行政院所屬各機關因公出國人員出國報告書

（出國類別： 實習 ）

水體優養化防治技術應用
出 國 報 告

服務機關：行政院環境保護署
出國人 職 稱：環境工程師
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出國地點：美 國
出國期間：九十年八月二十五日至九十年九月二十三日
報告日期：九十年十一月十九日

系統識別號:C09006433

公 務 出 國 報 告 提 要

頁數: 65　含附件: 否

報告名稱:

水體優養化防治技術應用

主辦機關:

行政院環境保護署

聯絡人／電話:

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出國人員:

廖全成　行政院環境保護署　水保處　環境工程師

出國類別: 實習

出國地區: 美國

出國期間: 民國 90 年 08 月 25 日 -民國 90 年 09 月 23 日

報告日期: 民國 90 年 11 月 19 日

分類號/目: G14／環境工程　G14／環境工程

關鍵詞:　水體優養化

內容摘要: 本報告爲筆者廖全成，由行政院環保署指派參加經濟部聯合技術協助訓練計畫，赴美國研習水體優養化防治技術應用，計美國華府、維吉尼亞州 Richmond、費城、紐約、西雅圖及舊金山六個城市拜會二十餘個單位，主要目的、過程、心得、建議，及在紐約遇九一一恐怖攻擊事件等報告。經多次討論與現勘，探討美國應用非點源污染控制以防治水體優養化之技術，及參考美國社會情形，提建議如下：一、建議充實並更新各單位全球資訊網頁外語版。二、轉達維吉尼亞大學余教授嘯雷之建議：以翡翠水庫集水區進行非點源污染控制示範實驗計畫，再考慮推廣全國。三、因應生化恐怖攻擊之潛在威脅，建議加強我國自來水水源水質監測、自來水場安全維護與供水水質警報系統。四、建議我國環保工作人力宜再評估適度調整或增加。五、因本計畫日支費八折給付，建議如委託美方代訂旅館，主動要求在該城市日支費（八折前）的55% 至60% 內訂房（含稅），以免生活費不足之窘境。 最後，筆者能得到經濟部委託之美國農業部，在結語信中對筆者赴美研習整體表現之肯定，甚感榮幸爲國爭光。

本文電子檔已上傳至出國報告資訊網

水體優養化防治技術應用

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壹、目的

一、瞭解美國水質保護工作與經驗交流

筆者任職於行政院環境保護署，參與水源水質保護工作數年，極為繁忙。於多年忙碌中，不免時常自問水源水質保護策略、方法與實施計畫之規劃及執行，是否流於閉門造車、自以為是之嫌？有幸今年有本計畫獲選奉派赴美國考察水質保護一個月，正好可用以釐清與思考平常工作時，心中的諸多疑點，並與美方二十餘個單位交流水質保護工作經驗，實屬極為珍貴，也非常感謝政府給予筆者此次赴美的機會。

二、研習水體優養化防治技術應用

水質保護可應用之方法頗多，此行係針對美國河川、湖泊、水庫與海灣等水體優養化防治技術之應用，包括營養源移除技術、非點源最佳管理控制、湖庫污染防治與水源集水區管理等，進行考察、討論、研習及現勘。期能返國後對於筆者未來工作中，有所實質重大之助益，並能學以致用，貢獻予我國政府與全體國民。

貳、過程

一、致謝

本次出國計畫自台灣出發赴美國至返抵國門，一個月

的行程六個城市（原訂七個城市）拜訪二十餘個單位，皆為筆者單獨一人，而此行能順利成行且平安歸來，一路上需致謝的人極多！

感謝行政院環境保護署各級長官選擇筆者參加英語測驗，有幸通過後並決定派筆者赴美國考察本計畫，尤其是水質保護處簡任技正蔡鴻德與馬科長念和對行程計畫的指導。

感謝經濟部國際合作處辦理本計畫，該部國際合作處盧專員美雅熱心提供各種協助。

感謝University of Virginia余教授嘯雷對參訪單位具體的建議名單，受用良多。

感謝美國農業部研究院（Graduate School/United States Department of Agriculture ,GS/USDA）的Erik Ronhovde先生，於筆者赴美國六個城市期間（原訂七個城市，因九一一恐怖攻擊滯留紐約，取消下一個城市），給予極為周詳完整行程、會議、交通、住宿的安排及提供相關資訊，於華府報到的第一站GS/USDA，當面給予筆者詳細完整的行程介紹，且更在九一一恐怖攻擊事件，因機場及相關交通關閉，筆者被迫滯留紐約期間，Erik Ronhovde先生非常敬業地提供大量密集且有效的支援資

訊與精神支持，特予致謝。

感謝美國華府、維吉尼亞州 Richmond、費城、紐約、芝加哥、西雅圖及舊金山等六個城市，負責安排當地詳細會議與現勘行程的組織及人員，細心周到。

感謝二十餘個受訪單位與受訪人員，熱心接待，會議準備完善，安排現場勘查，不吝分享工作經驗；其中尤其感謝美國環境保護署(US Environmental Protection Agency，USEPA)第三分區辦公室的 Francesca Di Cosmo 小姐，安排接待與會議準備最為周到；維吉尼亞州政府保育與改良部門 (Virginia Department of Conservation and Recreation)的 John R. McCutcheon, JR 先生，熱心開車加上徒步爬山，帶筆者深入 Richmond 近郊許多非點源污染控制工程地點，實地觀察，一直現勘到天黑才回程，收穫極豐；美國農業部研究服務單位 (USDA-Agricultural Research Service，ARS)Rosannah Taylor 博士的簡報，及熱心開車導覽美國農業部研究服務單位佔地廣大的實驗農場，現勘其各種實驗作物田野、非點源污染控制方式與污水處理設施；以及西雅圖市 Public Utilities Resource Development Division 的 Frank McDonald 先生，熱心開車深入西雅圖山區，勘

查水源集水區保護實況，並導覽參觀自來水淨水場。

感謝出國期間行政院環境保護署水質保護處劉技正蕙雯與葉工程師美青，於百忙中再加重分擔筆者原來繁重的水源保護工作。

感謝行政院環境保護署環境人員訓練所的同仁，轉達辦理經濟部國際合作處本次出國計畫。

感謝旅行社的副總經理詹淑娟，充分運用專業能力安排指定日期與目的地之國際機票機位、國外各城市尋找位置與價格合適的旅館（雖然大部分旅館未被美國農業部研究院 GS/USDA 接受採用）、再三主動詳細說明如何在極複雜的紐約 Newark 機場住宿並轉機、主動協助累積國際飛行里程、主動協助辦理平安保險，以及九一一恐怖攻擊事件機場關閉滯留紐約期間，即時有效跨國支援處理住宿事宜，旅行專業能力發揮極至。

最後，感謝母親、二姊春芳和姪兒偉良，出國時至機場送行，赴美期間每天的關心與祈禱，九一一恐怖攻擊事件期間為筆者極度擔心，以及筆者回國當天冒雨守候至午夜的溫暖迎接。

還有許多人許多事，無法一一詳列，在此一併致上深摯的謝忱！

二、行前準備與行程計畫

筆者於接獲通知本計畫獲准赴美國訪問考察後，即依規定著手訂定英文計畫執行書及英文簡歷表，準備提供美國農業部研究院（Graduate School/United States Department of Agriculture，GS/USDA），委託其代為安排赴美國期間一個月的詳細訪問考察行程，包括與各受訪單位排約開會時間、到達會場之交通描述、代訂各城市旅館及美國國內飛機、火車和巴士等交通工具等。

依規定英文計畫執行書至少需列二十餘個與計畫項目名稱（Project Title）水體優養化防治技術應用（Application of Eutrophication Prevention Technique on Water Bodies）相關之機構單位，並一一詳列位置（Location）與訪問目的（Purpose）。由於美國不同州主管相同水體水質執掌之單位名稱皆不盡相同，要從台灣預先一一列舉出二十餘個單位組織之正確完整名稱與位置，收集查詢過程確實遭遇一些困難問題。筆者透過查詢本署檔案、相關研討會論文集、圖書館書籍、上網際網路、詢問顧問公司及請教大學教授，在平日極度繁忙工作之餘，終於完成英文計畫執行書。

計畫原訂訪問的單位組織，包括：美國環境保護署(US

Environmental Protection Agency，USEPA)、美國環境保護署相關分區辦公室、顧問公司、民間環保團體、美國農業部研究院（GS/USDA)、美國農業部研究服務單位（USDA-Agricultural Research Service，ARS)、Chesapeake 海灣基金會（Chesapeake Bay Foundation)、維吉尼亞州政府環境品質部門（Virginia Department of Environmental Quality)、維吉尼亞州政府保育與改良部門（Department of Conservation and Recreation ,Virginia)、維吉尼亞大學（Univ. of Virginia)、污水處理場、五大湖水質管理單位、西雅圖市水質主管單位，及加州環境保護部水質管理局舊金山灣區（California Environmental Protection Agency California Regional Water Quality Control Board San Francisco Bay Region）等。惟實際安排結果，部分單位未能順利排定會議受訪，例如顧問公司、Chesapeake 海灣基金會及加州環境保護部水質管理局舊金山灣區。

但美國農業部研究院（GS/USDA）及其透過相關城市之當地交流組織，精心主動安排與計畫項目名稱相關之許多單位與機構，非常豐富精采，例如 Northern Virginia Regional Commission、西雅圖市的 Public Utilities

Resource Department Division、西雅圖 King County Department of Natural Resources、舊金山市污水處理廠及 Council of Great Lakes Governors 等，讓筆者不虛此行（其中位於芝加哥主動安排的 Council of Great Lakes Governors，因紐約九一一恐怖攻擊耽誤誤行程而未能拜訪，殊為可惜與遺憾）。

三、赴美國期間

此次赴美國的行程安排得相當豐富緊湊，往往在一天當中，上午與下午皆安排了拜訪不同單位。往往有些更遠在郊區，上午在市區參訪會議結束後，必需趕赴下午會議的單位，搭地鐵至郊區，再尋找換乘班次極少之巴士，乘車五十分鐘至一小時前往，下車後加上步行十餘分鐘才到，又需準時抵達，故找路的過程相當辛勞且有時間壓力。

又如美國環境保護署(US Environmental Protection Agency，USEPA)與美國環境保護署相關分區辦公室，往往在一天當中，會議從上午一直安排至下午，在同一個會議室分別由不同部門的同仁，輪流以電腦單槍投射設備向筆者簡報與討論，其中又以位於費城的美國環境保護署第三分區，會議準備與安排更是周到完整。

還有許多次現勘，開車深入山區的水源集水區，或開車加徒步爬山跑遍廣大郊區勘查非點源污染控制工程，經常到天黑才收工返程。

修正後實際行程依序為：美國華府、維吉尼亞州Richmond、費城、紐約、西雅圖及舊金山等六個城市。

第一站在美國華府拜會以下單位:美國農業部研究院（GS/USDA 討論整個月行程）、National Marine Manufacturers Association（NMMA）、States Organization for Boating Access（SOBA）、美國環境保護署 Office of Water（US Environmental Protection Agency，Office of Water）、美國環境保護署 Office of the Comptroller（US Environmental Protection Agency，Office of the Comptroller）、美國農業部研究服務單位（USDA-Agricultural Research Service，USDA-ARS)及 Northern Virginia Regional Commission。圖一為華府周邊公園水質分層之情形。

圖一：華府周邊波多馬克河Tidal Basin水質分層之情形。

第二站在維吉尼亞州 Richmond 拜會以下單位：維吉尼亞州環境品質部門（Virginia Department of Environmental Quality）、維吉尼亞州政府保育與改良部門（Virginia Department of Conservation and Recreation），以及位於Charlottesville的維吉尼亞大學（University of Virginia）。

第三站於費城拜會美國環境保護署第三分區（US Environmental Protection Agency，Region 3），詳細討論非點源污染最佳管理控制（BMP）、水質模式、飲用水水源水質及營養源移除技術等議題。圖二為筆者拜會第三分區之情形。

圖二：筆者拜會費城美國環保署第三分區之情形。

第四站於紐約拜會美國環境保護署第二分區（US Environmental Protection Agency，Region 2）Division of Environmental Planning and Protection/Fresh Water Protection Section、紐約市集水區團隊(New York City Watershed Team)，以及於前往紐約市環境保護部（Department of Environmental Protection，DEP，City of New York）的途中，遇到九一一恐怖攻擊紐約世貿中心（World Trade Center）事件影響，因而無法繼續前往該市環境保護部拜會。

飛機恐怖攻擊兩棟世貿大樓後，筆者才從地鐵站走出地面，見高樓失火，當時尚不知情飛機恐怖攻擊，以為只是一般的高樓火災，還曾對著失火的高樓攝影。

不料照相完畢約一分鐘，兩棟世貿中心大樓其中的一

棟即在筆者面前轟然應聲倒塌，距離筆者僅約三個街區（Block），大量金屬、玻璃碎片與煙塵迅速排山倒海迎面撲來，當時無論如何狂奔都來不及逃避，剎那間覺得必死無疑。

倒塌的第一時間，頃刻只有數秒鐘可思考如何反應，筆者本能地奔向最近的商業大樓尋求掩蔽，幸好該大樓安全人員即時示意進入，隨即關閉大門。惟部分煙塵已侵入一樓，安全人員於是引導大家至地下室避難，當時不知距第一棟世貿中心大樓倒塌約四十分鐘後，第二棟世貿中心大樓亦倒塌了。

在地下室避難三個小時後，大樓安全人員示意大家撤離該大樓，筆者以擦手紙沾水掩著口鼻充當緊急臨時口罩，走出避難大樓，看見地面與所有平面物體上面，更是蓋滿厚厚的落塵及小碎片。於大樓倒塌前筆者原拍攝高樓失火處路邊停放汽車的車窗，朝向碎片襲來方向的汽車玻璃已全部密密佈滿破碎裂痕，如果倒塌當時未當機立斷進入大樓掩蔽，多停留在街上幾秒鐘，必定滿身灰塵，非死即傷。

街上宛如戰爭後廢墟一般，巴士、地鐵及私人汽車一律禁止行駛，道路上只有警車、消防車及救護車奔馳，

數萬人皆以徒步方式撤離，許多路段亦管制行人通行，筆者以地圖與指北針找路繞道，費了將近三個小時才走回旅館。

回到旅館後看見電視新聞畫面，才知道有兩架飛機分別撞擊兩棟世貿中心大樓，碎片與煙塵覆蓋十個街區（Block），而筆者當時僅僅距離三個街區（Block），劫後餘生，餘悸猶存。

沒想到禍不單行，接下來的兩天傳出另兩次高樓炸彈消息。一次在午夜，距離筆者旅館只有兩個街區（Block）的帝國大廈有炸彈消息，紐約警方緊急疏散十個街區（Block），所有的人如驚弓之鳥奔逃，絲毫不敢大意，筆者亦隨之在紐約午夜的街頭狂奔逃命；另一次在中午，筆者旅館正對面的麥迪遜花園廣場大廈亦有炸彈消息，警方仍不敢大意緊急疏散十個街區（Block），筆者又在紐約中午的街上與眾多行人再次奔逃撤退。

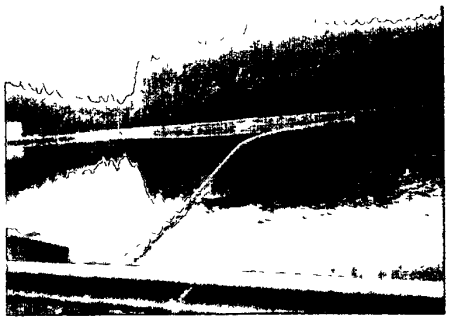
後來兩次炸彈經搜查證實均為恐嚇性質的假消息，但因前兩天恐怖攻擊已有數千人無辜喪生，紐約警方與人們都不敢忽視，當時置身超高建築眾多的紐約市，隨時有恐怖炸彈攻擊之可能。且本計畫派筆者一人單獨出國，一切得靠自己，須二十四小時注意新聞和警方消息

的變化，唯恐漏失任何一次消息未即時應變撤離而喪生或受傷，故精神、心理與體力的壓力極為龐大。

檢討起來，筆者於倒塌的第一時間，能夠正確奔向最近的商業大樓尋求掩蔽，毫髮無損，身上也無碎片與煙塵，有賴過去在軍中服役時的軍事安全訓練，與筆者任職行政院環境保護署的消防安全訓練，實際有效幫助筆者逃生。

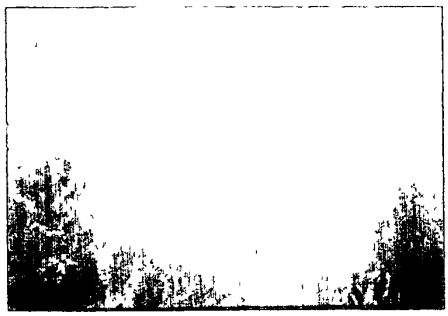
依軍事安全訓練的教導，當空中爆炸時不可就地臥倒，躲避自上往下快速襲來的破片須立刻尋求掩體；又依消防安全訓練的教導，遇煙塵時可將身體口鼻移至建物角落，有最後少許乾淨的空氣可供呼吸。正好當時離筆者最近的商業大樓可供掩蔽的外牆凹入處有一個門，也感謝該大樓安全人員即時示意筆者進入，隨即關閉大門，這才逃過一劫，這是最關鍵的瞬間決定。

