15
(iii)	Rocky Fountain Run and all tributaries	681/546	
(iv)	Fishing Creek and all tributaries	689.2/609.2	
(v)	Hunting Creek and all tributaries	698.5/625.5	
(vi)	Owens Creek and all tributaries	705.9/635.9	
(vii)	Friends Creek and all tributaries	697.2/689.1	
(viii)	Catoctin Creek and all tributaries	640.6/589.8	Above Alternate Rt. 40
(ix)	Little Bennett Creek and all tributaries	697/532	Above Md. Rt. 355
(x)	Furnace Branch	675/514	
Class IV:			
(i)	Monocacy River and tributaries except those designated above as Class III, natural trout waters	671/506.7	Above Rt. 40
(ii)	Catocin Creek	640.6/538	Mainstem only, below Alternate Rt. 40

(p) SUB-BASIN 02-14-05: UPPER POTOMAC RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II: None			
Class III:			
	(i) Town Creek tributaries	365/618.8	
	(ii) Beaver Ck. and all tributaries	599.9/620.3	In Antietam Creek Watershed
	(iii) Marsh Run and all tributaries	605.7/662.1	In Antietam Creek Watershed
	(iv) Little Antietam Creek and all tributaries	620/674	
	(v) Camp Spring Run and all tributaries	536/653	
Class IV:			
	(i) Town Creek	365/618.8	
	(ii) Fifteen Mile Creek and all tributaries	410.1/655	
	(iii) Sideling Hill Creek and all tributaries	424.5/660	
	(iv) Tonoloway Creek and all tributaries	474.8/679.8	
	(v) Licking Creek and all tributaries	504/663.5	
	(vi) Conococheague Creek and all tributaries	566.3/645.4	
	(vii) Antietam Creek and tributaries, except those designated above as Class III, natural trout waters	589.1/577.8	

(q) SUB-BASIN 02-14-10: NORTH BRANCH POTOMAC RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II: None			
Class III:			
	All Maryland tributaries to the North Branch Potomac River except for:	From 352.3/621.1 to the MD-W.VA State Line	
	(i) Those designated below as Class IV, recreational trout waters.		
	(ii) The mainstem of Georges Creek; and	222.8/607.4	Confluence of Georges Creek with North Branch
	(iii) Mill Run and its tributaries in Allegany County	272.2/625.8	Confluence of Mill Run with North Branch, (near Rawlings and Rawlings Heights)
Class IV:			
	(i) Wills Creek	303.3/655.5	Mainstem only
	(ii) Evitts Creek	310.2/656.8	Mainstem only

(r) SUB-BASIN 05-02-02: YOUGHIOGHENY RIVER AREA

Class	*Waters*	*MCGS*	*Limits*
Class II: None			
Class III:			
	Youghiogheny River and all tributaries joining the mainstem of the Youghiogheny River in Maryland	126.8/696.2	
	South Branch, Casselman River	187.7/674.0	Confluence of North and South Branch
Class IV:			
	Casselman River	205.5/694.8	Mainstem only, confluence of South Branch and North Branch to Pennsylvania line

(s) SUB-BASIN 02-05-03: CONEWEGO CREEK

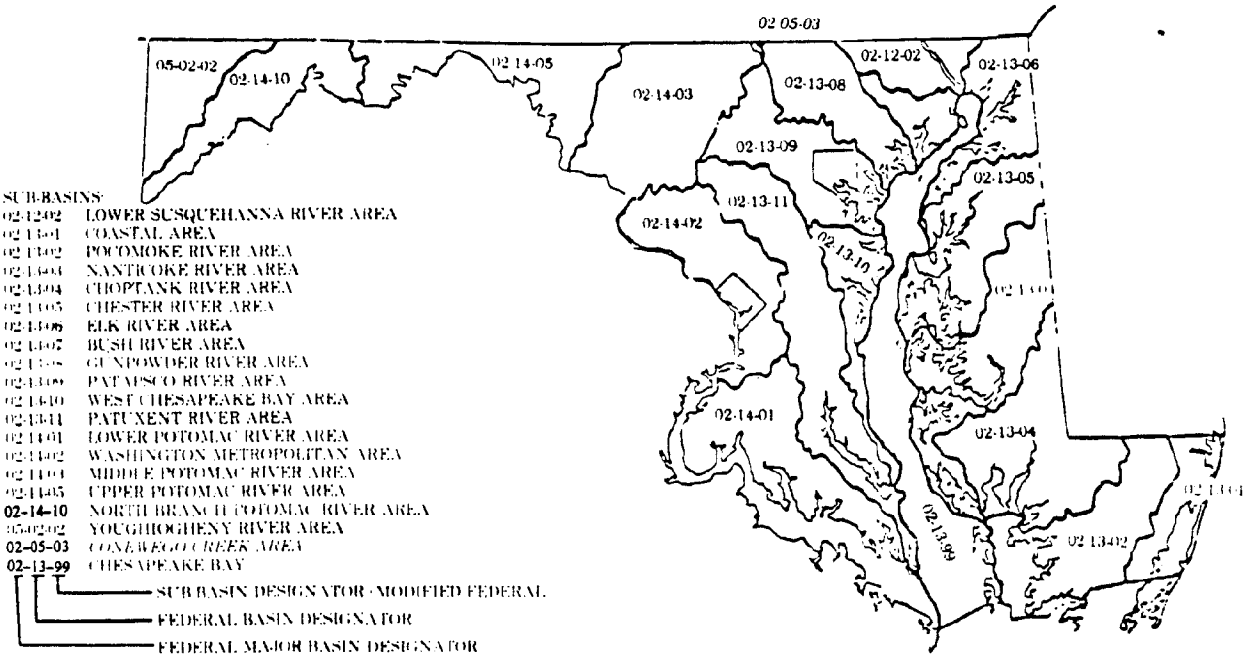
Class II: None
Class III: None
Class IV: None

(t) SUB-BASIN 02-13-19: CHESAPEAKE BAY (PROPER)

Class	*Waters*	*MCGS*	*Limits*
Class II:	All waters of the Chesapeake Bay Proper		From the Susquehanna River mouth to the Virginia State line, including: the tidal waters of the Chesapeake Bay bounded generally by the shoreline of the Bay and by "zero river mile" lines of estuaries and tributaries to the Bay, as designated by the Administration; and any peripheral waters designated as part of the Chesapeake Bay Proper by the Administration after consultation with the Maryland Tidewater Administration and the Maryland Wildlife Administration

Class III: None
Class IV: None

MARYLAND WATERSHED DESIGNATIONS



APPENDIX B

FEDERAL SURFACE WATER QUALITY CRITERIA

U.S. EPA WATER QUALITY CRITERIA SUMMARY. (SOURCE: U.S. EPA 1986)

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER REGULATIONS AND STANDARDS
STANDARDS BRANCH (WH-585)
401 M STREET S.W.
WASHINGTON, DC 20460

update 1.0

September 2, 1986

POLLUTANT	PRIORITY	ORGANIC	CONCENTRATIONS IN ug/L				UNITS PER LITER			DATE/REFERENCE	# OF STATES WITH AQUATIC LIFE STANDARD
			FRESH ACUTE CRITERIA	FRESH CHRONIC CRITERIA	MARINE ACUTE CRITERIA	MARINE CHRONIC CRITERIA	WATER AND FISH INGESTION	FISH CONSUMPTION ONLY	DRINKING WATER M.C.L.		
ACENAPTHENE	Y	N	*1,700.	*520.	*970.	*710.				1980 FR	1
ACROLEIN	Y	N	*68.	*21.	*55.		320.ug	780.ug		1980 FR	1
ACRYLONITRILE	Y	Y	*7,550.	*2,600.			0.058ug**	0.65ug**		1980 FR	1
ALDRIN	Y	Y	3.0		1.3		0.074ng**	0.079ng**		1980 FR	16
ALKALINITY	N	N		20,000.						1976 RB	
AMMONIA	N	N	CRITERIA ARE pH AND TEMPERATURE DEPENDENT - SEE DOCUMENT							1985 FR	34
ANTIMONY	Y	N	*9,000.	*1,600.			146.ug	45,000.ug		1980 FR	1
ARSENIC	Y	Y					2.2ng**	17.5ng**	0.05mg	1980 FR	31
ARSENIC(PENT)	Y	Y	*850.	048.	*2,319.	*13.				1985 FR	21
ARSENIC(TRI)	Y	Y	360.	190.	69.	36.				1985 FR	21
ASBESTOS	Y	Y					30k f/L**			1980 FR	
BACTERIA	N	N	FOR PRIMARY RECREATION AND SHELLFISH USES - SEE DOCUMENT						<1/100ml	1986 FR	50
BARIUM	N	N					1.mg		1.0mg	1976 RB	0
BENZENE	Y	Y	*5,300.		*5,100.	*700.	0.66ug**	40.ug**		1980 FR	1
BENZIDINE	Y	Y	*2,500.				0.12ng**	0.53ng**		1980 FR	6
BERYLLIUM	Y	Y	*130.	*5.3			6.8ng**	117.0g**		1980 FR	8
BHC	Y	N	*100.		*0.34					1980 FR	
CADMIUM	Y	N	3.9*	1.1*	43.	9.3	10.ug		0.010mg	1985 FR	21
CARBON TETRACHLORIDE	Y	Y	*35,200.		*50,000.		0.4ug**	6.94ug**		1980 FR	1
CHLORDANE	Y	Y	2.4	0.0043	0.09	0.004	0.46ng**	0.48ng**		1980 FR	12
CHLORINATED BENZENES	Y	Y	*250.	250.	*160.	*129.	488.ug			1980 FR	1
CHLORINATED NAPHTHALENES	Y	N	*1,600.		*7.5					1980 FR	1
CHLORINE	N	N	19.	11.	13.	7.5				1985 FR	21
CHLOROALKYL ETHERS	Y	N	*238,000.							1980 FR	1
CHLOROETHYL BIS-2	Y	Y					0.03ug**	1.36ug**		1980 FR	
CHLOROFORM	Y	Y	*28,900.	*1,240.			0.19ug**	15.7ug**		1980 FR	1
CHLOROISOPROPYL (BIS-2)	Y	N					34.7ug	4.36mg		1980 FR	
CHLOROMETHYL ETHER (BIS)	Y	N					0.00000276ng**	0.00184ug**		1980 FR	
CHLOROPHENOL 2	Y	N	*4,380.	*2,000.						1980 FR	1
CHLOROPHENOL 4	N	N			*28,700.					1980 FR	1
CHLOROPHENOXY HERBICIDES (2,4,5,-TP)	N	N					10.ug			1980 FR	
CHLOROPHENOXY HERBICIDES (2,4-D)	N	N					100.ug			1976 RB	7
CHLORO-4 METHYL-3 PHENOL	N	N	*30.							1980 FR	
CHROMIUM (HEX)	Y	N	16.	11.	1,100.	50.	50.ug		0.05mg	1985 FR	24
CHROMIUM (TRI)	N	N	1,700.*	210.*	*10,300.		170.mg	3,433.mg	0.05mg	1985 FR	24
COLOR	N	N	NARRATIVE STATEMENT - SEE DOCUMENT							1976 RB	
COPPER	Y	N	18.*	12.*	2.9	2.9				1985 FR	30
CYANIDE	Y	N	22.	5.2	1.	1.	200.ug			1985 FR	23
DDT	Y	Y	1.1	0.001	0.13	0.001	0.024ng**	0.024ng**		1980 FR	16
DDT METABOLITE (DDE)	Y	Y	*1,050.		*14.					1980 FR	
DDT METABOLITE (TDE)	Y	Y	*60.08		*3.6					1980 FR	
DEMETON	Y	N		0.1		0.1				1976 RB	
DIBUTYL PHTHALATE	Y	N					35.mg	154.mg		1980 FR	
DICHLOROBENZENES	Y	N	*1,120.	*763.	*1,970.		400.ug	2.6mg		1980 FR	1
DICHLOROBENZIDENE	Y	Y					0.01ug**	0.02ug**		1980 FR	1
DICHLOROETHANE 1,2	Y	Y	*118,000.	*20,000.	*113,000.		0.94ug**	243.ug**		1980 FR	1
DICHLOROETHYLENES	Y	Y	*11,600.		*224,000.		0.033ug**	1.85ug**		1980 FR	1
DICHLOROPHENOL 2,4	Y	N	*2,020.	*765.			3.09mg			1980 FR	1
DICHLOROPROPANE	Y	N	23,000.	5,700.	*10,300.	*3,040.				1980 FR	1
DICHLOROPROPENE	Y	N	*6,060.	*244.	*790.		87.ug	14.1mg		1980 FR	1
DIELDRIN	Y	Y	2.5	0.0019	0.71	0.0019	0.071ng**	0.076ng**		1980 FR	16
DIETHYL PHTHALATE	Y	N					350.mg	1.8g		1980 FR	
DIMETHYL PHENOL 2,4	Y	N	*2,120.							1980 FR	
DIMETHYL PHTHALATE	Y	N					313.mg	2.9g		1980 FR	
DINITROTOLUENE 2,4	N	Y					0.11ug**	9.1ug**		1980 FR	
DINITROPHENOLS	Y	N					70.ug	14.3mg		1980 FR	
DINITROTOLUENE	N	Y	8330.	4330.	*590.	*370.				1980 FR	1
DINITRO-O-CRESOL 3,4,	Y	N					13.4ug	765.ug		1980 FR	
DIOXIN (2,3,7,8 - TCDD)	Y	Y	**0.01	**0.00001			0.000013ng**	0.000014ng**		1984 FR	1
DIPHENYLHYDRAZINE	Y	N					42.ng**	0.54ug**		1980 FR	1
DIPHENYLHYDRAZINE 1,2	Y	N	1370.							1980 FR	
DI-2-ETHYLHEXYL PHTHALATE	Y	N					15.mg	50.mg		1980 FR	
ENDOSULFAN	Y	N	0.22	0.056	0.034	0.0087	74.ug	159.ug		1980 FR	16
ENDRIN	Y	N	0.18	0.0023	0.037	0.0023	1.ug		0.0002mg	1980 FR	16
ETHYLBENZENE	Y	N	32,000.		*430.		1.4mg	3.28mg		1980 FR	
FLUORANTHENE	Y	N	3,980.		40.	*16.	42.ug	54.ug		1980 FR	1
GASSES, TOTAL DISSOLVED	N	N	NARRATIVE STATEMENT - SEE DOCUMENT							1976 RB	
GUTHION	N	N		0.01		0.01				1976 RB	0

TABLE 2-1. (CONT.)

HALOETHERS	Y	N	*360.	*122.						1980	FR	
HALOMETHANES	Y	Y	*11,000.		*12,000.	*6,400.	0.19ug**	15.7ug**		1980	FR	
HEPTACHLOR	Y	Y	0.52	0.0038	0.053	0.0036	0.28ng**	0.39ng**		1980	FR	12
HEXACHLOROETHANE	N	Y	*980.	*540.	*210.		1.8ug	8.7ug		1980	FR	1
HEXACHLOROBENZENE	Y	N					0.72ng**	0.74ng**		1980	FR	
HEXACHLOROBUTADIENE	Y	Y	*90.	*9.3	*32.		0.45ug**	50.ug**		1980	FR	2
HEXACHLOROCYCLOHEXANE (LINDANE)	Y	Y	2.0	0.08	0.16				0.004mg	1980	FR	12
HEXACHLOROCYCLOHEXANE - ALPHA	Y	Y					9.2ng**	31.ng**		1980	FR	
HEXACHLOROCYCLOHEXANE - BETA	Y	Y					16.3ng**	54.7ng**		1980	FR	
HEXACHLOROCYCLOHEXANE - GAMA	Y	Y					18.6ng**	62.3ng**		1980	FR	
HEXACHLOROCYCLOHEXANE - TECHNICAL	Y	Y					12.3ng**	41.4ng**		1980	FR	
HEXACHLOROCYCLOPENTADIENE	N	N	*7.	*5.2	*7.		206.ug			1980	FR	3
IRON	N	N		1,000.			0.3mg			1976	NB	19
ISOPHORONE	Y	N	*117,000.		*12,900.		5.2mg	520.mg		1980	FR	
LEAD	Y	N	82.*	2.3*	140.	5.6	50.ug		0.05mg	1980	FR	20
MALATHION	N	N		0.01		0.01				1976	NB	7
MANGANESE	N	N					50.ug	100.ug		1976	NB	7
MERCURY	Y	N	2.4	0.012	2.1	0.025	144.ng	144.ng	0.002mg	1980	FR	17
METHOXYCHLOR	N	N		0.03		0.03	100.ug		0.1mg	1976	NB	12
MIREX	N	N		0.001		0.001				1976	NB	7
MONOCHLOROBENZENE	Y	N					488.ug			1980	FR	
NAPHTHALENE	Y	N	*2,300.	*620.	*2,350.					1980	FR	1
NICKEL	Y	N	1,800.*	96.*	160.	7.1	13.4ug	100.ug		1980	FR	10
NITRATES	N	N					10.mg		10.mg	1976	NB	5
NITROBENZENE	Y	N	*27,000.		*6,680.		10.8mg			1980	FR	1
NITROPHENOLS	Y	N	*230.	*150.	*4,850.					1980	FR	1
NITROSAMINES	Y	Y	*5,850.		*3,300,000		0.8ng**	1240.ng**		1980	FR	1
NITROSODIBUTYLAMINE N	Y	Y					6.4ng**	587.ng**		1980	FR	
NITROSODIETHYLAMINE N	Y	Y					0.8ng**	1,110.ng**		1980	FR	
NITROSODIMETHYLAMINE N	Y	Y					1.4ng**	14,000.ng**		2000	FR	
NITROSODIPHENYLAMINE N	Y	Y					4,900.ng**	16,100.ng**		1980	FR	
NITROSOPYRROLIDINE N	Y	Y					16.ng**	91,900.ng**		1980	FR	
OIL AND GREASE	N	N	NARRATIVE STATEMENT - SEE DOCUMENT							1976	NB	56
OXYGEN DISSOLVED	N	N	WARMWATER AND COLDWATER CRITERIA MATRIX - SEE DOCUMENT							1986	FR	54
PARATHION	N	N		0.04		0.04				1976	NB	8
PCB's	Y	Y	2.0	0.014	10.	0.03	0.079ng**	0.079ng**		1980	FR	16
PENTACHLORINATED ETHANES	Y	N	*7,240.	*1,100.	*590.	*261.				1980	FR	1
PENTACHLOROBENZENE	Y	N					74.ug	85.ug		1980	FR	
PENTACHLOROPHENOL	Y	N	*55.	*3.2	*51.	*14.	1.01mg			1980	FR	3
PH	N	N		6.5-8		6.5-8.5				1976	NB	56
PHENOL	Y	N	*10,200.	*2,560.	*5,800.		3.5mg			1980	FR	23
PHOSPHORUS ELEMENTAL	N	N				0.1				1976	NB	
PHTHALATE ESTERS	Y	N	*940.	*3.	*2,944.	*3.4				1980	FR	4
POLYNUCLEAR AROMATIC HYDROCARBONS	Y	Y			*300.		2.8ng**	31.1ng**		1980	FR	1
SELENIUM	Y	N	260.	35.	410.	54.	10.ug		0.01mg	1980	FR	15
SILVER	Y	N	4.1*	0.12	2.3		50.ug		0.05mg	1980	FR	14
SOLIDS DISSOLVED AND SALINITY	N	N					250.mg			1976	NB	56
SOLIDS SUSPENDED AND TURBIDITY	N	N	NARRATIVE STATEMENT - SEE DOCUMENT							1976	NB	64
SULFIDE-HYDROGEN SULFIDE	N	N		2.		2.				1976	NB	
TEMPERATURE	N	N	SPECIES DEPENDENT CRITERIA - SEE DOCUMENT							1976	NB	56
TETRACHLORINATED ETHANES	Y	N	*9,320.							1980	FR	
TETRACHLOROBENZENE 1,2,4,5	Y	N					30.ug	48.ug		1980	FR	
TETRACHLOROETHANE 1,1,2,2	Y	Y		*2,600.	*9,830.		0.17ug**	10.7ug**		1980	FR	1
TETRACHLOROETHANES	Y	N	*9,320.							1980	FR	1
TETRACHLOROETHYLENE	Y	Y	45,280.	*840.	*10,200.	*450.	0.8ug**	8.85ug**		1980	FR	1
TETRACHLOROPHENOL 2,3,5,6	N	N				*440.				1980	FR	
THALLIUM	Y	N	*1,400.	*40.	*2,130.		13.ug	48.ug		1980	FR	2
TOLUENE	Y	N	*17,500.		*6,300.	*5,000.	14.3mg	424.mg		1980	FR	1
TOXAPHENE	Y	Y	1.6	0.013	0.07		0.71ng**	0.73ng**	0.005mg	1980	FR	17
TRICHLORINATED ETHANES	Y	Y	*18,000.							1980	FR	
TRICHLOROETHANE 1,1,1	Y	N			*31,200.		18.4mg	1.03g		1980	FR	1
TRICHLOROETHANE 1,1,2	Y	Y		*9,400.			6.4ug**	41.8ug**		1980	FR	1
TRICHLOROETHYLENE	Y	Y	*45,000.	*21,900.	*2,000.		2.7ug**	80.7ug**		1980	FR	1
TRICHLOROPHENOL 2,4,5	N	N					2,600.ug			1980	FR	
TRICHLOROPHENOL 2,4,6	N	Y		*970.			1.2ug**	3.6ug**		1980	FR	
VINYL CHLORIDE	Y	Y					2.ug**	525.ug**		1980	FR	
ZINC	N	N	320.*	47.	170.	58.				1980	FR	19

g = grams
mg = milligrams
ug = micrograms
ng = nanograms
f = fibers

Y=YES
N=NO

* = HARDNESS DEPENDENT CRITERIA (100mg/L used)
\# = INSUFFICIENT DATA TO DEVELOP CRITERIA. VALUE PRESENTED IS THE L.O.E.L. - LOWEST OBSERVED EFFECT LEVEL.
** = HUMAN HEALTH CRITERIA FOR CARCINOGENS REPORTED FOR THREE RISK LEVELS. VALUE PRESENTED IS THE 10-6 RISK LEVEL.

FR = FEDERAL REGISTER
NB = QUALITY CRITERIA FOR WATER, 1976 (REDBOOK)

M.C.L. = MAXIMUM CONTAMINANT LEVEL

Note: This chart is for general information; please use criteria documents or detailed summaries in "Quality Criteria for Water 1986" for regulatory purposes.

APPENDIX C

EPA ANALYTICAL METHODS

WATER QUALITY SAMPLE COLLECTION

Water quality analyses are necessary to accurately describe the current conditions in the waterbody. Sampling location may vary according to waterbody size and location, as well as whether the construction is new or an expansion of existing facilities. Locations must be approved prior to sampling. In most cases, however, one sample at high tide and one at low tide in the immediate area of the facility is sufficient. Since average water quality of the waterbody is needed, samples should be collected every three weeks over the four month period from June to September.

A clean Van Dorn bottle is used to collect samples at the surface, middle-depth, and bottom of the water column were possible. Bottom samples are to be taken one foot from the bottom and care taken to avoid introducing any bottom sediment into the sampling device. Samples from each depth are composited and subsampled by parameter. Table 4-1 summarizes the parameters to be analyzed, preservative type, bottle size and type, sample size, and holding times for each parameter. All samples must be held on ice until returned to a laboratory for analysis. Values for pH, temperature, dissolved oxygen, and conductivity should be taken at sample collection. These are obtained using calibrated field instruments and measurements must be taken at the surface and at the bottom in areas less than six feet in depth and at the surface, mid-depth, and bottom for areas more than six feet in depth. Times of high and low tides, general weather conditions, wind direction and velocity, previous four day rainfall, and any outstanding observations that may effect sample integrity should be recorded on each sampling date and time.

LEAD
Method 239.2 (Atomic Absorption, furnace technique)

STORET NO. Total 01051
Dissolved 01049
Suspended 01050

Optimum Concentration Range: 5–100 *ug/l*
Detection Limit: 1 *ug/l*

Preparation of Standard Solution

1. Stock solution: Prepare as described under "direct aspiration method".
2. Lanthanum Nitrate Solution: Dissolve 58.64 g of ACS reagent grade La_2O_3 in 100 ml conc. HNO_3 and dilute to 1000 ml with deionized distilled water. 1 ml = 50 mg La.
3. Working Lead Solution: Prepare dilutions of the stock lead solution to be used as calibration standards at the time of analysis. Each calibration standard should contain 0.5% (v/v) HNO_3. To each 100 ml of diluted standard add 10 ml of the lanthanum nitrate solution.

Sample Preservation

1. For sample handling and preservation, see part 4.1 of the Atomic Absorption Methods section of this manual.

Sample Preparation

1. Prepare as described under "direct aspiration method". Sample solutions for analysis should contain 0.5% (v/v) HNO_3.
2. To each 100 ml of prepared sample solution add 10 ml of the lanthanum nitrate solution.

Instrument Parameters (General)

1. Drying Time and Temp: 30 sec–125°C.
2. Ashing Time and Temp: 30 sec–500°C.
3. Atomizing Time and Temp: 10 sec–2700°C.
4. Purge Gas Atmosphere: Argon
5. Wavelength: 283.3 nm
6. Other operating parameters should be set as specified by the particular instrument manufacturer.

Analysis Procedure

1. For the analysis procedure in the calculation see "Furnace Procedure", part 9.3 of the Atomic Absorption Methods section of this manual.

Approved for NPDES and SDWA
Issued 1978

Notes

1. The above concentration values and instrument conditions are for a Perkin-Elmer HGA-2100, based on the use of a 20 *ul* injection, continuous flow purge gas and non-pyrolytic graphite. Smaller size furnace devices or those employing faster rates of atomization can be operated using lower atomization temperatures for shorter time periods than the above recommended settings.
2. The use of background correction is recommended.
3. Greater sensitivity can be achieved using the 217.0 nm line, but the optimum concentration range is reduced. The use of a lead electrodeless discharge lamp at this lower wavelength has been found to be advantageous. Also a lower atomization temperature (2400°C) may be preferred.
4. To suppress sulfate interference (up to 1500 ppm) lanthanum is added as the nitrate to both samples and calibration standards. (Atomic Absorption Newsletter Vol. 15, No. 3, p 71, May-June 1976.)
5. Since glassware contamination is a severe problem in lead analysis, all glassware should be cleaned immediately prior to use, and once cleaned, should not be open to the atmosphere except when necessary.
6. For every sample matrix analyzed, verification is necessary to determine that method of standard addition is not required (see part 5.2.1 of the Atomic Absorption Methods section of this manual).
7. For quality control requirements and optional recommendations for use in drinking water analyses, see part 10 of the Atomic Absorption Methods section of this manual.
8. If method of standard addition is required, follow the procedure given earlier in part 8.5 of the Atomic Absorption Methods section of this manual.
9. Data to be entered into STORET must be reported as *u*g/1.

Precision and Accuracy

1. In a single laboratory (EMSL), using Cincinnati, Ohio tap water spiked at concentrations of 25, 50, and 100 *u*g Pb/1, the standard deviations were ±1.3, ±1.6, and ±3.7, respectively. Recoveries at these levels were 88%, 92%, and 95% respectively.

COPPER

Method 220.2 (Atomic Absorption, furnace technique)

STORET NO. 01042
Dissolved 01040
Suspended 01041

Optimum Concentration Range: 5–100 *ug/l*
Detection Limit: 1 *ug/l*

Preparation of Standard Solution

1. Stock solution: Prepare as described under "direct aspiration method".
2. Prepare dilutions of the stock solution to be used as calibration standards at the time of analysis. These solutions are also to be used for "standard additions".
3. The calibration standard should be diluted to contain 0.5% (v/v) HNO_3.

Sample Preservation

1. For sample handling and preservation, see part 4.1 of the Atomic Absorption Methods section of this manual.

Sample Preparation

1. Prepare as described under "direct aspiration method". Sample solutions for analysis should contain 0.5% (v/v) HNO_3.

Instrument Parameters (General)

1. Drying Time and Temp: 30 sec–125°C.
2. Ashing Time and Temp: 30 sec–900°C.
3. Atomizing Time and Temp: 10 sec–2700°C.
4. Purge Gas Atmosphere: Argon
5. Wavelength: 324.7 nm
6. Other operating parameters should be set as specified by the particular instrument manufacturer.

Analysis Procedure

1. For the analysis procedure and the calculation, see "Furnace Procedure" part 9.3 of the Atomic Absorption Methods section of this manual.

Notes

1. The above concentration values and instrument conditions are for a Perkin-Elmer HGA-2100, based on the use of a 20 *ul* injection, continuous flow purge gas and non-pyrolytic

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graphite. Smaller size furnace devices or those employing faster rates of atomization can be operated using lower atomization temperatures for shorter time periods than the above recommended settings.

2. Background correction may be required if the sample contains high dissolved solids.
3. Nitrogen may also be used as the purge gas.
4. For every sample matrix analyzed, verification is necessary to determine that method of standard addition is not required (see part 5.2.1 of the Atomic Absorption Methods section of this manual).
5. If method of standard addition is required, follow the procedure given earlier in part 8.5 of the Atomic Absorption Methods section of this manual.
6. Data to be entered into STORET must be reported as *ug/1*.

Precision and Accuracy

1. Precision and accuracy data are not available at this time.

PHENOLICS, TOTAL RECOVERABLE

Method 420.2 (Colorimetric, Automated 4-AAP with Distillation)

STORET NO. 32730

1. Scope and Application
   1.1 This method is applicable to the analysis of drinking, surface and saline waters, domestic and industrial wastes.
   1.2 The method is capable of measuring phenolic materials from 2 to 500 ug/1 in the aqueous phase using phenol as a standard. The working ranges are 2 to 200 ug/1 and 10 to 500 ug/1.
2. Summary of Method
   2.1 This automated method is based on the distillation of phenol and subsequent reaction of the distillate with alkaline ferricyanide and 4-aminoantipyrine to form a red complex which is measured at 505 or 520 nm. The same manifold is used with the AAI or AAII.
3. Sample Handling and Preservation
   3.1 Biological degradation is inhibited by the addition of 1 g/1 of copper sulfate to the sample and acidification to a pH of less than 4 with phosphoric acid. The sample should be kept at 4°C and analyzed within 24 hours after collection.
4. Interference
   4.1 Interferences from sulfur compounds are eliminated by acidifying the sample to a pH of less than 4.0 with H_3PO_4 and aerating briefly by stirring and adding $CuSO_4$.
   4.2 Oxidizing agents such as chlorine, detected by the liberation of iodine upon acidification in the presence of potassium iodide, are removed immediately after sampling by the addition of an excess of ferrous ammonium sulfate (6.5). If chlorine is not removed, the phenolic compounds may be partially oxidized and the results may be low.
   4.3 Background contamination from plastic tubing and sample containers is eliminated by filling the wash receptacle by siphon (using Kel-F tubing) and using glass tubes for the samples and standards.
5. Apparatus
   5.1 Technicon AutoAnalyzer (I or II)
      5.1.1 Sampler equipped with continuous mixer.
      5.1.2 Manifold.
      5.1.3 Proportioning pump II or III.
      5.1.4 Heating bath with distillation coil.
      5.1.5 Distillation head.
      5.1.6 Colorimeter equipped with a 50 mm flow cell and 505 or 520 nm filter.
      5.1.7 Recorder.
6. Reagents
   6.1 Distillation reagent: Add 100 ml of conc. phosphoric acid (85% H_3PO_4) to 800 ml of distilled water, cool and dilute to 1 liter.

Issued 1974

6.2 Buffered potassium ferricyanide: Dissolve 2.0 g potassium ferricyanide, 3.1 g boric acid and 3.75 g potassium chloride in 800 ml of distilled water. Adjust to pH of 10.3 with 1 N sodium hydroxide (6.3) and dilute to 1 liter. Add 0.5 ml of Brij-35. Prepare fresh weekly.

6.3 Sodium hydroxide (1N): Dissolve 40 g NaOH in 500 ml of distilled water, cool and dilute to 1 liter.

6.4 4-Aminoantipyrine: Dissolve 0.65 g of 4-aminoantipyrine in 800 ml of distilled water and dilute to 1 liter. Prepare fresh each day.

6.5 Ferrous ammonium sulfate: Dissolve 1.1 g ferrous ammonium sulfate in 500 ml distilled water containing 1 ml H_2SO_4 and dilute to 1 liter with freshly boiled and cooled distilled water.

6.6 Stock phenol: Dissolve 1.00 g phenol in 500 ml of distilled water and dilute to 1000 ml. Add 1 g $CuSO_4$ and 0.5 ml conc. H_3PO_4 as preservative. 1.0 ml = 1.0 mg phenol.

6.7 Standard phenol solution A: Dilute 10.0 ml of stock phenol solution (6.6) to 1000 ml. 1.0 ml = 0.01 mg phenol.

6.8 Standard phenol solution B: Dilute 100.0 ml of standard phenol solution A (6.7) to 1000 ml with distilled water. 1.0 ml = 0.001 mg phenol.

6.9 Standard solution C: Dilute 100.0 ml of standard phenol solution B (6.8) to 1000 ml with distilled water. 1.0 ml = 0.0001 mg phenol.

6.10 Using standard solution A, B or C prepare the following standards in 100 ml volumetric flasks. Each standard should be preserved by adding 0.1 g $CuSO_4$ and 2 drops of conc. H_3PO_4 to 100.0 ml.

ml of Standard Solution	Conc. ug/l
Solution C	
1.0	1.0
2.0	2.0
3.0	3.0
5.0	5.0
Solution B	
1.0	10.0
2.0	20.0
5.0	50.0
10.0	100.0
Solution A	
2	200
3	300
5	500

7. Procedure

7.1 Set up the manifold as shown in Figures 1 or 2.

7.2 Fill the wash receptacle by siphon. Use Kel-F tubing with a fast flow (1 liter/hr).

7.3 Allow colorimeter and recorder to warm up for 30 minutes. Run a baseline with all reagents, feeding distilled water through the sample line. Use polyethylene tubing for

sample line. When new tubing is used, about 2 hours may be required to obtain a stable baseline. This two hour time period may be necessary to remove the residual phenol from the tubing.

7.4 Place appropriate phenol standards in sampler in order of decreasing concentration. Complete loading of sampler tray with unknown samples, using glass tubes.

NOTE 1: If samples have not been preserved as instructed in (3.1), add 0.1 g $CuSO_4$ and 2 drops of conc. H_3PO_4 to 100 ml of sample.

7.5 Switch sample line from distilled water to sampler and begin analysis.

8. Calculation

8.1 Prepare standard curve by plotting peak heights of standards against concentration values. Compute concentration of samples by comparing sample peak heights with standards.

9. Precision and Accuracy

9.1 In a single laboratory (EMSL), using sewage samples at concentrations of 3.8, 15, 43 and 89 *ug*/1, the standard deviations were ±0.5, ±0.6, ±0.6 and ±1.0 *ug*/1, respectively. At concentrations of 73, 146, 299 and 447 *ug*/1, the standard deviations were ±1.0, ±1.8, ±4.2 and ±5.3 *ug*/1, respectively.

9.2 In a single laboratory (EMSL), using sewage samples at concentrations of 5.3 and 82 *ug*/1, the recoveries were 78% and 98%. At concentrations of 168 and 489 *ug*/1, the recoveries were 97% and 98%, respectively.

Bibliography

1. Technicon AutoAnalyzer II Methodology, Industrial Method No. 127–71W, AAII.
2. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 574, Method 510 (1975).
3. Gales, M.E. and Booth, R.L., "Automated 4 AAP Phenolic Method", AWWA 68, 540 (1976).