第五站原訂訪芝加哥，因九一一恐怖攻擊事件機場關閉，被迫滯留紐約延誤五天行程，改直飛西雅圖。在西雅圖拜會 Public Utilities Resource Development Division，與 King County Department of Natural Resources。圖三為西雅圖公共供水公司以攔索防止微量浮油污染飲用水體之情形。



圖三：西雅圖公共供水公司以攔索防止微量浮油污染飲用水體

第六站（此行最後一個城市）於舊金山拜會國際交流委員會（International Diplomacy Council）、舊金山污水處理廠（San Francisco Public Utilities Commission Oceanside Water Treatment Plant）及美國環境保護署第九分區（US Environmental Protection Agency，Region 9）。圖四為筆者自西雅圖飛舊金山途中俯瞰水庫之情形。



圖四：筆者自西雅圖飛舊金山途中俯瞰水庫之情形。

參、心得

筆者拜會美方各單位討論與依據其所提供之資料，主要心得如下：

一、營養源移除技術

（一）養分移除技術介紹

根據維吉尼亞理工州立大學教授 Clifford Randall 指出，生物廢水處理繼活性污泥法之後最大的發展就是養分移除技術。歷史上活性污泥法最重要的特色就是去除生化需氧量及懸浮固體。然而隨著都市化及人口發展，保護水體的工作就日益困難，尤其是氮磷去除就日益重要。

以生物處理法去除氮磷較化學法有下列優點：

1、不需化學加藥及鹼度處理。

2、同樣的養分移除不會產生太多污泥。

3、減少氣所需之能量費用。

4、可減少絲狀菌之產生。

5、增加好氧區的硝化速率。

若在活性污泥法加入生物脫硝，則能用進流生化需氧量作為碳源，並減少氧氣之輸送率及污泥之產生量，尤其是跟另行使用好氧硝化流程比較之後，益顯其優點。

生物除磷也能進一步降低氧氣輸送所需之能量。生物除磷也能安定污泥的沉降性質，雖然生物除磷，因磷能有效被併入污泥中而增加污泥之產量。生物氮去除及生物磷去除可以分開設置但是合併設置較為有效而經濟。

（二）生物養分去除原理介紹

I．生物除磷

A．所需條件：

1. 厭氧好氧序列。 2. 厭氧區可獲得之基質，例如揮發性有機酸。 3. 鉀及鎂。 4. 近中性的水質 pH。

B．生物除磷之優點

1. 減少或去除化學品之添加。 2. 減少或去除鹼度之添加。3. 可選擇細菌，降低絲狀菌產生之機率，因此對後續沉降性質效果較佳。 4. 減少曝氣設施操作成本。 5. 處理廠改裝較易。

C．生物除磷之缺點

1. 增加一些新設措施之成本(例擋板及混合漿)。2. 設計參數需更注意。3. 較難操作(須注意硝酸鹽溶氧，沉降槽之控制)。4. 污泥棄置須注意的地方較多。

II. 生物脫硝

A．所需條件

1. 無氧—好氧序列。 2. 硝酸鹽之循環。 3. 無氧區的養分供應。 4. 偏鹼性之 pH 值。 5. 消化所須之足夠的溶氧。

B· 優點

1. 減少或去除脫硝所須有機碳源。 2. 減少或去除鹼度之增加。 3. 減少曝氧之需要。 4. 減少污泥之產生。 5. 減少絲狀菌生成趨勢。 6. 當和脫硝過程併用時，可協助厭氧第一區所需之維護。

C· 缺點

1. 需要迴流所用的額外材料支出及其他設備，例如擋板、螺旋槳。 2. 降低細胞生長的水力停滯時間。 3. 增加作業之複雜度。

D· 微生物脫硝過程

D. 1. 硝化將氨氮化為硝酸氮

第一步，由 Nitrosomonas 進行

$NH_4^+ + 2/3O_2 \rightarrow NO_2 + 2H^+ + H_2O$

第二步，由 Nitrobactor 進行

$NO_2 + 1/2O_2 \rightarrow NO_3^-$

D. 2. 脫硝：將硝酸鹽碳化為氮氣。

$6NO_3^- + 5CH_3OH \rightarrow 5CO_2 + 3N_2 + 7H_2O + 6OH^-$

其中甲醇可由進流之生化需氧量及其他碳源代替。

生物除磷能安定污泥的沉降性質，雖然生物除磷因磷能有效被併入污泥中而增加污泥之產量。生物氮去除及生物磷去除可以分開設置，但是合併設置較為有效而經濟。

（三）生物養分去除技術介紹—湖庫管理技術簡介

湖庫管理技術向來為防治水質優養化之工作重點，以下為筆者在賓州環保部參訪交換之心得，該州之工作經驗以重點表示之。1. 殺藻劑：例：硫酸銅。2. 殺草劑：例：水草控制法。3. 水生植物收成：以採收代替毒殺，也可移除有機質及營養分。4.

疏浚法:移除底泥,增加湖庫面積,移除營養分，包括水力式及機械式移除。5. 曝氣法：包括：5. 1. 整個湖的曝氣法：曝氣機安裝於湖底，整個水體混合。但缺點是將底質有機質予以擴散。5. 2. 下層曝氣：只曝下層，避免混合。5. 3. 水面噴泉：ru/3僅有裝飾作用，並無實效。6. 明礬處理：6. 1. 批次式：每三到七年施放乙次將磷封存，以免再回到

水體。 6. 2. 連續式：將明礬施放於各支流以沉降吸附磷，但只在生長旺盛時施放。 7. 染料：極少數量施放，以減低底層光照抑制藻類生長。

（四）生物養分去除技術介紹—如何改裝污水處理廠以進行養份去除

防治水質優養化之另一工作重點，再於加強維護及更新集水區內之污水處理廠，以進行養份去除，維護水體水質，以下為筆者在，賓州環保部及與世界著名之西圖顧問工程公司人員交換之心得：

所有的污水處理廠近年來必須使用生物處理以應付日益嚴格之污水養份排放標準。在許多範例中，污水廠均能改裝，使用額外的處理容量，以進行生物養份去除 (Biological Nutrient Removal, BNR)。未使用之處理容量，原設計來應付尖峰、季節性之污水量所需，都可用來改裝為生物養份去除系統。

加入生物養份去除單元之選擇方案

在超過十年的研究之後，生物養份去除系統之原理與操作已較為人瞭解。生物養份去除系統必須根據

出流水質目標、污水廠原配置、及各廠之預算加以設計。然而只需要在現行的處理槽加入適當的迴流設施，污水廠便可控制所有的好氧、厭氧及無氧程序，進而達到以最少的改裝設施達到最高的養份去除目標。設計需要的考慮因素包括：

- 廢水特性及其所含養份及有機物之種類與濃度。
- 污水廠之水力配置，包括分流、水頭分布及單元容量。
- 維持適當的好氧、厭氧及無氧環境。
- 調勻池及沉澱池之容量。
- 污泥處理及迴流系統。
- 漂浮物及氣泡去除。

有些共通的污水廠改裝及設計規則：

- 處理廠的水力配置可能會限制水流之流程順序。
- 處理設施之設計應有彈性，以容許程序之最佳化。
- 氧氣及氮氣不應在厭氧區加入，氧氣亦應在無氧區控制在最小值。溶氧需控制，以減少能量支出。
- 在二級處理中增加的漂浮物應使用額外的機械去除設施。

改裝所需設施的介紹：

- 擋板(Baffle Walls)必須提供足夠的強度，以支撐兩邊不同的水頭差異。擋板的成本是由其材料、所需強度、及是否有額外的開口排水設施所決定。
- 擋水牆(Water-holding Walls)必須妥善設計，以免對原有設施造成額外負擔。新的擋水牆的配置，必須符合原結構之支撐處，並配合排水上的需求。若在現有的處理槽無法加裝排水，沉水泵浦便必須設置。
- 混合器(Mixers)在厭氧及無氧區可提供溫和及低速之混合，以防止處理中之污水沉降。過度的混合會降低生物養份處理之效率，在有些極端的例子，甚至會把氧氣移入。沉水式混合器特別適合在改裝時使用，因為很容易安裝在處理槽之壁上。
- 迴流泵浦(Recycle Pumps)通常為沉水式，並可依處理廠之水力及流程配置，作水平或垂直之安裝。若要達到操作之最佳化，則需提高作業之彈性，並充分利用迴流之容量。
- 漂浮物去除裝置(Scum-removal Devices)可能需要被裝置在現行二級沉降池，以提高去除效率。而且移除裝置需能連續操作，以防止漂浮物之堆積。

案例研究

- 案例一：馬里蘭州 Piscataway—Piscataway 污水處理廠

  原來設計為高級處理，提供二級處理、生物分段脫硝處理、化學除磷、及高級過濾。根據馬里蘭州在契沙比克灣水質改良約定之承諾，改良之生物養份去除程序，需達到每公升 8 毫克之總氮排放量。該處理廠為華盛頓郊區污水處理處所擁有及營運，該處聘請西圖公司找出最佳改裝方案，西圖公司建議下面三種方案：包括 Bardenpho、改良 Bardenpho、及分段進流(Step-feed)。圖五為三種方案之比較。改裝設計的第一步就是決定施工之可行性。因為現有的污水廠本身就是以分段進流活性污泥設計，改裝為分段進流生物養份去除需要最少的施工，這個優點以及分段進流使生物去除的可靠性、及其後續處理容量的擴充性，使得分段進流生物養份去除成為最佳方案。另外的優點是西圖公司推薦平行處理，可以有效的以最少的成本將沉澱池的有效容量擴為二倍。

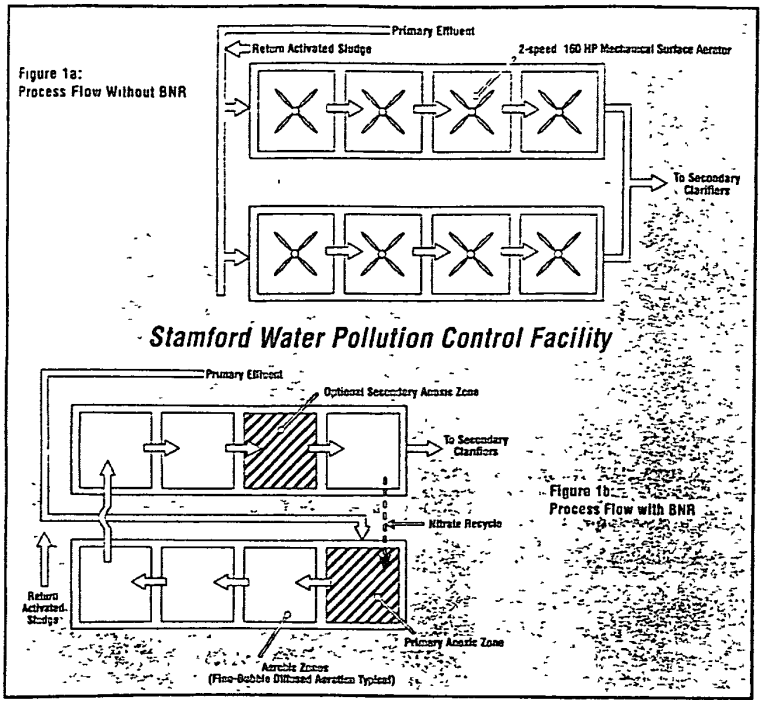
Table 3:
BNR Alternatives at Piscataway

Evaluation Criteria	Process Options		
	Bardenpho	Modified Bardenpho	Step-Feed
Process reliability	Good	Fair	Good
Ease of operation	Easy	Easy	Easy
Ease of construction	Difficult	Moderate	Easy
Tankage requirements	3.5 MG additional	5.7 MG additional	None
Yard piping requirements	Most	Moderate	Least
Incremental construction costs	High	High	Lowest
Operation and maintenance costs	Moderate	Low	Low

圖五： Bardenpho、改良 Bardenpho、分段進流(Step-feed)之比較。

- 案例二：康乃迪克州 Stamford—愈來愈嚴格的規定禁止在長島峽灣中增加總氮之排放，使得康乃迪克州必須將生物養份去除程序併入新的污水處理廠中，並且尋求一些低成本的替代方案，以改建海岸邊老舊的污水處理廠。Stamford 污水處理廠是第一個進行改裝的污水處理廠，其應用的觀念包括有：(1)改變進流形式、加強柱流(Plug-flow)，以加強各處理流程之區分。(2)將老舊的曝氣系統改為散氣盤，以改良控制降低成本，及增加處理體積。(3)增加一個硝酸鹽的循環。(4)在不同的作業組態中增加彈性。(5)抑制氣泡及漂浮物之生成。此外，其他作業的改變也在研究當中，例如同時硝化與脫硝、循環曝氣、

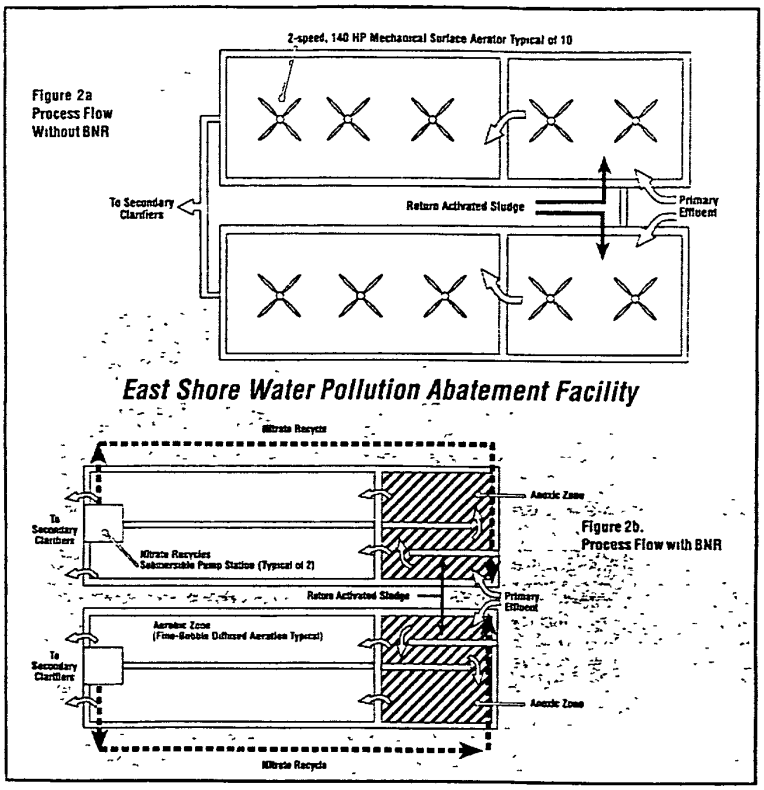
分段進流之生物養份去除等等。圖六為改裝後之示意圖。



圖六：康乃迪克州 Stamford 污水處理廠改裝工程示意圖。

案例三：康乃迪克州 New Haven—New Haven 污水處理廠也正在進行新的改裝：加入新的曝氣槽、處理槽，及生物養份去除系統，以降低出流水之總氮至每公升 4～6 毫克。該污水廠設計容量為每日四千萬加侖，但現在之操作量為每日三千七百萬加侖，已無多餘容量進行硝化。該污水廠原來僅靠二個大型污水處理槽，若一槽在維修中，該廠只能處理一半容量的污水。在改裝該廠以作為生物養份去除時，西圖公司將處理槽予以劃分，以進行更多流程，並提

供維護管理上之彈性。改裝包括了多程序之鼓風設備、陶瓷散氣盤、垂直螺槳沉水泵浦。圖七為該污水處理廠改裝工程示意圖。



圖七：康乃迪克州 New Haven 污水處理廠改裝工程示意圖。

將現有的污水處理廠改裝為生物養份去除用途，主要決定於該廠現有的特性，例如廢水流程、結構、容量及水力特性。評估上述的特徵，並應用一些設計的原理，就可完成改裝工作。除了改善下游水質之外，設計良好的生物養份去除改裝工作，可降低化學藥品的使用、減少氧氣的需要、維護鹼度、提高污泥的沉降性及產量。每一個成功的系統，