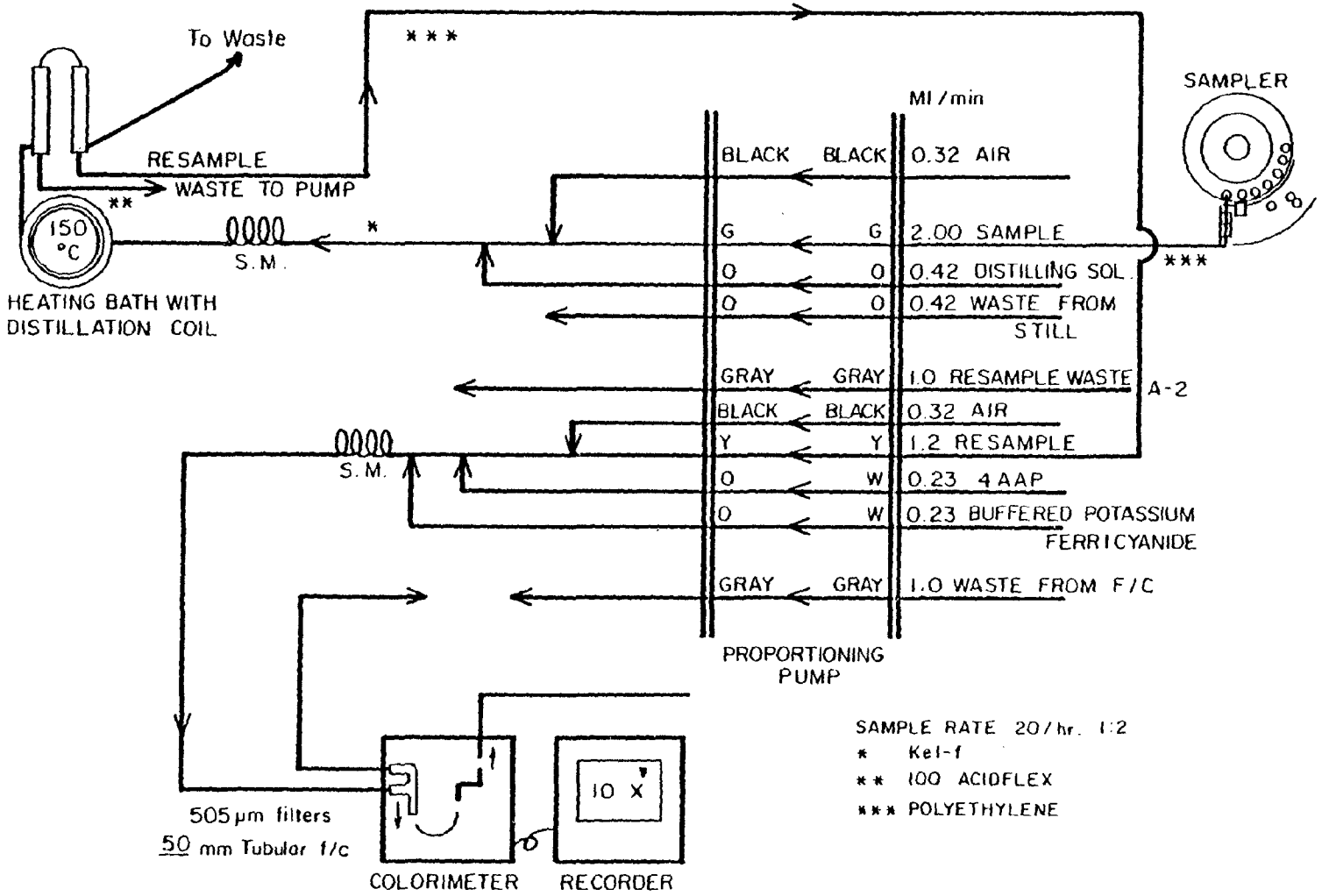

FIGURE 1. PHENOL AUTO ANALYZER I

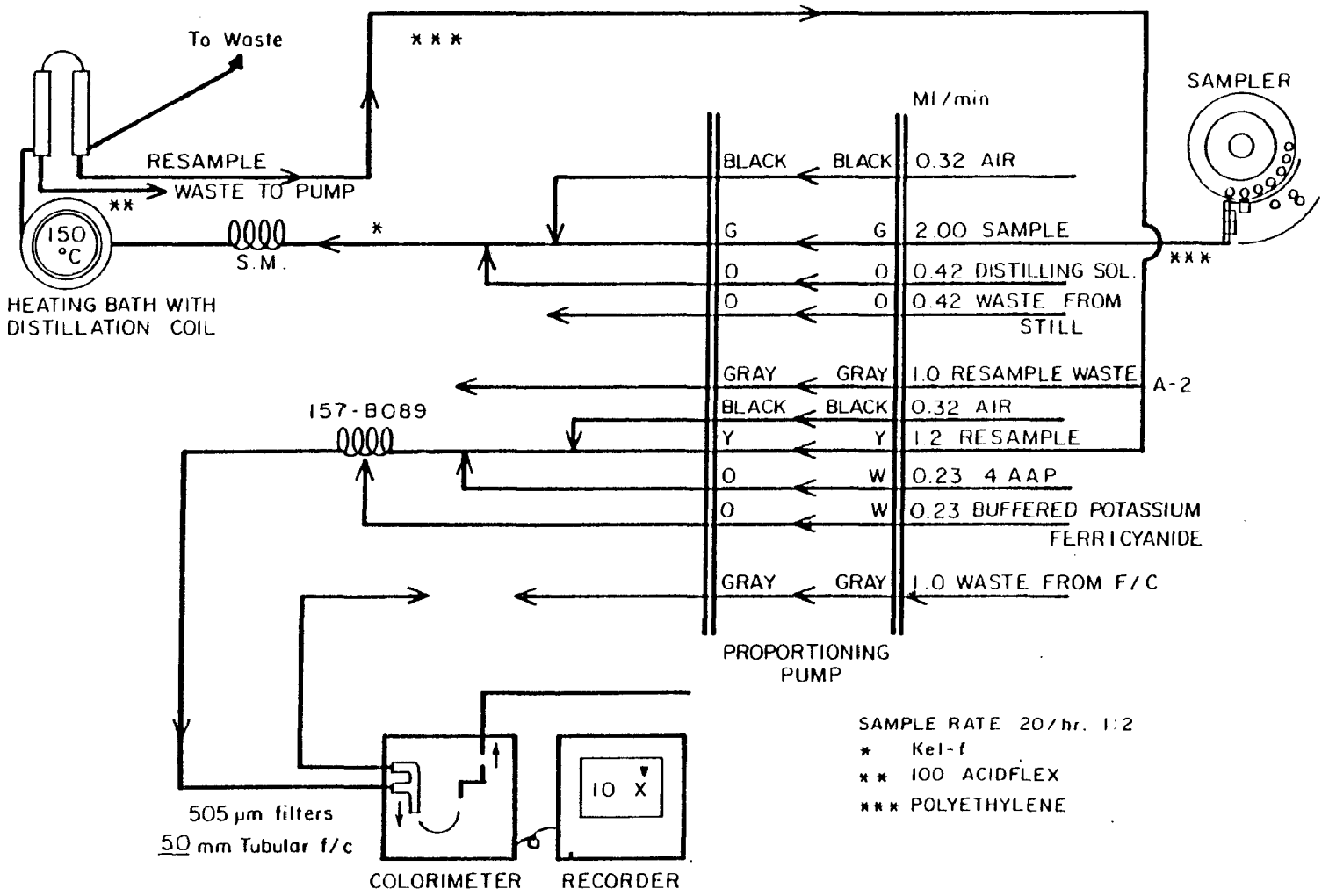

FIGURE 2. PHENOL AUTO ANALYZER II

ORGANIC CARBON, TOTAL

Method 415.1 (Combustion or Oxidation)

STORET NO. Total 00680
Dissolved 00681

1. Scope and Application
   1.1 This method includes the measurement of organic carbon in drinking, surface and saline waters, domestic and industrial wastes. Exclusions are noted under Definitions and Interferences.
   1.2 The method is most applicable to measurement of organic carbon above 1 mg/1.
2. Summary of Method
   2.1 Organic carbon in a sample is converted to carbon dioxide (CO_2) by catalytic combustion or wet chemical oxidation. The CO_2 formed can be measured directly by an infrared detector or converted to methane (CH_4) and measured by a flame ionization detector. The amount of CO_2 or CH_4 is directly proportional to the concentration of carbonaceous material in the sample.
3. Definitions
   3.1 The carbonaceous analyzer measures all of the carbon in a sample. Because of various properties of carbon-containing compounds in liquid samples, preliminary treatment of the sample prior to analysis dictates the definition of the carbon as it is measured. Forms of carbon that are measured by the method are:
      A) soluble, nonvolatile organic carbon; for instance, natural sugars.
      B) soluble, volatile organic carbon; for instance, mercaptans.
      C) insoluble, partially volatile carbon; for instance, oils.
      D) insoluble, particulate carbonaceous materials, for instance; cellulose fibers.
      E) soluble or insoluble carbonaceous materials adsorbed or entrapped on insoluble inorganic suspended matter; for instance, oily matter adsorbed on silt particles.
   3.2 The final usefulness of the carbon measurement is in assessing the potential oxygen-demanding load of organic material on a receiving stream. This statement applies whether the carbon measurement is made on a sewage plant effluent, industrial waste, or on water taken directly from the stream. In this light, carbonate and bicarbonate carbon are not a part of the oxygen demand in the stream and therefore should be discounted in the final calculation or removed prior to analysis. The manner of preliminary treatment of the sample and instrument settings defines the types of carbon which are measured. Instrument manufacturer's instructions should be followed.

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4. Sample Handling and Preservation

4.1 Sampling and storage of samples in glass bottles is preferable. Sampling and storage in plastic bottles such as conventional polyethylene and cubitainers is permissible if it is established that the containers do not contribute contaminating organics to the samples.
NOTE 1: A brief study performed in the EPA Laboratory indicated that distilled water stored in new, one quart cubitainers did not show any increase in organic carbon after two weeks exposure.

4.2 Because of the possibility of oxidation or bacterial decomposition of some components of aqueous samples, the lapse of time between collection of samples and start of analysis should be kept to a minimum. Also, samples should be kept cool (4°C) and protected from sunlight and atmospheric oxygen.

4.3 In instances where analysis cannot be performed within two hours (2 hours) from time of sampling, the sample is acidified ($pH \leq 2$) with HCl or H_2SO_4.

5. Interferences

5.1 Carbonate and bicarbonate carbon represent an interference under the terms of this test and must be removed or accounted for in the final calculation.

5.2 This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a microliter type syringe or pipette. The openings of the syringe or pipette limit the maximum size of particles which may be included in the sample.

6. Apparatus

6.1 Apparatus for blending or homogenizing samples: Generally, a Waring-type blender is satisfactory.

6.2 Apparatus for total and dissolved organic carbon:

6.2.1 A number of companies manufacture systems for measuring carbonaceous material in liquid samples. Considerations should be made as to the types of samples to be analyzed, the expected concentration range, and forms of carbon to be measured.

6.2.2 No specific analyzer is recommended as superior.

7. Reagents

7.1 Distilled water used in preparation of standards and for dilution of samples should be ultra pure to reduce the carbon concentration of the blank. Carbon dioxide-free, double distilled water is recommended. Ion exchanged waters are not recommended because of the possibilities of contamination with organic materials from the resins.

7.2 Potassium hydrogen phthalate, stock solution, 1000 mg carbon/liter: Dissolve 0.2128 g of potassium hydrogen phthalate (Primary Standard Grade) in distilled water and dilute to 100.0 ml.
NOTE 2: Sodium oxalate and acetic acid are not recommended as stock solutions.

7.3 Potassium hydrogen phthalate, standard solutions: Prepare standard solutions from the stock solution by dilution with distilled water.

7.4 Carbonate-bicarbonate, stock solution, 1000 mg carbon/liter: Weigh 0.3500 g of sodium bicarbonate and 0.4418 g of sodium carbonate and transfer both to the same 100 ml volumetric flask. Dissolve with distilled water.

7.5 Carbonate-bicarbonate, standard solution: Prepare a series of standards similar to step 7.3.

NOTE 3: This standard is not required by some instruments.

7.6 Blank solution: Use the same distilled water (or similar quality water) used for the preparation of the standard solutions.

8. Procedure

8.1 Follow instrument manufacturer's instructions for calibration, procedure, and calculations.

8.2 For calibration of the instrument, it is recommended that a series of standards encompassing the expected concentration range of the samples be used.

9. Precision and Accuracy

9.1 Twenty-eight analysts in twenty-one laboratories analyzed distilled water solutions containing exact increments of oxidizable organic compounds, with the following results:

Increment as TOC mg/liter	Precision as Standard Deviation TOC, mg/liter	Accuracy as Bias, %	Accuracy as Bias, mg/liter
4.9	3.93	+15.27	+0.75
107	8.32	+ 1.01	+1.08

(FWPCA Method Study 3, Demand Analyses)

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1. Annual Book of ASTM Standards, Part 31, "Water", Standard D 2574–79, p 469 (1976).
2. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 532, Method 505, (1975).

CHEMICAL OXYGEN DEMAND

Method 410.4 (Colorimetric, Automated; Manual)

STORET NO. 00340

1. Scope and Application
   1.1 This method covers the determination of COD in surface waters, domestic and industrial wastes.
   1.2 The applicable range of the automated method is 3–900 mg/1 and the range of the manual method is 20 to 900 mg/1.
2. Summary of Method
   2.1 Sample, blanks and standards in sealed tubes are heated in an oven or block digestor in the presence of dichromate at 150°C. After two hours, the tubes are removed from the oven or digestor, cooled and measured spectrophotometrically at 600 nm.
3. Sample Handling and Preservation
   3.1 Collect the samples in glass bottles if possible. Use of plastic containers is permissible if it is known that no organic contaminants are present in the containers.
   3.2 Samples should be preserved with sulfuric acid to a pH < 2 and maintained at 4°C until analysis.
4. Interferences
   4.1 Chlorides are quantitatively oxidized by dichromate and represent a positive interference. Mercuric sulfate is added to the digestion tubes to complex the chlorides.
5. Apparatus
   5.1 Drying oven or block digestor, 150°C
   5.2 Corning culture tubes, 16 x 100 mm or 25 x 150 mm with Teflon lined screw cap
   5.3 Spectrophotometer or Technicon AutoAnalyzer
   5.4 Muffle furnace, 500°C.
6. Reagents
   6.1 Digestion solution: Add 10.2 g $K_2Cr_2O_7$, 167 ml conc. H_2SO_4 and 33.3 g $HgSO_4$ to 500 ml of distilled water, cool and dilute to 1 liter.
   6.2 Catalyst solution: Add 22 g Ag_2SO_4 to a 4.09kg bottle of conc. H_2SO_4. Stir until dissolved.
   6.3 Sampler wash solution: Add 500 ml of conc H_2SO_4 to 500 ml of distilled water.
   6.4 Stock potassium acid phthalate: Dissolve 0.850 g in 800 ml of distilled water and dilute to 1 liter. 1 ml = 1 mg COD
      6.4.1 Prepare a series of standard solutions that cover the expected sample concentrations by diluting appropriate volumes of the stock standard.
7. Procedure
   7.1 Wash all culture tubes and screw caps with 20% H_2SO_4 before their first use to prevent contamination. Trace contamination may be removed from the tubes by igniting them in a muffle oven at 500°C for 1 hour.

Issued 1978

7.2 Automated

7.2.1 Add 2.5 ml of sample to the 16 x 100 mm tubes.

7.2.2 Add 1.5 ml of digestion solution (6.1) and mix.

7.2.3 Add 3.5 ml of catalyst solution (6.2) carefully down the side of the culture tube.

7.2.4 Cap tightly and shake to mix layers.

7.2.5 Process standards and blanks exactly as the samples.

7.2.6 Place in oven or block digestor at 150°C for two hours.

7.2.7 Cool, and place standards in sampler in order of decreasing concentration. Complete filling sampler tray with unknown samples.

7.2.8 Measure color intensity on AutoAnalyzer at 600 nm.

7.3 Manual

7.3.1 The following procedure may be used if a larger sample is desired or a spectrophotometer is used in place of an AutoAnalyzer.

7.3.2 Add 10 ml of sample to 25 x 150 mm culture tube.

7.3.3 Add 6 ml of digestion solution (6.1) and mix.

7.3.4 Add 14 ml of catalyst solution (6.2) down the side of culture tube.

7.3.5 Cap tightly and shake to mix layers.

7.3.6 Place in oven or block digestor at 150°C for 2 hours.

7.3.7 Cool, allow any precipitate to settle and measure intensity in spectrophotometer at 600 nm. Use only optically matched culture tubes or a single cell for spectrophotometric measurement.

8. Calculation

8.1 Prepare a standard curve by plotting peak height or percent transmittance against known concentrations of standards.

8.2 Compute concentration of samples by comparing sample response to standard curve.

9. Precision and Accuracy

9.1 Precision and accuracy data are not available at this time.

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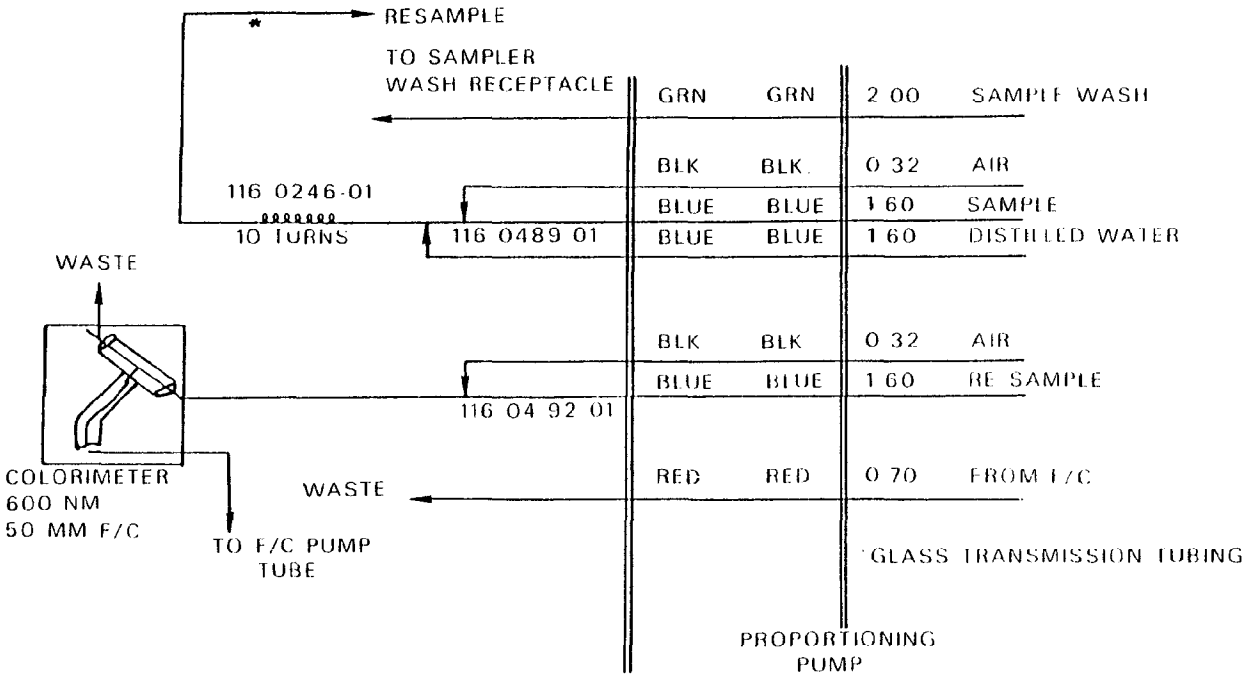

FIGURE 1 C O D MANIFOLD AA1 OR AA 11

BIOCHEMICAL OXYGEN DEMAND

Method 405.1 (5 Days, 20°C)

STORET NO. 00310

1. Scope and Application
   1.1 The biochemical oxygen demand (BOD) test is used for determining the relative oxygen requirements of municipal and industrial wastewaters. Application of the test to organic waste discharges allows calculation of the effect of the discharges on the oxygen resources of the receiving water. Data from BOD tests are used for the development of engineering criteria for the design of wastewater treatment plants.
   1.2 The BOD test is an empirical bioassay-type procedure which measures the dissolved oxygen consumed by microbial life while assimilating and oxidizing the organic matter present. The standard test conditions include dark incubation at 20°C for a specified time period (often 5 days). The actual environmental conditions of temperature, biological population, water movement, sunlight, and oxygen concentration cannot be accurately reproduced in the laboratory. Results obtained must take into account the above factors when relating BOD results to stream oxygen demands.
2. Summary of Method
   2.1 The sample of waste, or an appropriate dilution, is incubated for 5 days at 20°C in the dark. The reduction in dissolved oxygen concentration during the incubation period yields a measure of the biochemical oxygen demand.
3. Comments
   3.1 Determination of dissolved oxygen in the BOD test may be made by use of either the Modified Winkler with Full-Bottle Technique or the Probe Method in this manual.
   3.2 Additional information relating to oxygen demanding characteristics of wastewaters can be gained by applying the Total Organic Carbon and Chemical Oxygen Demand tests (also found in this manual).
   3.3 The use of 60 ml incubation bottles in place of the usual 300 ml incubation bottles, in conjunction with the probe, is often convenient.
4. Precision and Accuracy
   4.1 Eighty-six analysts in fifty-eight laboratories analyzed natural water samples plus an exact increment of biodegradable organic compounds. At a mean value of 2.1 and 175 mg/1 BOD, the standard deviation was ±0.7 and ±26 mg/1, respectively (EPA Method Research Study 3).
   4.2 There is no acceptable procedure for determining the accuracy of the BOD test.

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5. References

5.1 The procedure to be used for this determination is found in:
Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 543, Method 507 (1975).

PHOSPHORUS, ALL FORMS

Method 365.1 (Colorimetric, Automated, Ascorbic Acid)

STORET NO. See Section 4

1. Scope and Application
   1.1 These methods cover the determination of specified forms of phosphorus in drinking, surface and saline waters, domestic and industrial wastes.
   1.2 The methods are based on reactions that are specific for the orthophosphate ion. Thus, depending on the prescribed pre-treatment of the sample, the various forms of phosphorus given in Figure 1 may be determined. These forms are defined in Section 4.
      1.2.1 Except for in-depth and detailed studies, the most commonly measured forms are phosphorus and dissolved phosphorus, and orthophosphate and dissolved orthophosphate. Hydrolyzable phosphorus is normally found only in sewage-type samples. Insoluble forms of phosphorus are determined by calculation.
   1.3 The methods are usable in the ~~0.001~~ 0.01 to 1.0 mg P/1 range. Approximately 20–30 samples per hour can be analyzed.
2. Summary of Method
   2.1 Ammonium molybdate and antimony potassium tartrate react in an acid medium with dilute solutions of phosphorus to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-colored complex by ascorbic acid. The color is proportional to the phosphorus concentration.
   2.2 Only orthophosphate forms a blue color in this test. Polyphosphates (and some organic phosphorus compounds) may be converted to the orthophosphate form by manual sulfuric acid hydrolysis. Organic phosphorus compounds may be converted to the orthophosphate form by manual persulfate digestion[2]. The developed color is measured automatically on the AutoAnalyzer.
3. Sample Handling and Preservation
   3.1 If benthic deposits are present in the area being sampled, great care should be taken not to include these deposits.
   3.2 Sample containers may be of plastic material; such as cubitainers, or of Pyrex glass.
   3.3 If the analysis cannot be performed the same day of collection, the sample should be preserved by the addition of 2 ml conc. H_2SO_4 per liter and refrigeration at 4°C.
4. Definitions and Storet Numbers
   4.1 Total Phosphorus (P) – all of the phosphorus present in the sample regardless of form, as measured by the persulfate digestion procedure. (00665)
      4.1.1 Total Orthophosphate (P-ortho)–inorganic phosphorus $[(PO_4)^{-3}]$ in the sample as measured by the direct colorimetric analysis procedure. (70507)

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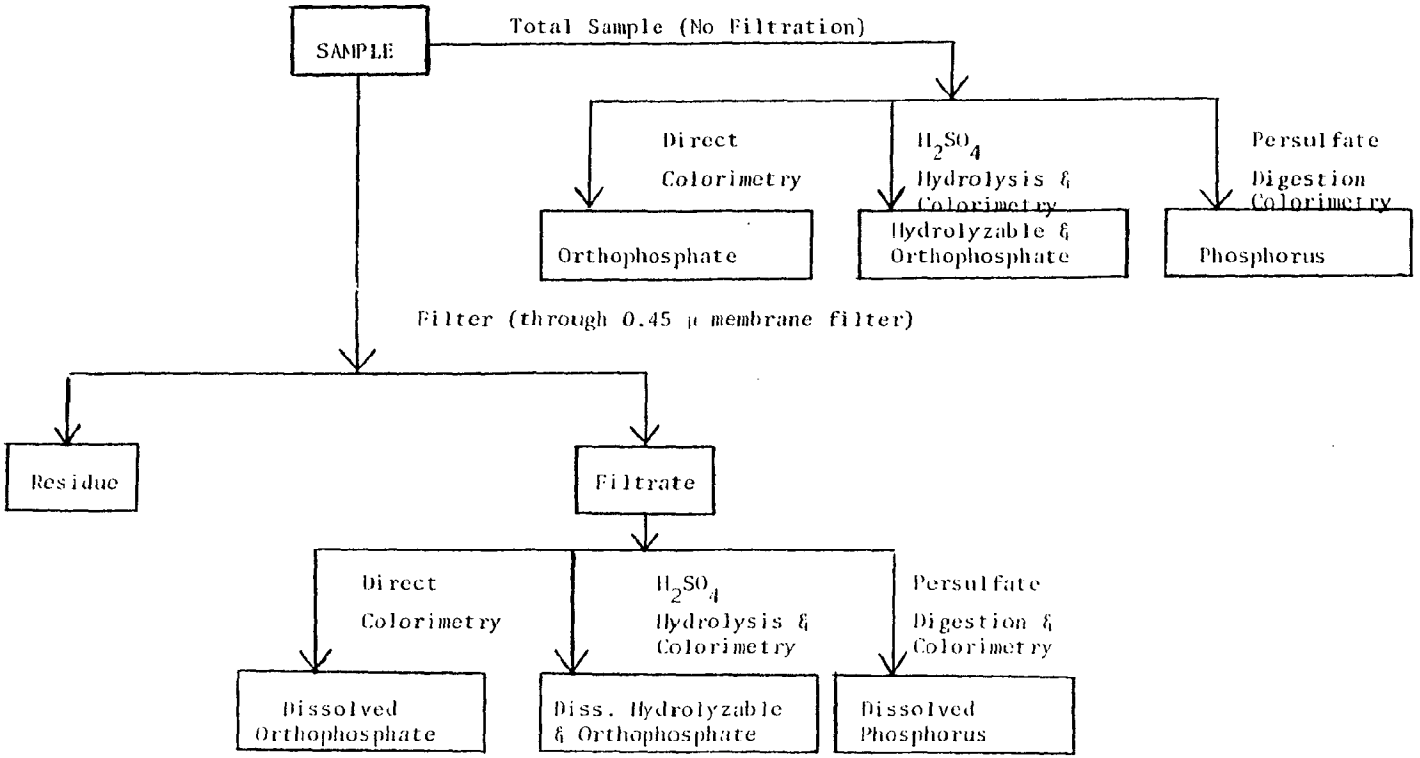

FIGURE 1. ANALYTICAL SCHEME FOR DIFFERENTIATION OF PHOSPHORUS FORMS

4.1.2 Total Hydrolyzable Phosphorus (P-hydro)–phosphorus in the sample as measured by the sulfuric acid hydrolysis procedure, and minus predetermined orthophosphates. This hydrolyzable phosphorus includes polyphosphates [$(P_2O_7)^{-4}$, $(P_3O_{10})^{-5}$, etc.] plus some organic phosphorus. (00669)

4.1.3 Total Organic Phosphorus (P-org)–phosphorus (inorganic plus oxidizable organic) in the sample as measured by the persulfate digestion procedure, and minus hydrolyzable phosphorus and orthophosphate. (00670)

4.2 Dissolved Phosphorus (P–D) – all of the phosphorus present in the filtrate of a sample filtered through a phosphorus-free filter of 0.45 micron pore size and measured by the persulfate digestion procedure. (00666)

4.2.1 Dissolved Orthophosphate (P–D, ortho) – as measured by the direct colorimetric analysis procedure. (00671)

4.2.2 Dissolved Hydrolyzable Phosphorus (P–D, hydro) – as measured by the sulfuric acid hydrolysis procedure and minus predetermined dissolved orthophosphates. (00672)

4.2.3 Dissolved Organic Phosphorus (P–D, org) – as measured by the persulfate digestion procedure, and minus dissolved hydrolyzable phosphorus and orthophosphate. (00673)

4.3 The following forms, when sufficient amounts of phosphorus are present in the sample to warrant such consideration, may be calculated:

4.3.1 Insoluble Phosphorus (P–I)=(P)–(P–D). (00667)

4.3.1.1 Insoluble orthophosphate (P–I, ortho)=(P, ortho) – (P–D, ortho). (00674)

4.3.1.2 Insoluble Hydrolyzable Phosphorus (P–I, hydro) = (P, hydro) – (P–D, hydro). (00675)

4.3.1.3 Insoluble Organic Phosphorus (P–I, org) = (P, org) – (P–D, org). (00676)

4.4 All phosphorus forms shall be reported as P, mg/1, to the third place.

5. Interferences

5.1 No interference is caused by copper, iron, or silicate at concentrations many times greater than their reported concentration in sea water. However, high iron concentrations can cause precipitation of and subsequent loss of phosphorus.

5.2 The salt error for samples ranging from 5 to 20% salt content was found to be less than 1%.

5.3 Arsenate is determined similarly to phosphorus and should be considered when present in concentrations higher than phosphorus. However, at concentrations found in sea water, it does not interfere.

5.4 Sample turbidity must be removed by filtration prior to analysis for orthophosphate. Samples for total or total hydrolyzable phosphorus should be filtered only after digestion. Sample color that absorbs in the photometric range used for analysis will also interfere.

6. Apparatus

6.1 Technicon AutoAnalyzer consisting of:

6.1.1 Sampler.
6.1.2 Manifold (AAI) or Analytical Cartridge (AAII).
6.1.3 Proportioning pump.
6.1.4 Heating bath, 50°C.
6.1.5 Colorimeter equipped with 15 or 50 mm tubular flow cell.
6.1.6 650–660 or 880 nm filter.
6.1.7 Recorder.
6.1.8 Digital printer for AAII (optional).

6.2 Hot plate or autoclave.

6.3 Acid-washed glassware: All glassware used in the determination should be washed with hot 1:1 HCl and rinsed with distilled water. The acid-washed glassware should be filled with distilled water and treated with all the reagents to remove the last traces of phosphorus that might be adsorbed on the glassware. Preferably, this glassware should be used only for the determination of phosphorus and after use it should be rinsed with distilled water and kept covered until needed again. If this is done, the treatment with 1:1 HCl and reagents is only required occasionally. Commercial detergent should never be used.

7. Reagents

7.1 Sulfuric acid solution, 5N: Slowly add 70 ml of conc. H_2SO_4 to approximately 400 ml of distilled water. Cool to room temperature and dilute to 500 ml with distilled water.

7.2 Antimony potassium tartrate solution: Weigh 0.3 g $K(SbO)C_4H_4O_6 \cdot 1/2H_2O$, dissolve in 50 ml distilled water in 100 ml volumetric flask, dilute to volume. Store at 4°C in a dark, glass-stoppered bottle.

7.3 Ammonium molybdate solution: Dissolve 4 g $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$ in 100 ml distilled water. Store in a plastic bottle at 4°C.

7.4 Ascorbic acid, 0.1M: Dissolve 1.8 g of ascorbic acid in 100 ml of distilled water. The solution is stable for about a week if prepared with water containing no more than trace amounts of heavy metals and stored at 4°C.

7.5 Combined reagent (AAI): Mix the above reagents in the following proportions for 100 ml of the mixed reagent: 50 ml of 5N H_2SO_4 (7.1), 5 ml of antimony potassium tartrate solution (7.2), 15 ml of ammonium molybdate solution (7.3), and 30 ml of ascorbic acid solution (7.4). Mix after addition of each reagent. All reagents must reach room temperature before they are mixed and must be mixed in the order given. If turbidity forms in the combined reagent, shake and let stand for a few minutes until the turbidity disappears before processing. This volume is sufficient for 4 hours operation. Since the stability of this solution is limited, it must be freshly prepared for each run.

NOTE 1: A stable solution can be prepared by not including the ascorbic acid in the combined reagent. If this is done, the mixed reagent (molybdate, tartrate, and acid) is pumped through the distilled water line and the ascorbic acid solution (30 ml of 7.4 diluted to 100 ml with distilled water) through the original mixed reagent line.

7.6 Sulfuric acid solution, 11 N: Slowly add 310 ml conc. H_2SO_4 to 600 ml distilled water. When cool, dilute to 1 liter.

7.7 Ammonium persulfate.

7.8 Acid wash water: Add 40 ml of sulfuric acid solution (7.6) to 1 liter of distilled water and dilute to 2 liters. (Not to be used when only orthophosphate is being determined).

7.9 Phenolphthalein indicator solution (5 g/l): Dissolve 0.5 g of phenolphthalein in a solution of 50 ml of ethyl or isopropyl alcohol and 50 ml of distilled water.

7.10 Stock phosphorus solution: Dissolve 0.4393 g of pre-dried (105°C for 1 hour) KH_2PO_4 in distilled water and dilute to 1000 ml. 1.0 ml = 0.1 mg P.

7.11 Standard phosphorus solution: Dilute 100.0 ml of stock solution (7.10) to 1000 ml with distilled water. 1.0 ml = 0.01 mg P.

7.12 Standard phosphorus solution: Dilute 100.0 ml of standard solution (7.11) to 1000 ml with distilled water. 1.0 ml = 0.001 mg P.

7.13 Prepare a series of standards by diluting suitable volumes of standard solutions (7.11) and (7.12) to 100.0 ml with distilled water. The following dilutions are suggested:

ml of Standard Phosphorus Solution (7.12)	Conc., mg P/l
0.0	0.00
2.0	0.02
5.0	0.05
10.0	0.10

ml of Standard Phosphorus Solution (7.11)	mg P/l
2.0	0.20
5.0	0.50
8.0	0.80
10.0	1.00

8. Procedure

8.1 Phosphorus

8.1.1 Add 1 ml of sulfuric acid solution (7.6) to a 50 ml sample and/or standard in a 125 ml Erlenmeyer flask.

8.1.2 Add 0.4 g of ammonium persulfate.

8.1.3 Boil gently on a pre-heated hot plate for approximately 30–40 minutes or until a final volume of about 10 ml is reached. Do not allow sample to go to dryness. Alternately, heat for 30 minutes in an autoclave at 121°C (15–20 psi).

8.1.4 Cool and dilute the sample to 50 ml. If sample is not clear at this point, filter.

8.1.5 Determine phosphorus as outlined in (8.3.2) with acid wash water (7.8) in wash tubes.

8.2 Hydrolyzable Phosphorus

8.2.1 Add 1 ml of sulfuric acid solution (7.6) to a 50 ml sample and/or standard in a 125 ml Erlenmeyer flask.

8.2.2 Boil gently on a pre-heated hot plate for 30–40 minutes or until a final volume of about 10 ml is reached. Do not allow sample to go to dryness. Alternatively, heat for 30 minutes in an autoclave at 121°C (15–20 psi).

8.2.3 Cool and dilute the sample to 50 ml. If sample is not clear at this point, filter.

8.2.4 Determine phosphorus as outlined in (8.3.2) with acid wash water (7.8) in wash tubes.

8.3 Orthophosphate

8.3.1 Add 1 drop of phenolphthalein indicator solution (7.9) to approximately 50 ml of sample. If a red color develops, add sulfuric acid solution (7.6) drop-wise to just discharge the color. Acid samples must be neutralized with 1 N sodium hydroxide (40 g NaOH/1).

8.3.2 Set up manifold as shown in Figure 2, AAI or Figure 3, AAII.

8.3.3 Allow both colorimeter and recorder to warm up for 30 minutes. Obtain a stable baseline with all reagents, feeding distilled water through the sample line.

8.3.4 For the AAI system, sample at a rate of 20/hr, 1 minute sample, 2 minute wash. For the AAII system, use a 30/hr, 2:1 cam, and a common wash.

8.3.5 Place standards in Sampler in order of decreasing concentration. Complete filling of sampler tray with unknown samples.

8.3.6 Switch sample line from distilled water to Sampler and begin analysis.

9. Calculation

9.1 Prepare a standard curve by plotting peak heights of processed standards against known concentrations. Compute concentrations of samples by comparing sample peak heights with standard curve. Any sample whose computed value is less than 5% of its immediate predecessor must be rerun.

10. Precision and Accuracy (AAI system)

10.1 Six laboratories participating in an EPA Method Study, analyzed four natural water samples containing exact increments of orthophosphate, with the following results:

Increment as Orthophosphate mg P/liter	Precision as Standard Deviation mg P/liter	Accuracy as Bias, %	Accuracy as Bias, mg P/liter
0.04	0.019	+16.7	+0.007
0.04	0.014	- 8.3	–0.003
0.29	0.087	–15.5	–0.05
0.30	0.066	–12.8	–0.04

10.2 In a single laboratory (EMSL), using surface water samples at concentrations of 0.04, 0.19, 0.35, and 0.84 mg P/1, standard deviations were ±0.005, ±0.000, ±0.003, and ±0.000, respectively.