將能被設計利用最多的現有設備，減少新的施工，並提供最佳的作業彈性，以因應未來不同的排放標準及排放許可的需求。

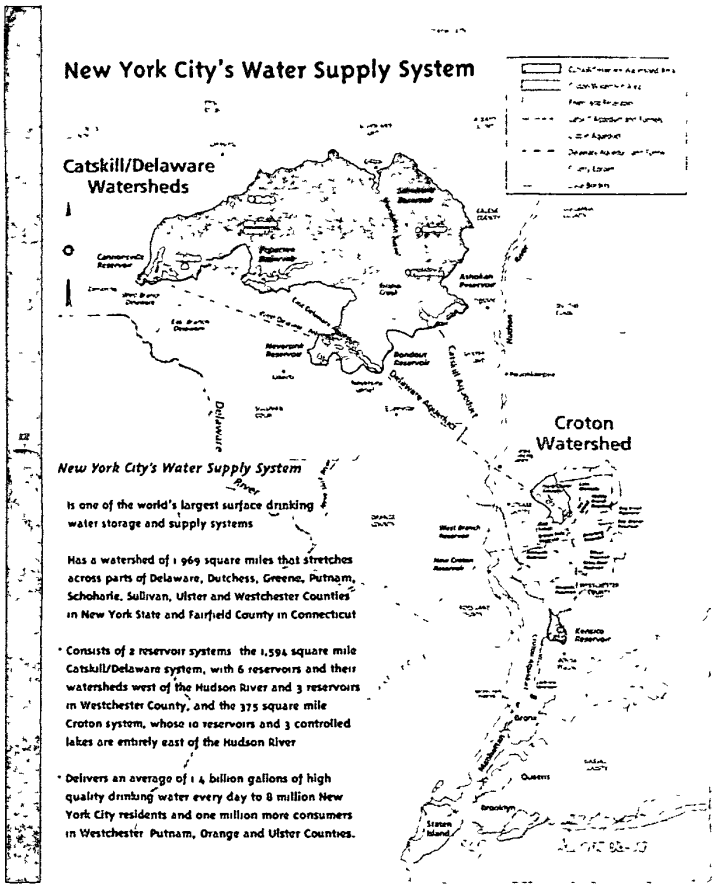
二、紐約市水源保護工作

自 1996 年開始，紐約市為了保護其水源，將在之後的 10 年花費十億美金進行水源保護工作，主要內容為購置集水區週邊土地作為緩衝帶，增訂集水區法規，及與集水區上源地區發展伙伴關係。

於 1996 年訂定的協議，解決了紐約市與上州圍繞著十九個水庫的各社區的爭端。本協議也讓紐約市節省了蓋新的過濾處理廠所需的八十億美金，因為如果水源保護政策在 1996 年底沒有實行的話，就需被迫籌設新廠。在 1989 年聯邦環保署要求紐約市籌設新的淨水處理廠，或是加強水源區之保護工作。所以紐約市開始修定自 1953 年開始使用的集水區管理規則，並規範上州各社區的經濟發展活動，在 1993 年底美國聯邦環保署同意給予紐約市三年的有條件免蓋過濾處理廠之許可，讓紐約市能發展加強集水區管理計畫。然而上州的社區也以法律行動控告這些限制他們經濟活動

的規章。在數年的爭訟及停滯不前後，紐約市終於和集水區各社區、聯邦環保署、紐約州達成協議。因此，聯邦環保署同意紐約市在1999年底以前，無需增設新的過濾處理廠。

八百萬紐約市民及一百萬郊區居民從涵蓋200公里範圍內之三大集水區(Catskill, Croton及Delaware)取水。圖八為紐約市飲用水集水區範圍示意圖。雖然Croton集水區的水質符合所有標準，紐約市仍要在那一區建設一個新的過濾處理廠，可以處理該區10%的給水量。



圖八：紐約市飲用水水源集水區範圍示意圖。

在紐約市的集水區共有 5200 平方公里，共有 20 萬人，在八個縣的範圍內居住，然而需要提供該市每日 380 萬立方公尺。

目前的供應水質符合所有聯邦法及州法的飲用水標準，然而根據紐約市環保部認為，根據集水區內日增的人口及經濟活動，以及對於暴雨逕流的進一步了解，使得更進一步的集水區控制非常有必要。為了支付此計畫之支出，水價需上漲 1%～2%，或是紐約市每用水戶需多付每年美金七元的支出。

本計畫主要內容為購置集水區週邊土地作為緩衝帶、增訂集水區法規、與集水區上源地區發展伙伴關係。另外最新的農業非點源防治工作亦加以介紹。

（一）土地取得

紐約市計畫用二億六千萬美元將其於集水區內所有之土地擴增三倍，包括靠近水庫之土地、靠近洪水平原之土地、濕地、及水庫週邊可用來作為緩衝區之緩坡地。紐約市同意只向同意售地的地主購買，除非該地區對水源保護有重大威脅。

（二）法規修訂

紐約市政府、聯邦環保署、及紐約州之衛生部、環保部，正在修訂自 1953 年以來之集水區規定。新規定著重於降低氮、磷、大腸桿菌及其他養份之負荷。其他重點包括：

- 所有區內之污水處理廠，需使用三級處理—包括微過濾或其他同級技術，以去除磷。新的處理廠需符合該標準，舊廠給予五年的改善時間。紐約市根據此協議將提供所有改善所需之經費。
- 紐約市會設定一個技術委員會，由該委員會、

州、郡、及地方官員所組成，用來審核區內所有暴雨逕流控制計畫及最佳管理技術規範。

- 在水庫週邊 90 公尺內範圍、及在行水區或濕地週邊30公尺內範圍，不得做不透水層之開發。終年溪流30公尺內範圍，或間歇溪流15公尺內範圍，不得開設道路。
- 對於地下污水系統滲漏至水體之可能性加強評估。

（三）伙伴關係

本協議設立一個區域性的協商組織，稱為集水區伙伴協會(Watershed Partnership Council)去討論所有關於水源與集水區的問題。本協會對於紐約市環保部或其他環保單位在區內進行之任何研究，皆有參與及審查之權利。

紐約市也會提供基金：以定期清除區內所有之化糞池、增修區內所有社區之暴雨逕流防治措施、改善區內所有營建工地之暴雨逕流防治措施、民眾教育計畫、河岸保護計畫、及森林最佳管理措施。

紐約市也會再花二億美元改善區內所有社區污

水處理廠，及花五千萬美元將其餘的105座公私立廢水處理廠予以升級，及二億四千萬美元更新所有市有給水設施及水壩。

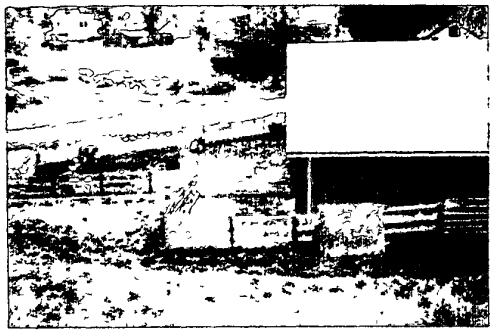
根據本協議，若區內水質下降，美國聯邦環保署及聯邦政府能隨時參與監測，並有要求計畫改變之權利。

(四)集水區農業計畫(Watershed Agricultural Program, WAP)

根據上述的伙伴關係及協議，紐約市出資設立一個集水區農業計畫，以農民自願參加及社區參與的方式，推廣最佳管理模式(Best Management Practices, BMP)，以降低農業非點源污染。本計畫分兩階段進行，第一階段為建立一個全農場示範計畫(Whole Farm Planning)，以專家指導，地方水土保持及環保單位監督之下，農民同意配合，先以十個農莊作示範，根據農莊作業形態及污染源型式，設計並施作最佳管理模式。第二階段將最佳管理模式推廣至集水區百分之八十五的農莊。最佳管理模式的目標在於選用多重的屏障(Barriers)以阻絕水生病原菌、養分、淤積物、殺蟲劑、燃料等污

染物進入水體。屏障可分為三種：

- 污染源屏障 (Source Barrier)：以農舍、穀倉為中心，設置草溝及緩衝帶等設施阻絕污染源，如圖九所示。



圖九：污染源屏障。

- 區段屏障 (Landscape Barrier)：根據集水區地形劃分放牧區，以設置之阻絕設施阻絕污染物之移動，如圖十所示。

圖十：非點源污染之區段屏障。

- 行水區廊道屏障 (Stream Corridor Barrier)：行水區周邊設緩衝帶，並以圍籬隔開放牧動物，阻絕污染物進入水體，如圖十一所示。

圖十一：行水區廊道非點源污染屏障。

此外，全農場示範計畫(Whole Farm Planning)還包括施肥控制、植栽輪作以控制土壤肥力、飼料管理、家畜糞尿堆肥回收再利用等措施。

三、維吉尼亞州非點源評估措施

維吉尼亞州休閒及自然資源保護部水土保持組評估該州的水體，以單元集水區發展出整個州的各流域非點源污染的評估，這是該州水質保護計畫的一部份。非點源污染評估以流域為單位，比較該州各水體的非點源污染顯著及潛在之影響。

本項評估尚包括維州環境部，維州森林部，及美國聯邦農業部，及該州各級水土保持機構之資料，也包括了自然保留區的一些集水區資料。

（一）維州集水區非點源污染之評估方法

年度之評估方法是從本年監測及歷年資料匯整

而成。下列段落即將討論如何利用本年及歷年監測資料之各部分來找出維州非點源污染較嚴重之地區。

歷年監測資料

以集水區為單位收集之歷年資料用一些特性來做非點源污染之分級，包括土地利用、動物密度及其他集水區之共同特性。土地利用資料可分為三類：農業區、都會區及森林。污染潛力是從不同土地利用區營養分之累積及土壤沖蝕估算而來。因為並沒有直接的從溪流內直接實際量測輸砂量之資料，若僅用估計值可能造成輸砂量之高估。

歷年資料是從1992年美國農業部普查，1990年的水土保持普查及 1992 年的自然資源普查資料估算而來，包括家禽跟家畜的數量，土地利用及沖蝕率都需要計算。

以縣為單位的資料是由集水區為單位發出不同問卷收集而來，問卷的資料是以集水區為單位收集的最新資料。不同的聯邦單位均協助發出問卷，在配合縣級的集水區地圖幫助分析。表三顯示出資料

的類型。保育及休閒部和政府的地方單位合作也提供了許多預防沖蝕的措施之位置及資料，這些資料都可用來評估因為都市發展所造成之輸砂量。

除此之外維吉尼亞州森林部也提供了許多森林伐採及育林作業的資訊，這些資料可以用來分析森林作業所造成之沖蝕。

為了跟其他非點源污染的資料能一致，集水區的評估資料需使用一致的單位及標準，前百分之二十被視為『高』，次百分之三十被視為『中』，後百分之五十被視為『低』。這些標準是用來討論各集水區的評價用，流域評估尚有其他的標準。

農業非點源污染之潛能

農業在維吉尼亞州佔有百分之三十的土地面積，是一個規模龐大而種類繁多的工業。雖然這個百分比比全國的平均數低，農業活動仍然是本州的重大非點源污染源。

農業非點源污染主要來自於許多不同的污染源，而且造成許多不同的衝擊。下面介紹一些主要的評估方法而且將三種主要的類型加以分類。這些非點源污染包括從(1)農業收成、放牧及牧草地造成的養分

市垃圾、重金屬、殺蟲劑、營建工地等等。私接雨水下水道之違法工廠、住宅區，及操作不良的污水處理廠也可能引發此等問題。主要的評估方法包括了來自於都會區之養分負荷，以及都市開發及營建工地沖蝕所造成污染。土地使用類型及單位面積沖蝕量將整合計算出各集水區之都會區污染負荷。

林非點源污染

維州森林部一直在調查各種森林作業對水質之影響。包括伐採整地、育林施肥作業等。這些調查配合其他研究可以用來協助管理非點源污染之控制。

沖蝕量的計算包括伐採及燃燒、切碎、及各種整地作業沖蝕量之總和。

（二）監測的資料

許多即時的監測資料配合現有的集水區工地利用分類用以估算各流域的水體污染量。監測資料包括固定測站的水體養分即時資料及其他即時通報的水體非點源污染情形。

業活動或都會區雖未有明顯之非點源污染，仍需列入損害水體之評估。

維州環保部所有的水體水質資料也會被評估，包括污染河段長度，污染出海口面積，污染源污染原因等等，皆會被加以整合探討。配合受損水質水體資料庫及集水分區的邊界，流域內的分部即可找出。

河川損害水體

次集水分區的污染河段可累計其長度，以進行流域整體集水區之分級，分段方法採用美國聯邦環保署規定之方法。另外一種方法是以加權計算找出集水區內污染河段比例以資比較。但若採取此法，則須以另外的函數統計加以比較以修正其對河川整體水質之影響，此等函數亦可用以估計無測站之水體水質，前百分之十為嚴重損害百分之二十為中度損害。

出海口損害水體

出海口損害水體根據出海口之主分區及次分區

(Infiltration Facilities)、滯留設施(Detention Facilities)、植生控制設施(Vegetative Controls)、過濾設施(Filtration)、泥砂流控制設施(Sediment Flow Controls)、截流設施(Diversion Facitities)及沈砂池(Sediment Basin)等。以下為筆者於維吉尼亞州參訪各種主要之結構性BMPs介紹。

• 草帶

草帶主要係用來作為一種緩衝區或過濾帶，使逕流流經草帶時，能降低流速，以減緩對水體的直接衝擊。草帶的功效在洪水平原、濕地附近、河岸以及緩坡特別顯著。過濾帶（或緩衝帶；Filter strip）為在邊坡的一種永久植生、呈現帶狀的農業措施，逕流則以薄膜流的方式流過過濾帶，可減緩對水體的直接衝擊。過濾帶的目的為：1. 將泥砂及其他污染物與逕流分離。2. 控制沖蝕。3. 保護鄰近水體。4. 提供各種野生生物的棲息地。

• 草溝(Grassed waterway)

為一種草類之自然或人工渠道，以集中暴雨逕流達到保護土壤的目的。草溝目的：1. 安全輸送逕流水。2. 降低溪流、農塘和湖泊的泥砂供應。

3. 幫助防止蝕溝的形成及其整治。4. 提供分水工和階段的出水口。5. 提供野生生物的棲息地。隆起草帶範例如圖十二。

圖十二：隆起草帶範例。

• 入滲溝(Infiltration Trench)

若開發地區之土壤入滲率較高且地下水位與地表間有足夠之深度，則入滲溝或下滲溝可被考慮做為減少地表逕流及改善水質之最佳管理作業。下滲溝對於溶解性(soluble)與顆粒性之污染物均有良好之去除率。由於下滲溝係利用地表下之空間貯存地表逕流，故一般均使用於集水面積不超過 5 英畝（2 公頃）之地區。圖十三為道路入滲溝池範例，圖十四為社區入滲溝池範例。

圖十三：道路入滲溝池範例。

圖十四：社區入滲溝池範例。

◦入滲設施

利用加強雨水入滲率來做雨水逕流管理之設施有入滲溝(Infiltration Trenches)及透水性舖面(Porous Pavement)、及組合舖面(Grid and Modular Pavement)等，分述如后：

• 透水性舖面(Porous Pavement)

透水性舖面通常包括一薄層之透水瀝青，下方為一層大顆粒之碎石，其作用為蓄積入滲之雨水，亦可用濾布來保護地下水及防止碎石層之空隙被堵塞。

• 組合舖面(Grid and Modular Pavement)

各種常用的組合舖面有其共同特點是每個單元留有開孔。舖設後青草會從開孔長出，增加舖面之綠意。此外開孔更可截留部分雨水入滲涵養地下水，減少地表逕流，降低尖峰流量和延長集流時間。也可以截留地面污染物加以淨化。

組合舖面適用於停車場、步道、人行道、護坡、各種遊憩設施，且應儘可能保持原來之綠地，以減少不透水舖面或組合舖面，其下方可併用碎石堤攔阻沖刷污染並入滲。圖十五為碎石堤攔阻沖刷污染並入滲。

圖十五：碎石堤攔阻沖刷污染並入滲。

入滲設施之污染物去除率相當高，入滲溝如設計及維護良好，據文獻資料可去除100%之懸浮固體物，30%至70%之營養鹽，以及15%至80%之金屬及細菌。透水性舖面去除污染成效之資料非常少，不過也有文獻報告已得到不錯之結果。在防洪方面，因入滲設施蓄水體積較小，故並不很實用。

部分污染物在通過入滲設施砂石層時會因過濾、吸附等作用而被去除，濾布也可去除較大顆粒之污染物，不過大部分污染物之去除是在雨水進入土壤中後，由於物理性（過濾、吸附）、化學性（化學反應）及生物性（根部攝取、轉換等）之作用將污染物去除。入滲設施之設計，主要需做以下之考量：

為控制初期沖刷帶來之污染，入滲溝及乾井之容量一般以能蓄積集水區不透水部分所產生之 13mm 之逕流為基準。在延時方面，入滲設施須能滯留設計流量 24 小時以上，且能在暴雨後 72 小時以內排完蓄水。滯留時間長可增加污染物去除效率，蓄水完全排放則可確定全部容積可以用來蓄積下次暴雨逕流。

所在地土壤需有相當之透水性，透水率低時需裝設排水管以利雨水排放。地下水位之高度亦應注意，入滲設施底部應距最高之地下水面至少 1 公尺以上，以減少雨水污染地下水之可能性。

入滲設施最常見之問題為泥砂堵塞，故其貯水及排水功能需定期測定，通常每年至少一次，在逕流含砂量高之地區則測定次數應相對增多，在堵塞情況嚴重時下滲溝及透水性路面之濾層可能必須換新。在歐洲（如德國），亦有用強力之吸塵器來清除下滲設施之報導。

• 滯留設施

傳統上滯留設施如滯留池（Detention Pond）主要為防洪目的而設計，但是近年來亦增加〝水質

改善”之考慮，達到防洪（延緩洪水出流）並兼顧水質改善（攔截逕流污染）之雙重目標。

滯留池之設計原理應考慮池之大小，滯留時間及進流水顆粒大小分佈，腐化及生物攝取等，而以顆粒沈降為一般滯留池去除污染物為主要之因素。圖十六為道路工程滯留池範例。

圖十六：道路工程滯留池範例。

◎緩衝草帶

或稱為植物性過濾帶(Vegetative Filter Strip)為一種造價低，但頗有益於去除雨水逕流污染的方法。通常需先將雨水引進一水平分佈槽(Level Spreader)內，槽內水滿時會沿槽緣滿溢出來而平均的分佈流過草帶(Grass Strip)，如此可避免形成渠道流(Channel Flow)而減低緩衝帶之

效率。

植物緩衝帶可以和其他管理方法結合起來，而得到較高的總污染去除效率。例如可將一停車場之雨水逕流先使其經過一植物緩衝帶然後再流入一入滲溝。另外，在住宅區及道路旁常見之草鋪排水渠道或草溝(Swales)，也可利用植物緩衝帶之設計來改良增進污染物之去除效率。圖十七：自然草帶之溝床。

圖十七：自然草帶之溝床。

緩衝草帶植物以土生或適於本地生長之草本為主，設計之主要考量為需使逕流以片流之形式流過草帶，速度需緩慢以增加接觸時間，草帶坡度以不大於 5%為宜，長度則應大於 20 公尺，如因地形關係坡度過大，則可在下游建一小型矮壩以減低流

速。上游逕流入口通常設有一水平分水槽，水滿時會沿槽緣溢出平均分佈流過草帶，如此可避免因形成渠流而減低緩衝帶之效率。

緩衝草帶及草溝之維護需求甚少，主要是定期剪草，及維持一般性之清潔，並注意有無沖蝕現象發生。人造濕地需要去除逕流帶入之漂浮物，邊坡若有沖蝕需加以修補，定期去除不適合的雜草並防止蚊蟲孳生。

- 覆蓋(Mulching)

如以稻草、稻草蓆、碎木片、碎石、人造纖維、不織布等鋪蓋裸露之地表，亦可以回收紙漿加草種籽噴灑於裸露之地表，藉以安定與植生。圖十八為以回收紙漿加草種籽噴灑於裸露地表之範例。

圖十八：以回收紙漿加草種籽噴灑於裸露地表之範例。

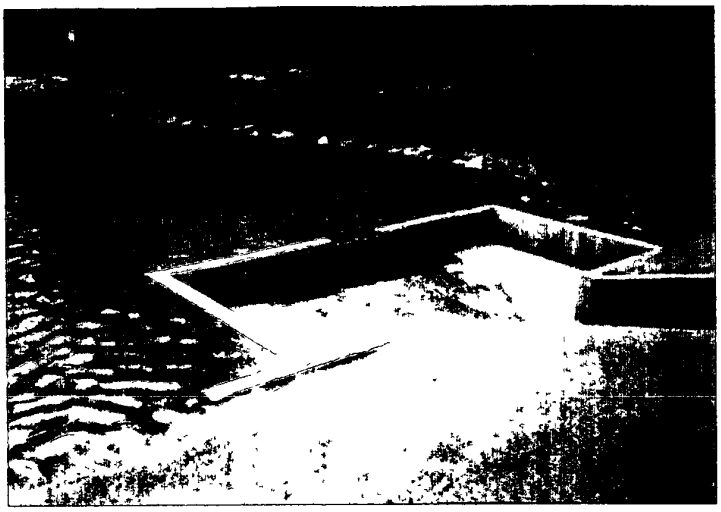
• 過濾設施

社區過濾設施是由一個沈澱池與一個濾池所構成，暴雨逕流在沈澱池中滯留，去除顆粒性物質後，再流入濾池中濾除微細懸浮物。濾池中之濾料一般為砂子，但也可以使用砂子與泥炭之混合物。過濾設施主要目的在去除顆粒性污染物，這一類設施大多用在較小的集水區（最大可到 40 公頃）或者個別的小社區，其效率高、佔地小，但必需經常維護。這一類的設施亦可設在地下。使用此類設施時必須確定集水區沒有嚴重的土壤侵蝕，以免頻頻維護、清理，造成操作上困難。

室外之開放式設計為最常用之形式，可以使用在大到 10 公頃的集水區，亦有兩種設計可以用在較小的集水區。設在街道沿線地下的過濾槽，使漫地流由不透水舖面邊緣之多孔蓋流入沈澱池，沈澱池中之水再溢流至砂濾。而地下砂濾槽接受集中的逕流，可以使用在個別的建築物內。

沈澱池大小之決定可參考乾式滯留池，但由於有砂濾，滯留時間可以比較短，一般沈澱池能去除懸浮固體 50~60%即不致造成頻繁的砂濾阻塞。圖十九

為雨水滯留沈澱池範例。



圖十九：雨水滯留沈澱池範例。

• 施工工地泥砂流控制設施

使用於施工地區之泥砂流抑制設施，常用者為砂欄(Silt Fence)，阻壩(Check Dam)，及濁度欄(Turbidity Fence)，而以砂欄之使用最為廣泛。砂欄為一暫時性攔阻泥砂流之設施，通常是將地工纖維或濾布以木樁固定橫置於泥砂流中，以阻截小量之泥砂流，以減少泥砂流出施工區，及減緩片流(Sheet Flow)或水溝之流速。圖二十為砂欄之範例。

圖二十：砂欄之範例。

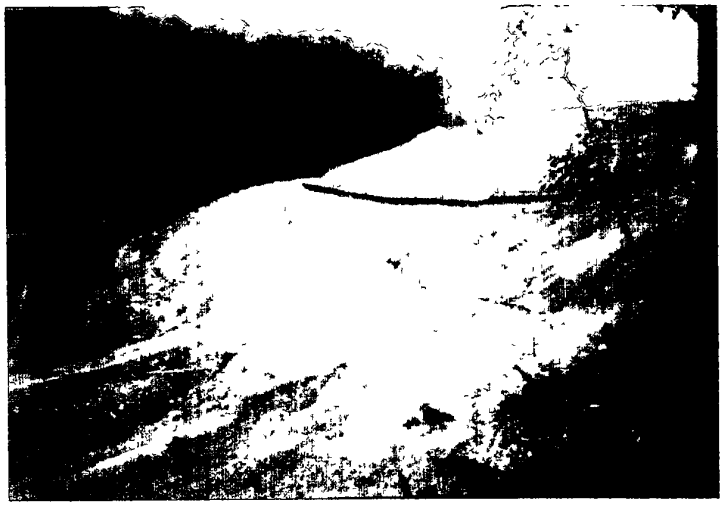
砂欄適合在沖蝕型態為層狀，指狀或溝狀；每 50 公尺砂欄所控制之集水區面積不超過 0.5 公頃，流量不超過 0.03cms。通常砂欄之高度以 1 至 1.5 公尺為宜。木樁格為 5 至 10 公分、長 1.5 公尺以上。濾布或地工纖維須符合下表最低規格需求。阻壩為用來降低泥砂流之流速。但要注意維護，以免發生短流或淤積沈質。

• 施工工地截流設施－截流堤(Diversion Dike)，截流溝(Diversion Dike)

截流設施包括臨時性之土堤、截流溝等。臨時性土堤為一臨時性之設施，建於開挖地區坡度之上方或底部。目的在於：建於開挖地區上游，將雨水逕流攔截引向一穩定出口，以避免開挖區產生沖

蝕。建於開挖地區下游，將開挖區之泥砂流引至一沈砂設備如沈砂池等。

截流堤適用於開挖面積小於 2 公頃之地區，其建造費用因可利用棄土故較砂欄設施為低。截流堤與泥砂池之合併使用為目前最適當控制工地沖蝕之作業，另有邊坡防沖刷之攔阻設施可一併使用。圖二十一為施工工地邊坡防沖刷之攔阻設施。



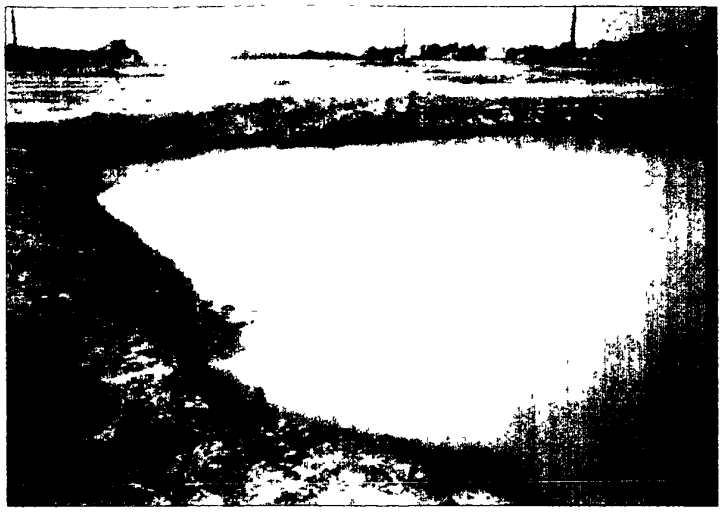
圖二十一：施工工地邊坡防沖刷之攔阻設施。

正式之設計準則，截流堤以高至少 0.5 公尺，底寬至少 1.5 公尺，邊坡坡度不超過 1.5 比 1（水平比垂直）為宜。土堤本身需緊密夯實。截流溝之目的亦類似，係將逕流導引至一指定區，避免沖蝕。圖二十二為施工工地截流溝與收集池範例。

圖二十二：施工工地截流溝與收集池範例。

• 施工工地沈砂池(Sediment Basins)

沈砂池(Sediment Basin)及沈砂塘(Sediment Trap)均為滯留泥砂流，而促進泥砂沈積之構造物。前者用於開挖面積小於 1 公頃，而後者用於大於 1 公頃之地區。沈砂塘在使用完畢後即回填而作其他開發之用途。沈砂池則有時可保留至竣工後改建為滯留池(Detention Pond)以控制雨水逕流。沈砂池為一以建築低壩或堤而形成之構造物，用以滯留泥砂流而去除泥砂，滯流自開發區產生之泥砂流於池內，停留一定時間後可促進大部分泥砂沈積於池內。圖二十三為整地工程排水滯留沈砂池。



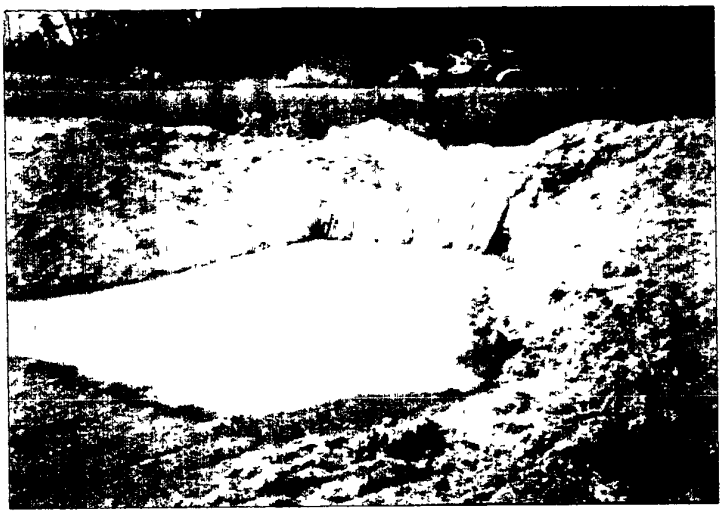
圖二十三：整地工程排水滯留沈砂池。

沈砂池用於開挖面積大於 1 公頃之地區，工地之地形及空間需有足夠建造沈砂池之條件。臨時沈砂池之設計使用年限一般為 18 個月。如將保留以做為竣工後滯留池時，則需在規劃時即加此項考慮。一般沈砂池之泥砂去除效率約為 60%左右，故應該與其他控制沖蝕作業，如植生方法一併執行。

沈砂池若建設在集水面積小於 50 公頃之地區時，可利用簡易之經驗法來推估所需沈砂池之體積。若集水面積大於 50 公頃時，則建議用較精確之水文及泥砂沖蝕估計方法，如萬用土壤沖蝕公式等，來計算所需體積。

為了增進泥砂之沈降率、沈砂池之長度應為寬度之 2 倍以上。有時可使用隔板來確保沈砂效率。

圖二十四為道路工程排水滯留沈砂池。



圖二十四：道路工程排水滯留沈砂池。

肆、建議

一、建議充實並隨時更新各單位全球資訊網頁之外語版面。

建議我國各級政府各單位加強宣導工作理念、展現成果及國際交流，特別是充實並隨時更新各單位全球資訊網頁之外語版面，積極向全世界介紹我國，參與國際社會。

二、參考美國應用非點源污染控制以防治水體優養化之技術，轉達維吉尼亞大學（University of Virginia）余教授嘯雷之建議：以翡翠水庫集水區進行非點源污染控制示範實驗計畫，再考慮推廣全國。

余教授嘯雷之建議為：「由台北水源特定區管理委員會或行政院環境保護署，邀集相關單位，以翡翠水庫集水區為例，進行非點源污染控制示範實驗計畫，尤其針對該集水區種植茶園之污染控制，將來視成效再決定是否推廣至全國」。

三、因應生化恐怖攻擊之潛在威脅，建議加強我國自來水水源水質監測、自來水場安全維護與供水水質警報系統。

因應美國遭受生化恐怖攻擊，建議加強我國自來水水

源水質監測、自來水場安全維護與供水水質警報系統，盡量縮短應變反應時間，保障廣大民眾自來水水質之安全。

四、建議我國環境保護工作人力宜再評估適度調整或增加。

此行美國二十餘個受訪單位，其工作人員有餘力與筆者開會討論，事前並準備充分的資料，有充足的時間完整思考工作計畫與修正策略方向。

相較之下，以筆者任職行政院環境保護署參與的水源水質保護工作，自民國八十六年（1997）迄今，全國二十餘縣（市）完成七十餘個「飲用水水源水質保護區」，與近五十個「飲用水取水口一定距離」之研商評估劃定，以及「飲用水水源水質保護綱要計畫」，其中「水源保護區養豬戶（場）依法拆除補償」研商規劃推動執行之工作，涉及十個縣（市）約五十個鄉（鎮、市、區）公所五千七百餘養豬戶（場）。

上述工作主要人力只有二人，筆者為其中之一，期間偶有一、二人短暫支援，惟仍不足。數年來工作負荷極為繁重，現勘研商協調規劃分析，各種個案及大小規模之陳情抗爭層出不窮，需一一耐心妥為處理回應。因此，

幾年來筆者平日多半被迫必須夜間加班，假日亦常須加班趕辦，沒有充足時間思考工作方向、問題檢討及因應對策等事宜。

為讓人員稍有時間於工作中仍可思考與修正策略方向、提高同仁工作士氣及提昇工作品質績效，故建議我國環境保護工作人力宜再評估適度調整或增加。

五、因本計畫日支費八折給付，建議如委託美方代訂旅館，主動要求在該城市日支費(打八折前)的55% 至60% 以內訂房（含稅），以免生活費不足之窘境。

因應今年本計畫出國日支費一律八折給付，筆者對八折沒意見，但建議以後如委託美方代訂旅館，不妨主動要求美方在該城市日支費(打八折前)的55% 至60% 以內訂房(含稅)，留25% ~20% 供用餐、搭乘大眾交通工具、郵寄資料、國際電話費及必要時計程車資等雜支(合計八成)。以免因住宿費過高而使用餐等其他費用捉襟見肘，甚至在有些城市無經費供用餐，更不用說其他費用了。

伍、其他相關事項

一、經濟部委託執行安排詳細行程之美國農業部研究院（Graduate School/United States Department of Agriculture, GS/USDA），於本計畫對筆者的結語信件（附錄一），其中述及筆者 **He is a great credit to his country and to the program**，對於赴美研習整體表現之肯定，筆者甚感榮幸為國爭光。

二、英文計畫執行書如附錄二。

三、攜回英文重點資料如附錄三。

四、美國一些城市（紐約、費城）的地下鐵系統相當老舊且骯髒，電扶梯與升降梯不太普遍；相較之下台北的捷運系統新穎乾淨舒適方便，國人應好好珍惜愛護，引以為榮。

附　　錄

附錄一

GS Graduate School, USDA International Institute

Suite 320
600 Maryland Avenue, SW
Washington, DC 20024-2520, USA

Telephone: (202) 314-3508
Fax: (202) 479-6803
e-mail erik_ronhovde@grad usda.gov

Date: September 21, 2001

To: Mr. Jerry M.S. Shyy
Fax: 886-2-2321 3275

From: Erik S. Ronhovde, Graduate School, USDA

Total no. of pages: 2

Subject: Mr. LIAO Chuan-Cheng (PIO/P #10321)

Dear Mr. Shyy:

As Mr. Liao approaches the end of his U S. program, I want to assure you that we have been in close touch with him every day, and everything seems to have gone well in Seattle and San Francisco. I also must tell you that Mr. Liao has been very brave and patient through a time of enormous stress and difficulty. He is a great credit to his country and to your program.