10.3 In a single laboratory (EMSL), using surface water samples at concentrations of 0.07 and 0.76 mg p/1, recoveries were 99% and 100%, respectively.

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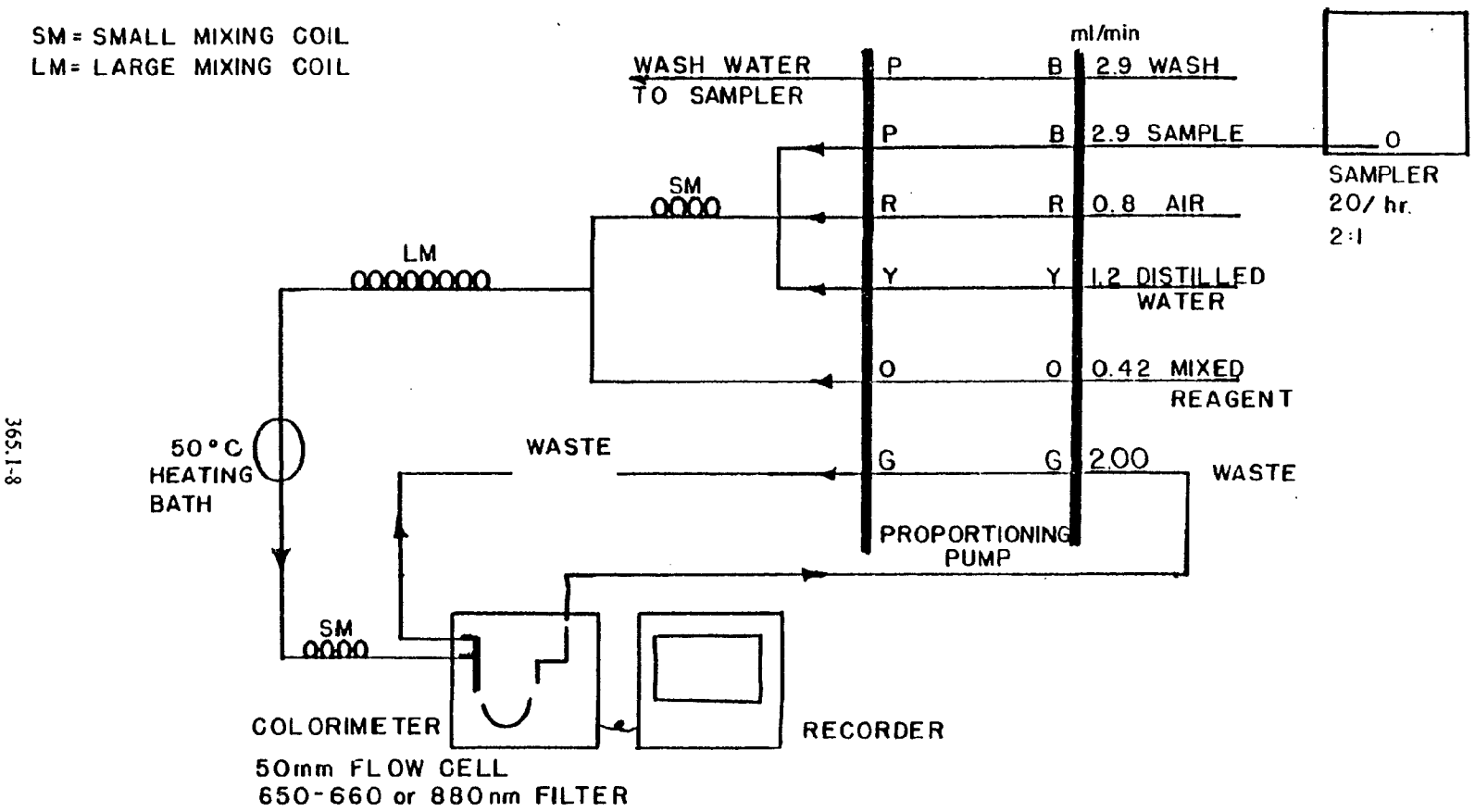

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FIGURE 2 PHOSPHORUS MANIFOLD AA I

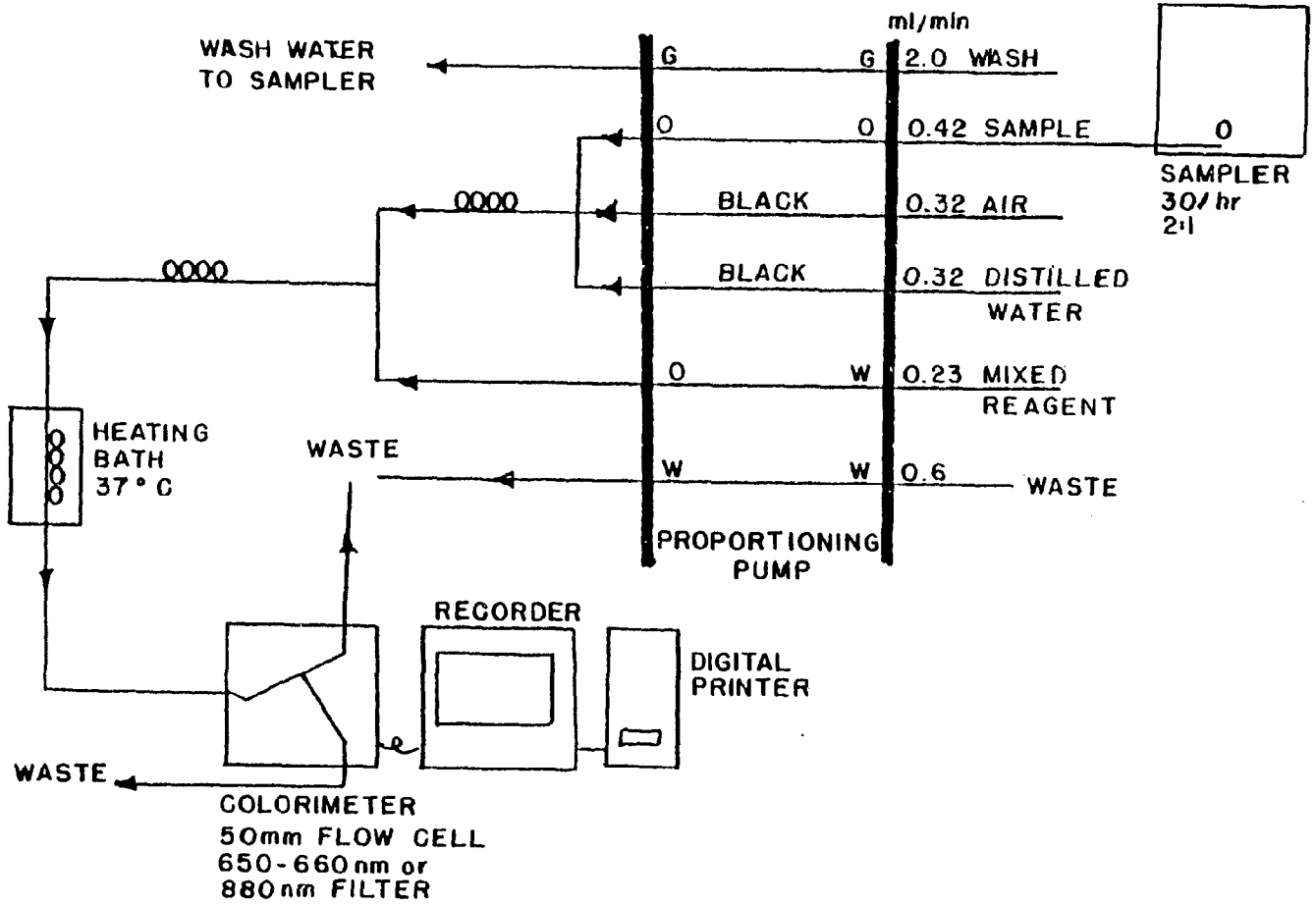

FIGURE 3 PHOSPHORUS MANIFOLD AA II

RESIDUE, NON-FILTERABLE

Method 160.2 (Gravimetric, Dried at 103–105°C)

STORET NO. 00530

1. Scope and Application
   1.1 This method is applicable to drinking, surface, and saline waters, domestic and industrial wastes.
   1.2 The practical range of the determination is 4 mg/l to 20,000 mg/l.
2. Summary of Method
   2.1 A well-mixed sample is filtered through a glass fiber filter, and the residue retained on the filter is dried to constant weight at 103–105°C.
   2.2 The filtrate from this method may be used for Residue, Filterable.
3. Definitions
   3.1 Residue, non-filterable, is defined as those solids which are retained by a glass fiber filter and dried to constant weight at 103–105°C.
4. Sample Handling and Preservation
   4.1 Non-representative particulates such as leaves, sticks, fish, and lumps of fecal matter should be excluded from the sample if it is determined that their inclusion is not desired in the final result.
   4.2 Preservation of the sample is not practical; analysis should begin as soon as possible. Refrigeration or icing to 4°C, to minimize microbiological decomposition of solids, is recommended.
5. Interferences
   5.1 Filtration apparatus, filter material, pre-washing, post-washing, and drying temperature are specified because these variables have been shown to affect the results.
   5.2 Samples high in Filterable Residue (dissolved solids), such as saline waters, brines and some wastes, may be subject to a positive interference. Care must be taken in selecting the filtering apparatus so that washing of the filter and any dissolved solids in the filter (7.5) minimizes this potential interference.
6. Apparatus
   6.1 Glass fiber filter discs, without organic binder, such as Millipore AP-40, Reeves Angel 934-AH, Gelman type A/E, or equivalent.
   NOTE: Because of the physical nature of glass fiber filters, the absolute pore size cannot be controlled or measured. Terms such as "pore size", collection efficiencies and effective retention are used to define this property in glass fiber filters. Values for these parameters vary for the filters listed above.
   6.2 Filter support: filtering apparatus with reservoir and a coarse (40–60 microns) fritted disc as a filter support.

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Issued 1971

NOTE: Many funnel designs are available in glass or porcelain. Some of the most common are Hirsch or Buchner funnels, membrane filter holders and Gooch crucibles. All are available with coarse fritted disc.

6.3 Suction flask.

6.4 Drying oven, 103–105°C.

6.5 Desiccator.

6.6 Analytical balance, capable of weighing to 0.1 mg.

7. Procedure

7.1 Preparation of glass fiber filter disc: Place the glass fiber filter on the membrane filter apparatus or insert into bottom of a suitable Gooch crucible with wrinkled surface up. While vacuum is applied, wash the disc with three successive 20 ml volumes of distilled water. Remove all traces of water by continuing to apply vacuum after water has passed through. Remove filter from membrane filter apparatus or both crucible and filter if Gooch crucible is used, and dry in an oven at 103–105°C for one hour. Remove to desiccator and store until needed. Repeat the drying cycle until a constant weight is obtained (weight loss is less than 0.5 mg). Weigh immediately before use. After weighing, handle the filter or crucible/filter with forceps or tongs only.

7.2 Selection of Sample Volume

For a 4.7 cm diameter filter, filter 100 ml of sample. If weight of captured residue is less than 1.0 mg, the sample volume must be increased to provide at least 1.0 mg of residue. If other filter diameters are used, start with a sample volume equal to 7 ml/cm^2 of filter area and collect at least a weight of residue proportional to the 1.0 mg stated above.

NOTE: If during filtration of this initial volume the filtration rate drops rapidly, or if filtration time exceeds 5 to 10 minutes, the following scheme is recommended: Use an unweighed glass fiber filter of choice affixed in the filter assembly. Add a known volume of sample to the filter funnel and record the time elapsed after selected volumes have passed through the filter. Twenty-five ml increments for timing are suggested. Continue to record the time and volume increments until fitration rate drops rapidly. Add additional sample if the filter funnel volume is inadequate to reach a reduced rate. Plot the observed time versus volume filtered. Select the proper filtration volume as that just short of the time a significant change in filtration rate occurred.

7.3 Assemble the filtering apparatus and begin suction. Wet the filter with a small volume of distilled water to seat it against the fritted support.

7.4 Shake the sample vigorously and quantitatively transfer the predetermined sample volume selected in 7.2 to the filter using a graduated cylinder. Remove all traces of water by continuing to apply vacuum after sample has passed through.

7.5 With suction on, wash the graduated cylinder, filter, non-filterable residue and filter funnel wall with three portions of distilled water allowing complete drainage between washing. Remove all traces of water by continuing to apply vacuum after water has passed through.

NOTE: Total volume of wash water used should equal approximately 2 ml per cm^2. For a 4.7 cm filter the total volume is 30 ml.

7.6 Carefully remove the filter from the filter support. Alternatively, remove crucible and filter from crucible adapter. Dry at least one hour at 103–105°C. Cool in a desiccator and weigh. Repeat the drying cycle until a constant weight is obtained (weight loss is less than 0.5 mg).

8. Calculations

8.1 Calculate non-filterable residue as follows:

$$\text{Non-filterable residue, mg/l} = \frac{(A - B) \times 1{,}000}{C}$$

where:

A = weight of filter (or filter and crucible) + residue in mg
B = weight of filter (or filter and crucible) in mg
C = ml of sample filtered

9. Precision and Accuracy

9.1 Precision data are not available at this time.

9.2 Accuracy data on actual samples cannot be obtained.

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PHOSPHORUS, TOTAL

Method 365.4 (Colorimetric, Automated, Block Digestor AA II)

STORET NO. 00665

1. Scope and Application
   1.1 This method covers the determination of total phosphorus in drinking water, surface water and domestic and industrial wastes. The applicable range of this method is 0.01 to 20 mg P/l.
2. Summary of Method
   2.1 The sample is heated in the presence of sulfuric acid, K_2SO_4 and $HgSO_4$ for two and one half hours. The residue is cooled, diluted to 25 ml and placed on the AutoAnalyzer for phosphorus determination.
3. Sample Handling and Preservation
   3.1 Sample containers may be of plastic material, such as a cubitainer, or of Pyrex glass.
   3.2 If the analysis cannot be performed the day of collection, the sample should be preserved by the addition of 2 ml of conc. H_2SO_4 per liter and refrigeration at 4°C.
4. Apparatus
   4.1 Block Digestor BD–40
   4.2 Technicon Method No. 327–74W for Phosphorus
5. Reagents
   5.1 Mercuric sulfate: Dissolve 8 g red mercuric oxide (HgO) in 50 ml of 1:4 sulfuric acid (10 conc. H_2SO_4: 40 ml distilled water) and dilute to 100 ml with distilled water.
   5.2 Digestion solution: (Sulfuric acid-mercuric sulfate-potassium sulfate solution): Dissolve 133 g of K_2SO_4 in 600 ml of distilled water and 200 ml of conc. H_2SO_4. Add 25 ml of mercuric sulfate solution (5.1) and dilute to 1 liter.
   5.3 Sulfuric acid solution (0.72 N): Add 20 ml of conc. sulfuric acid to 800 of distilled water, mix and dilute to 1 liter.
   5.4 Molybdate/antimony solution: Dissolve 8 g of ammonium molybdate and 0.2 g of antimony potassium tartrate in about 800 ml of distilled water and dilute to 1 liter.
   5.5 Ascorbic acid solution: Dissolve 60 g of ascorbic acid in about 600 ml of distilled water. Add 2 ml of acetone and dilute to 1 liter.
   5.6 Diluent water: Dissolve 40 g of NaCl in about 600 ml of distilled water and dilute to 1 liter.
   5.7 Sulfuric acid solution, 4%: Add 40 ml of conc. sulfuric acid to 800 ml of ammonia-free distilled water, cool and dilute to 1 liter.
6. Procedure

   Digestion

   6.1 To 20 or 25 ml of sample, add 5 ml of digestion solution and mix. (Use a vortex mixer).
   6.2 Add 4–8 Teflon boiling chips. Too many boiling chips will cause the sample to boil over.

Issued 1974

6.3 With Block Digestor in manual mode set low and high temperature at 160°C and preheat unit to 160°C. Place tubes in digestor and switch to automatic mode. Set low temperature timer for 1 hour. Reset high temperature to 380°C and set timer for 2 1/2 hours.

6.4 Cool sample and dilute to 25 ml with distilled water. If TKN is determined the sample should be diluted with ammonia-free water.

Colorimetric Analysis

6.4.1 Check the level of all reagent containers to ensure an adequate supply.

6.4.2 Excluding the molybdate/antimony line, place all reagent lines in their respective containers, connect the sample probe to the Sampler IV and start the proportioning pump.

6.4.3 Flush the Sampler IV wash receptacle with about 25 ml of 4% sulfuric acid (5.7).

6.4.4 When reagents have been pumping for at least five minutes, place the molybdate/antimony line in its container and allow the system to equilibrate.

6.4.5 After a stable baseline has been obtained, start the sampler.

7. Calculations

7.1 Prepare a standard curve by plotting peak heights of processed standards against concentration values. Compute concentrations by comparing sample peak heights with the standard curve.

8. Precision and Accuracy

8.1 In a single laboratory (EMSL) using sewage sample containing total P at levels of 0.23, 1.33, and 2.0, the precision was ±0.01, ±0.04, and ±0.06, respectively.

8.2 In a single laboratory (EMSL) using sewage samples of concentration 1.84 and 1.89, the recoveries were 95 and 98%, respectively.

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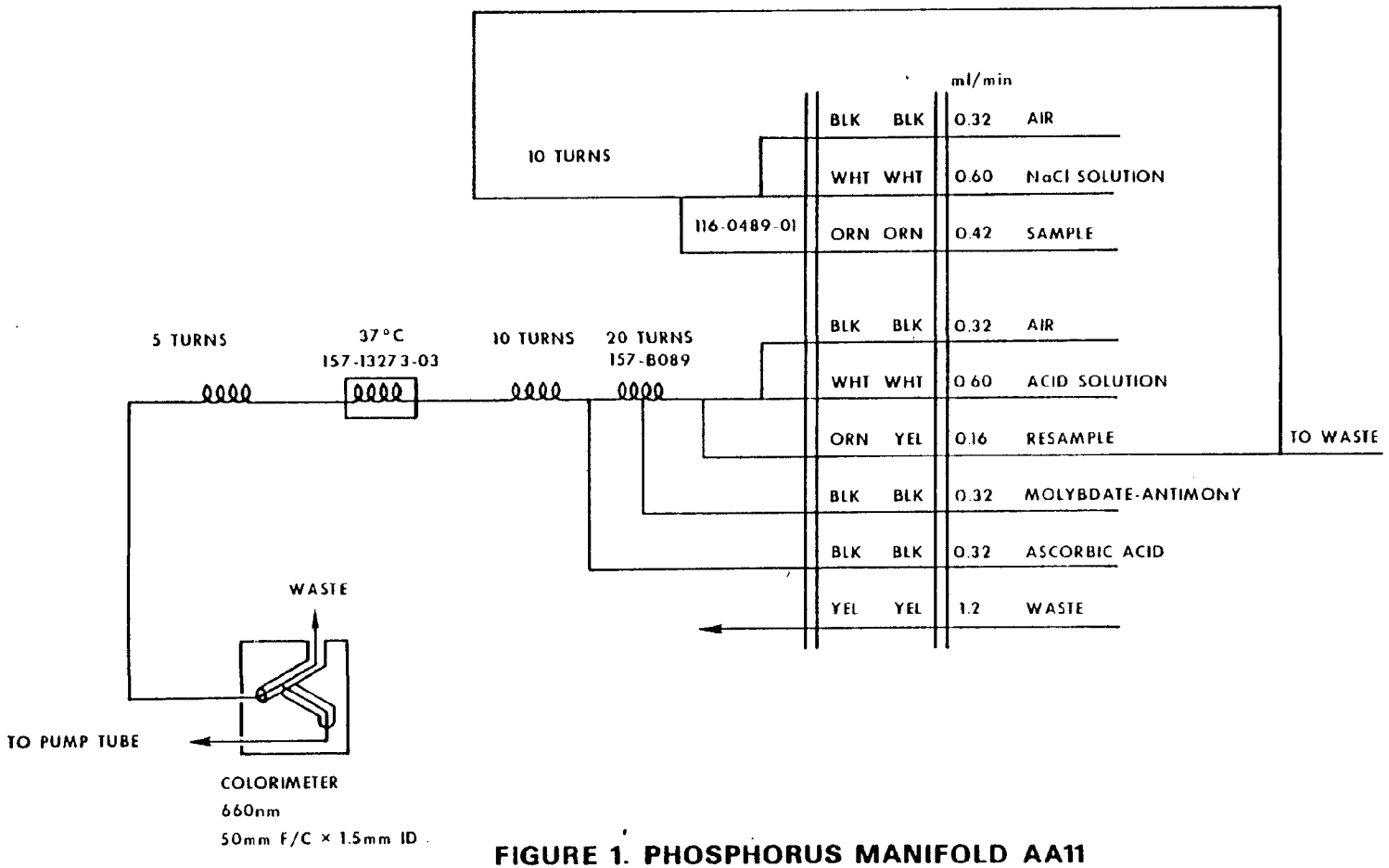


FIGURE 1. PHOSPHORUS MANIFOLD AA11

NITROGEN, NITRATE-NITRITE

Method 353.2 (Colorimetric, Automated, Cadmium Reduction)

STORET NO. Total 00630

1. Scope and Application
   1.1 This method pertains to the determination of nitrite singly, or nitrite and nitrate combined in surface and saline waters, and domestic and industrial wastes. The applicable range of this method is 0.05 to 10.0 mg/1 nitrate-nitrite nitrogen. The range may be extended with sample dilution.
2. Summary of Method
   2.1 A filtered sample is passed through a column containing granulated copper-cadmium to reduce nitrate to nitrite. The nitrite (that originally present plus reduced nitrate) is determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye which is measured colorimetrically. Separate, rather than combined nitrate-nitrite, values are readily obtained by carrying out the procedure first with, and then without, the Cu-Cd reduction step.
3. Sample Handling and Preservation
   3.1 Analysis should be made as soon as possible. If analysis can be made within 24 hours, the sample should be preserved by refrigeration at 4°C. When samples must be stored for more than 24 hours, they should be preserved with sulfuric acid (2 ml conc. H_2SO_4 per liter) and refrigeration.
   Caution: Samples for reduction column must not be preserved with mercuric chloride.
4. Interferences
   4.1 Build up of suspended matter in the reduction column will restrict sample flow. Since nitrate-nitrogen is found in a soluble state, the sample may be pre-filtered.
   4.2 Low results might be obtained for samples that contain high concentrations of iron, copper or other metals. EDTA is added to the samples to eliminate this interference.
   4.3 Samples that contain large concentrations of oil and grease will coat the surface of the cadmium. This interference is eliminated by pre-extracting the sample with an organic solvent.
5. Apparatus
   5.1 Technicon AutoAnalyzer (AAI or AAII) consisting of the following components:
      5.1.1 Sampler.
      5.1.2 Manifold (AAI) or analytical cartridge (AAII).
      5.1.3 Proportioning Pump
      5.1.4 Colorimeter equipped with a 15 mm or 50 mm tubular flow cell and 540 nm filters.
      5.1.5 Recorder.

Approved for NPDES and SDWA
Issued 1971
Editorial revision 1974 and 1978

5.1.6 Digital printer for AAII (Optional).

6. Reagents

MCB Reagents

6.1 Granulated cadmium: 40–60 mesh (~~E M Laboratories, Inc., 500 Exec. Blvd., Elmsford, NY 10523~~, Cat. 2001 Cadmium, Coarse Powder).

6.2 Copper-cadmium: The cadmium granules (new or used) are cleaned with dilute HCl (6.7) and copperized with 2% solution of copper sulfate (6.8) in the following manner:

6.2.1 Wash the cadmium with HCl (6.7) and rinse with distilled water. The color of the cadmium so treated should be silver.

6.2.2 Swirl 10 g cadmium in 100 ml portions of 2% solution of copper sulfate (6.8) for five minutes or until blue color partially fades, decant and repeat with fresh copper sulfate until a brown colloidal precipitate forms.

6.2.3 Wash the cadmium-copper with distilled water (at least 10 times) to remove all the precipitated copper. The color of the cadmium so treated should be black.

6.3 Preparation of reduction column AAI: The reduction column is an 8 by 50 mm glass tube with the ends reduced in diameter to permit insertion into the system. Copper-cadmium granules (6.2) are placed in the column between glass wool plugs. The packed reduction column is placed in an up-flow 20° incline to minimize channeling. See Figure 1.

6.4 Preparation of reduction column AAII: The reduction column is a U-shaped, 35 cm length, 2 mm I.D. glass tube (Note 1). Fill the reduction column with distilled water to prevent entrapment of air bubbles during the filling operations. Transfer the copper-cadmium granules (6.2) to the reduction column and place a glass wool plug in each end. To prevent entrapment of air bubbles in the reduction column be sure that all pump tubes are filled with reagents before putting the column into the analytical system.

NOTE 1: A 0.081 I.D. pump tube (purple) can be used in place of the 2 mm glass tube.

6.5 Distilled water: Because of possible contamination, this should be prepared by passage through an ion exchange column comprised of a mixture of both strongly acidic-cation and strongly basic-anion exchange resins. The regeneration of the ion exchange column should be carried out according to the manufacturer's instructions.

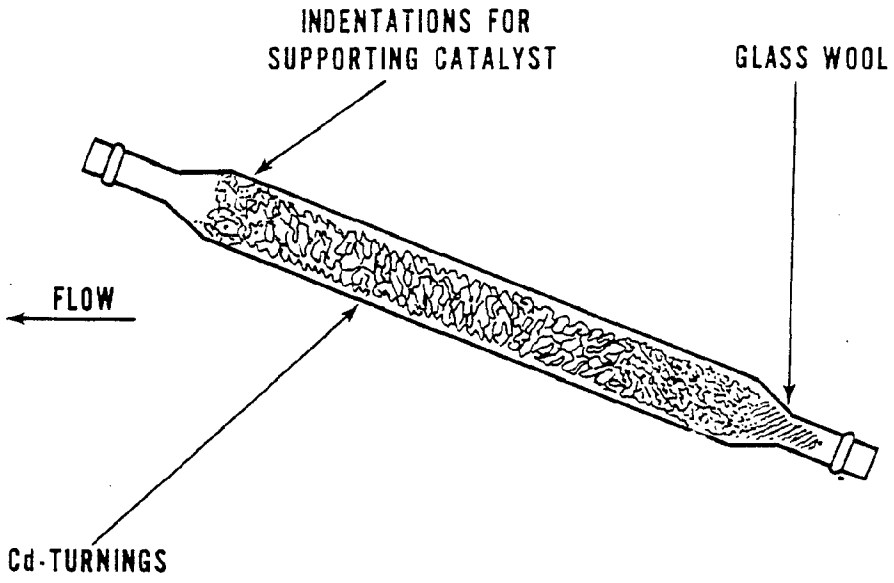
6.6 Color reagent: To approximately 800 ml of distilled water, add, while stirring, 100 ml conc. phosphoric acid, 40 g sulfanilamide, and 2 g N-1- naphthylethylenediamine dihydrochloride. Stir until dissolved and dilute to 1 liter. Store in brown bottle and keep in the dark when not in use. This solution is stable for several months.

6.7 Dilute hydrochloric acid, 6N: Dilute 50 ml of conc. HCl to 100 ml with distilled water.

6.8 Copper sulfate solution, 2%: Dissolve 20 g of $CuSO_4 \cdot 5H_2O$ in 500 ml of distilled water and dilute to 1 liter.

6.9 Wash solution: Use distilled water for unpreserved samples. For samples preserved with H_2SO_4, use 2 ml H_2SO_4 per liter of wash water.

6.10 Ammonium chloride–EDTA solution: Dissolve 85 g of reagent grade ammonium chloride and 0.1 g of disodium ethylenediamine tetracetate in 900 ml of distilled water. Adjust the pH to 8.5 with conc. ammonium hydroxide and dilute to 1 liter. Add 1/2 ml Brij-35 (available from Technicon Corporation).



TILT COLUMN TO 20° POSTION

FIGURE 1. COPPER CADMIUM REDUCTION COLUMN
(1 1/2 ACTUAL SIZE)

6.11. Stock nitrate solution: Dissolve 7.218 g KNO_3 and dilute to 1 liter in a volumetric flask with distilled water. Preserve with 2 ml of chloroform per liter. Solution is stable for 6 months. 1 ml = 1.0 mg NO_3–N.

6.12 Stock nitrite solution: Dissolve 6.072 g KNO_2 in 500 ml of distilled water and dilute to 1 liter in a volumetric flask. Preserve with 2 ml of chloroform and keep under refrigeration. 1.0 ml = 1.0 mg NO_2–N.

6.13 Standard nitrate solution: Dilute 10.0 ml of stock nitrate solution (6.11) to 1000 ml. 1.0 ml = 0.01 mg NO_3-N. Preserve with 2 ml of chloroform per liter. Solution is stable for 6 months.

6.14 Standard nitrite solution: Dilute 10.0 ml of stock nitrite (6.12) solution to 1000 ml. 1.0 ml = 0.01 mg NO_2-N. Solution is unstable; prepare as required.

6.15 Using standard nitrate solution (6.13), prepare the following standards in 100.0 ml volumetric flasks. At least one nitrite standard should be compared to a nitrate standard at the same concentration to verify the efficiency of the reduction column.

Conc., mgNO_2–N or NO_3-N/l	ml Standard Solution/100 ml
0.0	0
0.05	0.5
0.10	1.0
0.20	2.0
0.50	5.0
1.00	10.0
2.00	20.0
4.00	40.0
6.00	60.0

NOTE 2: When the samples to be analyzed are saline waters, Substitute Ocean Water (SOW) should be used for preparing the standards; otherwise, distilled water is used. A tabulation of SOW composition follows:

NaCl – 24.53 g/l	$MgCl_2$ – 5.20 g/l	Na_2SO_4 – 4.09 g/l
$CaCl_2$ – 1.16 g/l	KCl – 0.70 g/l	$NaHCO_3$ – 0.20 g/l
KBr – 0.10 g/l	H_3BO_3 – 0.03 g/l	$SrCl_2$ – 0.03 g/l
NaF – 0.003 g/l		

7. Procedure

7.1 If the pH of the sample is below 5 or above 9, adjust to between 5 and 9 with either conc. HCl or conc. NH_4OH.

7.2 Set up the manifold as shown in Figure 2 (AAI) or Figure 3 (AAII). Note that reductant column should be in 20° incline position (AAI). Care should be taken not to introduce air into reduction column on the AAII.

7.3 Allow both colorimeter and recorder to warm up for 30 minutes. Obtain a stable baseline with all reagents, feeding distilled water through the sample line.

NOTE 3: Condition column by running 1 mg/l standard for 10 minutes if a new reduction column is being used. Subsequently wash the column with reagents for 20 minutes.

7.4 Place appropriate nitrate and/or nitrite standards in sampler in order of decreasing concentration of nitrogen. Complete loading of sampler tray with unknown samples.

7.5 For the AAI system, sample at a rate of 30/hr, 1:1. For the AAII, use a 40/hr, 4:1 cam and a common wash.

7.6 Switch sample line to sampler and start analysis.

8. Calculations

8.1 Prepare appropriate standard curve or curves derived from processing NO_2 and/or NO_3 standards through manifold. Compute concentration of samples by comparing sample peak heights with standard curve.