Mr. Liao has asked me to inform you that during the Richmond portion of his program he was forced to take taxis four times (initial arrival, roundtrip to Charlottesville, and final departure) because of the absence of public transportation. He also asked that I send you his actual itinerary in the United States, and I have included it on the following page.

I will write to you again on Monday, September 24 .

Best wishes.

Mr. Liao's Actual Itinerary in the United States

Sunday, 8/26	Arrive Washington, DC
Monday, 9/3	Travel to Richmond, Virginia by train
Wednesday, 9/5	Roundtrip to Charlottesville, Virginia by train
Thursday, 9/6	Travel to Philadelphia, Pennsylvania by air
Saturday, 9/8	Travel to New York, New York by train
Monday, 9/17	Travel to Seattle, Washington by air
Wednesday, 9/19	Travel to San Francisco, California by air
Saturday, 9/22	Travel to Taipei by air

附 錄 二

International Cooperation Department
Ministry of Economic Affairs
Project Implementation Order/Participant

Name of Participant	**Project Title**
Mr. LIAO, Chuan-Cheng 廖 全 成	05-Application of Eutrophication Prevention Technique on Water Bodies. (watershed or water quality related) 水體優養化防治技術應用
PIO/P No. 484-C01-10321	

Name of participant : Mr. LIAO, Chuan-Cheng

Sponsoring agency : Environmental Protection Administration

Kinds of Training Needed and Method of Carrying out :

The activity target for this training is to provide an opportunity for the participant to study "Application of Eutrophication Prevention Technique on Water Bodies. (watershed or water quality related)"for a period of one-month in U.S..

Major field of study will include :

1.Removal technology of nutrients.
2.Measurements of best management practice (BMP) for non-point source pollution control.
3.Planning in source water protection area delineation.
4.Lake and reservoir eutrophication Prevention methods.
5.Watershed pollution protection methods.
6.Organizations or authorities for watershed.
7.Modeling of nutrients removal and watershed Management.

GS/USDA is requested to arrange an one-month observational training program for the participant, beginning August 2001.The outline of the visit which serves as the reference for the program arrangement is as follows :

LOCATION	PURPOSE
1. GS/USDA, Washington D.C.	To confirm visiting schedule. (Including project title related schedule and site visiting recommended by GS/USDA.)
2. US Environmental Protection Agency Office of Water, Washington D.C.	To observe a) Watershed nutrient management Programs. b) Eutrophication studies under the Clean Lake Program. c) Chesapeake bay programs. d) Organizations or authorities for

	watershed. e) Project title related topic and site visiting recommended by them.
3.Camp Dresser & McKee Inc. (C.D.M.,a consultant), Washington D.C.	To observe a) Planning in Measurements of best management practice (BMP) for non-point source pollution control. b) Planning in Removal technology of nutrients. c) Project title related topic and site visiting recommended by them.
4.The State Organization for Boating Access, Washington D.C. Tel:202-944-4987	To observe a) Water quality protection working on Chesapeake Bay. b) Project title related topic and site visiting recommended by them.
5.USDA-Agricultural Research Service (ARS),Beltsville, Maryland.	To observe a) Sediment/Erosion Control. b) Watershed modeling. c) Project title related topic and site visiting recommended by them.
6.Maryland Department of Environmental Protection.	To observe a) State nutrient management. b) Non-point source pollution control programs. c) Chesapeake bay water quality protection. d) Project title related topic and site visiting recommended by them.
7.Univ. of Maryland(Dr. Oliver Hao), College Park, Maryland.	To observe a) Nutrient Control Studies. b) Eutrophication Prevention Studies. c) Project title related topic and site visiting recommended by them.
8.Chesapeake Bay Foundation, Annapolis, Maryland.	To observe a) Private group working on water quality protection for the bay. b) Project title related topic and site visiting recommended by them.
9.Virginia Department of Environmental Quality	To observe a) State nutrient management. b) Non-point source pollution control programs. c) Chesapeake bay water quality

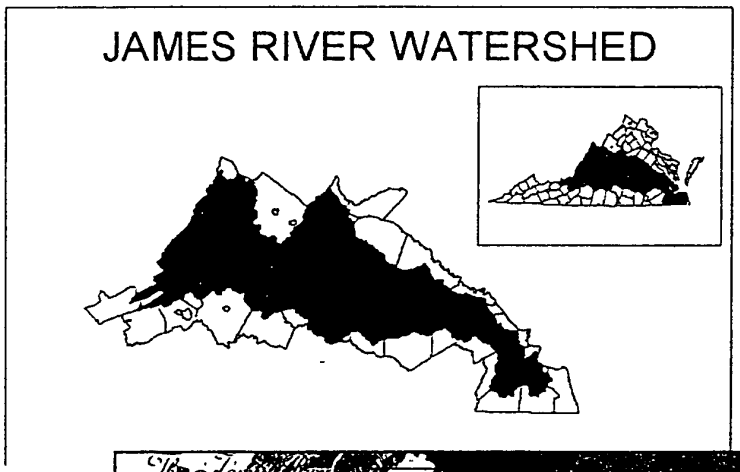
	protection. d) Project title related topic and site visiting recommended by them.
10.Department of Conservation and Recreation in Richmond, Virginia	To observe a) State nutrient management. b) Non-point source pollution control programs c) Chesapeake bay water quality protection. d) Project title related topic and site visiting recommended by them.
11.Univ. of Virginia (Dr. W.S. Lung & Dr. Shaw L. Yu), Charlottesville,Virginia	To observe a)Nutrient Control Studies. b) Eutrophication Prevention Studies. c) Project title related topic and site visiting recommended by them.
12. US Environmental Protection Agency Office of watersheds, Philadelphia.	To observe a)Watershed nutrient management programs in region 3. b) Eutrophication studies under the Clean Lake Program. c) Measurements of best management practice (BMP) for non-point source pollution control. d) Project title related topic and site visiting recommended by them.
13. US Environmental Protection Agency. Region 2, New York.	To observe a) Watershed nutrient management in region 2. b) Eutrophication prevention. c) Project title related topic and site visiting recommended by them.
14. New York City Sewage treatment plant	To observe a) Design function and operation. b) Project title related topic and site visiting recommended by them.
15. US Environmental Protection Agency. Region 5, Chicago	To observe a) Watershed nutrient management in region 5(especially in 5 great lakes area). b) Eutrophication prevention working in 5 great lakes area. c) Project title related topic and site visiting recommended by them.

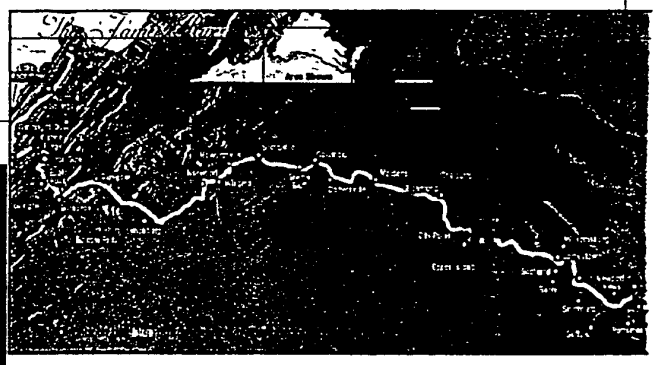
16 US Environmental Protection Agency. Region 9,San Francisco.	To observe a) Watershed pollution protection in California & region 9. b) Eutrophication prevention in California lakes and reservoir. c) Project title related topic and site visiting recommended by them.
17.California Environmental Protection Agency California Regional Water Quality Control Board San Francisco Bay Region,Oakland. (Dr. Teng-Chung Wu or related person.) Tel: (510)622-2445	To observe a) Lake and reservoir eutrophication prevention enforcement. b) Watershed pollution protection methods. c) Project title related topic and site visiting recommended by them.
18.US Environmental Protection Agency. Region 10,Seattle	To observe a) Non-point source pollution control In Washington State. b) Eutrophication prevention in bay area. c) Project title related topic and site visiting recommended by them.
19. Seattle City Water Quality Control Board. (or Water Quality Authorities) Seattle.	To observe a) Water pollution protection methods. b) Seattle City Water supply treatment plant. c) Project title related topic and site visiting recommended by them.
20.Related Facilities or Agencies or Institutions or Symposium or Organizations or Authorities or Site Visiting or Exhibition or Reservoir or Lake or Water supply plant or Sewage treatment plant, concerning "Application of Eutrophication Prevention Technique on Water Bodies (watershed or water quality related)".	

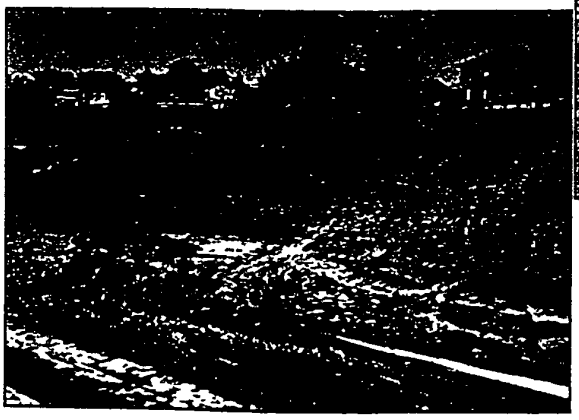
附錄三

Overview of Virginia's Nonpoint Source Pollution Reduction Activities

September 4, 2001







DCR
Department of Conservation & Recreation
CONSERVING VIRGINIA'S NATURAL & RECREATIONAL RESOURCES

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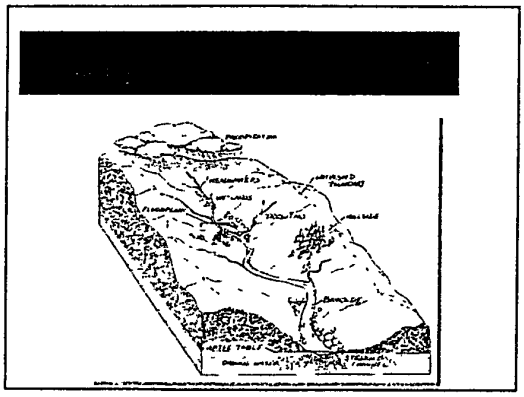
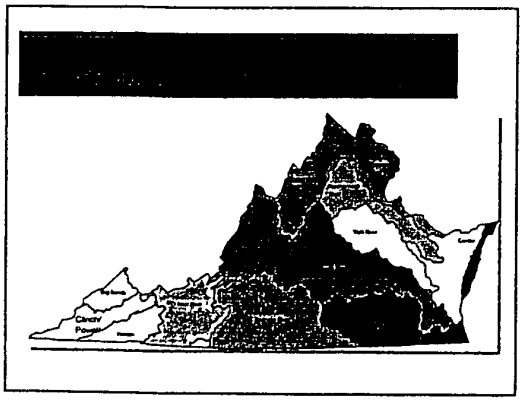
Cooperative Management of Virginia's Watersheds

DCR
Department of Conservation & Recreation





Cooperative mgmt of VA's watersheds - general.ppt

What is watershed management?

- A framework for coordinating water quality goals and management activities within the boundaries of a river basin.
  - Not a new regulatory program.
  - Realignment of natural resources programs and citizen involvement to operate in a more comprehensive and integrated manner.
  - Encourages active coordination across full range of resource management programs.

Water Pollution Sources

- Nonpoint source pollution - (DCR)
- Point source pollution - (DEQ)

Cooperative Watershed Management

- A watershed-based approach to coordinating point source pollution permitting with nonpoint source pollution reduction actions to achieve water quality goals.

Common goals of watershed management

- Focus to environmental goals
- Integrate programs to address "big picture"
- Maximize efficient use of resources
- Increase public awareness/involvement
- Improve management consistency & continuity
- Increase innovation and long range planning capabilities

Common River Basin Concerns

- Drinking water supply
- Development impacts (sediment & increased runoff)
- Forest harvesting impacts
- Agriculture impacts
- Inadequate septic systems
- Other basin-wide & local issues

Benefits of Watershed Management

Common River Basin Benefits

- Protect drinking water supplies and intakes
- Protect in-stream living resources
- Enhance recreational uses and protect water dependent commerce
- Reduce flooding hazards
- Reduce sedimentation/siltation
- Others

Increased public participation & support

- Promote public involvement & increase public awareness
- Informed public more likely to have realistic expectations regarding water resources management
- Facilitates agency response to public concerns

Improved intergovernmental relationships

- By providing a common framework for assessment & implementation, watershed management can help build and improve on existing partnerships between federal, state, and local governments and citizens
- Strengthens partnerships between private & public interests

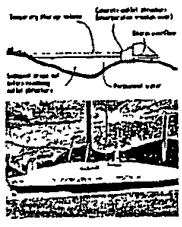
DCR's Programs and Initiatives

Erosion & Sediment Control

- A program and regulations for the effective control of soil erosion, sedimentation and non-agricultural runoff.
- Controls are designed to prevent the unreasonable degradation of properties, stream channels, waters, and other natural resources.

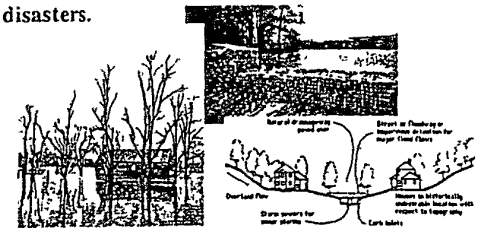
Stormwater Management

- Manage the runoff from land development projects to mitigate stream channel erosion, flooding, and water pollution.



Floodplain Management

- Manage land uses to protect lives and property from loss and lessen the physical and monetary damages that result from flooding and flood disasters.

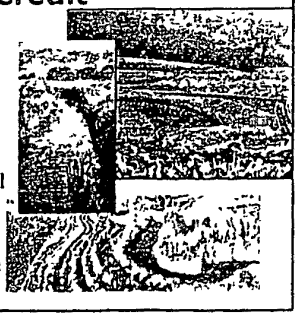


Shoreline Erosion Control

- Provides technical advice to shoreline and streambank property owners on erosion problems and control measures.

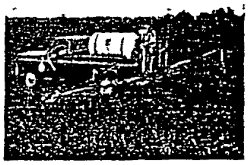
Agricultural Cost Share & Tax Credit

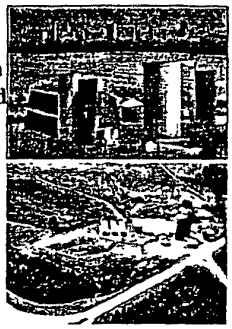
- Promotes installation of agricultural Best Management Practices (BMPs).
- Based on financial incentives and voluntary participation by the agricultural

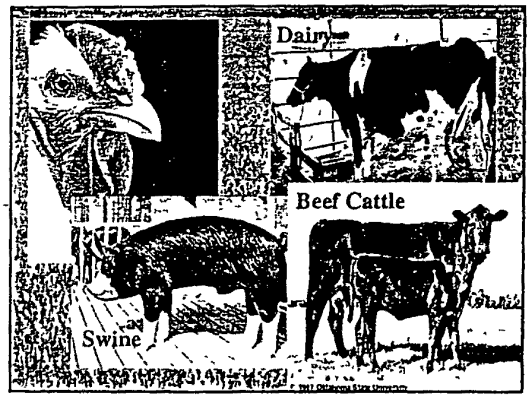


Nutrient Management

- Manage the use of nutrients on farm fields and other crop production land to protect ground and surface water from excessive nutrient loads.





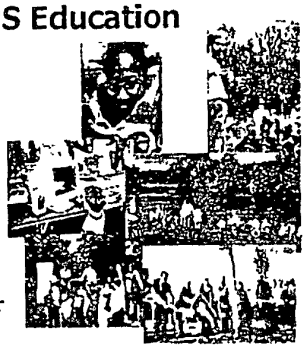


Assistance to Soil & Water Conservation Districts

Providing technical and financial assistance to SWCDs to effectively implement local soil and water conservation programs.

NPS Education

Providing NPS education and resources to agricultural and urban/suburban landowners on methods that reduce land use impacts to water resources.



Current Initiatives

- Chesapeake Bay Program
- Albemarle-Pamlico National Estuary Program
- American Heritage Rivers
- Tributary Strategies
- Total Maximum Daily Loads
- Water Quality Improvement Act (WQIA)
- Watershed Conservation Roundtables
- Adopt-A-Stream

Chesapeake Bay Program

- Comprehensive monitoring and restoration program for water quality, habitat, and living resources.
- Partnership between federal, state, and local agencies, conservation organizations, and citizens.

Albemarle-Pamlico National Estuary Program

- The nation's second largest estuary system.
- One of North Carolina's most important natural and economic resources.
- Virginia covers 75% of the Chowan Watershed and 21% of the Albemarle Watershed headwaters.

American Heritage Rivers

- This initiative spotlights rivers across the country and transforms rivers into a priority for our nation's environmental agenda.
- Virginia's New River is included as an American Heritage River.

Tributary Strategies

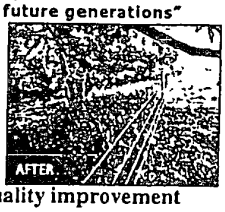
- Implement Chesapeake Bay nutrient reductions targeted by major river basin.
- Status:

Total Maximum Daily Loads

- The amount of pollution a water body can assimilate without violating water quality standards.
- TMDL's are numerical pollution limits used to address water pollution sources and corrective measures.

Water Quality Improvement Act

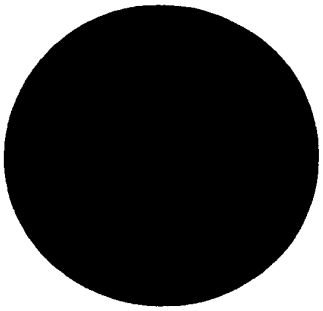
"Improve & restore the quality of the Commonwealth's waters for current & future generations"



- Funding targets water quality improvement projects such as agricultural BMP cost-share & special projects that introduce innovative methods.

Adopt-A-Stream

Watershed Conservation Roundtables



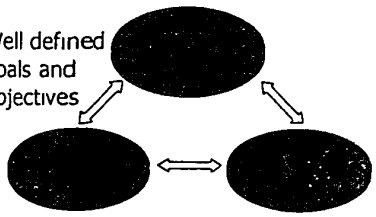
Watershed Management - What Does It Look Like?

Supporting agencies & Organizations

- Resource Conservation & Development Councils
- Soil & Water Conservation Districts
- Local Governments
- State Agencies (VDOT, CBLAD, DEQ, etc.)
- Federal Agencies
- HRPDC
- Extension and Academia
- Others

Triad approach

- Well defined goals and objectives



- Selection criteria
- Flexible process

Problem identification

- Geographic targeting
- Impairments to human health, ecological resources, or designated uses
- Identify problems; those with greatest potential for impairment are targeted
- Difficult management problems may not be fully addressed over one planning cycle

Integrated solutions

- Interdisciplinary team to develop the most appropriate actions needed
- Provides a framework to design optimal mix of water quality management strategies
- Application of resources in a timely and geographically targeted manner

Cooperative partner & stakeholder involvement

- All parties with a stake in specific local situation should participate
- Participation of affected parties is crucial to success of watershed action plans
- Manner of involvement may vary between watersheds

Practical lessons learned

Lessons learned...

- Success is more likely & lasting
- Positive impact on teamwork, morale, and relationships
- Enhanced public involvement
- Clear process of decision-making
- Phased implementation provides time for abilities to develop

Lessons learned...

- Cost impact is reduced
- Time and effort to develop and implement a watershed approach is substantial
- Comprehensive rotating basin approach versus targeted priority watersheds
- THE JOB IS NEVER OVER!!!

Cooperative Watershed Management - Conclusions:

- Opportunities to enhance service delivery and directly improve water quality in Virginia's waters.
- Enable us to more effectively meet state and federal legal requirements & achieve locally established goals.

Cooperative Watershed Management - Conclusions:

- Strengthens partners and stakeholders working together on prioritized issues and problems.
- Development of action plans serves as an organizing framework to provide greater efficiencies.
- Creates a vehicle to support attracting additional resources to achieve goals.

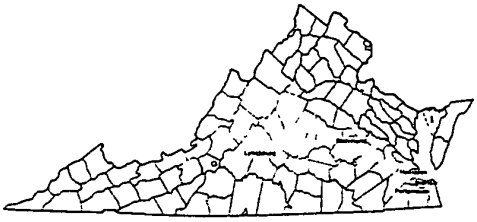
"All the acts of government are of slight importance to conservation except as they affect the acts and thoughts of citizens"

Aldo Leopold

James River Tributary Strategy

Goals for Nutrient & Sediment Reduction

James River Basin



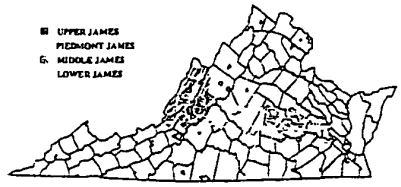
James River Strategy

- Examine nutrient & sediment sources

- Evaluate actions

1

James River Tributary Strategy Development Process

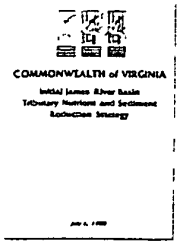


Stakeholder Involvement

- Local Government Officials
- Planning District Commissions
- Soil & Water Conservation Districts
- Conservation Organizations
- Business Interest Groups
- Industry
- Wastewater Treatment Facilities
- Citizens

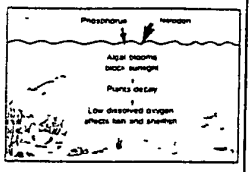
Initial James River Tributary Strategy

- Did not set nutrient & sediment reduction goals
- Essential tool for setting goals, the Chesapeake Bay Water Quality Model, had not yet been completed.
- Completed initial strategy on July 1, 1998



Environmental Factors Considered in Goal-setting

- Living resources
- Habitat conditions
- Water quality indicators



Nutrient & Sediment: Sources

- Nutrients
  - point sources
  - nonpoint sources
- Sediment
  - Virtually all is associated with NPS runoff

James River Key Issues

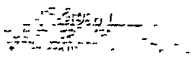
- Sediment load is very high. Suspended sediment reduces light and prevents the growth of SAV
- No dissolved oxygen problem.
- Nitrogen reduction in upper tidal James could promote SAV growth
- Chlorophyll levels throughout the James estuary are elevated

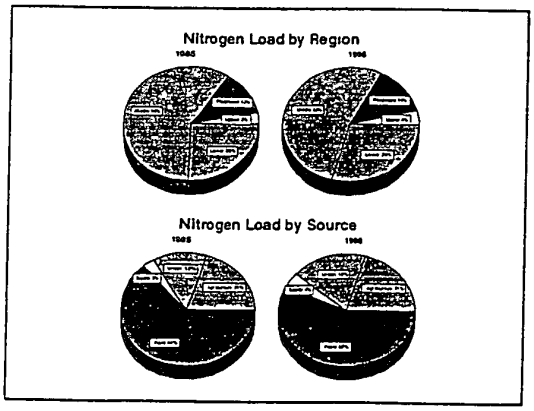
1996 Loading

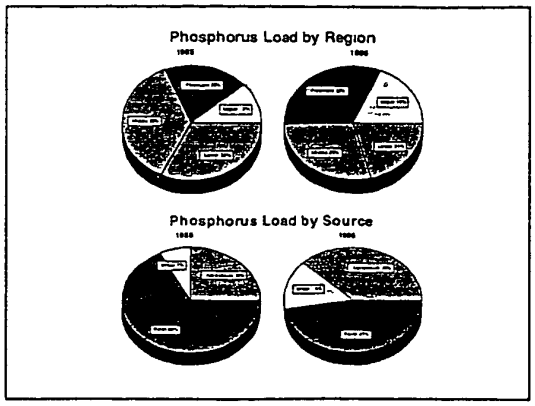
- Nitrogen
- Phosphorus
- Sediment

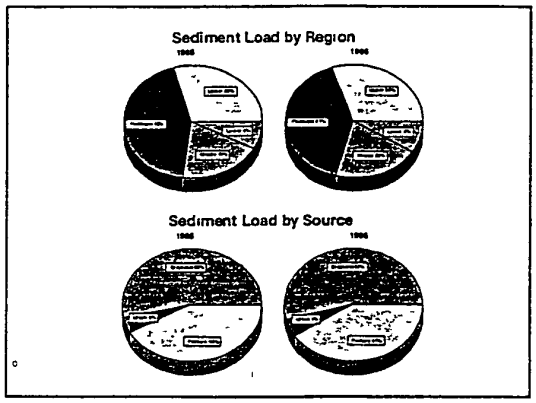
Changes in Controllable Loads, 1985-1996

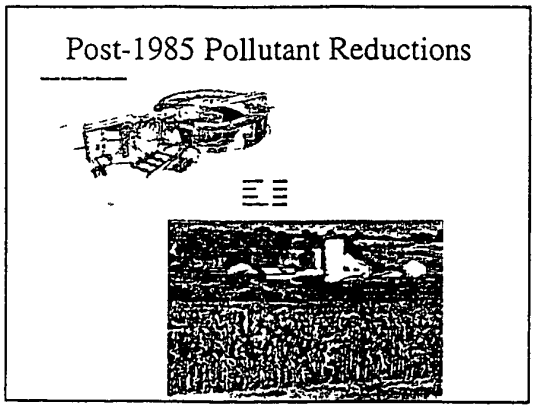
1985 Load






Phosphorus Load by Region
Phosphorus Load by Source


Sediment Load by Region
Sediment Load by Source


Post-1985 Pollutant Reductions

Sediment Input is Significant

- Large magnitude of the load
  - James has 3rd highest measured sediment loading of all the Bay tributaries, behind only the Potomac & Susquehanna
- Impact it can have on water clarity
  - blocks sunlight needed for growth & survival of SAV, as well as limits algae growth
- Negative effect it can have on critical streambed habitat
  - non-tidal, free flowing regions of the James River, west of the fall line

Post-1985 Pollutant Reductions

- A wide array of nutrient & sediment control actions have been implemented in the James River basin to reduce both PS & NPS input of these pollutants.

Post-1985 Pollutant Reductions

- Control actions include
  - municipal wastewater treatment plant upgrades & improvements to control nitrogen & phosphorus discharges
  - pollution prevention actions taken at industrial facilities
  - greater use of Best Management Practices (BMPs) by farmers & foresters
  - improved stormwater management & erosion & sediment control by local governments
  - other initiatives

Point Source Reductions

- BWXT significant reduction in nitrogen concentration
- Lynchburg STP process change contributed to nitrogen reduction
- Allied Signal reduced nitrogen concentrations by nearly 68%
- Henrico STP BNR capability
- Hopewell STP 30% reduction in nitrogen concentration
- South Central Wastewater Authority STP 63% reduction in nitrogen concentration
- Proctors Creek STP BNR capability
- Richmond STP nitrification capability
- Tyson Foods 20% reduction in nitrogen levels
- HRSD-VIP installed BNR
- HRSD-Nansemond STP installed BNR

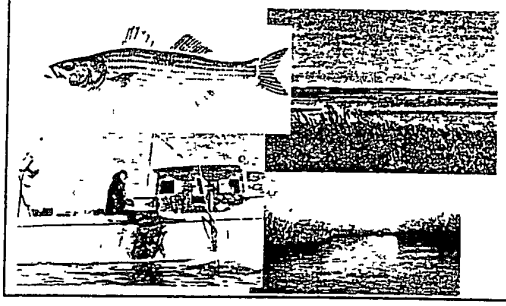
Nonpoint Source Reductions

- Majority of NPS reductions have been achieved through agricultural BMPs
- BMPs include animal waste control facilities, stream protection, & buffer strip cropping
- More than 4,678 cost-share BMPs planned & installed, 1985-1996
- BMP implementation has resulted in an 8% reduction in phosphorus & a 4% reduction in nitrogen between 1985 & 1996

NPS Control Practices Identified Through Stakeholder Input

- Riparian Buffer Establishment
- Riparian Buffer Protection
- Conservation Easements
- Streambank Stabilization
- Stream Restoration
- Constructed Wetlands
- Onsite Sewage Disposal
- Stormwater Management
- Urban BMPs
- Stormwater Facility Retrofits
- Erosion & Sediment Enhancement
- Agricultural BMPs
- Urban Nutrient Management
- Marina Management
- Organic Waste Management

Living Resources & Habitat Conditions



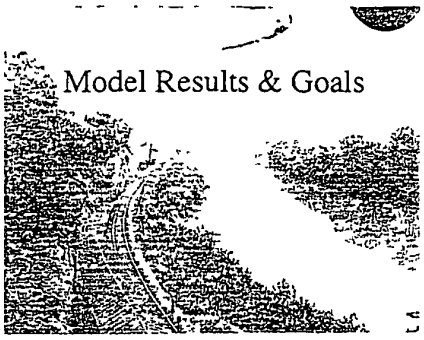
Water Quality Indicators

- Nitrogen fair to good, improving
- Phosphorus fair to good, generally improving
- Dissolved Oxygen good, compared with other Bay tributaries
- Water Clarity generally poor
- Suspended Solids fair in most sections of the river
- Algae favorable conditions, improving

Habitat & Living Resources

- Phytoplankton favorable conditions, degrading in lower estuary
- Benthic Community healthiest conditions in the Bay
- Planktivorous Fish decreasing trend
- Zooplankton mixed conditions, degrading trend in lower estuary
- SAV very little SAV, habitat conditions are poor

Model Results & Goals



Scenarios Completed

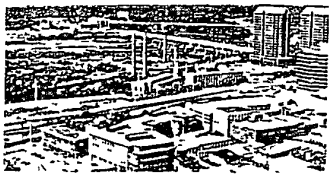
- 1985 Baseline Conditions
- 1996 Progress
- 1996 Progress / Trib. Strat. Above
- James AFL BNR Equiv / James BFL & Appo 1996 / Trib Strat. Above
- James AFL, Appo & BFL TF James BNR Equiv / Trib Strat. Above
- James TF BNR Equiv For N / Trib. Strat. Above
- BNR Equivalent / Trib Strat. Above
- Current Limit of Technology Sediment / Trib Strat. Above
- Extreme Sediment Reduction / Trib. Strat. Above
- Midpoint 1996 - Full Voluntary Impl
- East Shore VA Full Volun. Impl / Trib Strat. Above
- West Shore VA Full Volun Impl. / Trib. Strat Above
- Full Voluntary Impl. / Trib Strat. Above
- Current Limit of Technology

James Findings

- In the lower tidal James, there is no meaningful oxygen or bay grasses response to maximum nutrient & sediment reductions.
  - Other living resources benefits may result from load reductions (e g., reduced blooms of potentially harmful algae), but are unquantifiable with the current model capabilities

James Findings

- Loads from the James River above Richmond have less direct effect on the water quality of the upper tidal James than loads directly to the upper tidal James



James Findings

- Only reductions in the upper tidal James loads will improve upper tidal James water quality

James Findings

- Nitrogen reductions are principally responsible for water quality improvements in the upper tidal James, but reducing upstream phosphorus & sediment loads will make important improvements to upstream water quality

Staff Recommendations

- 9 % sediment reduction for the entire basin by 2010.
- BNR/BNR equivalent for areas draining directly to tidal fresh by 2010.
- Cap net nutrient loads to the lower estuary from all areas at 1996 levels.
- Reassess goals in 2005.

Living Resources Benefits

- 354 % improvement in SAV area in the tidal fresh.
- 221 % improvement in SAV density.
- 52 % chlorophyll reduction

Estimated Costs

- $164 million for point source improvements
- $135 million for nonpoint source implementation.

Implementation Process

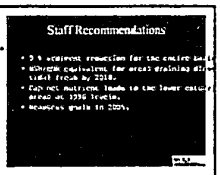
- Stakeholder meetings
  - SWCDs, local & regional jurisdictions, others
  - Watershed Conservation Roundtables
- Process to begin following approval of Goals document by SONR Probable year+ duration
- An Implementation plan will be prepared

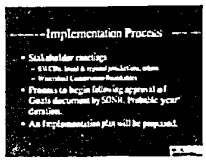
Implementation Plan Development

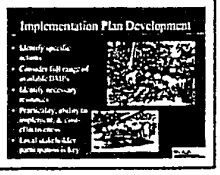
- Identify specific actions
- Consider full range of available BMPs
- Identify necessary resources
- Practicality, ability to implement, & cost-effectiveness
- Local stakeholder participation is key

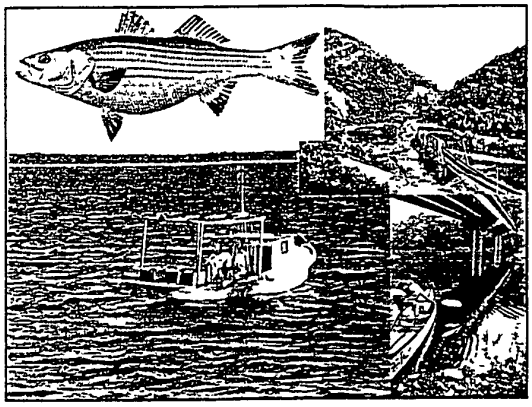
The game is changing...