9. Precision and Accuracy

9.1 Three laboratories participating in an EPA Method Study, analyzed four natural water samples containing exact increments of inorganic nitrate, with the following results:

Increment as Nitrate Nitrogen mg N/liter	Precision as Standard Deviation mg N/liter	Accuracy as Bias, %	Accuracy as Bias, mg N/liter
0.29	0.012	+ 5.75	+0.017
0.35	0.092	+18.10	+0.063
2.31	0.318	+ 4.47	+0.103
2.48	0.176	− 2.69	−0.067

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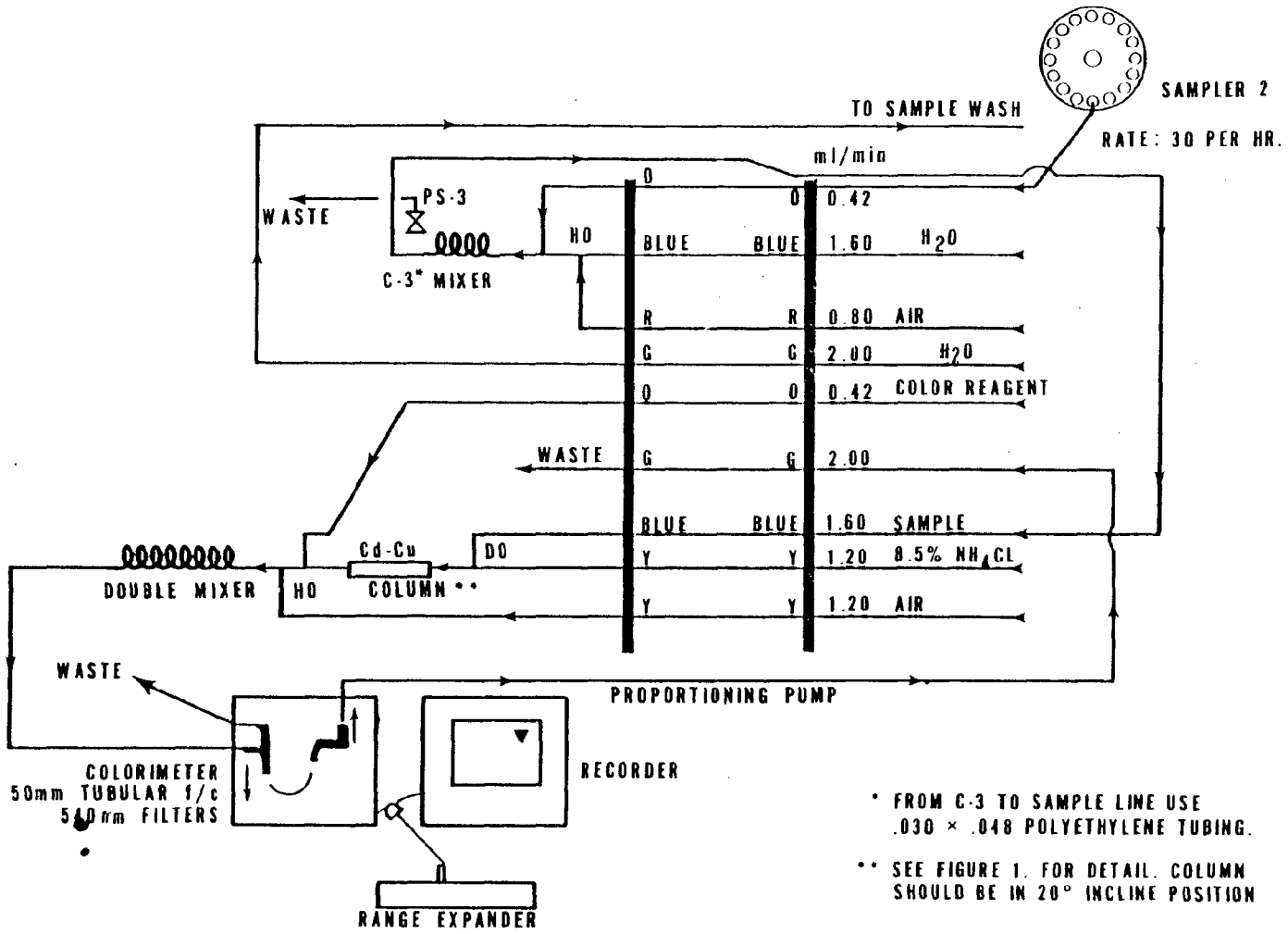
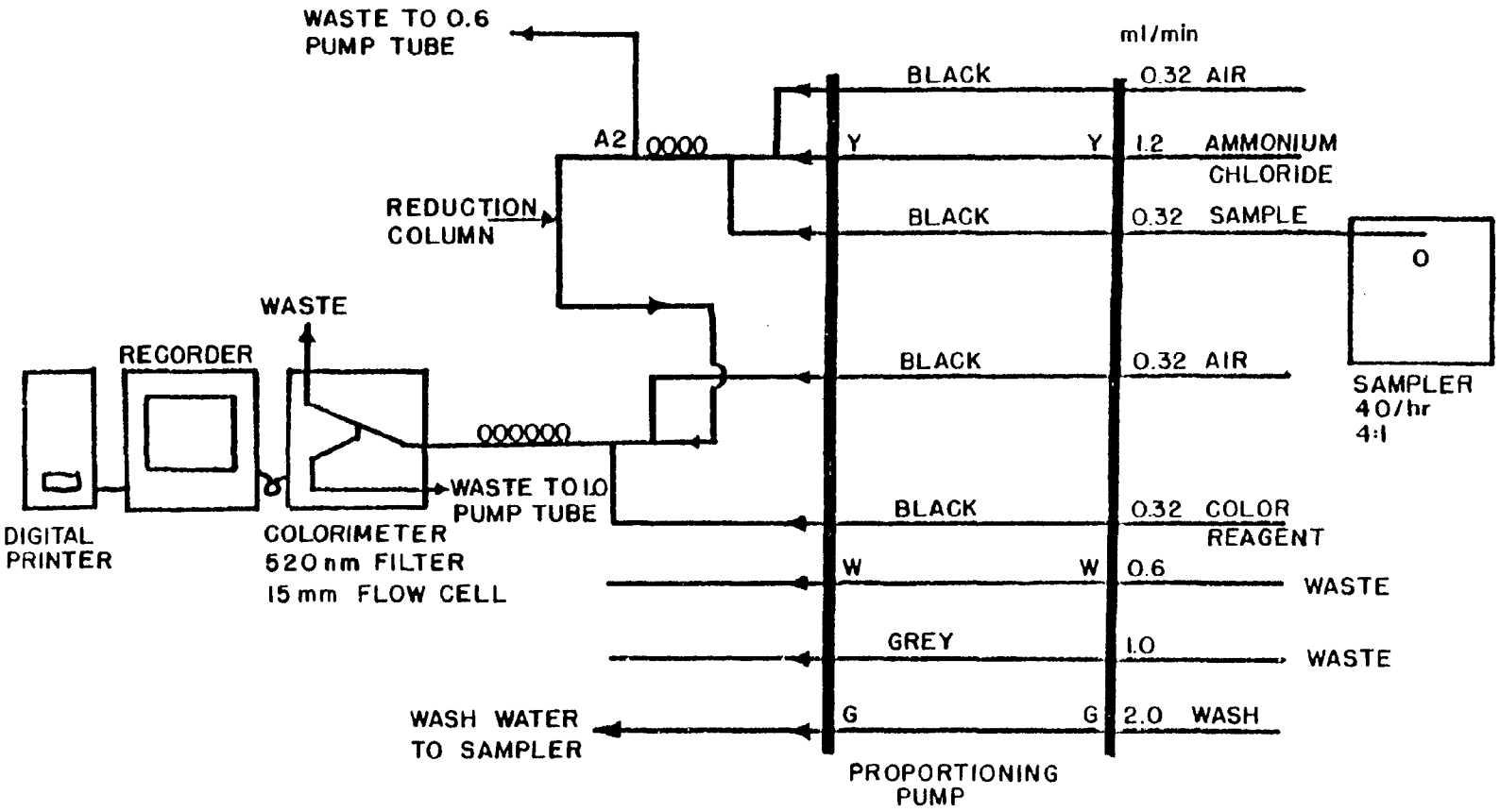


FIGURE 2. NITRATE - NITRITE MANIFOLD AA-I



353.2-7

FIGURE 3 NITRATE-NITRITE MANIFOLD AA II

NITROGEN, KJELDAHL, TOTAL

Method 351.2 (Colorimetric, Semi-Automated Block Digester, AAII)

STORET NO. 00625

1. Scope and Application
   1.1 This method covers the determination of total Kjeldahl nitrogen in drinking and surface waters, domestic and industrial wastes. The procedure converts nitrogen components of biological origin such as amino acids, proteins and peptides to ammonia, but may not convert the nitrogeneous compounds of some industrial wastes such as amines, nitro compounds, hydrazones, oximes, semicarbazones and some refractory tertiary amines. The applicable range of this method is 0.1 to 20 mg/1 TKN. The range may be extended with sample dilution.
2. Summary of Method
   2.1 The sample is heated in the presence of sulfuric acid, K_2SO_4 and $HgSO_4$ for two and one half hours. The residue is cooled, diluted to 25 ml and placed on the AutoAnalyzer for ammonia determination. This digested sample may also be used for phosphorus determination.
3. Definitions
   3.1 Total Kjeldahl nitrogen is defined as the sum of free-ammonia and organic nitrogen compounds which are converted to ammonium sulfate $(NH_4)_2SO_4$, under the conditions of digestion described below.
   3.2 Organic Kjeldahl nitrogen is defined as the difference obtained by subtracting the free-ammonia value (Method 350.2, Nitrogen, Ammonia, this manual) from the total Kjeldahl nitrogen value.
4. Sample Handling and Preservation
   4.1 Samples may be preserved by addition of 2 ml of conc H_2SO_4 per liter and stored at 4°C. Even when preserved in this manner, conversion of organic nitrogen to ammonia may occur. Therefore, samples should be analyzed as soon as possible.
5. Apparatus
   5.1 Block Digestor–40
   5.2 Technicon Manifold for Ammonia (Figure 1)
   5.3 Chemware TFE (Teflon boiling stones), Markson Science, Inc., Box 767, Delmar, CA 92014)
6. Reagents
   6.1 Mercuric Sulfate: Dissolve 8 g red mercuric oxide (HgO) in 50 ml of 1:4 sulfuric acid (10 ml conc H_2SO_4: 40 ml distilled water) and dilute to 100 ml with distilled water.
   6.2 Digestion Solution: (Sulfuric acid-mercuric sulfate-potassium sulfate solution): Dissolve 133 g of K_2SO_4 in 700 ml of distilled water and 200 ml of conc H_2SO_4. Add 25 ml of mercuric sulfate solution and dilute to 1 liter.

Issued 1978

6.3 Sulfuric Acid Solution (4%): Add 40 ml of conc. sulfuric acid to 800 ml of ammonia free distilled water, cool and dilute to 1 liter.

6.4 Stock Sodium Hydroxide (20%): Dissolve 200 g of sodium hydroxide in 900 ml of ammonia-free distilled water and dilute to 1 liter.

6.5 Stock Sodium Potassium Tartrate Solution (20%): Dissolve 200 g sodium potassium tartrate in about 800 ml of ammonia-free distilled water and dilute to 1 liter.

6.6 Stock Buffer Solution: Dissolve 134.0 g of sodium phosphate, dibasic (Na_2HPO_4) in about 800 ml of ammonia free water. Add 20 g of sodium hydroxide and dilute to 1 liter.

6.7 Working Buffer Solution: Combine the reagents in the stated order: add 250 ml of stock sodium potassium tartrate solution (6.5) to 200 ml of stock buffer solution (6.6) and mix. Add xx ml sodium hydroxide solution (6.4) and dilute to 1 liter. See concentration ranges, Table I, for composition of working buffer.

6.8 Sodium Salicylate/Sodium Nitroprusside Solution: Dissolve 150 g of sodium salicylate and 0.3 g of sodium nitroprusside in about 600 ml of ammonia free water and dilute to 1 liter.

6.9 Sodium Hypochlorite Solution: Dilute 6.0 ml sodium hypochlorite solution (clorox) to 100 ml with ammonia free distilled water.

6.10 Ammonium chloride, stock solution: Dissolve 3.819 g NH_4Cl in distilled water and bring to volume in a 1 liter volumetric flask. 1 ml = 1.0 mg NH_3-N.

7. Procedure

Digestion

7.1 To 20 or 25 ml of sample, add 5 ml of digestion solution (6.2) and mix (use a vortex mixer).

7.2 Add (4–8) Teflon boiling stones (5.3). Too many boiling chips will cause the sample to boil over.

7.3 With Block Digestor in manual mode set low and high temperature at 160°C and preheat unit to 160°C. Place tubes in digestor and switch to automatic mode. Set low temperature timer for 1 hour. Reset high temperature to 380°C and set timer for 2 1/2 hours.

7.4 Cool sample and dilute to 25 ml with ammonia free water.

Colorimetric Analysis

7.5 Check the level of all reagent containers to ensure an adequate supply.

7.6 Excluding the salicylate line, place all reagent lines in their respective containers, connect the sample probe to the Sampler IV and start the proportioning pump.

7.7 Flush the Sampler IV wash receptacle with about 25 ml of 4.0% sulfuric acid (6.3).

7.8 When reagents have been pumping for at least five minutes, place the salicylate line in its respective container and allow the system to equilibrate. If a precipitate forms after the addition of salicylate, the pH is too low. Immediately stop the proportioning pump and flush the coils with water using a syringe. Before restarting the system, check the concentration of the sulfuric acid solutions and/or the working buffer solution.

TABLE 1

CONCENTRATION RANGES
(NITROGEN)

No.	Dilution loops: Initial sample — Sample line	Initial sample — Diluent line	Resample — Resample line	Resample — Diluent line	Approx. std. cal. setting	Range PPM N (± 10%)	ml stock NaOH per liter working buffer solution
1	.80 (RED/RED)	.80 (RED/RED)	.32 (BLK/BLK)	.80 (RED/RED)	700	0–0.5	250
2	.80 (RED/RED)	.80 (RED/RED)	.32 (BLK/BLK)	.80 (RED/RED)	100	0–1.5	250
3	.16 (ORN/YEL)	.80 (RED/RED)	.32 (BLK/BLK)	.80 (RED/RED)	700	0–1	120
4	.16 (ORN/YEL)	.80 (RED/RED)	.32 (BLK/BLK)	.80 (RED/RED)	100	0–5	120
5	.16 (ORN/YEL)	.80 (RED/RED)	.16 (ORN/YEL)	.80 (RED/RED)	700	0–2	80
6	.16 (ORN/YEL)	.80 (RED/RED)	.16 (ORN/YEL)	.80 (RED/RED)	100	0–10	80

7.9 To prevent precipitation of sodium salicylate in the waste tray, which can clog the tray outlet, keep the nitrogen flowcell pump tube and the nitrogen Colorimeter "To Waste" tube separate from all other lines or keep tap water flowing in the waste tray.

7.10 After a stable baseline has been obtained start the Sampler.

8. Calculations

8.1 Prepare standard curve by plotting peak heights of processed standards against concentration values. Compute concentrations by comparing sample peak heights with standard curve.

9. Precision and Accuracy

9.1 In a single laboratory (EMSL), using sewage samples of concentrations of 1.2, 2.6, and 1.7 mg N/1, the precision was ±0.07, ±0.03 and ±0.15, respectively.

9.2 In a single laboratory (EMSL), using sewage samples of concentrations of 4.7 and 8.74 mg N/1, the recoveries were 99 and 99%, respectively.

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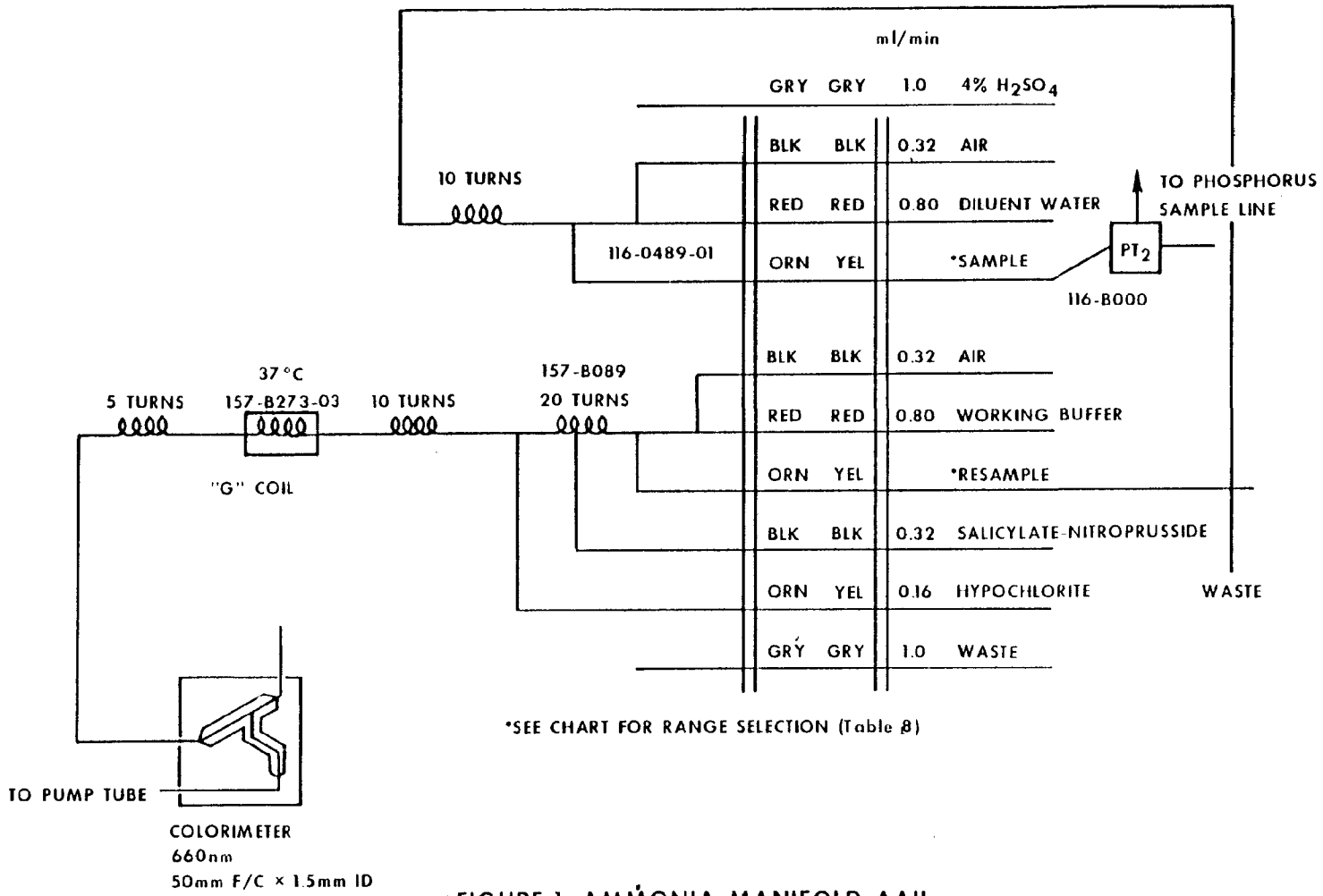

FIGURE 1. AMMONIA MANIFOLD AAII

NITROGEN, AMMONIA

Method 350.1 (Colorimetric, Automated Phenate)

STORET NO. Total 00610
Dissolved 00608

1. Scope and Application
   1.1 This method covers the determination of ammonia in drinking, surface, and saline waters, domestic and industrial wastes in the range of 0.01 to 2.0 mg/l NH_3 as N. This range is for photometric measurements made at 630–660 nm in a 15 mm or 50 mm tubular flow cell. Higher concentrations can be determined by sample dilution. Approximately 20 to 60 samples per hour can be analyzed.
2. Summary of Method
   2.1 Alkaline phenol and hypochlorite react with ammonia to form indophenol blue that is proportional to the ammonia concentration. The blue color formed is intensified with sodium nitroprusside.
3. Sample Handling and Preservation
   3.1 Preservation by addition of 2 ml conc. H_2SO_4 per liter and refrigeration at 4°C.
4. Interferences
   4.1 Calcium and magnesium ions may be present in concentration sufficient to cause precipitation problems during analysis. A 5% EDTA solution is used to prevent the precipitation of calcium and magnesium ions from river water and industrial waste. For sea water a sodium potassium tartrate solution is used.
   4.2 Sample turbidity and color may interfere with this method. Turbidity must be removed by filtration prior to analysis. Sample color that absorbs in the photometric range used will also interfere.
5. Apparatus
   5.1 Technicon AutoAnalyzer Unit (AAI or AAII) consisting of:
      5.1.1 Sampler.
      5.1.2 Manifold (AAI) or Analytical Cartridge (AAII).
      5.1.3 Proportioning pump.
      5.1.4 Heating bath with double delay coil (AAI).
      5.1.5 Colorimeter equipped with 15 mm tubular flow cell and 630–660 nm filters.
      5.1.6 Recorder.
      5.1.7 Digital printer for AAII (optional).

Approved for NPDES following preliminary distillation, Method 350.2.
Issued 1974
Editorial revision 1978

6. Reagents

6.1 Distilled water: Special precaution must be taken to insure that distilled water is free of ammonia. Such water is prepared by passage of distilled water through an ion exchange column comprised of a mixture of both strongly acidic cation and strongly basic anion exchange resins. The regeneration of the ion exchange column should be carried out according to the instruction of the manufacturer.

NOTE 1: All solutions must be made using ammonia-free water.

6.2 Sulfuric acid 5N: Air scrubber solution. Carefully add 139 ml of conc. sulfuric acid to approximately 500 ml of ammonia-free distilled water. Cool to room temperature and dilute to 1 liter with ammonia-free distilled water.

6.3 Sodium phenolate: Using a 1 liter Erlenmeyer flask, dissolve 83 g phenol in 500 ml of distilled water. In small increments, cautiously add with agitation, 32 g of NaOH. Periodically cool flask under water faucet. When cool, dilute to 1 liter with distilled water.

6.4 Sodium hypochlorite solution: Dilute 250 ml of a bleach solution containing 5.25% NaOCl (such as "Clorox") to 500 ml with distilled water. Available chlorine level should approximate 2 to 3%. Since "Clorox" is a proprietary product, its formulation is subject to change. The analyst must remain alert to detecting any variation in this product significant to its use in this procedure. Due to the instability of this product, storage over an extended period should be avoided.

6.5 Disodium ethylenediamine-tetraacetate (EDTA) (5%): Dissolve 50 g of EDTA (disodium salt) and approximately six pellets of NaOH in 1 liter of distilled water.

NOTE 2: On salt water samples where EDTA solution does not prevent precipitation of cations, sodium potassium tartrate solution may be used to advantage. It is prepared as follows:

6.5.1 Sodium potassium tartrate solution: 10% $NaKC_4H_4O_6 \cdot 4H_2O$. To 900 ml of distilled water add 100 g sodium potassium tartrate. Add 2 pellets of NaOH and a few boiling chips, boil gently for 45 minutes. Cover, cool, and dilute to 1 liter with ammonia-free distilled water. Adjust pH to 5.2 ±.05 with H_2SO_4. After allowing to settle overnight in a cool place, filter to remove precipitate. Then add 1/2 ml Brij-35[4] (available from Technicon Corporation) solution and store in stoppered bottle.

6.6 Sodium nitroprusside (0.05%): Dissolve 0.5 g of sodium nitroprusside in 1 liter of distilled water.

6.7 Stock solution: Dissolve 3.819 g of anhydrous ammonium chloride, NH_4Cl, dried at 105°C, in distilled water, and dilute to 1000 ml. 1.0 ml = 1.0 mg NH_3–N.

6.8 Standard Solution A: Dilute 10.0 ml of stock solution (6.7) to 1000 ml with distilled water. 1.0 ml = 0.01 mg NH_3–N.

6.9 Standard solution B: Dilute 10.0 ml of standard solution A (6.8) to 100.0 ml with distilled water. 1.0 ml = 0.001 mg NH_3–N.

6.10 Using standard solutions A and B, prepare the following standards in 100 ml volumetric flasks (prepare fresh daily):

NH_3–N, mg/l	ml Standard Solution/100 ml
	Solution B
0.01	1.0
0.02	2.0
0.05	5.0
0.10	10.0
	Solution A
0.20	2.0
0.50	5.0
0.80	8.0
1.00	10.0
1.50	15.0
2.00	20.0

NOTE 3: When saline water samples are analyzed, Substitute Ocean Water (SOW) should be used for preparing the above standards used for the calibration curve; otherwise, distilled water is used. If SOW is used, subtract its blank background response from the standards before preparing the standard curve.

Substitute Ocean Water (SOW)

NaCl	24.53 g/l	$NaHCO_3$	0.20 g/l
$MgCl_2$	5.20 g/l	KBr	0.10 g/l
Na_2SO_4	4.09 g/l	H_3BO_3	0.03 g/l
$CaCl_2$	1.16 g/l	$SrCl_2$	0.03 g/l
KCl	0.70 g/l	NaF	0.003 g/l

7. Procedure

7.1 Since the intensity of the color used to quantify the concentration is pH dependent, the acid concentration of the wash water and the standard ammonia solutions should approximate that of the samples. For example, if the samples have been preserved with 2 ml conc. H_2SO_4/liter, the wash water and standards should also contain 2 ml conc. H_2SO_4/liter.

7.2 For a working range of 0.01 to 2.00 mg NH_3–N/l (AAI), set up the manifold as shown in Figure 1. For a working range of .01 to 1.0 mg NH_3–N/l (AAII), set up the manifold as shown in Figure 2. Higher concentrations may be accommodated by sample dilution.

7.3 Allow both colorimeter and recorder to warm up for 30 minutes. Obtain a stable baseline with all reagents, feeding distilled water through sample line.

7.4 For the AAI system, sample at a rate of 20/hr, 1:1. For the AAII use a 60/hr 6:1 cam with a common wash.

7.5 Arrange ammonia standards in sampler in order of decreasing concentration of nitrogen. Complete loading of sampler tray with unknown samples.

7.6 Switch sample line from distilled water to sampler and begin analysis.

8. Calculations

8.1 Prepare appropriate standard curve derived from processing ammonia standards through manifold. Compute concentration of samples by comparing sample peak heights with standard curve.

9. Precision and Accuracy

9.1 In a single laboratory (EMSL), using surface water samples at concentrations of 1.41, 0.77, 0.59 and 0.43 mg NH_3–N/l, the standard deviation was ±0.005.

9.2 In a single laboratory (EMSL), using surface water samples at concentrations of 0.16 and 1.44 mg NH_3–N/l, recoveries were 107% and 99%, respectively.

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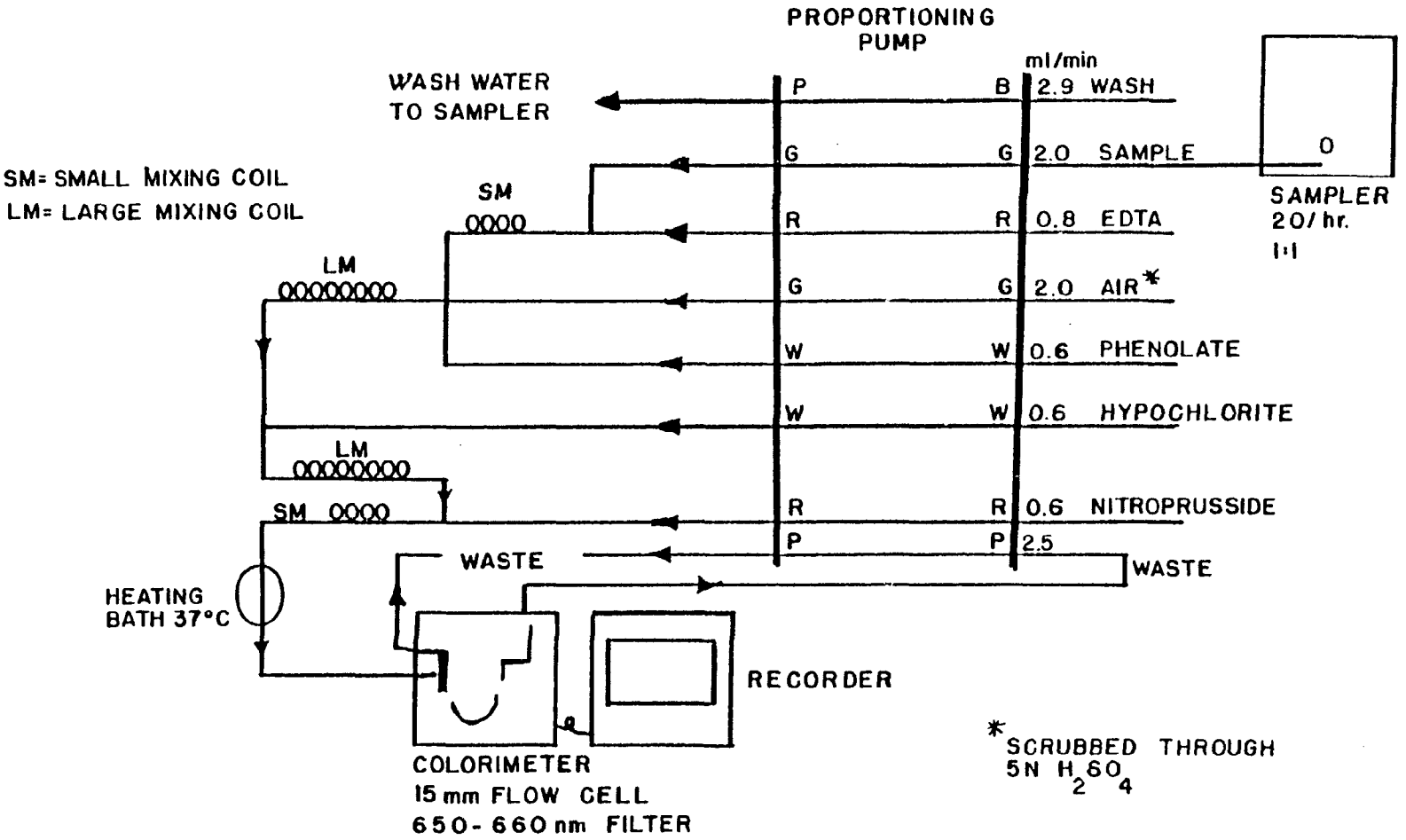

FIGURE 1 AMMONIA MANIFOLD AA I

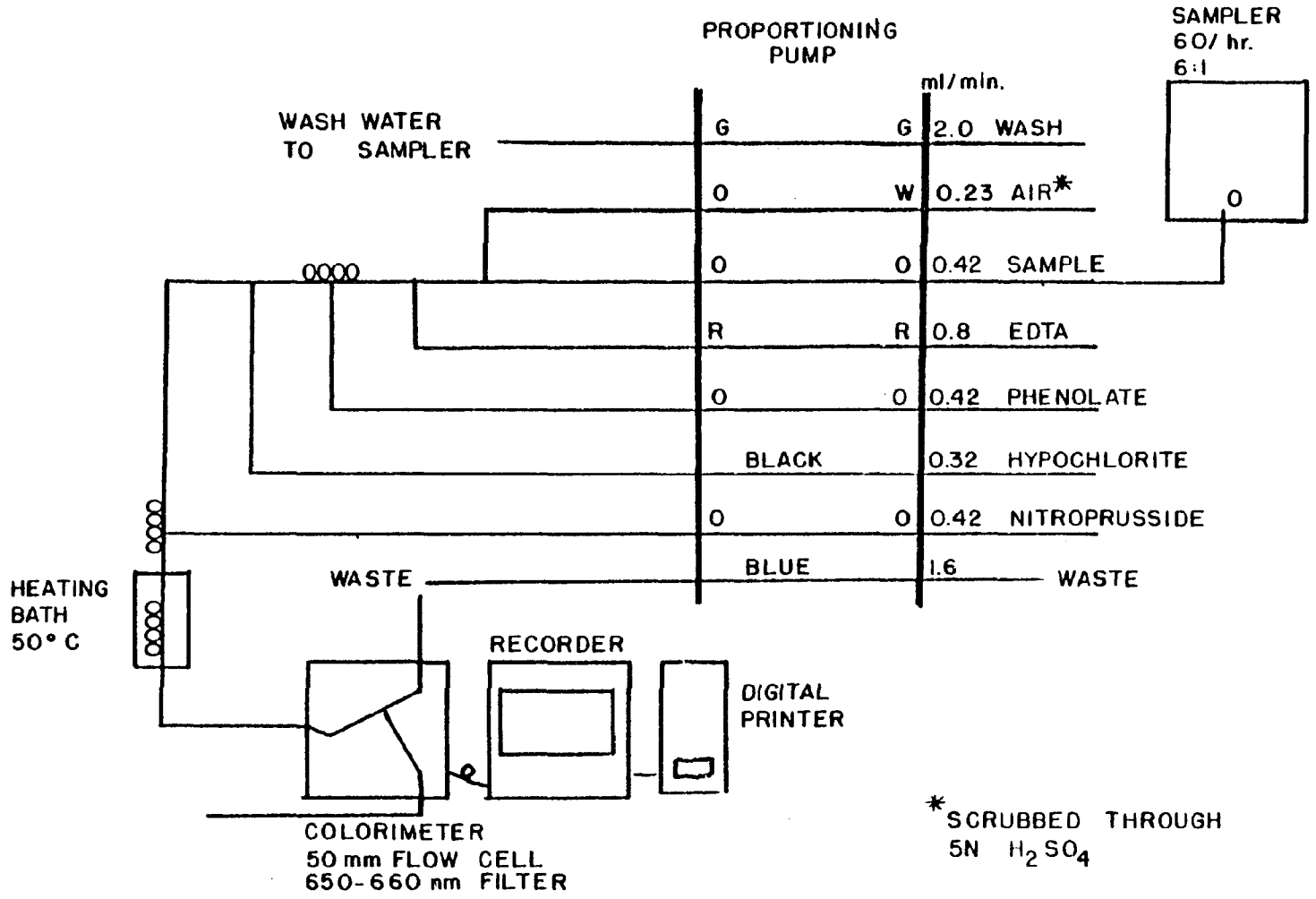

FIGURE 2. AMMONIA MANIFOLD AA II

Chlorophyll is a common indicator of phytoplankton biomass. All green plants contain chlorophyll *a* and, for planktonic algae, it constitutes about 1 to 2% of the dry weight. Other pigments that occur in plankton algae are chlorophyll *b* and *c*, xanthophylls, and carotenes. The presence or absence of the various pigments is used, among other features, to separate the major algal groups.

The determination of chlorophylls by the trichromatic method is of questionable value.[59,60] It tends to overestimate chlorophyll *a* when no correction is made for the presence of the degradation product, pheophytin *a*. Chlorophyll *b* and *c* values are calculated from readings taken on the slope of the chlorophyll *a* curve and are unreliable. For routine work in fresh water, determination of chlorophyll *a* and pheophytin *a* by spectrophotometry is the most valuable technique.

Two methods for determining chlorophyll *a* in phytoplankton are available, the spectrophotometric[23,61-63] and fluorometric.[23,64-66] Fluorometry is more sensitive than spectrophotometry, requires less sample, and can be used for in-vivo measurements.[67]

Pheophytin *a*, a common degradation product of chlorophyll *a*, can interfere with the determination of chlorophyll *a* because it absorbs light and fluoresces in the same region of the spectrum as chlorophyll *a* and, if present, may cause errors in chlorophyll *a* values.[68,69] It can be measured either by spectrophotometry or fluorometry, but in fresh water fluorometric measurement is unreliable. The fluorometric method was developed for marine work (chlorophyll *b* is undetectable in the open ocean) and depends on the absence of chlorophyll *b*, because after acidification the fluorescence emission of pheophytin *b* is coincident with that of pheophytin *a*. When measuring chlorophyll *a* measure also the concentration of pheophytin *a*. The ratio of chlorophyll *a* to pheophytin *a* serves as a good indicator of physiological condition of phytoplankton. When pheophytin *a* is measured by spectrophotometry, accurate acidification is required to avoid interference from accessory pigments present in some algae.[70]

Conduct work with chlorophyll extracts in subdued light to avoid degradation. Use opaque containers or wrap with aluminum foil.

1. Spectrophotometric Determination of Chlorophyll

The pigments are extracted from the plankton concentrate with aqueous acetone and the optical density (absorbance) of the extract is determined with a spectrophotometer. The ease with which the chlorophylls are removed from the cells varies considerably with different algae. To achieve consistently the complete extraction of the pigments, disrupt the cells mechanically with a tissue grinder.

Glass fiber filters are preferred for removing algae from water. The glass fibers assist in breaking the cells during grinding, larger volumes of water can be filtered, and no precipitate forms after acidification. Membrane filters may be used where these factors are irrelevant.

a. Equipment and reagents:

1) *Spectrophotometer,* with a narrow band (pass) width (0.5 to 2.0 nm) because the chlorophyll absorption peak is relatively narrow. At a spectral band width of 20 nm the chlorophyll *a* concentration may be underestimated by as much as 40%.

2) *Cuvettes,* with 1-, 4-, and 10-cm path lengths.

3) *Clinical centrifuge.*

4) *Pipets,* 0.1- and 5.0-mL.

5) *Tissue grinder:** Successfully macerating glass fiber filters in tissue grinders with grinding tube and pestle of conical design may be difficult. Preferably use round-bottom grinding tubes with a matching pestle having grooves in the TFE tip.

6) *Centrifuge tubes,* 15-mL graduated, screw-cap.

7) *Filtration equipment,* filters, glass fiber† membrane (0.45-μm porosity, 47-mm diam); vacuum pump; solvent-resistant disposable filter assembly, 1.0-μm pore size;‡ 10-mL solvent-resistant syringe.

*Kontes Glass Co., Vineland, N.J. 08360: Glass/glass grinder, Model No. 8855: Glass/TFE grinder, Model 886000; or equivalent.
†GF/C or GF/A 4.5 cm diam, or equivalent.
‡Gelman Acrodisc or equivalent.

8) *Saturated magnesium carbonate solution:* Add 1.0 g finely powdered $MgCO_3$ to 100 mL distilled water.

9) *Aqueous acetone solution:* Mix 90 parts acetone (reagent grade BP 56°C) with 10 parts saturated magnesium carbonate solution.

b. Extraction procedure:

1) Concentrate sample by centrifuging or filtering. Whole water samples can be held up to 2 weeks in the dark at 4°C. Use opaque bottles because even brief exposure to light during storage will alter chlorophyll values. Samples on filters taken from water having pH 7 or higher may be placed in airtight plastic bags and stored frozen for 3 weeks. Samples from acidic water must be processed promptly to prevent chlorophyll degradation. Use glassware and cuvettes that are clean and acid-free.

2) Place sample in a tissue grinder, cover with 2 to 3 mL 90% aqueous acetone solution, and macerate at 500 rpm for 1 min. Use TFE/glass grinder for a glass-fiber filter and glass/glass grinder for a membrane filter.

3) Transfer sample to a screw-cap centrifuge tube, rinse grinder with a few milliliters 90% aqueous acetone, and add the rinse to the extraction slurry. Adjust total volume to a constant level, 5 to 10 mL, with 90% aqueous acetone. Use solvent sparingly and avoid excessive dilution of pigments. Steep samples at least 2 h at 4°C in the dark.

4) Clarify by filtering through a solvent-resistant disposable filter (to minimize retention of extract in filter and filter holder, force 1 to 2 mL air through the filter after the extract), or by centrifuging in closed tubes for 20 min at 500 *g*. Decant clarified extract into a clean, calibrated, 15-mL, screw-cap centrifuge tube and measure total volume. Proceed as in *c* or *d* below.

c. Determination of chlorophyll a *in the presence of pheophytin* a: Chlorophyll *a* may be overestimated by including pheopigments that absorb near the same wavelength as chlorophyll *a*. Addition of acid to chlorophyll *a* results in loss of the magnesium atom, converting it to pheophytin *a*. Acidify carefully to a final molarity of not more than $3 \times 10^{-3} M$ to prevent certain accessory pigments from changing to absorb at the same wavelength as pheophytin *a*.[70] When a solution of pure chlorophyll *a* is converted to pheophytin *a* by acidification, the absorption-peak-ratio (OD664/OD665) of 1.70 is used in correcting the apparent chlorophyll *a* concentration for pheophytin *a*.

Samples with an OD664 before/OD665 after acidification ratio ($664_b/665_a$) of 1.70 are considered to contain no pheophytin *a* and to be in excellent physiological condition. Solutions of pure pheophytin show no reduction in OD665 upon acidification and have a $664_b/665_a$ ratio of 1.0. Thus, mixtures of chlorophyll *a* and pheophytin *a* have absorption peak ratios ranging between 1.0 and 1.7. These ratios are based on the use of 90% acetone as solvent. Using 100% acetone as solvent results in a chlorophyll *a* before-to-after acidification ratio of about 2.0.[61]

1) Equipment and reagents—In addition to those listed under *a* above,

Hydrochloric acid, HCl, 0.1*N*.

2) Spectrophotometric procedure—Transfer 3 mL clarified extract to a 1-cm cuvette and read optical density (OD) at 750 and 664 nm. Acidify extract in the cuvette with 0.1 mL 0.1*N* HCl. Gently agitate the acidified extract and read OD at 750 and at 665 nm, 90 s after acidification. The volumes of extract and acid and the time after acidification are critical for accurate, consistent results.

The OD664 before acidification should be between 0.1 and 1.0. For very dilute extracts use cuvettes having a longer path length. If a larger cell is used, add a proportionately larger volume of acid. Correct OD obtained with larger cuvettes to 1 cm before making calculations.

Subtract the 750-nm OD value from the

readings before (OD 664 nm) and after acidification (OD 665 nm).