- CBP endpoints & water quality criteria more to follow









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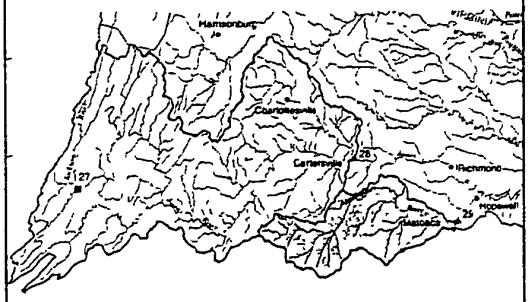
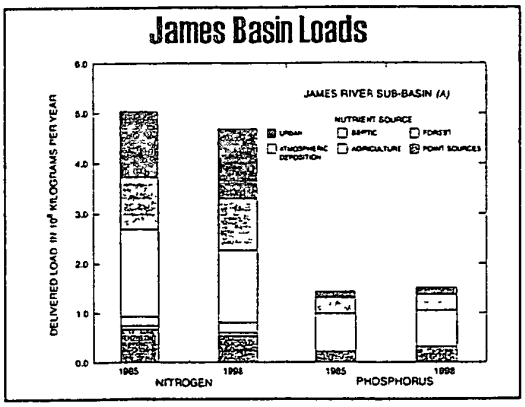
James River Water Quality

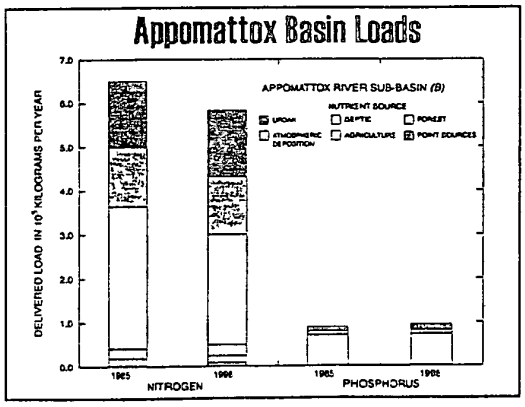
James Basin – Above Fall Line Area

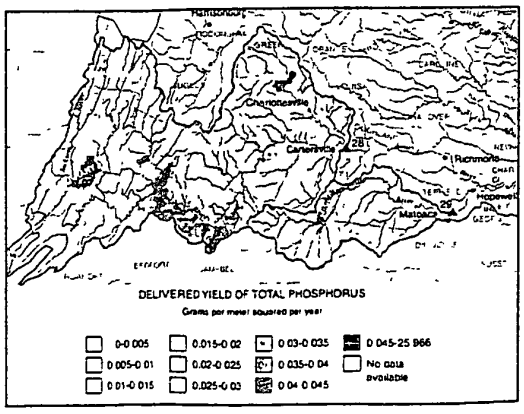
- Highest percentage of forest cover (80%) of large Bay watersheds
- Third largest Baywide basin
  - third largest input of Sediment and Nutrients (after Susquehanna, Potomac)
- NPS Dominated Loading Sources

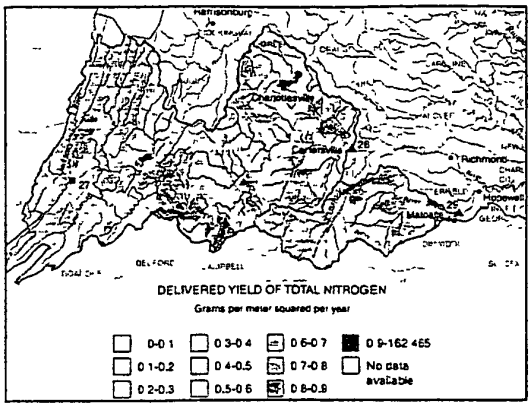
James Basin USGS Monitoring Stations




James Basin Loads
JAMES RIVER SUB-BASIN (A)
NUTRIENT SOURCE
URBAN
SEPTIC
FOREST
ATMOSPHERIC DEPOSITION
AGRICULTURE
POINT SOURCES
DELIVERED LOAD IN 10⁶ KILOGRAMS PER YEAR
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1985
1998
1985
1998
NITROGEN
PHOSPHORUS


Appomattox Basin Loads
APPOMATTOX RIVER SUB-BASIN (B)
NUTRIENT SOURCE
URBAN
SEPTIC
FOREST
ATMOSPHERIC DEPOSITION
AGRICULTURE
POINT SOURCES
DELIVERED LOAD IN 10³ KILOGRAMS PER YEAR
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1985
1998
1985
1998
NITROGEN
PHOSPHORUS


DELIVERED YIELD OF TOTAL PHOSPHORUS
Grams per meter squared per year
0-0 005
0 005-0 01
0 01-0 015
0 015-0 02
0 02-0 025
0 025-0 03
0 03-0 035
0 035-0 04
0 04-0 045
0 045-25 866
No data available



James Inputs to Tidal Waters

- Phosphorus loads decreasing (James)
  - Nitrogen, Sediment loads unchanged
- N and P concentrations decreasing
  - James and Appomattox Rivers
  - Phosphorus concentration decreasing on Jackson River near Covington
  - Sediment concentrations borderline decreasing (James)

James River
Water Quality Assessment
August 2000 305(b) Report

The "Big Picture"

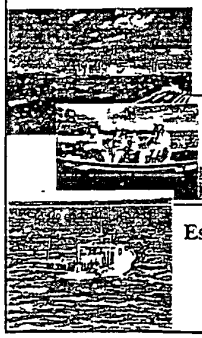
James River Water Quality Assessment

- Based on two types of WQ data/info
  - monitored water column, sediment, biological
  - evaluated land use, PS disch, NPS polluuon potential, fishery info, staff knowledge, other
- DEQ ambient monitoring stations and other federal, state, and citizen monitoring programs
- Overall quality is assessed in reference to designated uses and water quality standards

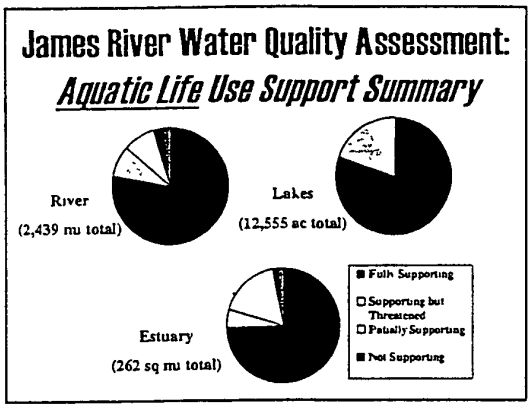
Designated Uses

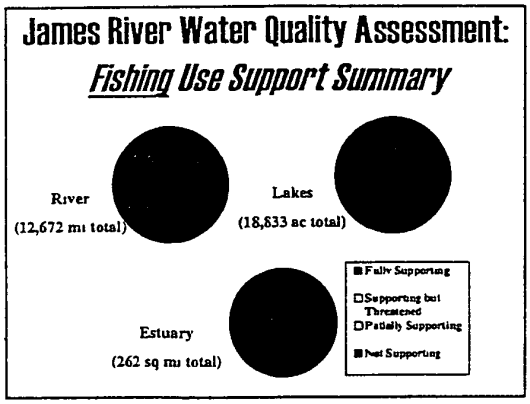
AQUATIC LIFE	Conventional Pollutants (DO, pH, temp); Toxics in water column, Toxics in sediment, biological evaluation
FISH CONSUMPTION	Advisories limiting consumption and restrictions by VDH; Toxics in fish tissue exceeding DEQ screening value
SHELLFISH CONSUMPTION	Restictions on harvesting/marketing made by VDH Div of Shellfish San.
SWIMMING	Conventional Pollutants (fecal coliform bacteria) and/or beach closure by VDH
PUBLIC WATER SUPPLY	Closures or advisories by VDH

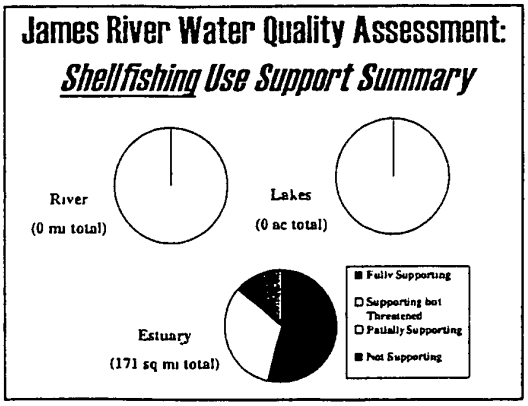
James River Water Quality Assessment

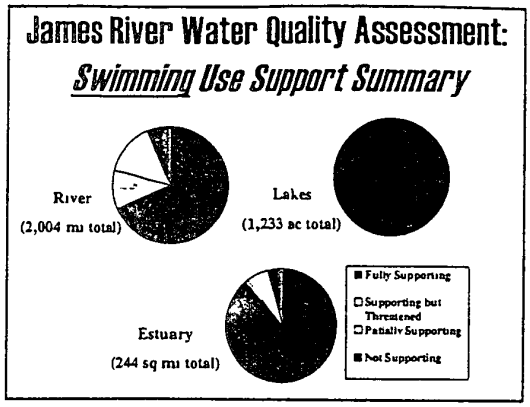


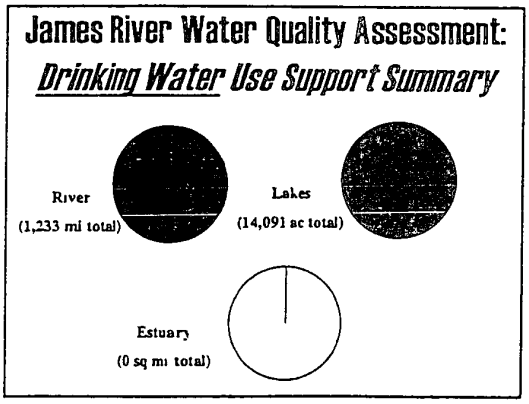
Rivers	12,822 miles	2,491 miles
Lakes	20,854 acres	10.883 acres
Estuaries	264 sq. miles	264 sq miles

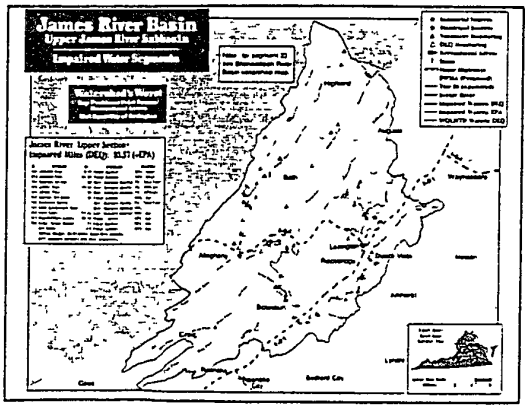

James River Water Quality Assessment:
Aquatic Life Use Support Summary
River
(2,439 mi total)
Lakes
(12,555 ac total)
Estuary
(262 sq mi total)
Fully Supporting
Supporting but Threatened
Partially Supporting
Not Supporting

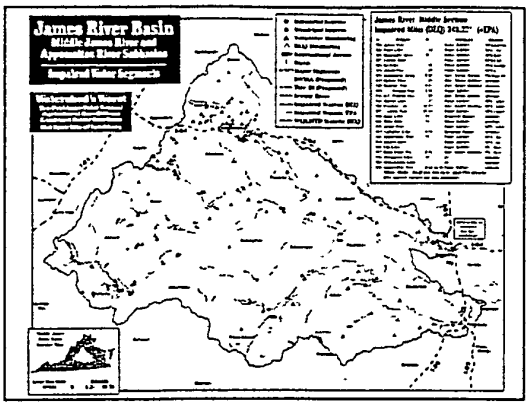

James River Water Quality Assessment:
Fishing Use Support Summary
River
(12,672 mi total)
Lakes
(18,833 ac total)
Estuary
(262 sq mi total)
Fully Supporting
Supporting but Threatened
Partially Supporting
Not Supporting

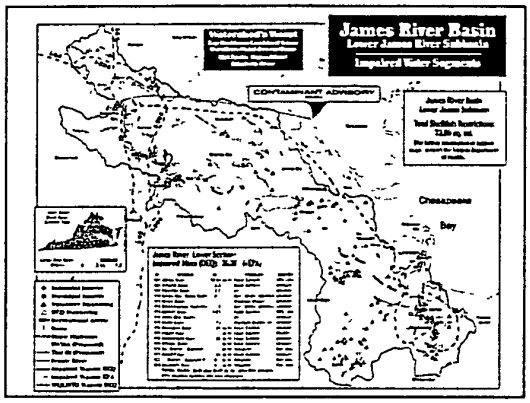

James River Water Quality Assessment:
Shellfishing Use Support Summary
River
(0 mi total)
Lakes
(0 ac total)
Estuary
(171 sq mi total)
Fully Supporting
Supporting but Threatened
Partially Supporting
Not Supporting


James River Water Quality Assessment:
Swimming Use Support Summary
River
(2,004 mi total)
Lakes
(1,233 ac total)
Estuary
(244 sq mi total)
Fully Supporting
Supporting but Threatened
Partially Supporting
Not Supporting


James River Water Quality Assessment:
Drinking Water Use Support Summary
River
(1,233 mi total)
Lakes
(14,091 ac total)
Estuary
(0 sq mi total)