Using the corrected values calculate chlorophyll *a* and pheophytin *a* per cubic meter as follows:

$$\text{Chlorophyll } a, \text{ mg/m}^3 = \frac{26.7\,(664_b - 665_a) \times V_1}{V_2 \times L}$$

$$\text{Pheophytin } a, \text{ mg/m}^3 = \frac{26.7\,[1.7\,(665_a) - 664_b] \times V_1}{V_2 \times L}$$

where:

V_1 = volume of extract, L,
V_2 = volume of sample, m^3,
L = light path length or width of cuvette, cm, and
664_b, 665_a = optical densities of 90% acetone extract before and after acidification, respectively,

The value 26.7 is the absorbance correction and equals $A \times K$

where:

A = absorbance coefficient for chlorophyll *a* at 664 nm = 11.0, and
K = ratio expressing correction for acidification,

$$= \frac{\left(\frac{664_b}{665_a}\right)_{\text{pure chlorophyll } a}}{\left(\frac{664_b}{665_a}\right)_{\text{pure chlorophyll } a} - \left(\frac{664_b}{665_a}\right)_{\text{pure pheophytin } a}}$$

$$= \frac{1.7}{1.7 - 1.0} = 2.43$$

d. Determination of chlorophyll a, b, *and* c *(trichromatic method):*

Spectrophotometric procedure—Transfer extract to a 1-cm cuvette and measure optical density (OD) at 750, 664, 647, and 630 nm. Choose a cell path length or dilution to give an OD664 between 0.1 and 1.0.

Use the optical density readings at 664, 647, and 630 nm to determine chlorophyll *a*, *b*, and *c*, respectively. The OD reading at 750 nm is a correction for turbidity. Subtract this reading from each of the pigment OD values of the other wavelengths before using them in the equations below. Because the OD of the extract at 750 nm is very sensitive to changes in the acetone-to-water proportions, adhere closely to the 90 parts acetone:10 parts water (v/v) formula for pigment extraction. Turbidity can be removed easily by filtration through a disposable, solvent-resistant filter attached to a syringe or by centrifuging for 20 min at 500 *g*.

Calculate the concentrations of chlorophyll *a*, *b*, and *c* in the extract by inserting the corrected optical densities in following equations:[63]

a) $C_a = 11.85(OD664) - 1.54(OD647) - 0.08(OD630)$
b) $C_b = 21.03(OD647) - 5.43(OD664) - 2.66(OD630)$
c) $C_c = 24.52(OD630) - 7.60(OD647) - 1.67(OD664)$

where:

C_a, C_b, and C_c = concentrations of chlorophyll *a*, *b*, and *c*, respectively, mg/L, and
OD664, OD647, and OD630 = corrected optical densities (with a 1-cm light path) at the respective wavelengths.

After determining the concentration of pigment in the extract, calculate the amount of pigment per unit volume as follows:

$$\text{Chlorophyll } a, \text{ mg/m}^3 = \frac{C_a \times \text{extract volume, L}}{\text{Volume of sample, m}^3}$$

2. Fluorometric Determination of Chlorophyll *a*

The fluorometric method for chlorophyll *a* is more sensitive than the spectrophotometric method and thus smaller samples can be used. Calibrate the fluorometer spectrophotometrically with a sample from the same source to achieve acceptable results. Optimum sensitivity for chlorophyll *a* extract measurements is obtained at an excitation wavelength of 430 nm and an emission wavelength of 663 nm. A method for continuous measurement of chlorophyll *a* in vivo is available, but is reported to be less efficient than the in-vitro method given here, yielding about one-tenth as much fluorescence per unit weight as the same amount in solution. Pheophytin *a* also can be determined fluorometrically.[24]

a. Equipment and reagents: In addition to those listed under 1*a* above,

Fluorometer,§ equipped with a high-intensity F4T.5 blue lamp, photomultiplier tube R-446 (red-sensitive), sliding window orifices 1×, 3×, 10×, and 30×, and filters for light emission (CS-2-64) and excitation (CS-5-60). A high-sensitivity door is preferable.

b. Extraction procedure: Prepare sample as directed in 1*b* above.

1) Calibrate fluorometer with a chlorophyll solution of known concentration as follows: Prepare chlorophyll extract and analyze spectrophotometrically. Prepare serial dilutions of the extract to provide concentrations of approximately 2, 6, 20, and 60 μg chlorophyll *a*/L. Make fluorometric readings for each solution at each sensitivity setting (sliding window orifice): 1×, 3×, 10×, and 30×. Using the values obtained, derive calibration factors to convert fluorometric readings in each sensitivity level to concentrations of chlorophyll *a*, as follows:

$$F_s = \frac{C_a'}{R_s}$$

where:

F_s = calibration factor for sensitivity setting S,
R_s = fluorometer reading for sensitivity setting S, and,
C_a' = concentration of chlorophyll *a* determined spectrophotometrically, μg/L.

2) Measure sample fluorescence at sensitivity settings that will provide a mid-scale reading. (Avoid using the 1× window because of quenching effects.) Convert fluorescence readings to concentrations of chlorophyll *a* by multiplying the readings by the appropriate calibration factor.

c. Determination of chlorophyll a *in the presence of pheophytin* a: This method is not applicable to freshwater samples. See discussion under 1002G and 1*c* above.

1) Equipment and reagents—In addition to those listed under 2*a* above, pure chlorophyll *a*‖ (or a plankton chlorophyll extract with a spectrophotometric before-and-after acidification ratio of 1.70 containing no chlorophyll *b*).

2) Fluorometric procedure—Calibrate fluorometer as directed in ¶ 2*b*1). Determine extract fluorescence at each sensitivity setting before and after acidification. Calculate calibration factors (F_s) and before-and-after acidification fluorescence ratio by dividing fluorescence reading obtained before acidification by the reading obtained after acidification. Avoid readings on the 1× scale and those outside the range of 20 to 80 fluorometric units.

3) Calculations—Determine the "corrected" chlorophyll *a* and pheophytin *a* in sample extracts with the following equations:[24,66]

§Model 111, Sequoia-Turner Corp., 755 Ravendale Dr., Mountain View, Calif. or equivalent.

‖Purified chlorophyll *a*, Sigma Chemical Company, St. Louis, Mo., or equivalent.

$$\text{Chlorophyll } a,\ \text{mg/m}^3 = F_s \frac{r}{r-1}(R_b - R_a)$$

$$\text{Pheophytin } a,\ \text{mg/m}^3 = F_s \frac{r}{r-1}(rR_a - R_b)$$

where:

F_s = conversion factor for sensitivity setting S (see ¶ 2*b*, above),

R_b = fluorescence of extract before acidification,

R_a = fluorescence of extract after acidification, and

$r = R_b/R_a$, as determined with pure chlorophyll *a* for the instrument. Redetermine r if filters or light source are changed.

908 A. Standard Total Coliform Multiple-Tube (MPN) Tests

1. Presumptive Phase

Use lauryl tryptose broth in the presumptive portion of the multiple-tube test. Lactose broth may be used as an alternative medium provided that it has been demonstrated not to increase the frequency of false positives nor mask coliforms present in drinking water samples.

a. Reagents and culture media:

1) *Lauryl tryptose broth:*

Tryptose	20.0	g
Lactose	5.0	g
Dipotassium hydrogen phosphate, K_2HPO_4	2.75	g
Potassium dihydrogen phosphate, KH_2PO_4	2.75	g
Sodium chloride, NaCl	5.0	g
Sodium lauryl sulfate	0.1	g
Distilled water	1	L

pH should be 6.8 ± 0.2 after sterilization. The addition of 0.01 g/L bromcresol purple to presumptive medium is optional as a guide to determine acid productivity and growth (without gas formation) to be confirmed. Before sterilization, dispense, in fermentation tubes with an inverted vial, sufficient medium to cover inverted vial at least partially after sterilization.

Make lauryl tryptose broth of such strength that adding 100-mL or 10-mL portions of sample to medium will not reduce ingredient concentrations below those of the standard medium. Prepare in accordance with Table 908:I.

2) *Brilliant green lactose bile broth:*

Peptone	10.0	g
Lactose	10.0	g
Oxgall	20.0	g
Brilliant green	0.0133	g
Distilled water	1	L

pH should be 7.2 ± 0.2 after sterilization. Before sterilization, dispense, in fermentation tubes with an inverted vial, sufficient medium to cover inverted vial at least partially after sterilization.

3) *Lactose broth:*

Beef extract	3.0	g
Peptone	5.0	g
Lactose	5.0	g
Distilled water	1	L

pH should be 6.9 ± 0.2 after sterilization. Before sterilization, dispense in fermentation tubes of such dimensions that the liquid in the inoculated tube will cover the inverted vial at least partially after sterilization.

Make lactose broth of such strength that adding 100-mL or 10-mL portions of sample to medium will not reduce ingredient concentrations below those of the standard medium. Prepare in accordance with Table 908:II.

b. Procedure:

1) Inoculate a series of presumptive-phase fermentation tubes with appropriate decimal quantities (multiples and submultiples of 1 mL) of sample. If 100-mL sample portions are used, prewarm culture bottles to room temperature. After adding sample, mix thoroughly. The portions of sample used for inoculating lauryl tryptose broth

TABLE 908:I. PREPARATION OF LAURYL TRYPTOSE BROTH

Inoculum *mL*	Amount of Medium in Tube *mL*	Volume of Medium + Inoculum *mL*	Dehydrated Lauryl Tryptose Broth Required *g/L*
1	10 or more	11 or more	35.6
10	10	20	71.2
10	20	30	53.4
100	50	150	106.8
100	35	135	137.1
100	20	120	213.6

TABLE 908:II. PREPARATION OF LACTOSE BROTH

Inoculum *mL*	Amount of Medium in Tube *mL*	Volume of Medium + Inoculum *mL*	Dehydrated Lactose Broth Required *g/L*
1	10 or more	11 or more	13.0
10	10	20	26.0
10	20	30	19.5
100	50	150	39.0
100	35	135	50.1
100	20	120	78.0

fermentation tubes will vary in size and number with the character of the water examined, but in general use decimal multiples of 1 mL. Select these in accordance with the discussion of the multiple-tube test above.

In making dilutions and measuring diluted sample volumes, follow the precautions given in Section 907A.2. Use Figure 907:1 as a guide to preparing dilutions.

2) Incubate inoculated fermentation tubes at 35 ± 0.5°C. After 24 ± 2 h shake each tube gently and examine it for gas production and, if no gas has formed and been trapped in the inverted vial, reincubate and reexamine at the end of 48 ± 3 h. Record presence or absence of gas formation (and acid if a pH indicator was incorporated in the medium) regardless of amount at each examination of the tubes.

c. Interpretation: Formation of gas in any amount in the inverted tubes or vials within 48 ± 3 h constitutes a positive presumptive reaction.

Do not confuse the appearance of an air bubble in a clear tube with actual gas production. If gas is formed as a result of fermentation, the broth medium will become cloudy. Active fermentation may be shown by the continued appearance of small bubbles of gas throughout the medium outside the inner vial when the fermentation tube is shaken gently.

The absence of gas (and acid) formation at the end of 48 ± 3 h of incubation constitutes a negative test for sewage effluent samples. Confirm presumptive tubes with heavy growth and no visible gas from drinking and recreational waters in brilliant green lactose bile broth to check for

coliform suppression. An arbitrary limit of 48 h for observation doubtless excludes from consideration occasional members of the coliform group that form gas very slowly.

2. Confirmed Phase

a. Reagents and culture media: See ¶ 1*a* above. Use brilliant green lactose bile broth fermentation tubes for the confirmed phase.

b. Procedure: Submit all primary fermentation tubes showing any amount of gas within 24 h of incubation to the confirmed phase. If active fermentation appears in the primary fermentation tube earlier than 24 h, transfer to the confirmatory medium, preferably without waiting for the full 24-h period to elapse. If additional primary fermentation tubes show gas production or heavy growth (for drinking or recreational water samples) at the end of a 48-h incubation period, submit these to the confirmed phase.

Gently shake or rotate primary fermentation tube showing gas. With a sterile metal loop 3 mm in diameter, transfer one loopful of culture to a fermentation tube containing brilliant green lactose bile broth or insert a sterile wooden applicator at least 2.5 cm into the culture, promptly remove, and plunge applicator to bottom of fermentation tube containing brilliant green lactose bile broth. Remove and discard applicator.

Incubate the inoculated brilliant green lactose bile broth tube for 48 ± 3 h at 35 ± 0.5°C.

Formation of gas in any amount in the inverted vial of the brilliant green lactose bile broth fermentation tube at any time within 48 ± 3 h constitutes a positive confirmed phase.

c. Alternative procedure: Use this alternative only for polluted water or wastewater known to produce positive results consistently.

If all presumptive tubes are positive in two or more consecutive dilutions within 24 h, submit to the confirmed phase only the tubes of the highest dilution (smallest sample inoculum) in which all tubes are positive and any positive tubes in still higher dilutions. Submit to the confirmed phase all tubes in which gas is produced only after 48 h.

3. Completed Test

Use the completed test on positive confirmed tubes to establish definitively the presence of coliform bacteria and to provide quality-control data. Double confirmation into brilliant green lactose bile broth for total coliforms and EC broth for fecal coliforms (see Section 908C below) may be used. Consider positive EC broth elevated temperature (44.5°C) results as a positive completed test response. Parallel positive brilliant green lactose bile broth cultures with negative EC broth cultures indicate the presence of nonfecal coliforms and must be submitted to the completed test procedure to obtain an MPN test value.

a. Culture medium and reagents:

1) *Nutrient agar:*

Peptone	5.0 g
Beef extract	3.0 g
Agar	15.0 g
Distilled water	1 L

pH should be 6.8 ± 0.2 after sterilization.

2) *Gram-stain reagents:*

a) *Ammonium oxalate-crystal violet (Hucker's):* Dissolve 2 g crystal violet (90% dye content) in 20 mL 95% ethyl alcohol; dissolve 0.8 g $(NH_4)_2C_2O_4 \cdot H_2O$ in 80 mL distilled water; mix the two solutions and age for 24 h before use; filter through paper into a staining bottle.

b) *Lugol's solution, Gram's modification:* Grind 1 g iodine crystals and 2 g KI in a mortar. Add distilled water, a few milliliters at a time, and grind thoroughly after each addition until solution is complete. Rinse solution into an amber glass bottle

with the remaining water (using a total of 300 mL).

c) *Counterstain:* Dissolve 2.5 g safranin dye in 100 mL 95% ethyl alcohol. Add 10 mL to 100 mL distilled water.

d) *Acetone alcohol:* Mix equal volumes of ethyl alcohol (95%) with acetone.

b. Procedure:

1) Streak one LES Endo agar (Section 909A.2) plate from each tube of brilliant green lactose bile broth showing gas, as soon as possible after the observation of gas. Streak plates in a manner to insure presence of some discrete colonies separated by at least 0.5 cm. Observe the following precautions when streaking plates to obtain a high proportion of successful isolations if coliform organisms are present: (*a*) Use an inoculating needle slightly curved at the tip; (*b*) tap and incline the fermentation tube to avoid picking up any membrane or scum on the needle; (*c*) insert end of needle into the liquid in the tube to a depth of approximately 0.5 cm; and (*d*) streak plate with curved section of the needle in contact with the agar to avoid a scratched or torn surface.

Incubate plates (inverted) at 35 ± 0.5°C for 24 ± 2 h.

2) The colonies developing on LES Endo agar are defined as *typical* (nucleated, with or without metallic sheen); *atypical* (opaque, unnucleated, mucoid, pink after 24 h incubation), or *negative* (all others). From each of these plates pick one or more typical, well-isolated coliform colonies or, if no typical colonies are present, pick two or more colonies considered most likely to consist of organisms of the coliform group, and transfer growth from each isolate to a lauryl tryptose broth fermentation tube and onto a nutrient agar slant.

Use a colony magnifying device to provide optimum magnification when colonies are picked from the LES Endo agar plates. When transferring colonies, choose well-isolated colonies and barely touch the surface of the colony with a flame-sterilized, air-cooled transfer needle to minimize the danger of transferring a mixed culture.

Incubate secondary broth tubes (lauryl tryptose broth) at 35 ± 0.5°C for 24 ± 2 h; if gas is not produced within 24 ± 2 h reincubate and examine again at 48 ± 3 h. Microscopically examine Gram-stained preparations from those 24-h nutrient agar slant cultures corresponding to the secondary tubes that show gas.

3) Gram-stain technique—The Gram stain may be omitted from the completed test for potable water samples only because the occurrence of gram-positive bacteria and spore-forming organisms surviving this selective screening procedure are infrequent in drinking water.

Various modifications of the Gram stain exist. Use the following modification by Hucker for staining smears of pure culture; include a gram-positive and a gram-negative culture as controls.

Prepare separate light emulsions of the test bacterial growth and positive and negative control cultures on the same slide using drops of distilled water on the slide. Air-dry and fix by passing slide through a flame and stain for 1 min with ammonium oxalate-crystal violet solution. Rinse slide in tap water; apply Lugol's solution for 1 min.

Rinse the stained slide in tap water. Decolorize for approximately 15 to 30 s with acetone alcohol by holding slide between the fingers and letting acetone flow across the stained smear until no more stain is removed. Do not over-decolorize. Counterstain with safranin for 15 s, then rinse with tap water, blot dry with bibulous paper or air dry, and examine microscopically.

Cells that decolorize and accept the safranin stain are pink and defined as gram-negative in reaction. Cells that do not decolorize but retain the crystal violet stain are deep blue and are defined as gram-positive. Results are acceptable only when controls have given proper reactions.

c. Interpretation: Formation of gas in the secondary tube of lauryl tryptose broth within 48 ± 3 h and demonstration of gram-negative, nonspore-forming, rod-shaped bacteria from the agar culture constitute a positive result for the completed test, demonstrating the presence of a member of the coliform group.

908 C. Fecal Coliform MPN Procedure

Elevated-temperature tests for the separation of organisms of the coliform group into those of fecal origin and those derived from nonfecal sources are available. Modifications in technical procedures, standardization of methods, and detailed studies of members of the coliform group found in the feces of various warm-blooded animals compared with those from other environmental sources have established the value of a fecal coliform determination. The test can be performed by one of the multiple-tube procedures described here or by membrane filter methods as described in Section 909. The procedure using EC medium yields adequate information about the source of the coliform group (fecal or nonfecal) when used as a *confirmatory test.* Do not use it for direct isolation of coliforms from water because prior enrichment in a presumptive medium for optimum recovery of fecal coliforms is required. The procedure using A-1 broth is a single-step method not requiring confirmation.

The fecal coliform test (EC medium) is applicable to investigations of stream pollution, raw water sources, wastewater treatment systems, bathing waters, seawaters, and general water-quality monitoring. The procedure is not recommended as a substitute for the coliform test in the examination of potable waters, because no coliform bacteria of any kind should be tolerated in a treated water. The test using A-1 medium is applicable to seawater and treated wastewater.

1. Fecal Coliform Test (EC Medium)

The fecal coliform test differentiates between coliforms of fecal origin (intestines of warm-blooded animals) and coliforms from other sources. Use EC medium or, for a more rapid test of the quality of shellfish waters, use A-1 medium in a direct test.

a. EC medium:

Tryptose or trypticase	20.0 g
Lactose	5.0 g
Bile salts mixture or bile salts No. 3	1.5 g
Dipotassium hydrogen phosphate, K_2HPO_4	4.0 g
Potassium dihydrogen phosphate, KH_2PO_4	1.5 g
Sodium chloride, NaCl	5.0 g
Distilled water	1 L

pH should be 6.9 ± 0.2 after sterilization. Before sterilization, dispense in fermentation tubes, each with an inverted vial, sufficient medium to cover the inverted vial at least partially after sterilization.

b. Procedure: Make transfers from all positive presumptive tubes and from 48-h negative tubes showing growth, from the total coliform MPN test to EC medium. Make this examination simultaneously with the confirmatory procedure using brilliant green lactose bile broth. Use a sterile metal loop with a minimum 3-mm diam or a sterile wooden applicator to transfer to EC medium. When making such transfers, first gently shake the presumptive tube or mix by rotating. Incubate inoculated tubes in a water bath at 44.5 ± 0.2°C for 24 ± 2 h. Place all EC tubes in the water bath within 30 min after inoculation. Maintain a sufficient water depth in the water bath incubator to immerse tubes to the upper level of the medium.

c. Interpretation: Gas production in a fermentation tube within 24 h or less is considered a positive reaction indicating coliforms of fecal origin. Failure to produce gas (growth sometimes occurs) constitutes a negative reaction indicating a source other than the intestinal tract of warm-blooded animals. Calculate fecal coliform densities as described in Section 908D.

2. Fecal Coliform Test (A-1 Medium)

a. A-1 broth: This medium may not be available in dehydrated form and may require preparation from the basic ingredients.

Lactose	5.0 g
Tryptone	20.0 g
Sodium chloride, NaCl	5.0 g
Salicin	0.5 g
Polyethylene glycol *p* isooctylphenyl ether*	1.0 mL
Distilled water	1 L

Heat to dissolve solid ingredients, add polyethylene glycol *p* isooctylphenyl ether, and adjust to pH 6.9 ± 0.1. Before sterilization dispense in fermentation tubes with an inverted vial sufficient medium to cover the inverted vial at least partially after sterilization. Sterilize by autoclaving at 121°C for 10 min. Store in dark at room temperature for not longer than 7 d. Ignore formation of precipitate.

Make A-1 broth of such strength that adding 10-mL sample portions to medium will not reduce ingredient concentrations below those of the standard medium. For 10-mL samples prepare double-strength medium.

b. Procedure: Inoculate tubes of A-1 broth as directed in Section 908A.1*b*1). Incubate for 3 h at 35 ± 0.5°C. Transfer tubes to a water bath at 44.5 ± 0.2°C and incubate for an additional 21 ± 2 h.

c. Interpretation: Gas production in a fermentation tube within 24 h or less is a positive reaction indicating coliforms of fecal origin. Calculate fecal coliform densities as described in Section 908D.

APPENDIX D

FLUSHING RATES AND STEADY STATE CALCULATIONS

APPENDIX D

D1. FLUSHING RATES AND STEADY STATE CALCULATIONS

The Chesapeake Bay Critical Areas legislation requires that each county develope guidelines for permitting water dependent facilities. Under Section 14.15.03.04, local jurisdiction are required to develope plans which consider the following for all water dependent facilities:

1. Activities will not significantly affect or alter existing water circulation patterns or salinity regions.

2. The water bodies upon which these activities are planned are adequately flushed.

It is not anticipated that most water dependent facilities will have a significant impact upon circulation or salinity patterns. In order to meet the requirements of Item #2, however, it will be necessary to define existing flushing rates accurately and to provide guidance regarding acceptable and unacceptable rates. This task is both complicated and difficult. To date, the most common method has been to rely upon existing information, generalized criteria and simplistic models. In general, the larger the water both in width and total exchange, the better the flushing rate. The following discussion will be restricted to tidal rivers and estuaries because the Critical Area legislation applies only to tidal conditions. A primary resource for information regarding this discussion is the Coastal Marinas Assessment Handbook (EPA, 1985).

There are two primary mechanisms by which water is exchanged in tidal rivers and estuaries. These are 1) tidal exchange and 2) fresh water input. The following formula is one approach to defining flushing rates in tidal waters. While such imperical formulal are relatively simplistic, they provide a first cut approach to defining flushing rates and can be used to determine the need for further study. The most important aspect of such models is the basis of the assumptions used in defining each parameter.

Flushing and circulation are important physical characteristics of a water body that should be considered in facility review. Since site-specific information on flushing and circulation are usually not readily available during the site selection and design phase, simplistic mathematical models are utilized as a screening procedure.

Semi-Enclosed Areas

Flushing time for facilities within a semi-enclosed area can be estimated using simplified dilution calculations. The variables required for the estimation are:

- Average depth of the water body segment or marina at low and high tide following completion of dredging, based upon the representative tidal range for the area
- Volume of non-tidal freshwater inflow into the segmentor marina
- Surface area of the waterbody segmentor marina
- The percentage of discharged water returning to the basin on the following tidal cycle.

Equation 1 represents the semi-enclosed case:

$$(1) \qquad T_f = \frac{T_c \text{LogD}}{\text{Log} \frac{AL + bAR - ITc}{AH}}$$

where:
T_f = Time of flushing (hours)
T_c = Tidal cycle, high tide to high tide (hours)
A_c = Surface area of the waterbody segment of the marina(m^2)
D = Desired dilution factor
R = Range of tide (m)
b = Return flow factor (dimensionless expressed as a fraction)
I = Non-tidal freshwater inflow (m^3/hours)
L = Average deth at low tide (m)
H = Average depth at high tide (m).
AL = Segment or marina low water volume (m^3)
AR = Tidal prism volume (m^3) of segment or marina

The parameter "b" is the percentage of the tidal prism ("AR"), in Equation 1) that was previously flushed from the water body on the outgoing tide and is expressed as a decimal fraction. It represents the fraction of the water which has moved out from the segment adjacent to the facility after the completion of one tidal cycle which flows back into the waterbody segment on the incoming tide. This portion of the water mass would not be considered as aiding flushing for water quality considerations.

Non-tidal freshwater inflow from runoff or stream discharge into the estuary can be estimated using available data. Frequently, particularly in small subestuearies this number is small compared to tidal flushing.

If "ITc" is much less than "AL + bAR," this component of the equation can be ignored and the simplified (Equation (2) is as follows:

$$(2) \qquad T_f = \frac{T_c \text{LogD}}{\text{Log} \frac{AL + bAR}{AH}}$$

One assumption of Equations (1) and (2) is that the physical shape of the segment includes relatively vertical sides, particularly from the low to high water marks. If this is not the accepted case, Equation (3) is represented as the following:

$$(2) \qquad T_f = \frac{T_c \text{LogD}}{\text{Log} \frac{V_L + bVp}{V_H}}$$

where: T_f, T_c, b and D are as defined previously
V_L = Volume of the segment at low tide (m^3)
V_H = volume of the segment at high tide (m^3)
V_p = Volume of the segment tidal prism ($V_H - V_L$).

This simplified approach to estimating flushing incorporates the following assumptions:

- The tidal prism volume completely mixes with basin waters
- The pollutant concentration decreases with each tidal dilution but will never completely flush
- The segment basin is fairly uniform with relatively vertical sides (Equations 1 and 2)
- The influx of non-tidal freshwater serves to decrease the polluted volume without affecting the level of tide
- The majority of flushing is due to tidal flow.

The most difficult parameter to determine is the volume of "b". This value may be determined with the greatest precision by dye tracer tests for the actual site, or it can be estimated based upon the circulation characteristics of the affected water bodies. Values of "b" may be greater than 0.5 for slow circulating estuaries or less than 0.5 if freshwater inflow is high or receiving water circulation is fast. Without original field data, estimations must be made. For example, if ebb flow is at least 50 percent faster than flood flow, (as in tidal river conditions) flushing should be expected to be fair and a value for "b" would probably be less than 0.5.

The value for "D" should be chosen depending upon the amount of flushing desired. If complete flushing is desired, a very low value of "D" can be selected, such as 0.01. Since pollutant concentrations are steadily

diluted by each tidal cycle, complete flushing will be approached asymptotically, so a reasonable cutoff value for dilution must be chosen. We have selected a 67% reduction or as a convention, and this represents ~.33 as a value for "D".
In any case, the estimated flushing time for water bodies is an approximate value where these models are used. Many characteristics of the site, including location relative to other water bodies, ambient water quality, biological activity, total volume, proposed activity, and type and volume of any discharges, would also all affect the steady state concentrations of any given chemical constituent. For most cases a two to four day flushing time is satisfactory while longer flushing times may not be acceptable (Boozer, 1979). Evaluation of the buildup of particular toxic pollutants or the decrease in dissolved oxygen would be required to more adequately evaluate the flushing characteristics.

Example

The flushing example given here uses the flushing model discussed above. The equation used is equation no. 2 (4-5 of the Coastal Marinas Asessment Handbook). The area is upper Frog Mortar Creek in Middle River, Baltimore County, Maryland. The following additional assumptions were made in the example given:

1. The tidal prism volume assumes complete mixing within the creek waters and the proposed marina basin. This is based upon the determination through field assessments that the vertical distribution of conductivity is uniform. It is also possible to use dissolved oxygen or temperature, but salinity is the most commonly used variable in defining the presence or absence of complete mixing in shallow estuarine water bodies.

2. The flushing of the basin and the upper portion of Frog Mortar Creek is due to tidal flow only.

3. The factor for D (desired final dilution) was assigned a value of .33. This is the fraction of the original concentration remaining in the water column. This is based on the Corps of Engineers convention that the flushing rate be calculated based upon the amount of time required for 67% of a given conservative material to be removed due to tidal action or other components of the flushing model.

4. It is recommended that the value for "b" (fractional recirculation) be initially assigned a value of 0.5, and that additional model calculations to be run at 0.25 and 0.0. This is based upon studies conducted by the Chesapeake Bay Institute and reported in Special Report no. 49 of the Chesapeake Bay Institute entitled: Simple One Dimensional Kinematic Model Results For The Bush River and Rumney Creek (Carter, H.H., 1976). Attached is a copy of this reference (Appendix E). As can be seen on page 21, for the Bush River in the fall of 1972, three sets of data were used to plot predicted and

measured dye concentrations in the river. The value of .5 is recommended as the value for the portion of the tidal volume recirculated on each tidal cycle in order to use the model in a very conservative fashion. From the Figure 11 as depicted on page 21 of the CBI report, the best approximation of real field data (represented by the black dots) is actually the 0.0 assumption, i.e., that all water on any given tide cycle is completely exchanged and that none of the water from the previous tidal period is recirculated. It is, therefore, a conservative assumption that a significant fraction of water is recirculated on a tidal cycle and moves us somewhat further away from the real situation as defined by dye concentrations.

In view of the above information, the interpretation of the flushing model and the utilization of each of the parameters has been conservative and the predicted flushing times would be somewhat longer than might be expected. The use of 67% as a desired reduction in constituent concentration is a convention so that the model runs will be used and compared on the same basis. The use of .5 or half of the tidal volume being recirculated on a tidal cycle is a very conservative estimate to assure that there is no under estimate of flushing time. The same information and assumptions are applied to the steady state model used to define concentrations of conservative materials in the water column over time. In this model, the same parameters as defined in the flushing model were used and the assumptions of .5 for b, and 0.33 for the value for D were used.

Example:

The flushing or exchange rate of water in upper Frog Mortar Creek was estimated in 1984 the U.S. Army Corps of Engineers, Baltimore District (COE, 1984) to be about 8 tidal periods, or about 4 days. This period would be required to reduce a one-time pollutant load by 67 percent. By comparison, a comparable estimate for nearby Dark Head Cove was 6.6 days.

Using the EPA (1985) flushing model reviewed above and assumptions developed by the U.S. COE (1979) regarding volume calculations, a comparison was made between existing and post-development flshing periods. These calculations are summarized below.

Flushing Comparision of A Proposed yacht basin, Before and After Construction, Using The EPA(1985) Flushing Model

Model $$T_f = \frac{T_c \text{ Log } D}{\text{Log } \frac{AL + b\ AR}{AH}}$$ (EPA 1985)

Where:

T_f = time of flushing (hrs) to achieve a specified D

T_c = tidal cycle period = 12.4 hours

D = desired final dilution = 0.33 (fraction of original concentration)

AL = area x low water depth = MLW volume

pre	post
702,720 ft^3	1,633,520 ft^3

AR = area x tidal range = tidal volume

pre	post
210,816 ft^3	416,256 ft^3

AH = area x high water depth = MHW volume

pre	post
913,536 ft^3	2,049,776 ft^3

b = fractional recirculation (assumed) (= 0.50)

Calculation:

$$T_{f\ existing} = 12.4 \times \frac{-0.4815}{\text{Log}\ \frac{702{,}720 + (0.5 \times 210{,}816)}{913{,}536}}$$

$$= 12.4 \times \frac{-0.815}{-0.05325}$$

$$= 12.4 \times 9.042$$

= 112.12 hours or 9.04 tidal cycles or 4.7 days

Calculation:

$$T_{f\ new} = 12.4 \times \frac{-0.815}{\text{Log}\ \frac{1{,}633{,}520 + -0.5(416{,}256)}{2{,}049{,}776}}$$

$$= 12.4 \times \frac{-0.815}{-0.0465}$$

= 128.40 hours or 10.35 tidal cycles or 5.4 days

These data indicate that Frog Mortar Creek in the vicinity of the proposed yacht basin is moderately flushed at the present time, relative to Dark Head Cove. The construction of the expanded marina would result in a slight increase in the average depth, thus reducing flushing (from 4.7 days to 5.4 days). The change represents a 14.5 percent increase in exchange time required for a 67 percent dilution of the water in the creek. This increase is a little more than one tidal cycle.

D2. STEADY STATE CALCULATIONS

Toxic Substances

The bottom paint used on boats is designed to reduce fouling and, as such, contains toxic compounds. Because the use of anti-fouling paints can not be avoided, on a practical basis, with boating and marina use, it is evident that there are few available options to reduce the effects of such paints. EPA (1985) and COE (1979) both conclude in their assessment documents that mitigation largely depends upon paint manufacturers success in developing non-polluting paints in the future, and the role of marina operators in minimizing the exposure and loss of paint to water. Because the recent EPA (1985) Assessment Handbook only cited a rather dated publication by Siebarth and Conover (1965) (wherein an antifouling paint was developed by utilizing the antibiotic activity of seaweed as the control agent) as evidence of possible future approaches to developing non-polluting paints, it is clear that the marina operator and individual boaters have an important role in minimizing the effects of antifouling paints. Because the incentive to control paint use is dependent upon knowledge of potential effects, it is useful to review the recent COE (1979) assessment of copper, (a common antifouling agent), at Mariners Two Marina in Dark Head Cove, Middle River.

This marina, proposed for the Dark Head Cove area, was designed to moor 330 boats. COE (1979) assumed that each boat hull would be freshly painted at the beginning of the season with 1-gallon (3.79 liters) of antifouling paint (Staats, 1978) containing an average of 766 g/l of

copper (Ratheon 1978). If the rate of copper loss was constant and resulted in a 50 percent loss over one season (183 days), then a total of about 2,600 g of copper would be lost per day from all boat hulls combined. Further, if all the copper was dissolved and evenly distributed in the 230,000 m^3 volume of the cove and then subject to a flushing rat of 7 percent per tidal cycle, then the model of Ratheon (1978) allows calculation of an expected steady-state concentration of 80 ug/l of dissolved copper. Because only about 1 percent of total dissolved copper may be expected to be in the toxic cupric (Cu^{++}) ion form (Mantoura et al.; Zirino and Yamamoto 1972; cited by COE 1979), the maximum possible ionic concentration of copper in the cove would not be expected to be higher than an average of 0.8 ug/l.

The importance of the 0.8 ug/l value is evident by comparison with the finding that as little as 2 ug/l ionic copper may reduce successful hatching of spot and Atlantic silverside eggs by 50 percent (Engel and Sundra 1979, cited by COE 1979). These data suggest that some aquatic organisms may be sensitive to copper pollution. COE (1979) observed that the average concentration of ionic copper in Dark Head Cove would probably be lower than 0.8 ug/l for various reasons. Much of the copper lost would be lost as particulate and would not be dissolved, and some copper would be lost outside of the cove while boating. Winds would be expected to increase cove flushing. It is also reasonable to assume that concentrations would vary throughout the cove and would be highest near the moored boats.

For the proposed yacht basin project site, the steady-state model of EPA (1985, Equation 13) was used to calculate the concentration of total copper that might result for a 296 boat facility. The assumptions of COE (1979) were applied as was the bathymetry of the completed (dredged) site. The resulting estimated maximum total copper concentration was 218.5 mg/l, lower than that found for Dark Head Cove because of the better flushing rate predicted for Frog Mortar Creek. The ionic copper level, then, is estimated to be a maximum of 2.2 mg/l.

It should be noted that only 1-13 ug/l total copper were recorded in field studies at the site, where approximately 60 boats are presently moored. However, because these boats are presently moored at the site and several larger marinas are present downstream, there is reason to believe that the steady-state estimations for the post-construction conditions are overly conservative (high) and that 218.5 ug/l of copper would not be measured after site development. Nixon et al. (1973) recorded about 10 ug/l in a cove occupied by 300-400 boats in Rhode Island, suggesting that copper may be rapidly deposited in sediments and relatively unavailable in the ionic form. The following shows the calculation of copper steady-state concentrations following the construction of the proposed water-dependent facility in Frog Mortar Creek. Model (EPA 1985, Equation 13):

Task: Calculation of Copper Steady-State Concentration After Construction, Using the EPA (1985) Model

$$C = \sum_{t=1}^{j} \left\{ \left[\frac{(AL) + (b\ AR)}{AH} \right]^{\frac{24\ t}{T_c}} \cdot \frac{M}{F_{11}\ V_L} \right\}$$

Where

C = Concentration (mg/l)
AL = MLW volume = 1,633,520 ft^3 or 46, 261 m^3
AR = Tidal prism = 416,256 ft^3
AH = MHW volume = 2,049,776 ft^3
b = fractional recirculation (assumed) = 0.5
24/Tc = 24/12.4 = 1.935
M = mg pollutant discharged/day; if 330 boats = 2,600 g/d, 296 boats = 2,332 g/day or 2.332×10^6 mg/d
F_{11} = 1,000 ($m^3 \rightarrow$ l)
V_L = AL

$$C = \sum \left\{ \left[\frac{1{,}633{,}520\ ft^3 + (.5 \times 416{,}256\ ft^3)}{2{,}049{,}776\ ft^3} \right]^{1.935t} \frac{2.332 \times 10^6}{1{,}000 \times 46{,}261\ m^3} \right\}$$

$$= \sum \left\{ (0.89846)^{1.935t} (0.05041) \right\}$$

The daily cumulative concentration of total dissolved copper and the predicted steady-state value are shown in Table 1.

Based on the analysis and discussion above and the fact that copper will not be used on most boats, copper is not expected to result in any significant adverse effect on the biota. Efforts should be made, however, at Golden Ring and other marinas to reduce possible contamination of the water with antifouling paints. These efforts could include the following (EPA 1985):

- Restrict the use of antifouling paints to boat hulls and avoid painting piers and other in-water structures.
- Conduct scraping and painting operations away from the water in protected areas to avoid the loss of particulate and raw paint.
- Avoid repainting hulls after a year during which fouling was minimal.
- Dry store boats not in use for extended periods.

Nutrients

The following calculations compare existing loading at the proposed site with background levels. The existing loadings were calculated to be as follows:

BOD	495.7 lbs/year
Total phosphorus	5.6 lbs/year
Total nitrogen	60.7 lbs/year

These were estimated from average values for stormwater loadings obtained through use of the COG (1981).

The average background values were as follows:

BOD	4.4 mg/l
Total phosphorus	0.01 mg/l
Total nitrogen	1.2 mg/l

These values are from actual onsite field data collected for high and low tide values.

The steady-state model is used as above:

$$C = \sum_{t=1}^{j} \left\{ \left[\frac{(AL) + (b\ AR)}{AH} \right]^{\frac{24\ t}{T_c}} \cdot \frac{M}{1{,}000 \times V_L} \right\}$$

$$C = \Sigma \left\{ 0.89846^{1.935t} \times \frac{M}{1{,}000 \times 46{,}261} \right\}$$

for BOD, M = 495.7 lbs/year
= 1.358 lbs/year
= 0.616 kg/year
= 616 g/day
= 6.16×10^5 mg/day

The daily cumulative concentrations and approximate steady-state value are shown in Table 1. Because 57.7 ug/l is the BOD steady-state with existing site runoff and 4.4 mg/l or 4,400 ug/l is the existing background, then the site contributes approximately 1 percent of that value. (Note: assuming no decay of BOD) If stormwater loading is reduced to 238.7 lbs/year, expected change in the proportion of BOD loading attributable to the proposed site would be approximately 0.5 percent of the background, assuming no changes in other overall impact occurred.

If the total phosphorus loading from the existing site is 5.6 lbs/year (6.96×10^3 mg/day), then the steady-state portion attributable to the proposed site would be 0.199 ug/l.

Because the background concentration is 0.01 mg/l = (10 ug/l), the site presently contributes 2 percent of existing background. Post-construction loadings would be not expected to change significantly.

If the total post-construction site loading of nitrogen is 75.2 lbs/day (9.34×10^4 mg/day), then the steady-state contribution from the site would be 2.67 ug/l.

Because background is 1.2 mg/l = (1,200 ug/l), the finished marina site would contribute 0.22 percent of existing background.

TABLE D-1 CALCULATIONS OF EXISTING STEADY-STATE CONDITIONS OF TOTAL DISSOLVED COPPER AND CONDITIONS OF TOTAL BIOCHEMICAL OXYGEN DEMAND (BOD) IN FROG MORTAR CREEK

Equation: $C\ (\mu g/l) = (0.89846)^{1.935(t)}\ (F)$

where

F = 50.41 total dissolved copper
F = 13.32 total BOD

Daily Incremental Concentration (µg/l)		Cumulative Concentration (µg/l)	
$C_1 = 0.813$	(x F)	0.813	(x F)
$C_2 = 0.661$		1.474	
$C_3 = 0.537$		2.011	
$C_4 = 0.437$		2.448	
$C_5 = 0.355$		2.803	
$C_6 = 0.288$		3.091	
$C_7 = 0.234$		3.325	
$C_8 = 0.191$		3.516	
$C_9 = 0.155$		3.671	
$C_{10} = 0.126$		3.797	
$C_{11} = 0.102$		3.899	
$C_{12} = 0.083$		3.982	
$C_{13} = 0.068$		4.050	
$C_{14} = 0.055$		4.105	
$C_{15} = 0.045$		4.150	
$C_{16} = 0.036$		4.186	
$C_{17} = 0.030$		4.216	
$C_{18} = 0.024$		4.240	
$C_{19} = 0.020$		4.260	
$C_{20} = 0.015$		4.275	
$C_{21} = 0.013$		4.288	
$C_{22} = 0.010$		4.298	
$C_{23} = 0.009$		4.307	
$C_{24} = 0.007$		4.314	
$C_{25} = 0.006$		4.320	
$C_{26} = 0.005$		4.324	
$C_{27} = 0.004$		4.328	
$C_{28} = 0.003$		4.331	
$C_{29} = 0.002$		4.333	
$C_{30} = 0.002$		4.335	

Therefore: Total dissolved copper = 4.335 x 50.41 = 218.5 µg/l.
Total BOD = 4.335 x 13.32 = 57.7 µg/l.

```
W   W   000   RRRR   DDDD            1      1
W   W  0   0  R   R  D   D          11     11
W   W  0   0  R   R  D   D        1 1    1 1
W W W  0   0  RRRR   D   D  -----    1      1
W W W  0   0  R R    D   D           1      1
WW WW  0   0  R  R   D   D           1      1
W   W   000   R   R  DDDD         11111  11111
```

```
U   U  IIIII   CCC                          DDDD    000    CCC
U   U    I    C   C                        D   D  0   0  C   C
U   U    I    C                            D   D  0   0  C
U   U    I    C                            D   D  0   0  C
U   U    I    C                            D   D  0   0  C
U   U    I    C   C                        D   D  0   0  C   C
 UUU   IIIII   CCC                         DDDD    000    CCC
```

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3333    000    000       /  3333    666    666          000    000      1
   3  0   0  0   0      /       3  6      6            0   0  0   0     11
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APPENDIX E

SIMPLE ONE DIMENSIONAL KINEMATIC MODEL RESULTS FOR THE BUSH RIVER AND ROMNEY CREEK

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SPECIAL REPORT 49

SIMPLE ONE DIMENSIONAL KINEMATIC MODEL RESULTS FOR THE BUSH RIVER AND ROMNEY CREEK

by

H.H. Carter

This report contains results of work carried out for the State of Maryland, Department of Natural Resources as part of the Power Plant Siting Program.

This report does not necessarily constitute final publication of the material presented.

Reference 76-2
March 1976

M. Grant Gross
Director

62921

EXECUTIVE SUMMARY

A site known as Perryman located on the eastern shore of the Bush River adjacent to the Aberdeen Proving Ground has been proposed by the Baltimore Gas and Electric Company as a potential site for a generating station. Although a construction schedule has not been finalized, the site is still in the company's 10-year plan (as of 1 January 1976).

This report describes simple one dimensional transient state transport, i.e., kinematic, models of the Bush River and of Romney Creek, both potential receivers of excess heat and/or contaminants from the blowdown of any cooling towers associated with a generating station constructed at the site. In addition, the results of an independent verification of the Bush River model by means of two dye experiments (spring and fall, 1972) are presented together with a quantitative comparison of the two systems as potential receivers of waste according to the two models.

The Romney Creek model was also run with a hypothetical heat source and a surface cooling term to illustrate the effect of surface cooling on the distribution of excess heat.

No conclusions as to site suitability are drawn in the report; analysis and interpretation of the model predictions in terms of environmental impact will be contained in a separate report.

ACKNOWLEDGEMENTS

I wish to acknowledge the cooperation of the Baltimore Gas and Electric Company in permitting us to use their Bush River and Romney Creek transport models and model results, and to reprint certain figures from the reports describing these models.

Mr. M.T. Miyasaki and R.C. Orth of the Applied Physics Laboratory, The Johns Hopkins University, were major participants in both the collection and reduction of the dye data for both spring and fall dye experiments; their considerable contributions to verification of the Bush River model are gratefully acknowledged.

TABLE OF CONTENTS

		Page
I.	Introduction	1
II.	A One Dimensional Transient State Model of the Bush River	8
III.	A One Dimensional Transient State Model of Romney Creek	28
	References	37

ILLUSTRATIONS

Figure		Page
1.	Chart showing the location of the Bush River and Romney Creek.	2
2.	Map of Bush River Region.	3
3.	Tidal variation in salinity at mouth of Bush River 24 July 1971.	6
4.	Schematic of one-dimensional segmented model indicating segmentation and exchange parameters used to characterize flow.	10
5.	Predicted and measured dye concentrations in Box 1, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.	15
6.	Predicted and measured dye concentrations in Box 2, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.	16
7.	Predicted and measured dye concentrations in Box 3, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.	17
8.	Predicted and measured dye concentrations in Box 4, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.	18
9.	Predicted and measured dye concentrations in Box 5, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.	19
10.	Predicted and measured dye concentrations in Box 6, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.	20

ILLUSTRATIONS *(continued)*

Figure Page

11. Predicted and measured dye concentrations in Box 1, Bush River (Fall, 1972); solid vertical line is time dye source was terminated. 21

12. Predicted and measured dye concentrations in Box 2, Bush River (Fall, 1972); solid vertical line is time dye source was terminated. 22

13. Predicted and measured dye concentrations in Box 3, Bush River (Fall, 1972); solid vertical line is time dye source was terminated. 23

14. Predicted and measured dye concentrations in Box 4, Bush River (Fall, 1972); solid vertical line is time dye source was terminated. 24

15. Predicted and measured dye concentrations in Box 5, Bush River (Fall, 1972); solid vertical line is time dye source was terminated. 25

16. Predicted and measured dye concentrations in Box 6, Bush River (Fall, 1972); solid vertical line is time dye source was terminated. 26

17. Romney Creek showing location of segment boundaries and sampling stations. 29

18. Predicted dye concentration in ppb in Segment 1 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 1; solid vertical line is time dye source was terminated. 32

ILLUSTRATIONS *(continued)*

Figure Page

19. Predicted dye concentration in ppb in Segment 2 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 2; solid vertical line is time dye source was terminated. 32

20. Predicted dye concentration in ppb in Segment 3 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 3; solid vertical line is time dye source was terminated. 33

21. Predicted dye concentration in ppb in Segment 4 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 4; solid vertical line is time dye source was terminated. 33

22. Predicted dye concentration in ppb in Segment 5 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 5; solid vertical line is time dye source was terminated. 34

23. Predicted dye concentration in ppb in Segment 6 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 6; solid vertical line is time dye source was terminated. 34

LIST OF TABLES

Table		Page
1.	Volume Exchange Rates (k_{ij})	13
2.	Volume Exchange Rates (k_{ij})	30
3.	Steady State Dye Concentrations for Bush River and Romney Creek	31
4.	Excess Temperatures in Romney Creek under Various Cooling Conditions	36

I. Introduction

The Maryland Power Plant Siting Act directs the electric utilities and the Maryland Public Service Commission to engage in long range planning and to develop forecasts for electric demand and supply. Each year the PSC must submit to the Department of Natural Resources for environmental evaluation a formal ten-year plan, forecasting Maryland's future electric needs and designating all proposed power plant sites and associated transmission facilities. Seven sites were proposed in the first ten-year plan, two of which were selected for detailed site investigation, namely, Brandon Shores on the Patapsco River and Perryman on the Bush River.

Accordingly, the Department of Natural Resources contracted with the Applied Physics Laboratory, the Chesapeake Bay Institute, and the Department of Geography and Environmental Engineering of The Johns Hopkins University to conduct the detailed site investigations at these two locations. The purpose of this report is to characterize the physical hydrography of the Bush River estuary based on these detailed site investigations and studies performed by BG&E consultants[1]. Analysis and interpretation of these data in terms of environmental impact of the proposed installations are contained in a separate report entitled *Distribution of contaminants and excess heat in the Bush River and Romney Creek from the proposed Perryman Electric Power Plant.*

Figure 1 is a small scale chart of Chesapeake Bay showing the general location of the study area, i.e., the Bush River and Romney Creek. Figure 2 is a larger scale chart of the study area. As may be seen from Figures 1 and 2, the Bush River is a tributary estuary of the Chesapeake Bay. It is located on the western shore of the Bay approximately 15 miles down the bay from the mouth of the Susquehanna River.

[1]Hydrocon, Inc., Baltimore, MD and Shepard T. Powell Associates, Baltimore, MD.

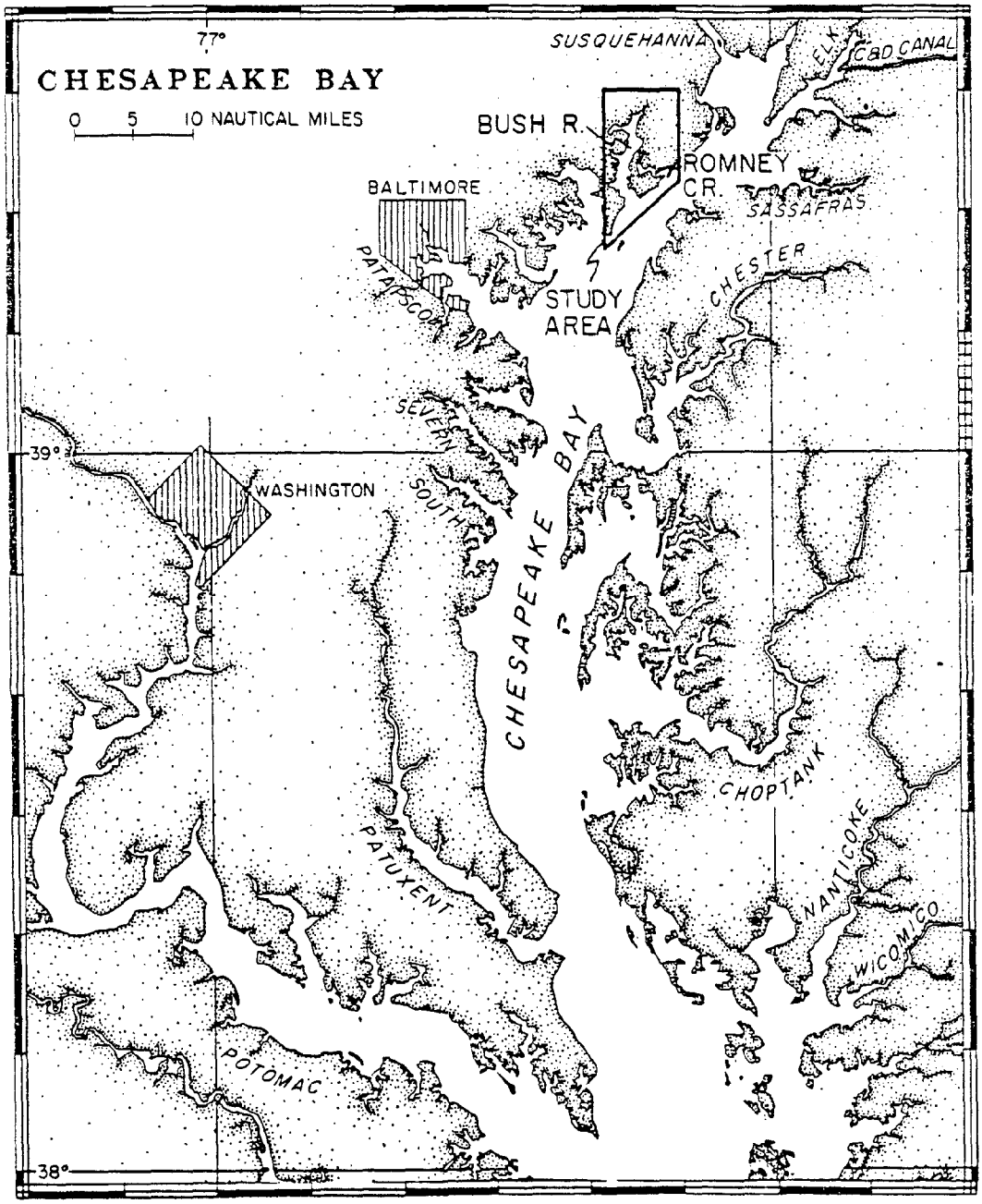

Figure 1. Chart showing the location of the Bush River and Romney Creek.

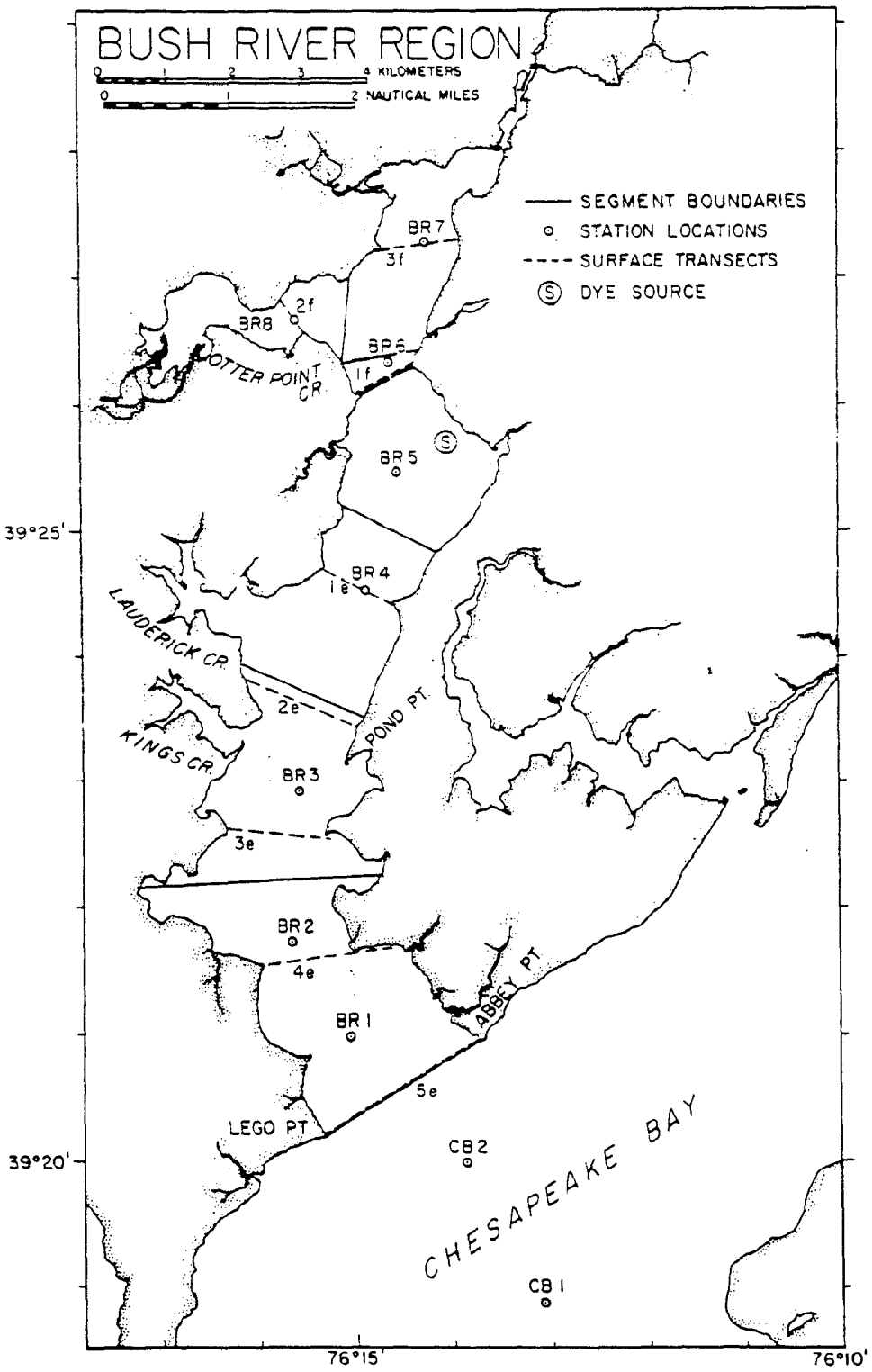

Figure 2. *(Reprinted with permission of BG&E)*

The Bush River estuary is a drowned river valley estuary formed by the most recent rise in sea level. The age of the *estuary* is less than 5,000 years and it may be only 2 - 3,000 years. Its drainage area is small, approximately 113.29 square miles (statute), resulting in a mean annual run-off of the order of 130 $ft^3\ sec^{-1}$ (3.68 m^3). Consequently, waters in the Bush are derived mainly from the adjacent Chesapeake Bay.

The tide in the Bush River is semidiurnal with a mean range of 1.4 feet reported for Pond Point. This tidal range results in an intertidal volume of approximately $42.9 \times 10^7\ ft^3$. This is about 20% of the volume below mean tide level (MTL) which is $20.64 \times 10^8\ ft^3$. At the time of maximum tidal velocity at the entrance, the discharge through the mouth of the river is approximately $30 \times 10^3\ ft^3\ sec^{-1}$.

Measured along its axis the Bush is approximately 8.5 nautical miles from mouth to head. The depth increases generally from head to mouth with the maximum depth of 32 feet near Briery Point; the mean depth is approximately 6 feet. At its widest point, the Bush is approximately 2 nautical miles wide.

The salinity throughout the Bush varies little with depth. This is probably due to the combination of small local fresh water inflow, shallow mean depth, and low stratification of the adjacent Bay waters. Lateral salinity variations are small everywhere except in the vicinity of Otter Point Creek. Longitudinal salinity variations can be considerable, however, with differences as large as 2 - 3‰ from head to mouth on occasion. Because of the proximity of the Bush River to the Susquehanna River, the salinity in the Bush does not necessarily increase or decrease monotonically along the length of the river. That is, at any given instant the longitudinal salinity

distribution is determined primarily by the Bay salinity and to a lesser extent by the fresh water inflow to the Bush from Otter Point Creek. As a result, a salinity maximum located in the central portion of the Bush is not an uncommon feature. There are also salinity variations with tidal periods at a fixed point with amplitudes ranging from 0.5‰ near the mouth to essentially zero near the head. Figure 3 shows a typical variation of salinity over a tidal period for a location at or near the mouth. These data were collected in conjunction with a different study[2] by the Chesapeake Bay Institute during July of 1971. Points represent salinity data averaged over a cross section between Lego Point and Abbey Point.

The continual striving by the Bush to match its salinity to that of the adjacent Bay waters by gravitational convection is the principal mechanism for exchange. The primary modes of this density driven convective exchange may be inferred from our previous remarks regarding the longitudinal salinity distribution. That is, when the salinity in the Bay waters adjacent to the mouth of the Bush River are relatively constant or slowly rising, the local fresh water inflow at Otter Point Creek is apparently sufficient to maintain the usual estuarine type of circulation, i.e., outflow at the surface and inflow in the lower layers. These conditions should prevail primarily during late summer and early fall. In the spring, on the other hand, rapid and large salinity fluctuations occur in the Bay waters off of the Bush. This often results in a situation where the water in the Bush River is more saline and therefore heavier than that in the adjacent Bay. The typical estuarine flow is now reversed with inflow at the surface and outflow at depth.

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[2] The Chesapeake Bay Hydraulic Model Study

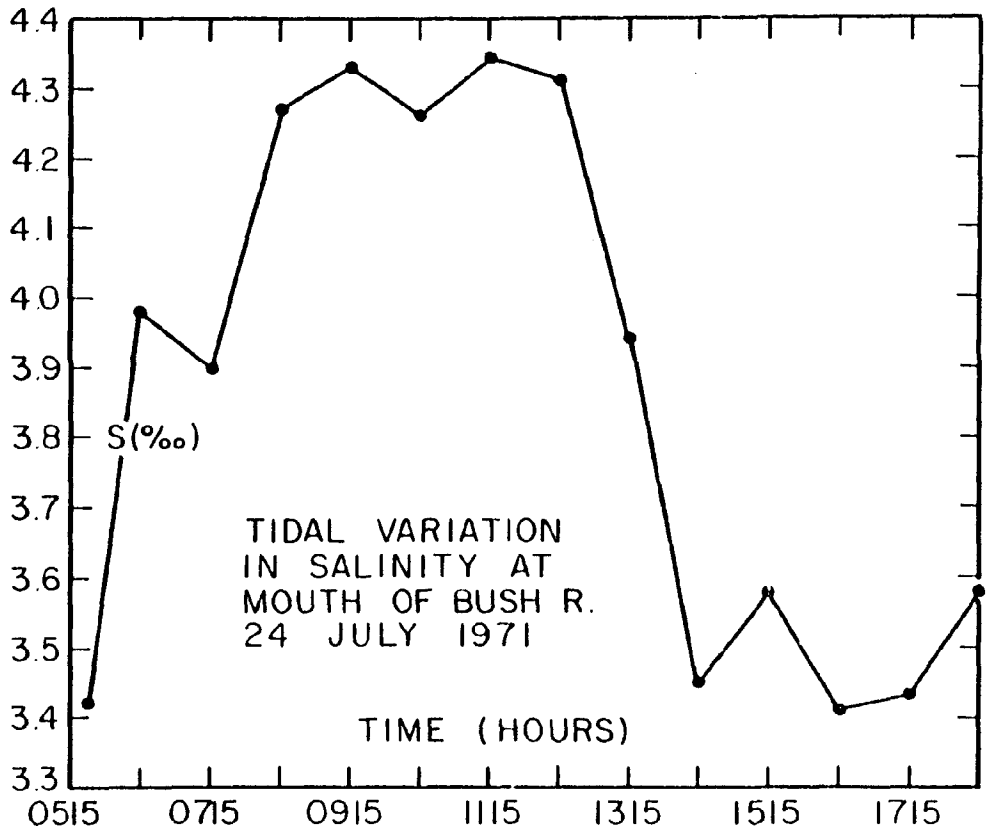


Figure 3. *(Reprinted with permission of BGSE)*

In addition to motions caused by density differences and astronomical tides, there are undoubtedly important wind-induced motions present from time to time.

Romney Creek is a shallow tributary estuary of the Chesapeake Bay located on the western shore of the Bay just north of the Bush River. Its origin and age are undoubtedly similar to those of the Bush River. Its drainage area, however, is considerably smaller than that of the Bush River, approximately 13 square miles (statute). Assuming a tidal range similar to that of the Bush River, the intertidal volume of Romney Creek is 1.8×16^5 m^3 or 72% of its volume below mean low water (2.5×10^6 m^3). This latter figure could conceivably be larger since the quantity of tidal water in the marshland upstream from the Poverty Island Bridge is not known.

The mean depth of Romney Creek is slightly under 2 feet. Vertical and lateral salinity variations are small. Longitudinal variations as high as 3 - 4 ‰ were observed, however, which, like the Bush River, have a similar dependence on the recent history of Bay salinity and local fresh water run-off. Figure 17 in Section III is a large scale chart of Romney Creek.

II. A One Dimensional Transient State Model of the Bush River

This section describes a simple one-dimensional transient state model of the Bush River constructed by *Hydrocon, Inc.* for the Baltimore Gas and Electric Company utilizing salt as the tracer. The segmented model approach, the construction of a segmented model of the Bush River estuary, and results of its numerical evaluation are contained in *Hydrocon, Inc.* Research Report entitled "A One Dimensional Segmented Transient State Model of the Bush River Estuary," Reference 110A, December 1972. Because of the limited distribution of that report, selected portions of it are included herein with minor modification with the permission of the Baltimore Gas and Electric Company.

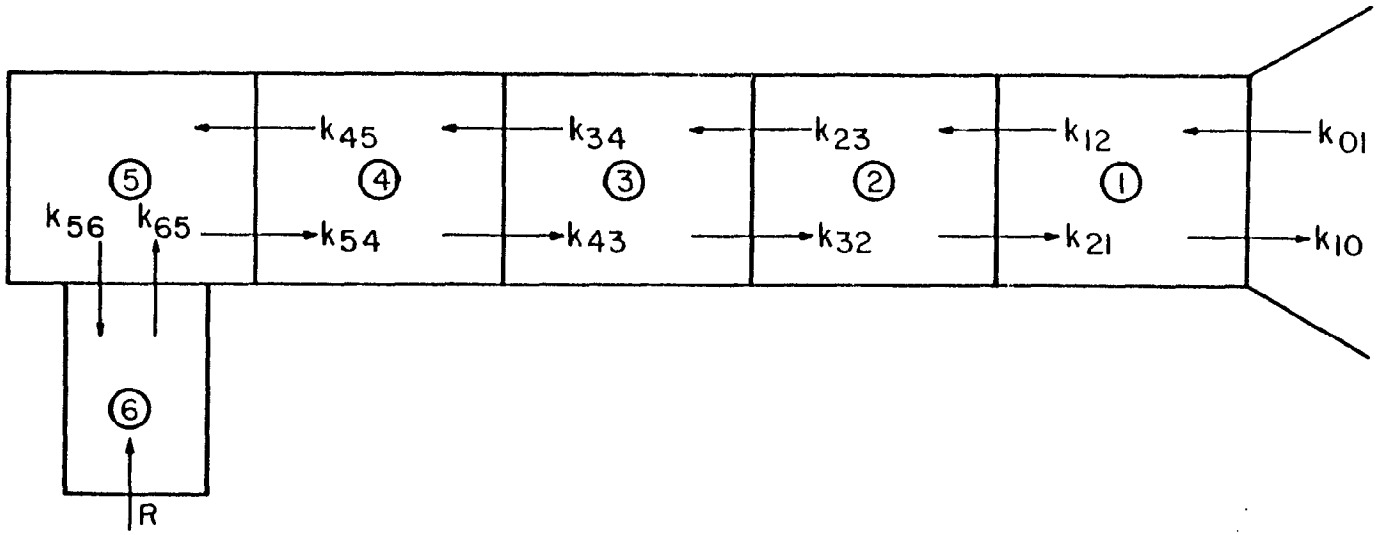
The general transport equation that governs the distribution of any passive waterborne contaminant is well-known. It is a first order partial differential equation involving the three spatial coordinates and time as the independent variables. Solution of the transport equation for advective and diffusive fluxes, given the spatial and temporal distribution of some tracer material, is intractable, however, without considerable simplification.

To put the problem in a more tractable form, the usual procedure is to divide the volume of the region under study into a finite number of segments. The appropriate form of the transport equation is found by integrating the original equation over each segment volume. The resulting equations relate the advective and diffusive flux of a tracer across the faces of a segment to the time rate of change of tracer material within the segment. The same integration procedure is also applied to the continuity equation.

The segmented model approach is then as follows: determine the temporal and spatial distribution of a tracer; average these data over the volumes of the segments; then solve the system of equations formed by the integrated transport and continuity equations for advective and diffusive fluxes at the faces of each segment.

Material suitable as a tracer may occur naturally, such as ocean derived salt, or it may be added artificially. If salinity gradients are significant and if the magnitude and location of the sources of fresh water are known, salt will be useful. Because these conditions were met in the Bush River, salt was selected as the primary tracer.

The Bush River was divided longitudinally into 6 segments as shown in Figure 2. Most segments were either 1.5 or 2 nautical miles long and were selected to be at least as great as the local tidal excursion. Other considerations were system geometry and future source positions. Because lateral and vertical salinity gradients are small (see Section I), no provision was made for vertical or lateral variation in the segmentation scheme. Two equations were then written for each segment; the integrated transport equation and the continuity equation. Simplified versions were utilized by replacing the terms representing advective and diffusive fluxes of salt or water by simple inward and outward directed exchanges at the face of each segment, k_{ij}, having the units of volume per unit time. Figure 4 is a schematic of the one-dimensional segmented model. It indicates segmentation and exchange parameters used to characterize the mass fluxes. R is the volume rate of fresh water inflow.



SCHEMATIC OF ONE-DIMENSIONAL SEGMENTED MODEL INDICATING SEGMENTATION AND EXCHANGE PARAMETERS USED TO CHARACTERIZE FLOW.

Figure 4. *(Reprinted with permission of BG&E)*

The exchanges, k_{ij}, were evaluated as follows. Salinity data were collected at intervals of approximately one day and at sufficient locations so that a volume averaged salinity was obtained for each segment as a function of time. A polynomial was fitted to these data resulting in a continuous function of volume averaged salinity as a function of time. These polynomials and their first derivatives were evaluated at 24 hour intervals to obtain S_i, the volume averaged salinity for the ith segment, and $\frac{dS_i}{dt}$, its rate of change with time.

R, the fresh water inflow, for the same period of time was obtained from U.S.G.S. records for the gauge station located on Winters Run at a point 10.5 miles upstream from its point of discharge into Otter Point Creek. The drainage area upstream from the gauge station on Winters Run is 35 square miles (statute); the total area drained by Winters Run and Otter Point Creek is estimated to be 113 square miles. Therefore, the recorded discharges were multiplied by a factor of 113/35 or 3.23.

The transport and continuity equation sets now represent a determinate system for the k_{ij}'s (exchanges) if the salinity of the bay water that exchanges with the water in box 1 is known. For this purpose, the cross-sectionally averaged salinity at the mouth of the Bush River was used. The k_{ij} so determined differed from one 24 hour period to another, sometimes considerably. The value taken as representative of the sampling period was the median of all 24 hour periods.

The ultimate goal was, of course, to predict concentration distributions resulting from hypothesized contaminant sources, q_i, from the transport and continuity equation sets and the k_{ij}'s determined from the salinity data. The

sampling periods should, therefore, be representative of the periods for which predictions are desired. Salinity data were taken and k_{ij}'s computed for a spring or high flow period (5 - 23 March 1972) and a fall period or low runoff condition (28 September - 4 October 1972). The k_{ij}'s for both spring and fall conditions are listed in Table 1. It is important to realize that the k_{ij}'s listed in Table 1 are statistically obtained values and represent the combined effects of both advection and turbulent diffusion on the contaminant source. Concentration distributions from actual sources will differ from predicted values as one approaches the source and when hydrographic conditions depart markedly from the conditions that existed during the time the salinity data were taken.

Verification of the *Hydrocon* model was carried out by APL/CBI scientists during two dye tracer experiments. The first study was conducted during April of 1972 and was designed to verify the spring exchanges. A second study for verification of the fall exchanges was carried out during November 1972.

The spring experiment consisted of a continuous release of 5.168 pounds of dry Rhodamine WT dye per day in segment 4[3] commencing at 1600 hours on 15 April 1972 and ending at 0800 on 30 April 1972. The fall dye release was at the rate of 4.25 pounds of dry Rhodamine WT dye per day in segment 4 starting at 1705 on 2 November 1972 and ending at 1035 on 18 November 1972. Dye concentrations were sampled during the buildup for the spring experiment and during the die away during the fall experiment. The dye concentration data thus obtained were averaged volumetrically for comparison with the model predictions.

[3] The proposed site of the Perryman plant is on the east bank of segment 4.

TABLE 1

Volume Exchange Rates* (k_{ij})

(cubic feet per second)

	Spring Conditions	Fall Conditions
k_{01}	5800 - R/2	2050 - R/2
k_{10}	5800 + R/2	2050 + R/2
k_{12}	1250 - R/2	2800 - R/2
k_{21}	1250 + R/2	2800 + R/2
k_{23}	600 - R/2	1790 - R/2
k_{32}	600 + R/2	1790 + R/2
k_{34}	2680 - R/2	860 - R/2
k_{43}	2680 + R/2	860 + R/2
k_{45}	510 - R/2	540 - R/2
k_{54}	510 + R/2	540 + R/2
k_{56}	790 - R/2	720 - R/2
k_{65}	790 + R/2	720 + R/2

*Continuity requires that k_{ij} and k_{ji} at a segment boundary differ by R, the fresh water discharge. The exchanges are therefore listed as a median value ± R/2.

After the addition of a dye source term, q_d, in segment 4, the transport and continuity equation sets were integrated in time to obtain predicted concentrations for each segment as a function of time corresponding to spring and fall exchanges. Required for this computation, however, were concentration values for the boundary between the Bay and segment 1. Since these were unknown, they were set equal to α times the concentration in segment 1. Computations were carried out for values of α of 0.75, i.e., the incoming Bay water has a concentration 0.75 of that in segment 1 with which it exchanges, and α equal to 0. The predicted concentrations together with the dye concentration field data are shown in Figures 5 through 16. Steady state values were estimated by integrating in time without terminating the source until the concentrations reached steady values.

In order to apply our results we assume that the dye source, $\dot{q}_d$, was discharged into a hypothetical plant discharge, Q_c. Its initial concentration at the point of discharge is therefore

$$C_o = q_d/Q_c \quad . \tag{1}$$

We define the dilution ratio[4] of the ith segment as

$$(D_i) = C_o/(C_d)_i \tag{2}$$

where $(C_d)_i$ is the dye concentration in the ith segment.

---

[4] The dilution ratio is $1 + \sigma$ where σ is the volume of receiving water into which a unit volume of effluent is mixed.

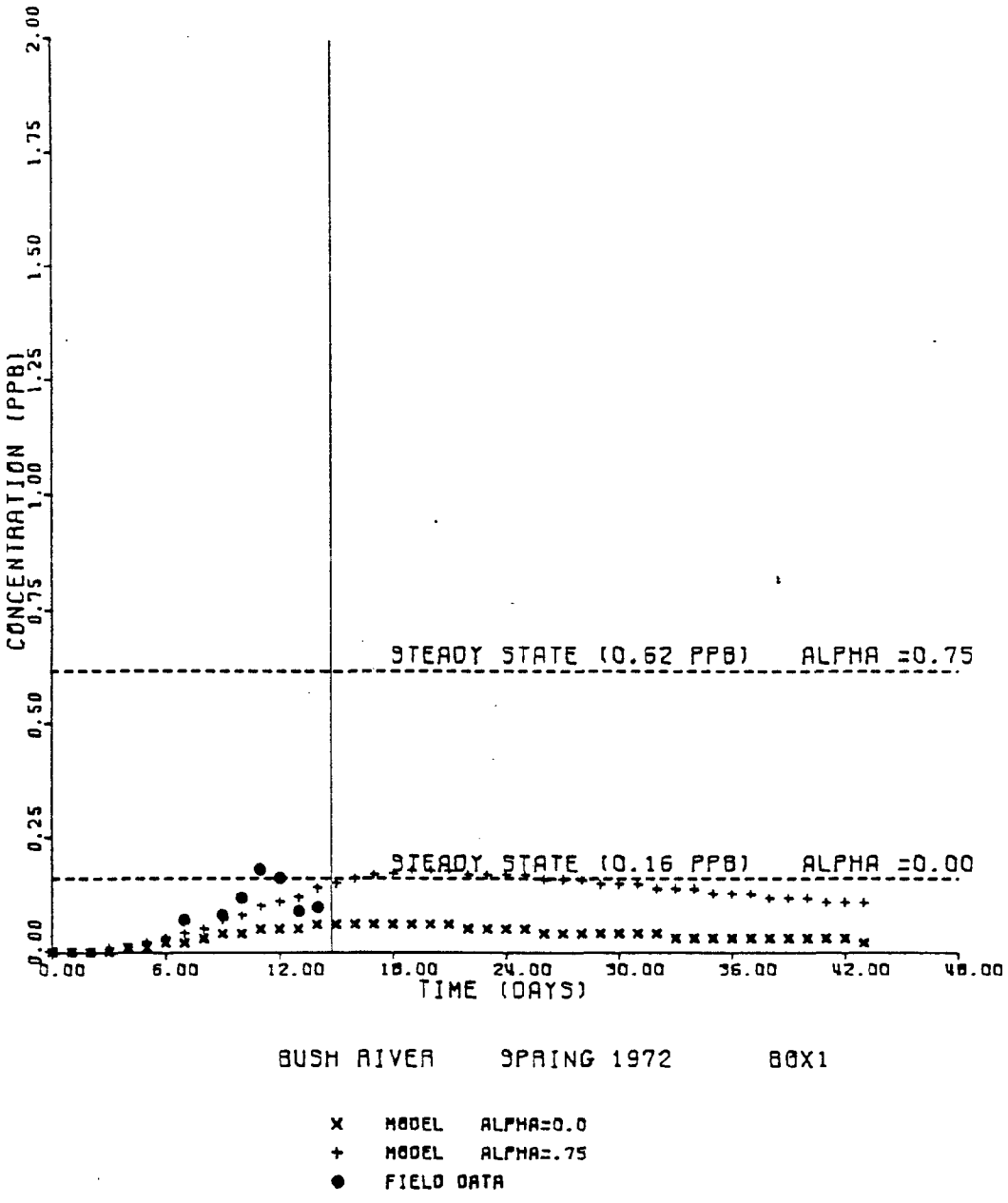


Figure 5. Predicted and measured dye concentrations in Box 1, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.

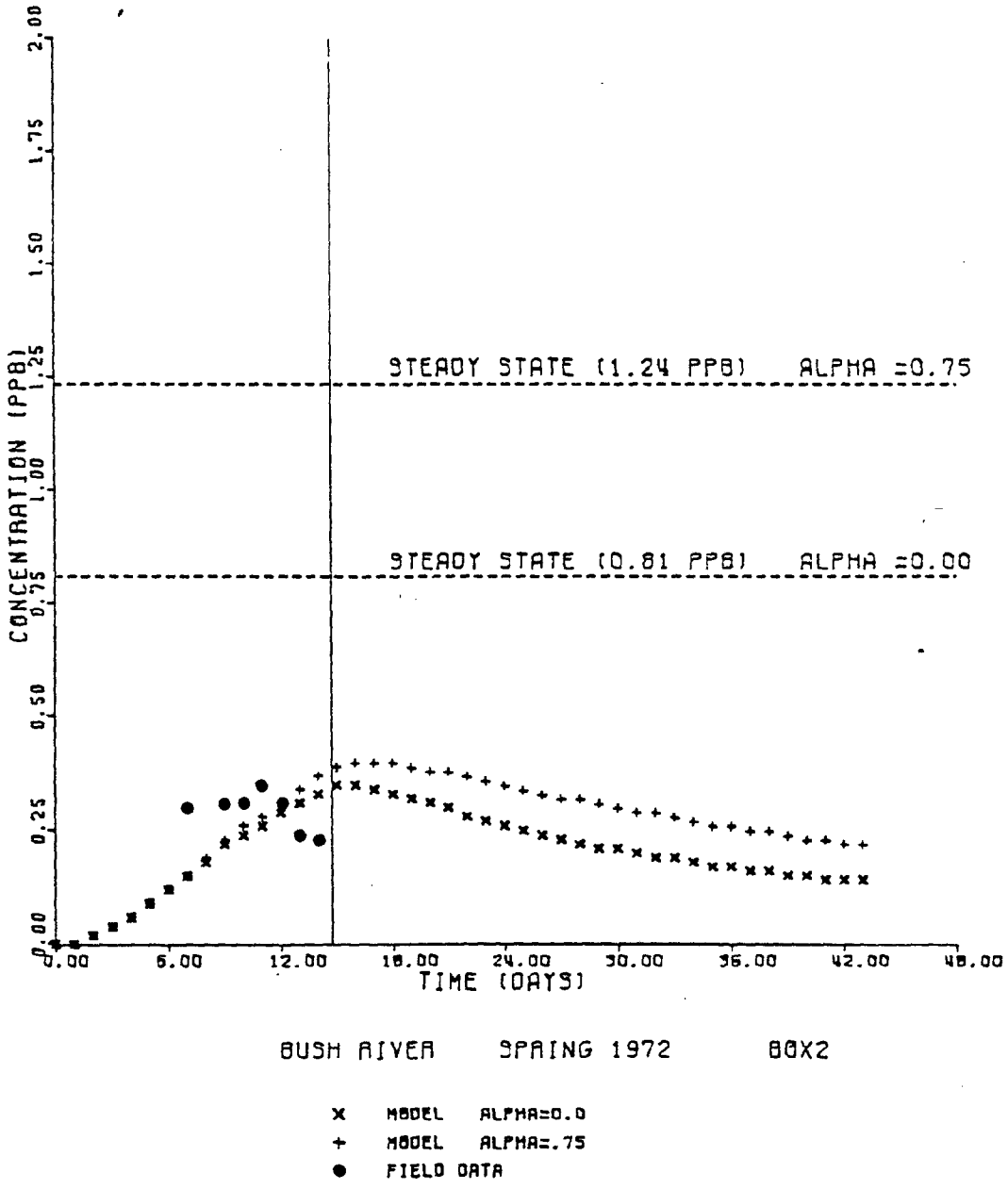


Figure 6. Predicted and measured dye concentrations in Box 2, Bush River (Spring 1972); solid vertical line is time dye source was terminated.

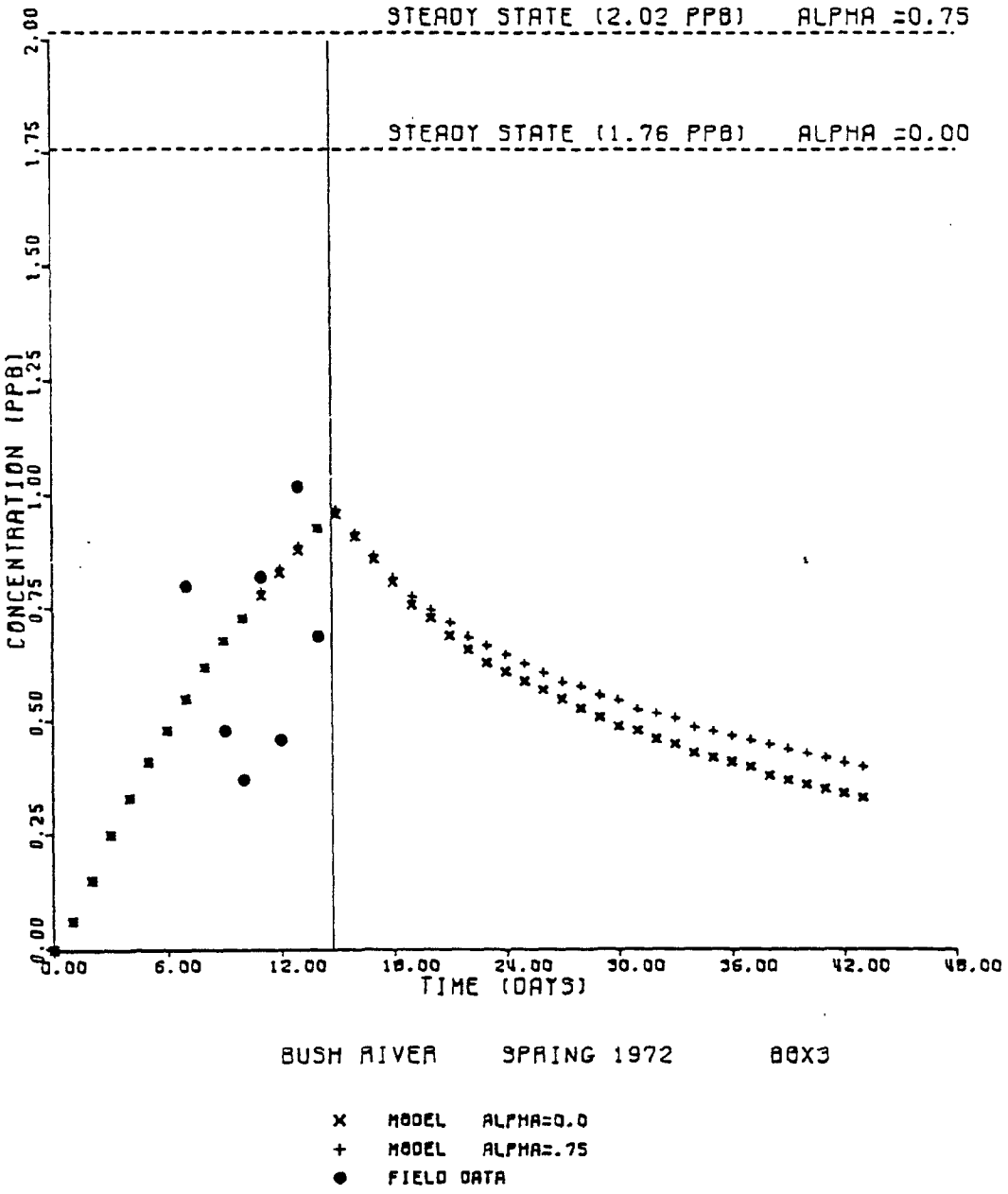


Figure 7. Predicted and measured dye concentrations in Box 3, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.

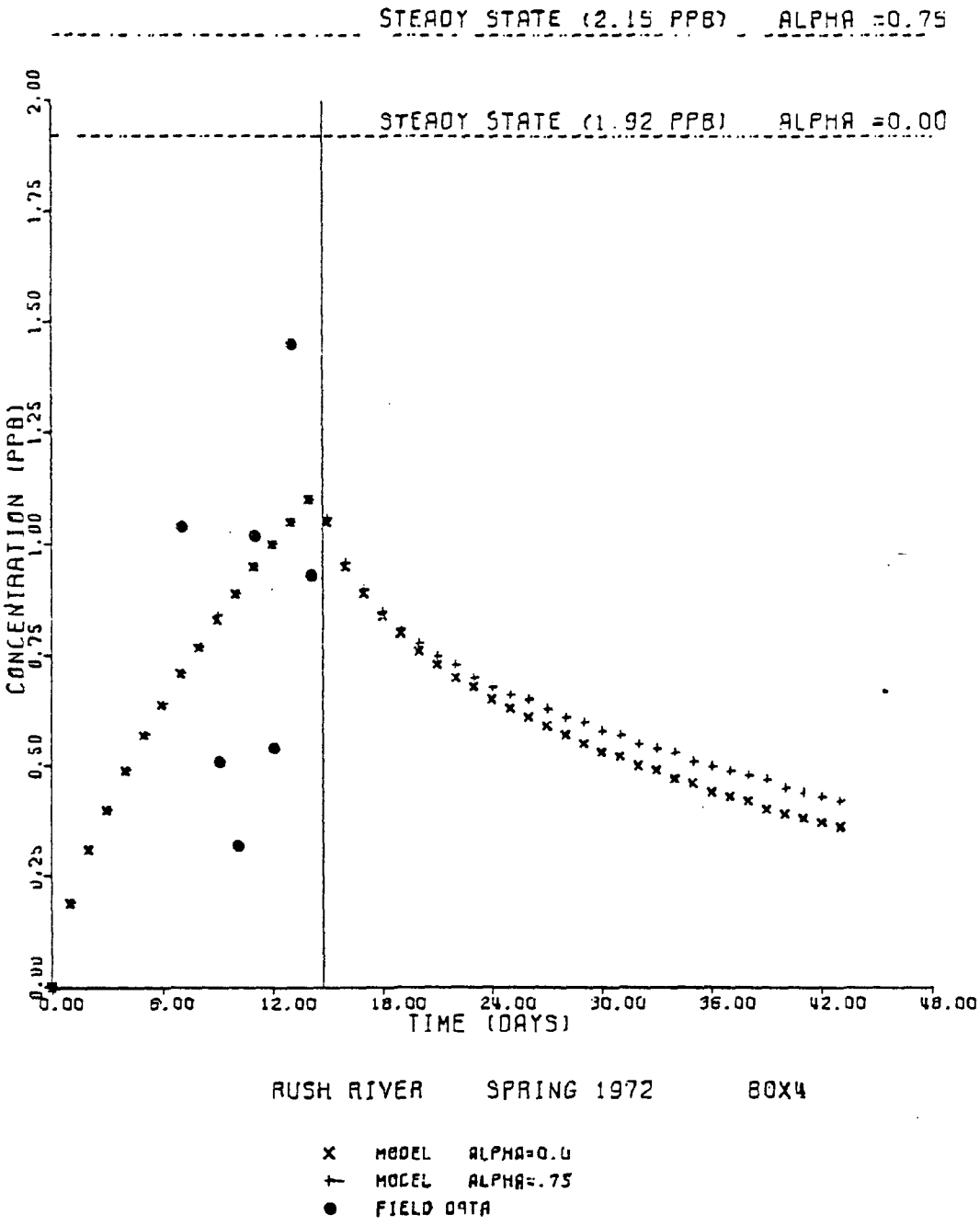


Figure 8. Predicted and measured dye concentrations in Box 4, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.

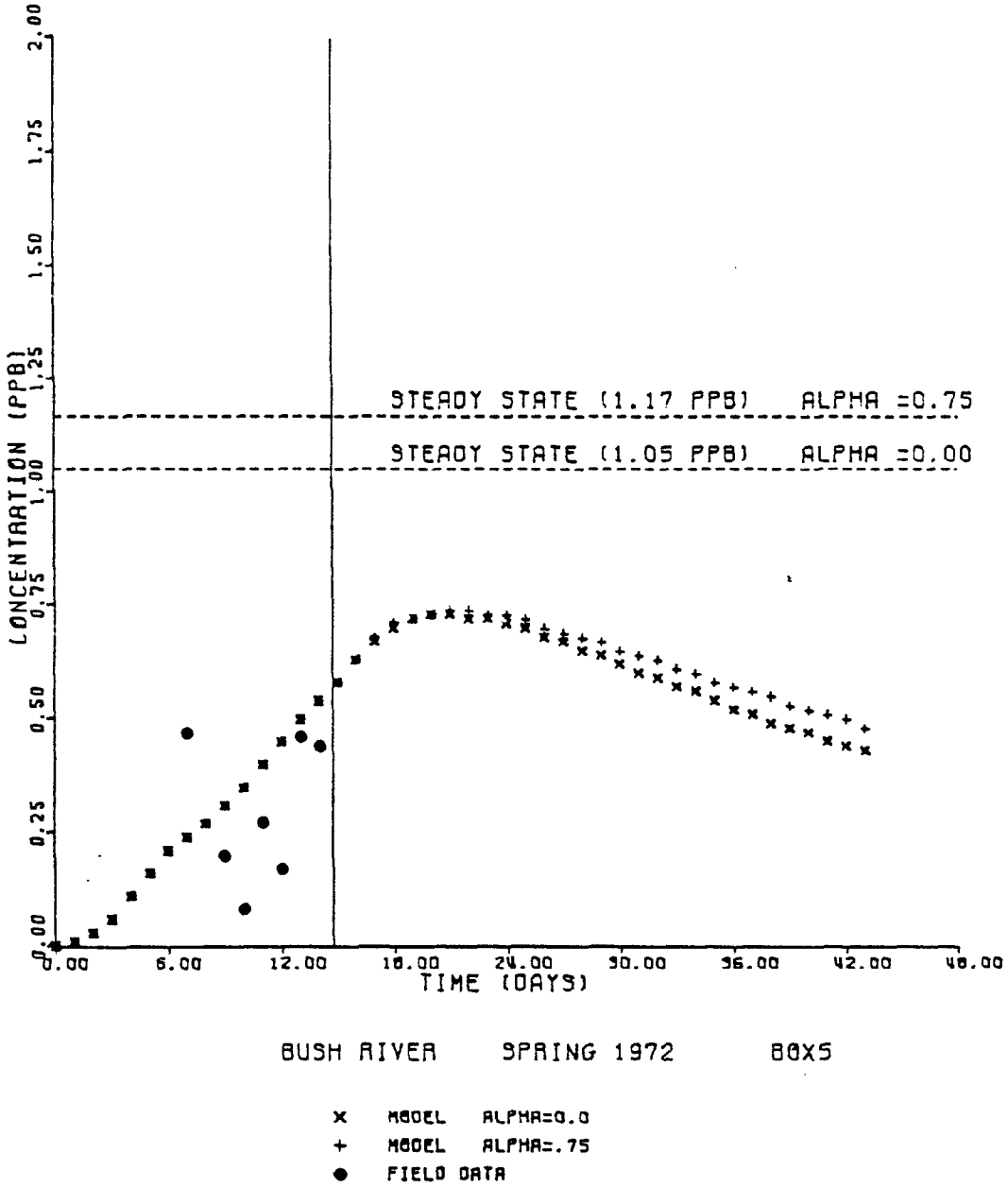


Figure 9. Predicted and measured dye concentrations in Box 5, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.

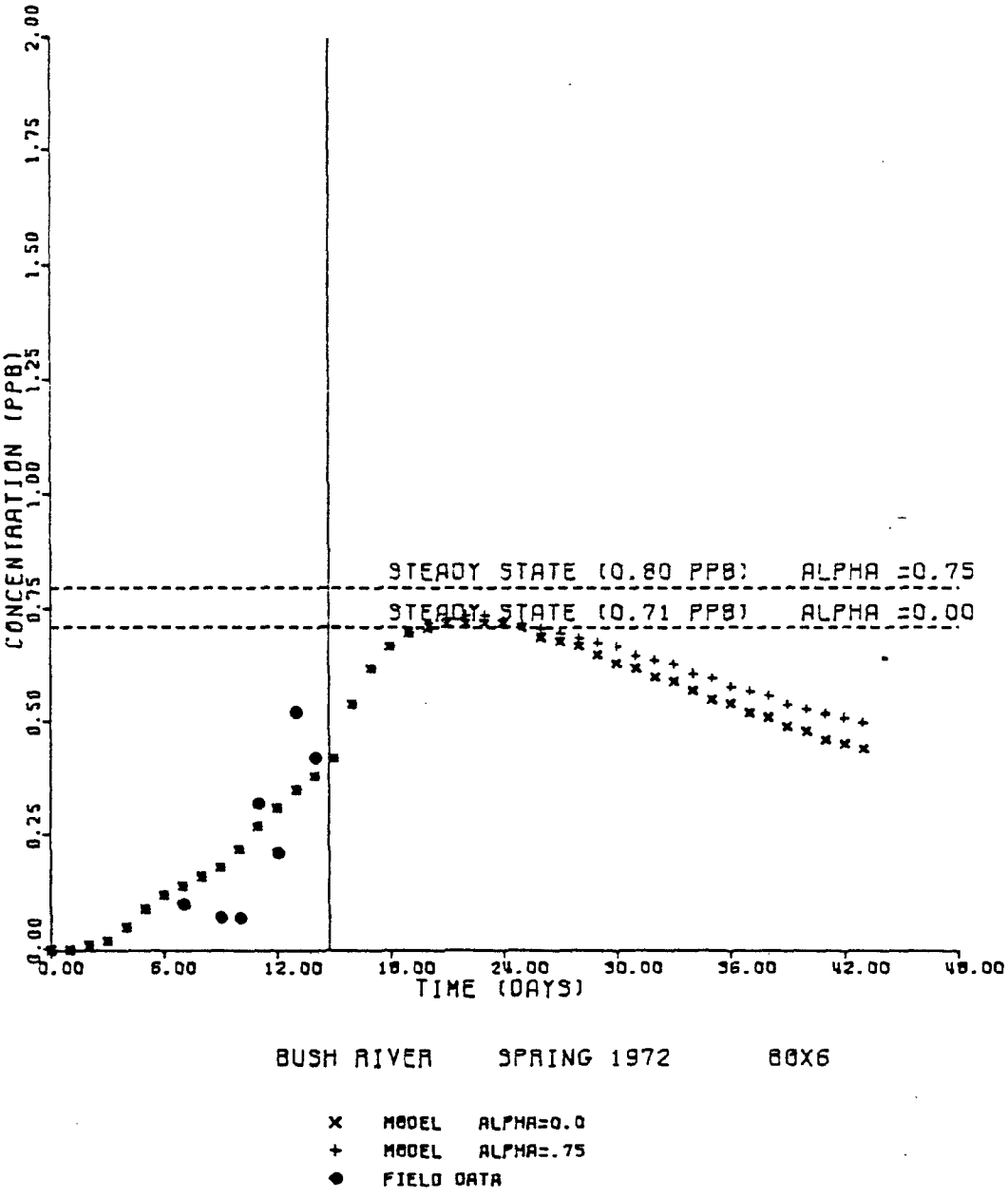


Figure 10. Predicted and measured dye concentrations in Box 6, Bush River (Spring, 1972); solid vertical line is time dye source was terminated.

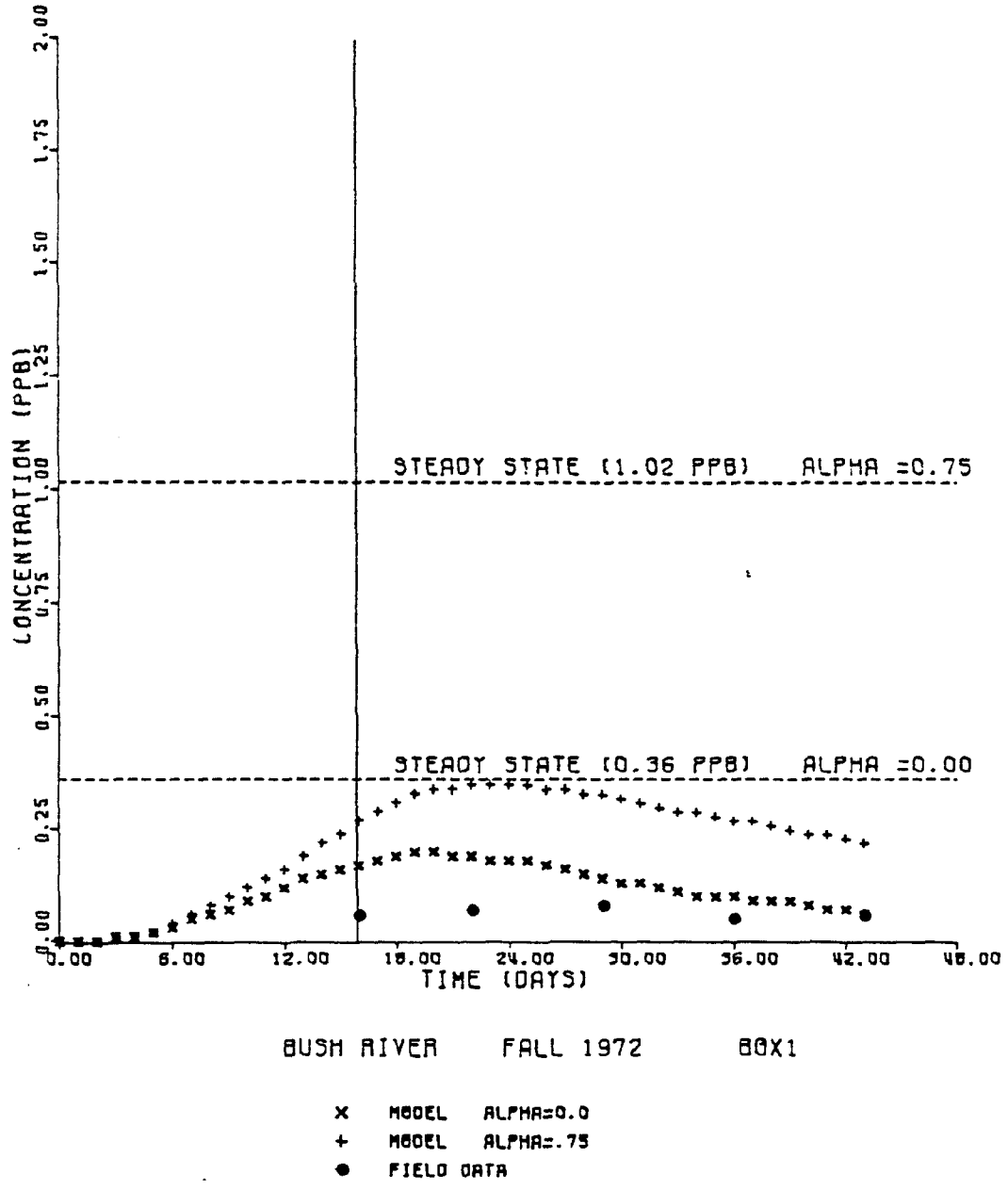


Figure 11. Predicted and measured dye concentrations in Box 1, Bush River (Fall, 1972); solid vertical line is time dye source was terminated.

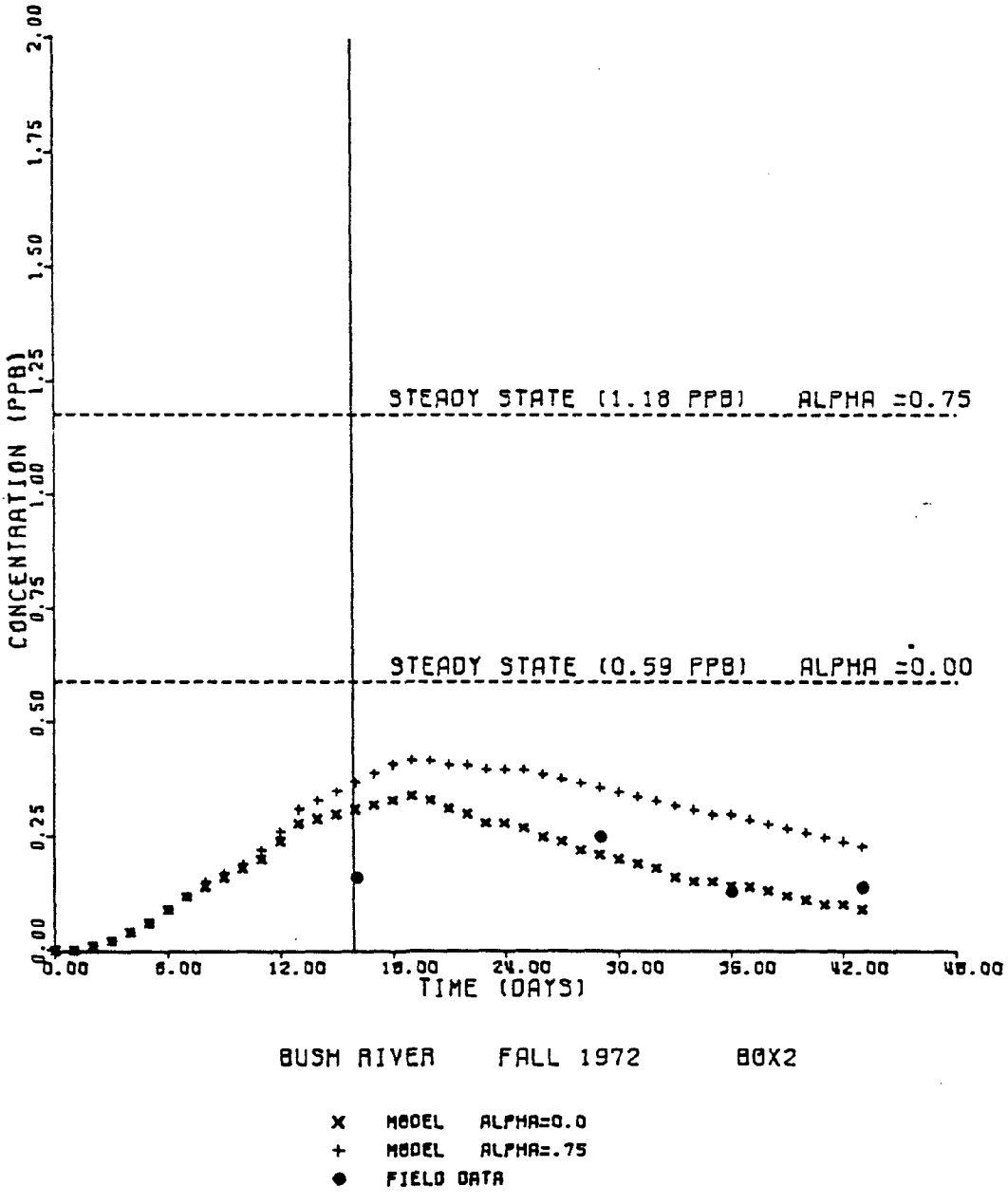


Figure 12. Predicted and measured dye concentrations in Box 2, Bush River (Fall, 1972); solid vertical line is time dye source was terminated.

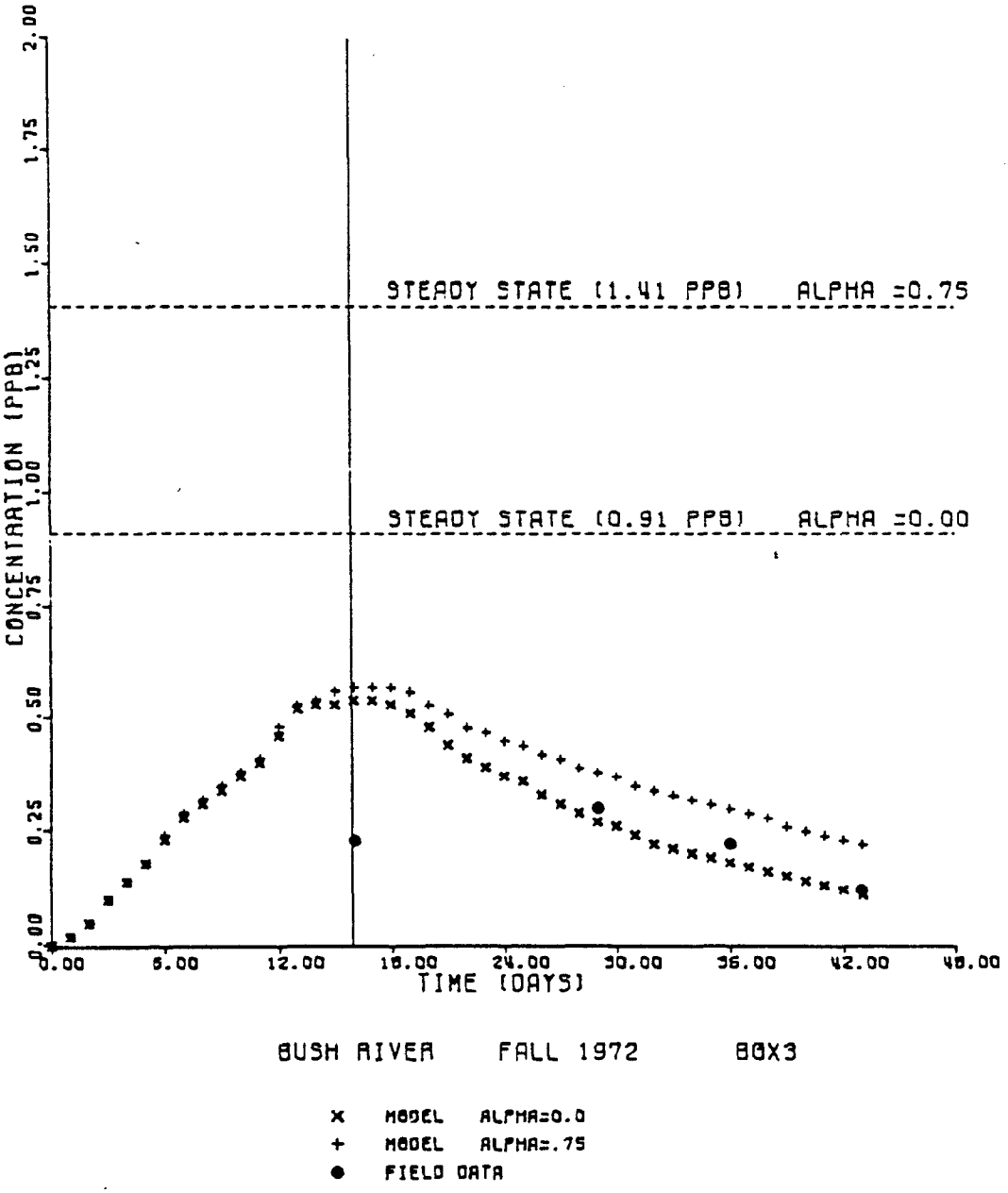


Figure 13. Predicted and measured dye concentrations in Box 3, Bush River (Fall, 1972); solid vertical line is time dye source was terminated.

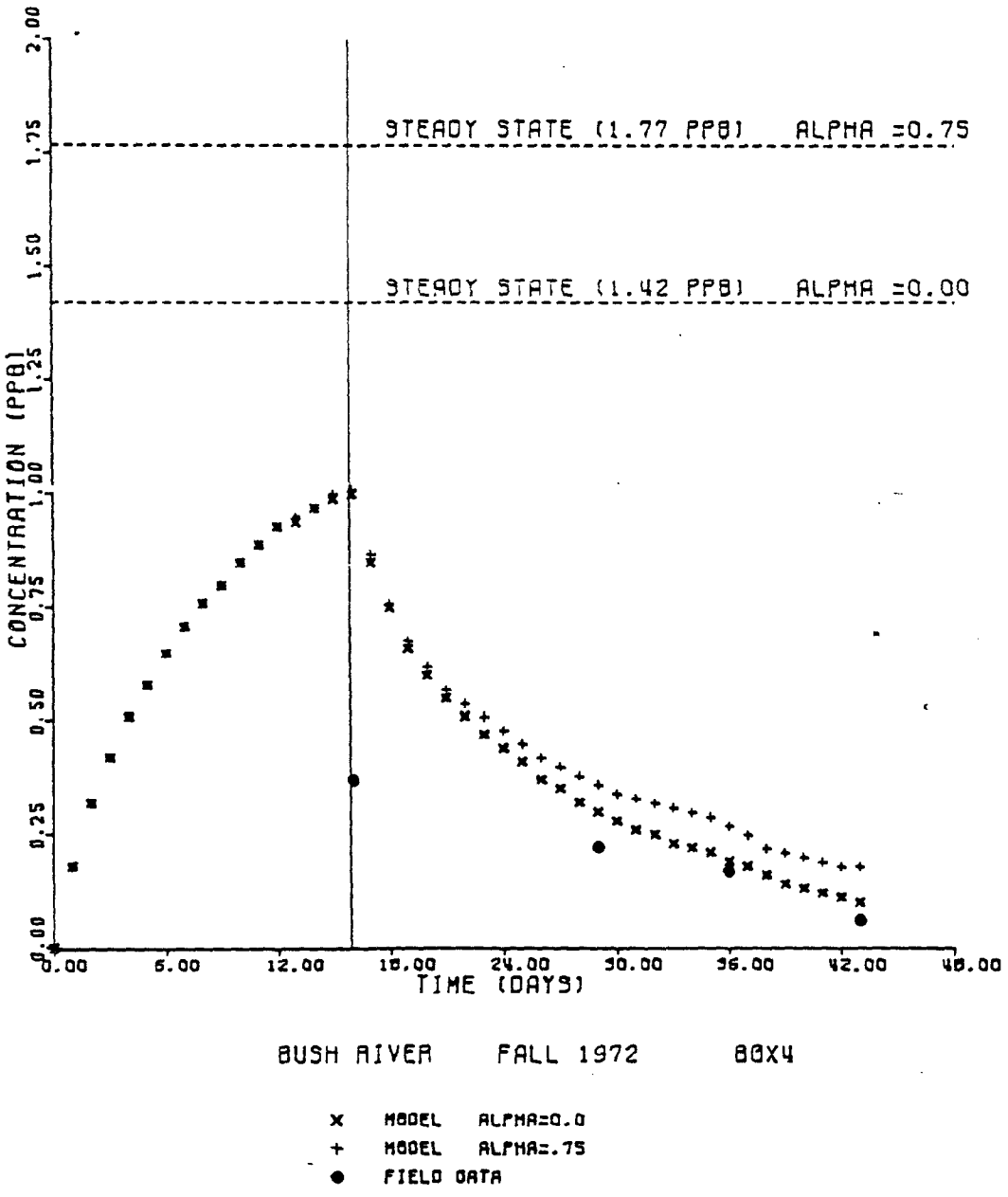


Figure 14. Predicted and measured dye concentrations in Box 4, Bush River (Fall, 1972); solid vertical line is time dye source was terminated.

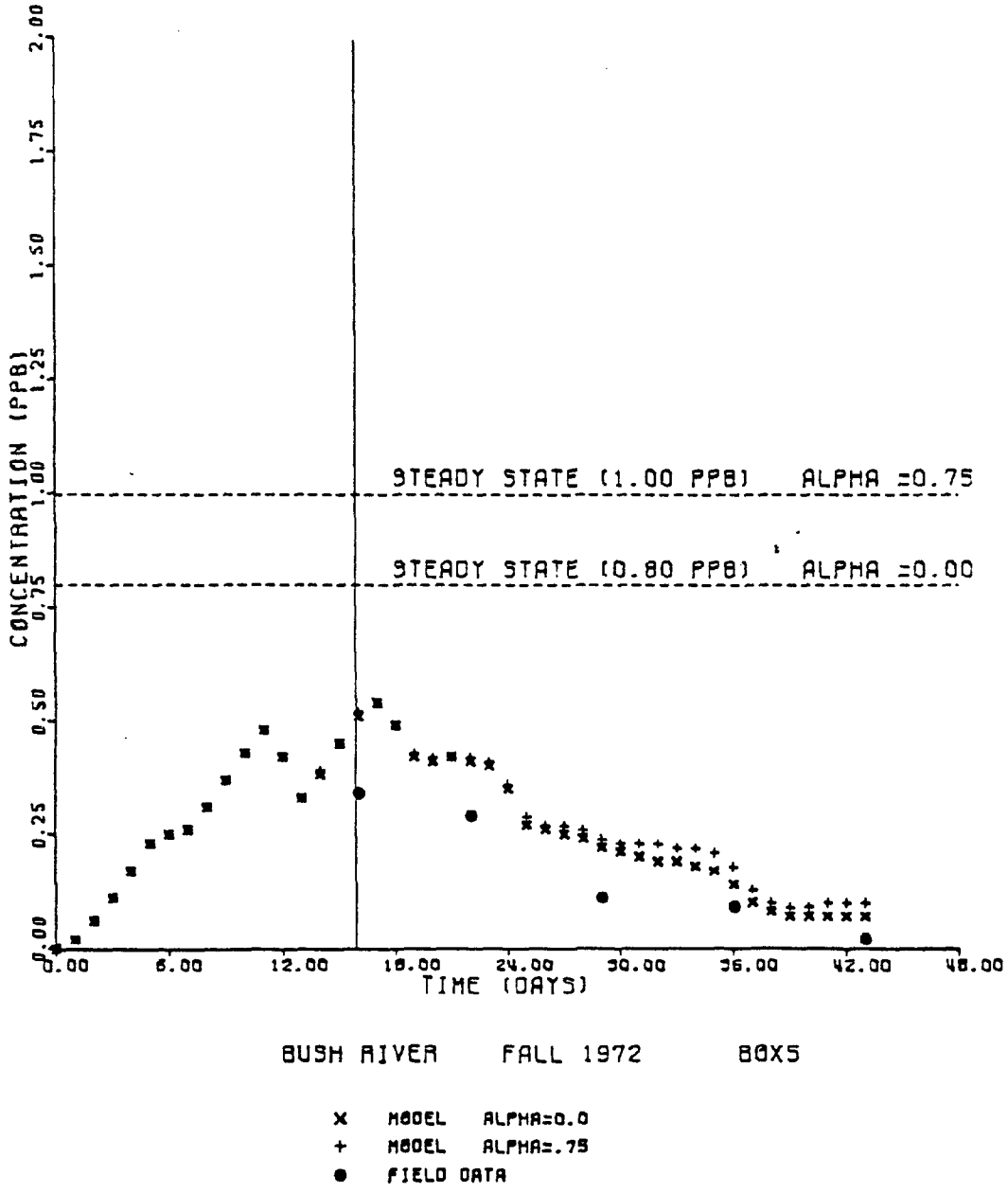


Figure 15. Predicted and measured dye concentrations in Box 5, Bush River (Fall, 1972); solid vertical line is time dye source was terminated.

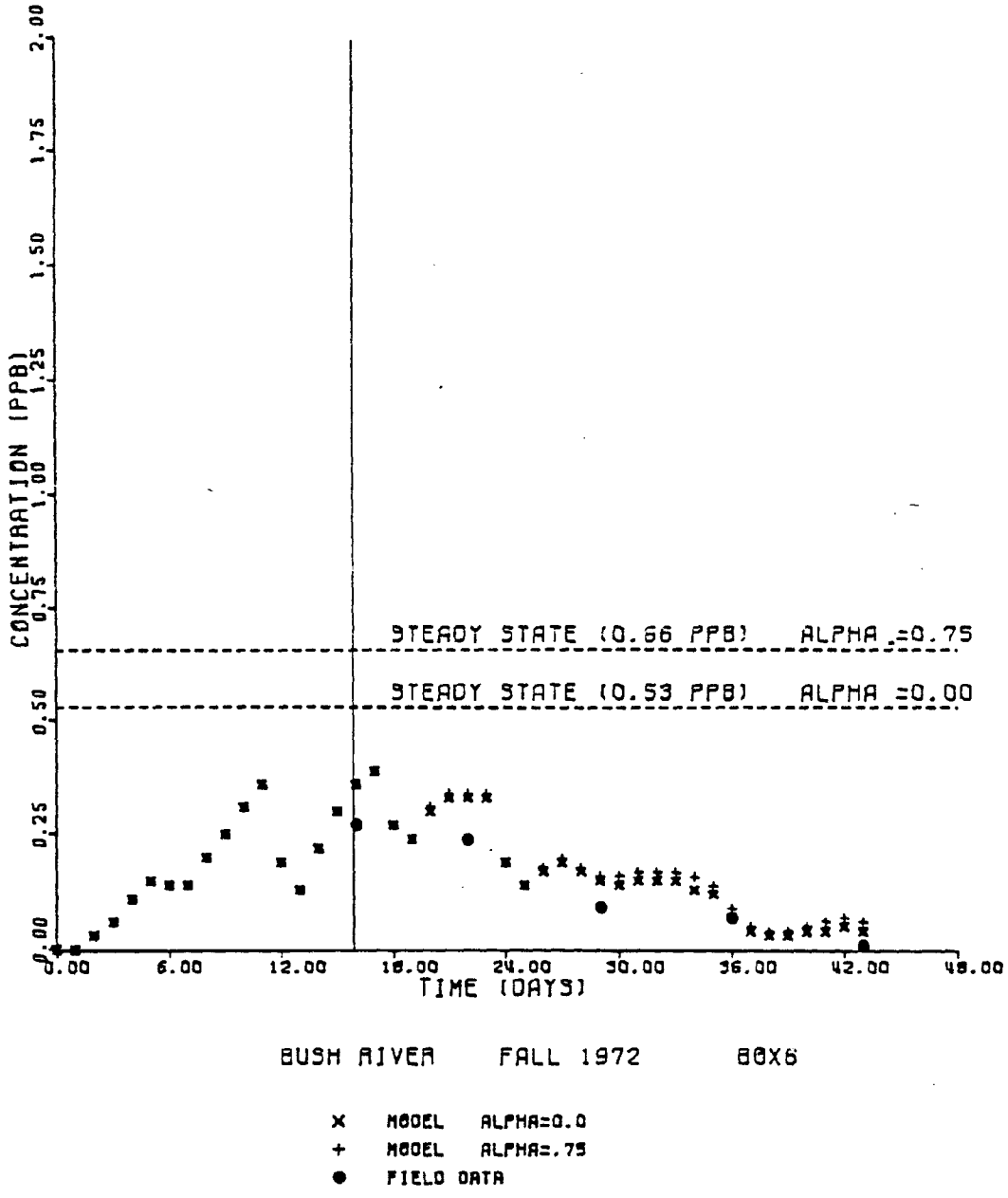


Figure 16. Predicted and measured dye concentrations in Box 6, Bush River (Fall, 1972); solid vertical line is time dye source was terminated.

From (1) and (2) we have that

$$(D_i) = q_d/Q_c(C_d)_i \quad . \tag{3}$$

In our case, we assign the following values to equation (3):

q_d = 5.163 pounds $days^{-1}$ (spring), and

4.25 pounds $days^{-1}$ (fall).

Q_c = 7000 gallons min^{-1} .

If we express $(C_d)_i$ in parts per billion, equation (3) may be written as

$$(D_i) = 61.438/(C_d)_i \text{ for spring conditions, and} \tag{4a}$$

$$(D_i) = 50.525/(C_d)_i \text{ for fall conditions.} \tag{4b}$$

which are the required relations for scaling dye concentrations to dilution ratios. That is, on the figures a segment concentration of 1 ppb represents a dilution ratio of 1 to 61.4 at high flow and 1 to 50.5 at low flow.

III. A One Dimensional Transient State Model of Romney Creek

Although the Perryman site of the Baltimore Gas and Electric Company is on the Bush River, it is also in close proximity to Romney Creek. See Figures 1 and 2. Therefore, any evaluation of the Perryman site must also consider the potential of Romney Creek as a receiver of cooling water blowdown from the proposed plant.

There are several features of Romney Creek that make it an attractive alternative to the Bush River as a receiver of the plant's wastes. First of all, it is close enough to the site so that piping the blowdown to the creek is economically feasible. Secondly, it lies entirely within the boundaries of the U.S. Army's Aberdeen Proving Ground and hence is closed to the public. Furthermore, it is quite likely to remain closed in the foreseeable future since, according to the Army, its bottom is literally covered with unexploded ordnance. As a result, its potential as a recreational area for the public is essentially nil.

In view of the foregoing, BG&E arranged with the U.S. Army for *Hydrocon* personnel to collect salinity data for eight consecutive days commencing on 11 November 1972 for the purpose of constructing a simple one-dimensional transient state model of Romney Creek similar to that described in Section II for the Bush River. Data were collected at the six stations marked on Figure 17 during the very early morning hours, i.e., prior to 0700, in order to avoid interference with weapons testing.

Since the approach was basically identical to that utilized in the construction of the Bush River model, details will not be repeated here; the reader is referred to *Hydrocon* Report entitled "A One Dimensional Segmented Transient State Model of Romney Creek," Reference 110C, February 1973, It

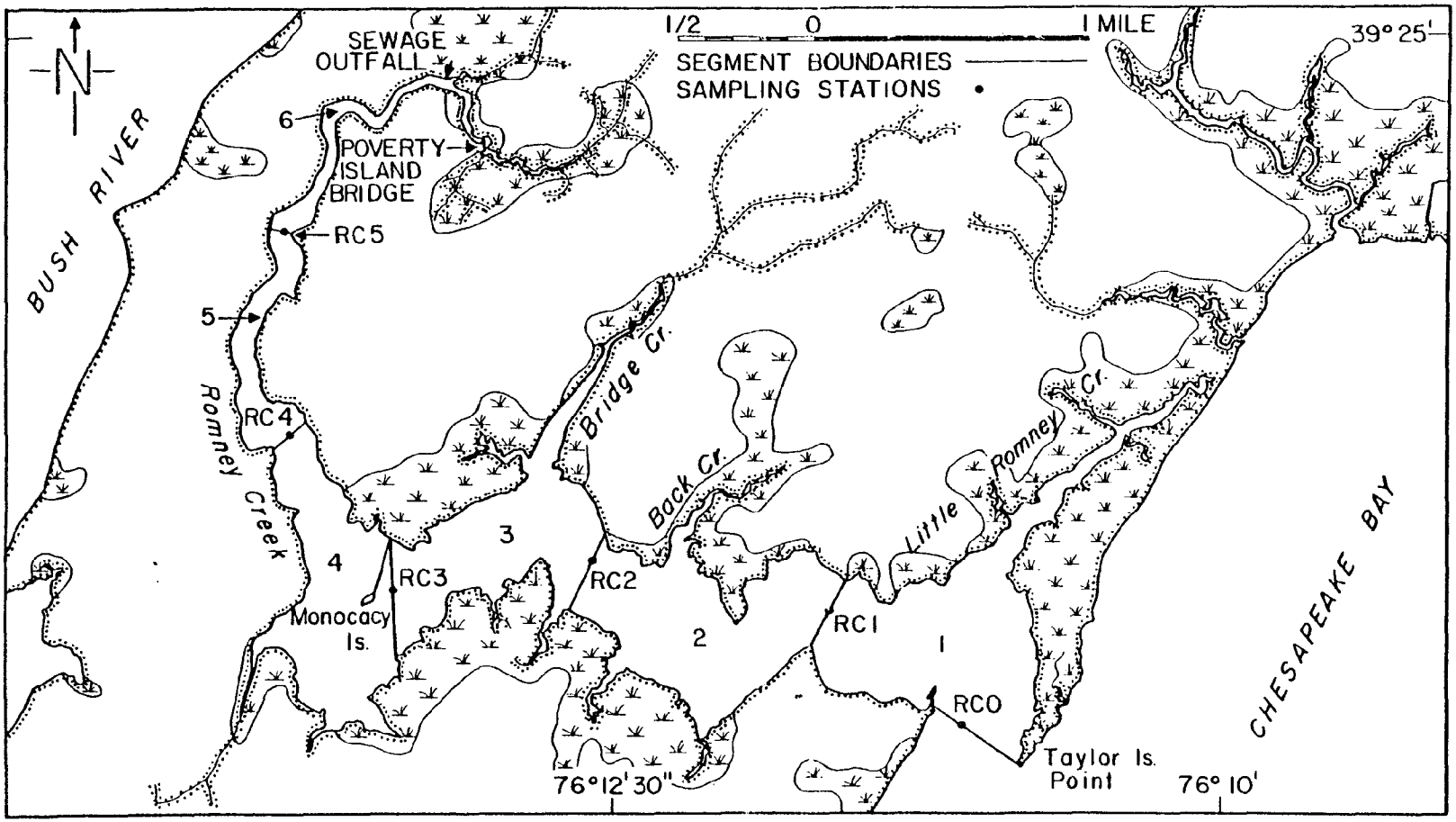


Figure 17. Romney Creek showing location of segment boundaries and sampling stations.
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was not possible to verify the model by means of a dye tracer experiment; verification consisted of integrating the transport and continuity equation sets in time, to ensure that the measured salinity distribution was predictable from the initial conditions, the daily run-off, and the salinity at the mouth.

The landward limit of the model was taken at the Poverty Island Bridge. The exchange here was assumed to be entirely fresh water run-off from the 13.2 square mile drainage area. The creek is not gauged, however, so that it was necessary to estimate the fresh water run-off by converting mean daily discharges from Winter's Run to cfs per square mile of drainage area. This factor was then multiplied by 13.2 to provide the required estimate. An additional 3.9 cfs was assumed to enter box 6 from the Harford County Treatment Plant (see Figure 17). The k_{ij}'s obtained are listed below in Table 2.

TABLE 2

Volume Exchange Rates (k_{ij})

(cubic feet per second)

$k_{01} = 3100$	$k_{10} = 3121$
$k_{12} = 320$	$k_{21} = 341$
$k_{23} = 160$	$k_{32} = 181$
$k_{34} = 99$	$k_{43} = 120$
$k_{45} = 35$	$k_{54} = 56$
$k_{56} = 7$	$k_{65} = 28$

In order to directly compare the two bodies of water as receivers of waste, the April 1972 dye experiment of 5.168 pounds per day of dry Rhodamine

WT was *numerically* injected into segment 6 of the Romney Creek model by integrating the transport and continuity equation sets. R was set at 21 cfs and the initial concentrations at zero. α, the ratio of the incoming Bay water concentration to that in box 1, was estimated to be 0.5. After 14 days and 8 hours, the dye source was terminated and the integration continued for another 35 days. Figures 18 through 23 show the resulting concentrations in the various segments as functions of time. The steady state values shown in the figures were obtained by setting the time derivatives in the equation sets equal to zero and solving the resulting system.

As might have been expected, the predicted concentrations are generally larger in Romney Creek than in the Bush River with the steady state condition being approached much more rapidly. In Romney Creek, nearly all segments were in steady state when the dye source was terminated; in the Bush River, less than 50% of steady state values had been achieved at the time the dye source was shut off. A segment by segment comparison of the steady state dye concentrations for the two systems for a source strength of 5.168 pounds per day of tracer is shown in Table 3, below.

TABLE 3

Steady State Dye Concentrations for Bush R. and Romney Cr.

	Concentrations in ppb	
SEGMENT	Bush River	Romney Creek
1	0.62	0.60
2	1.24	3.40
3	2.02	8.4
4	2.15 (source box)	15.0
5	1.17	26.6
6	0.80	41.5 (source box)

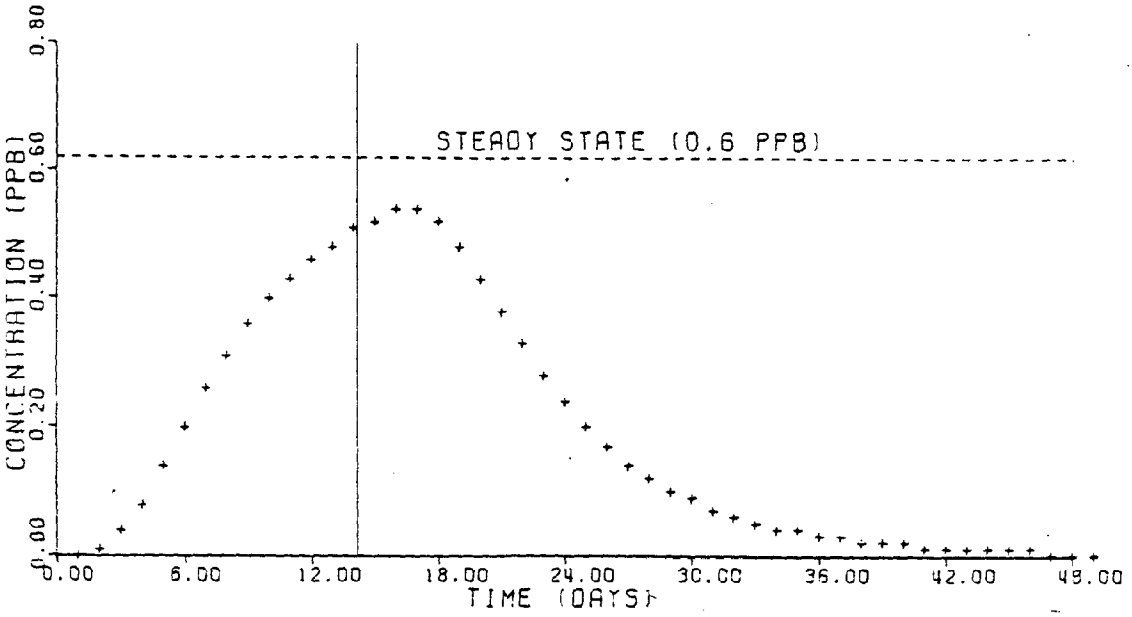

Figure 18. Predicted dye concentration in ppb in Segment 1 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 1; solid vertical line is time dye source was terminated.
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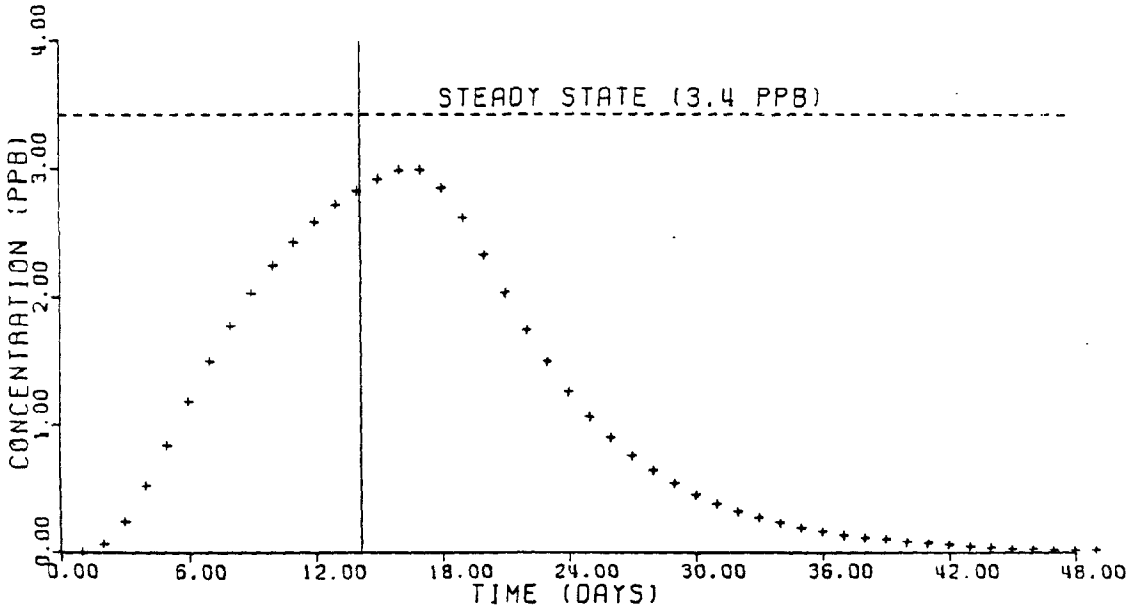

Figure 19. Predicted dye concentration in ppb in Segment 2 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 2; solid vertical line is time dye source was terminated.
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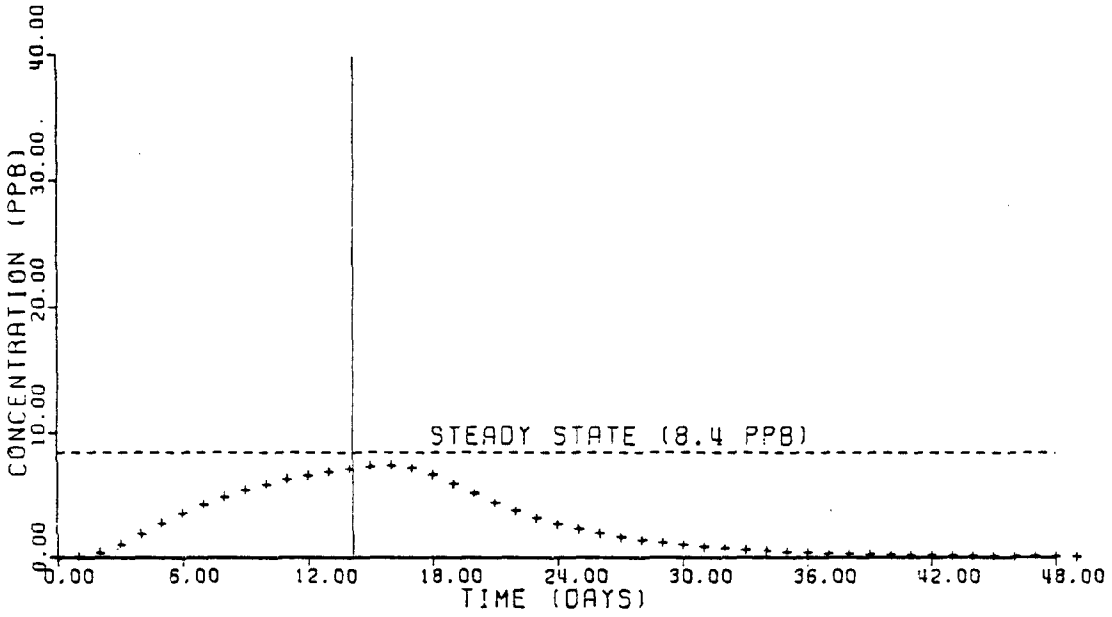

Figure 20. Predicted dye concentration in ppb in Segment 3 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 3; solid vertical line is time dye source was terminated.
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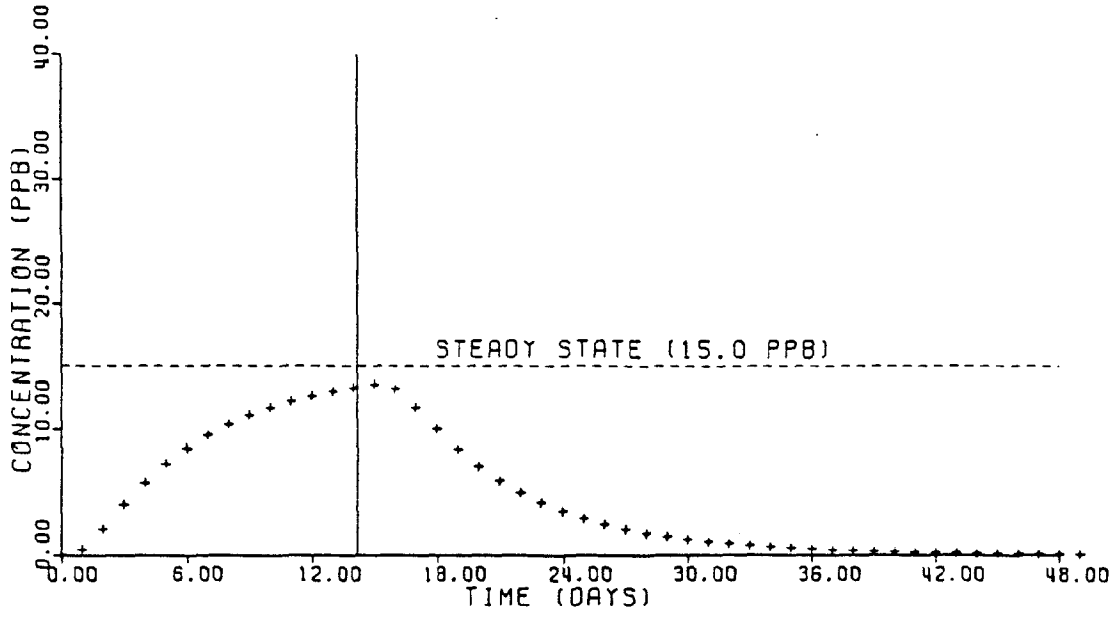

Figure 21. Predicted dye concentration in ppb in Segment 4 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 4; solid vertical line is time dye source was terminated.
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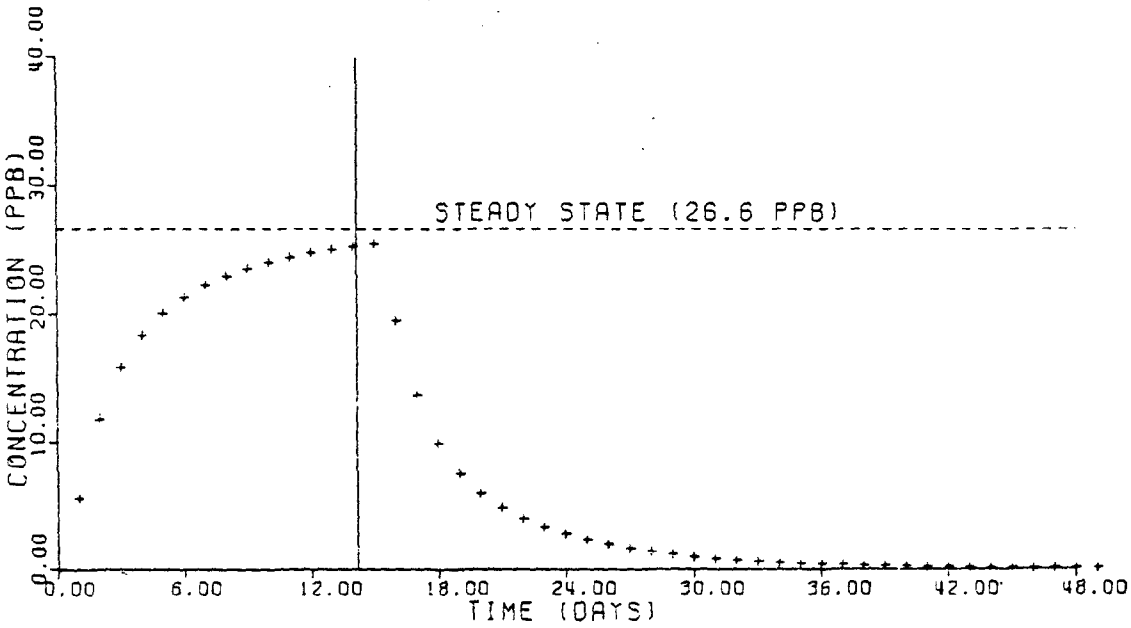

Figure 22. Predicted dye concentration in ppb in Segment 5 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 5; solid vertical line is time dye source was terminated.
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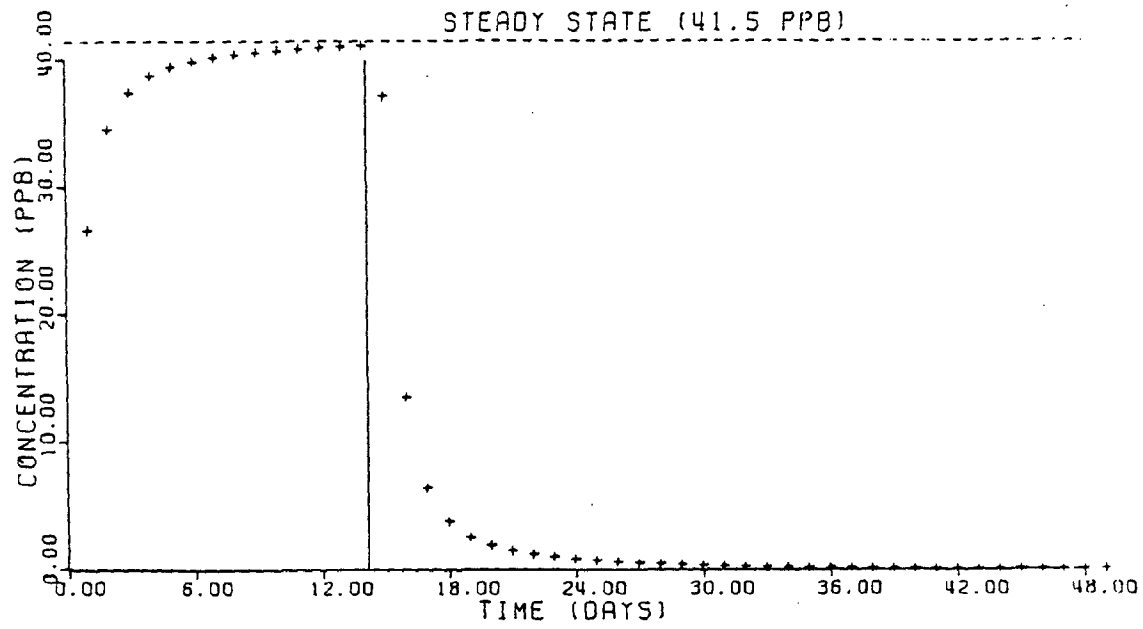

Figure 23. Predicted dye concentration in ppb in Segment 6 (crosses) for a hypothetical source of 5.168 lbs day^{-1} of dry dye in Segment 6; solid vertical line is time dye source was terminated.
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The values listed for the Bush River are, of course, the spring exchanges and for an α of 0.75.

The proper scaling factor for the Romney Creek results shown in Figures 18 - 23 and Table 3, above is equation 4a. That is

$$\text{dilution} = (D_i) = 61.438/(C_d)_i \qquad (4a)$$

If the contaminant in question is excess heat, then the results obtained in Sections II and III should be corrected for surface cooling. To illustrate the order of magnitude of the cooling corrections, the Romney Creek model was run with a cooling term for the following conditions:

Q_c = 7800 gallons per minute

$\Delta T = 20°F$

$T_n = 70°F$

$\theta = 10°F$

W = 0 and 10 miles per hour

where ΔT is the excess temperature of the blowdown, T_n is the assumed ambient water temperature of a given segment under natural conditions, θ is the excess temperature of a given segment or that part of the measured temperature of the segment due to the plant, and W is the wind velocity.

The model is then run with a heat source, Q_h, equal to $Q_c \Delta T \rho c_p$ together with a cooling term[5], $-A_i \gamma \theta_i$ where γ is the surface cooling coefficient and A_i the surface area of the ith segment. According to Pritchard

[5] See D.W. Pritchard and H.H. Carter (1965), "On the prediction of the distribution of excess temperature from a heated discharge in an estuary," CBI Tech. Rept. No. 33. Ref. 65-1.

(unpublished notes), the value of γ under the conditions assumed is 0.0183 feet hour^{-1} for W = 0 and 0.102 feet hour^{-1} for W = 10 miles per hour. The resulting excess temperatures for the various segments of Romney Creek for the three conditions, i.e., γ = 0, and γ for W = 0 and W = 10 miles per hour are listed in Table 4 below.

TABLE 4

Excess Temperatures in Romney Creek under Various Cooling Conditions

	Excess Temperature in °F Cooling Condition		
SEGMENT	γ = 0	γ = .0183 FT HR^{-1}	γ = 0.102 FT HR^{-1}
1	0.22	0.05	0.001
2	1.24	0.27	0.008
3	3.03	0.74	0.04
4	5.42	1.64	0.15
5	9.63	4.61	1.01
6	15.00	10.70	4.95

References

Hydrocon, Inc. 1972. A one dimensional segmented transient state model of the Bush River estuary. Hydrocon Ref. 110A.

Hydrocon, Inc. 1973. A one dimensional segmented transient state model of Romney Creek. Hydrocon Ref. 110C.

Pritchard, D.W. and H.H. Carter. 1965. On the prediction of the distribution of excess temperature from a heated discharge in an estuary. Chesapeake Bay Institute, The Johns Hopkins University, Tech. Rept. 33, Ref. 65-1.

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