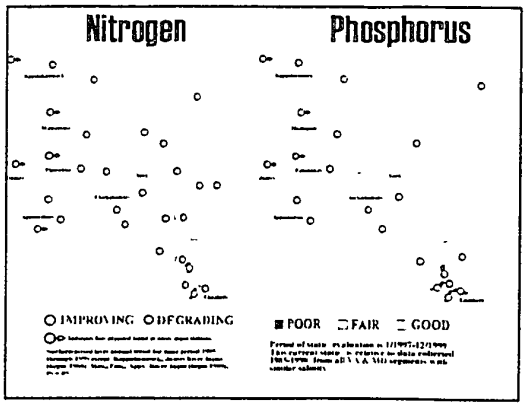

James River Basin

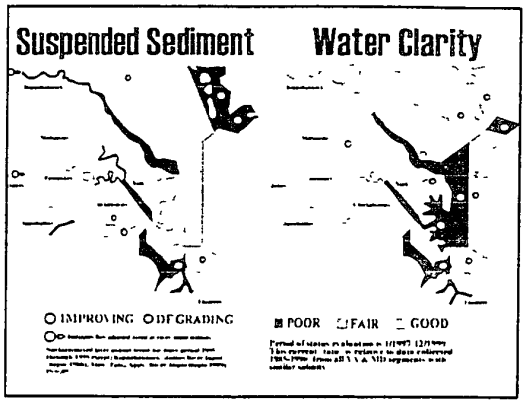




Tidal Water Quality

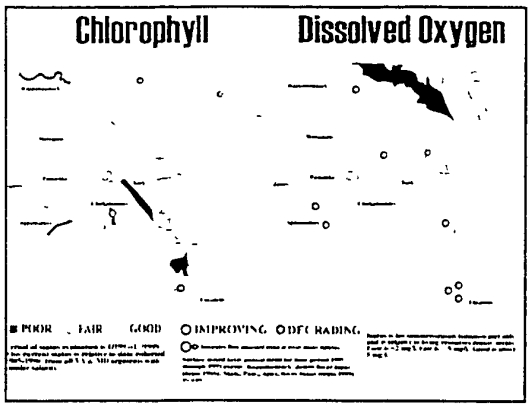
"Stressor" Parameters





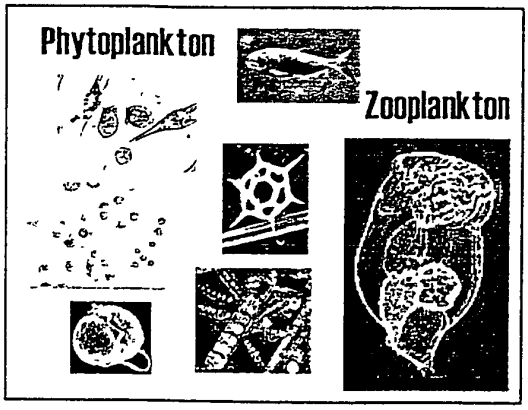
Tidal Water Quality

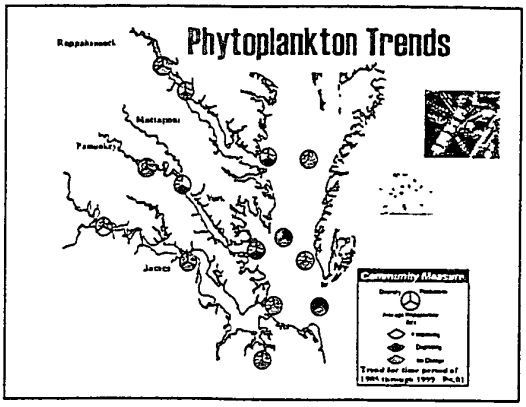
"Response" Parameters

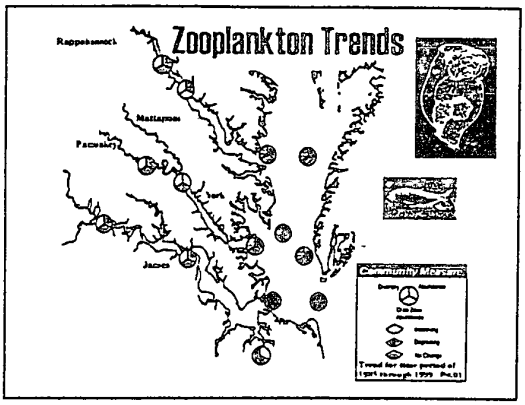


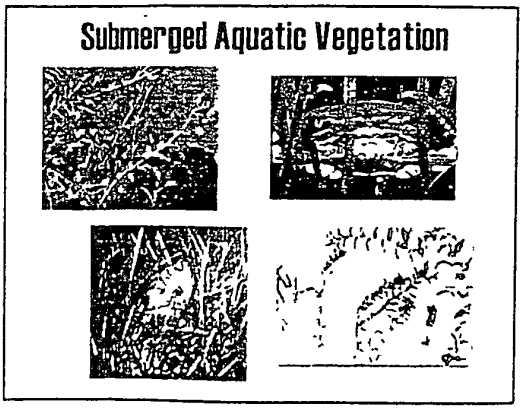
Tidal Living Resources

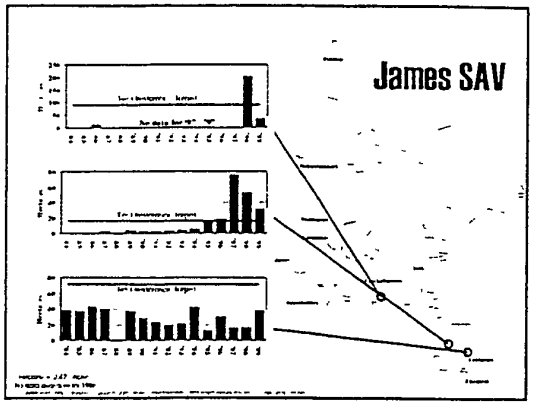
"Bottom" of food web

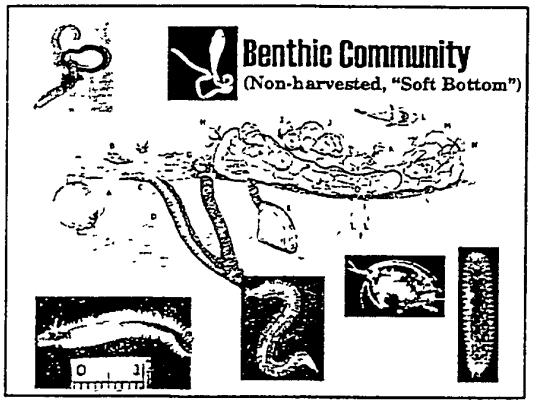


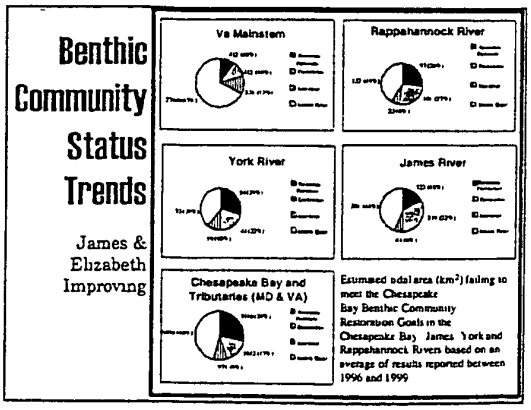

Phytoplankton Trends


Zooplankton Trends


Submerged Aquatic Vegetation


James SAV


Benthic Community
(Non-harvested, "Soft Bottom")


Benthic Community Status Trends
James & Elizabeth Improving
Va Mainstem
Rappahannock River
York River
James River
Chesapeake Bay and Tributaries (MD & VA)
Estimated tidal area (km²) failing to meet the Chesapeake Bay Benthic Community Restoration Goals in the Chesapeake Bay, James, York and Rappahannock Rivers based on an average of results reported between 1996 and 1999

James Summary

- Loading reduction management actions are showing positive results (nutrients and sediment)
- Tidal water quality improving for nutrients
- Tidal water quality poor and unchanged for water clarity

James Summary - Continued

- Tidal water quality "response" parameters generally unchanged
  - Except dissolved oxygen improving in upper tidal James and Appomattox, and Elizabeth
- Living Resources mixed
  - Plankton status generally good, improving in upper river, slightly degrading at river mouth
  - Benthos fair and improving
  - Submerged Aquatic Vegetation poor and degrading

Management Efforts Are Having Effect

- Improving fall line trends
  - TN, TP have improving concentration trends
  - TSS has borderline improving concentration trend
  - N from Groundwater inputs decreased by 30%
- Improving Nutrient Concentrations in Tidal Waters
  - TN and TP

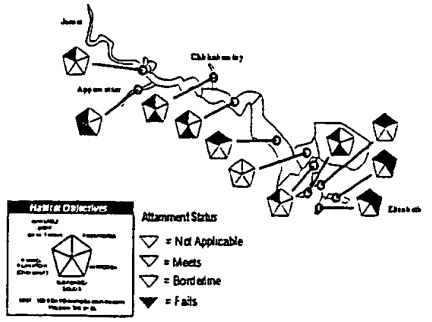
Improving Water Quality is Positively Affecting Living Resources

- Improvements mainly in Upper and Middle portions of tidal river
- Improving trends in plankton indices
  - Algal community structure improving
  - Zooplankton community improving, fully supportive of larval fish food requirements
- Improving trends in bottom dwelling worms/clams community

Still Much Restoration Needed

- Dissolved Oxygen and Water Clarity Generally unchanged
  - Scattered DO improvements
  - Water Clarity degrading at River mouth
- SAV levels are low
  - Bay grasses only 25% of historical levels (largest loss is in tidal fresh area)
  - Many SAV habitat Criteria not met

SAV Habitat Criteria



Restoration Needed - Cont.

- Signs of poor quality algae remain
  - Blue-green algae abundance increasing
  - Dinoflagellate blooms possibly increasing
- Zooplankton community degrading in lower River
- 50% of benthic community area remains degraded

Upper James Management Implications

- Further reductions in nitrogen loads needed .
  - Chlorophyll levels have not responded yet
  - Nitrogen concentrations (4 mg/l) still well above algae growth limitation value of 0 07 mg/L
- . to reduce growth of poor quality algae
  - More balanced population
- and increase light penetration for SAV
  - Initial estimate is to reduce chlorophyll *a* by appx 10 ug/l to attain water clarity criteria

Upper James - Management Implications (continued)

- Further reductions in sediment loads needed
  - TSS levels have not responded yet
- .to improve light penetration for SAV
  - Estimate is to reduce TSS concentrations by 10-15 mg/l to attain water clarity criteria
- and remove light limitation of algae growth
  - To shift community structure to "good" algae

Middle James Management Implications

- Algae levels lower than upper river, contribute less to reduced light conditions
- Sediment becomes more significant contributor to reduced light: possible local sources, dredging, shoreline erosion, coastal plain loads (i e BFL loads) etc.
- Need further nutrient, sediment reductions to attain water clarity needed for Bay grasses
  - Chlorophyll *a* needs to drop appx 5 ug/L
  - TSS needs to drop appx 10-15 mg/L

Lower James Management Implications

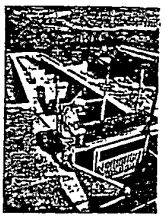
- Further reductions in sediment loads needed
  - TSS principal contributor to reduced light conditions
- More questions than clear causes/sources
  - Urban NPS may be factor
  - Resuspension, erosion, sea level rise, coastal plain loads (i e BFL loads)
  - Effect of Bay Mainstem?

James River Special Studies

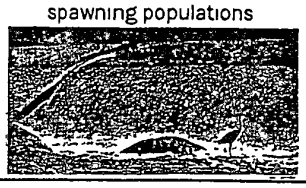
- VCU study on living resources in James River above the fall line
  - ➡substantially impacted benthic community primarily due to sediment

Upstream migratory fish passage

Improved water quality & habitat



Successful re-establishment of spawning populations



Virginia's TMDL Process

DCR

Steps in TMDL Process

- Monitor Waters for Compliance with Standards
- Place Impaired Waters on 303(d) List
- Develop TMDL - Total Maximum Daily Load - for Each Pollutant Causing Impairment
- Develop Implementation Plan
- Implement TMDL
- Remove Waters from 303(d) List when Water Quality Standards Achieved

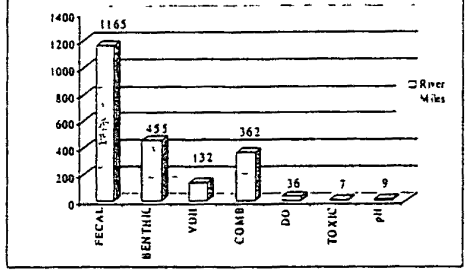
Water Quality Standards

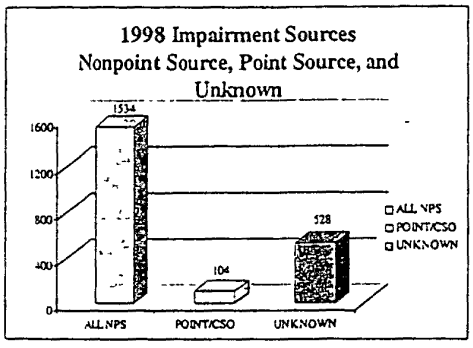
- Standards are regulations based on federal and state law that set:
  - **numeric** and **narrative** limits on pollutants.
- Purpose of standards:
  - **protection** of 5 designated uses: aquatic life, fishing, shellfish, swimming, & drinking water
  - **restoration** of state waters - TMDLs
- Listing of impaired waters and TMDL development are based on WQ standards.

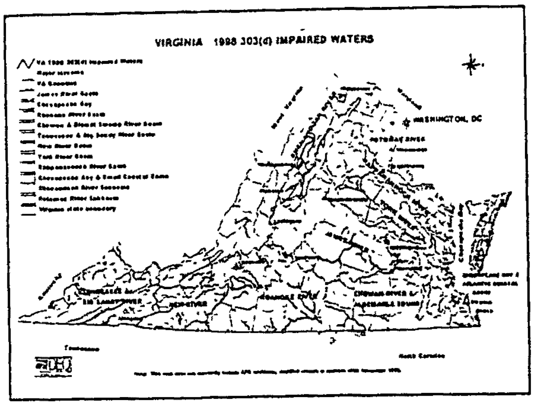
Identifying Impaired Waters

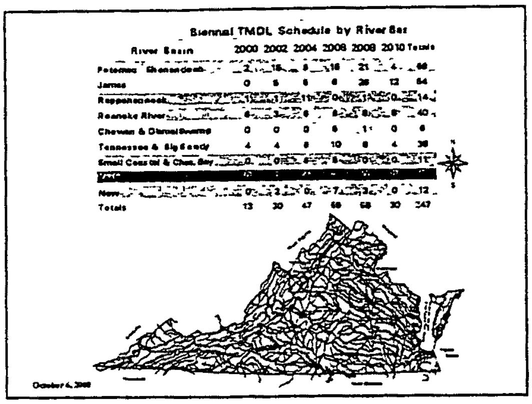
305(b) and 303(d)
WATER QUALITY
REPORTS

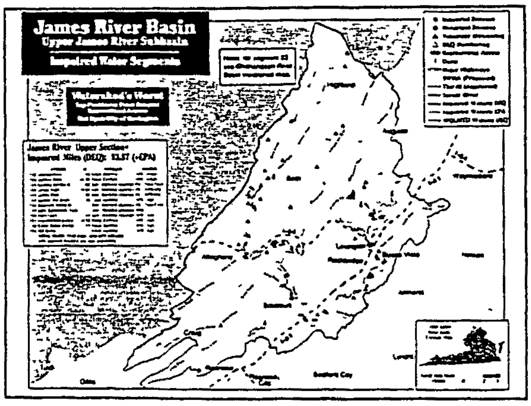
DEQ DCR

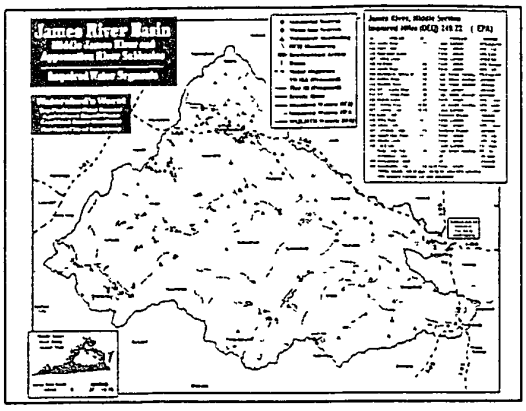


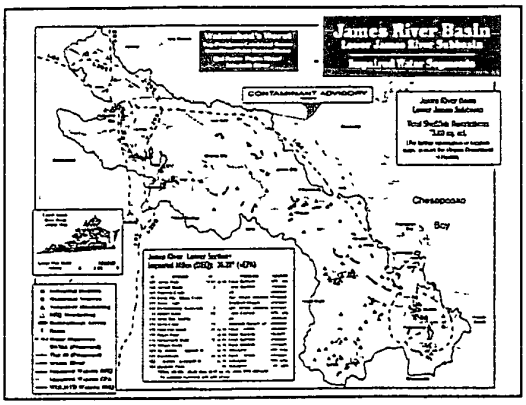



VIRGINIA 1998 303(d) IMPAIRED WATERS
WASHINGTON, DC


Biennial TMDL Schedule by River Bas
River Basin
2000 2002 2004 2006 2008 2010 Totals
Potomac Shenandoah
James
Rappahannock
Roanoke River
Tennessee & Big Sandy
Small Coastal & Ches. Bay
New
Totals


James River Basin
Impaired Water Segments





James River Watershed Impaired Streams Schedule

- Montebello Spring Branch, Nelson BC – 2002
- Coursey Springs Branch, Bath BC – 2002
- Castaline Spring Branch, Augusta BC – 2002
- Willis River, Cumberland FC – 2002
- Moore's Creek, Albemarle FC – 2002

James River Watershed Impaired Streams Schedule

• Fourmile Creek, Henrico	pH/FC – 2004
• Tuckahoe Creek, Henrico	FC/DO – 2004
• White Oak Swamp, Henrico	FC/pH – 2004
• Winterpock Creek, Chesterfield	pH/DO – 2004
• Winticomack Creek, Amelia	pH/DO – 2004

Memorandum of Agreement Between DCR and DEQ on TMDL Development

- DEQ has overall lead for all TMDL activities
- DCR agreed to assist in development of Nonpoint Source (NPS) TMDLs
- DEQ retains responsibility for public participation and EPA approval process

How is a TMDL done?

A Special Study to:

- Identify all sources of pollution contributing to violation of water quality standards.
- Calculate the amount of pollutants entering the stream from each source.
- Calculate the reductions in pollutants, by source, needed to attain/maintain water quality standards.

TMDL Study/Model Process

- Data collection
  - stream flow
  - pollutant levels
- Pollutant sources
  - land use
  - point sources
  - livestock populations
  - # of septic systems
  - agricultural practices
- Calibrate model
- Assess mgt. options to meet WQS

What is Virginia's TMDL Development Process?

- Hire Contractor
- Public Meeting - Start TMDL Process
- Work with local stakeholders
- Public Meeting - Progress/Model Dev.
- Public Meeting - Draft TMDL
- Finalize TMDL based on comments
- Submit to EPA for Approval
- SWCB Adoption of TMDL
- Include TMDL in Basin WQMP

TMDL ACTIONS TO DATE

- 1999 - 1 Nitrate TMDL Approved
- 2000 - 10 FC TMDLs Approved
  3 Benthic Waters Delisted
- Nine FC TMDLs approved for streams that also have benthic impairments

Consent Decree TMDL Development Schedule

Submittal Dates	EPA Action Dates	Consent Decree (Current Schedule for Impaired Waters)	Credit Limit for Waters Removed from List
5/1/99	5/1/00	1	0
5/1/00	5/1/01	12	2
5/1/02	5/1/03	30	6
5/1/04	5/1/05	74	11
5/1/06	5/1/07	213	13
5/1/08	5/1/09	127	14
5/1/10	5/1/11	179	14
TOTAL		636	60

Note Includes estimates for shellfish and plaintiff's waters

2002 TMDL Schedule

30 TMDLs

- Shenandoah
  - 12 TMDLs
- Potomac
  - 6 TMDLs
- Rappahannock
  - 1 TMDL
- James
  - 5 TMDLs
- New
  - 2 TMDLs
- Roanoke
  - 1 TMDL
- Tenn/Big Sandy
  - 3 TMDLs

No TMDLs scheduled for York, Chowan, Small Coastal basins.

TMDL Implementation Plan Status

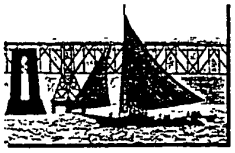
- Three IPs under contract and development
  - North River watershed [Shenandoah Basin]
    - 4 TMDLs
  - Blackwater Watershed [Roanoke Basin]
    - 4 TMDLs
  - Holston Watershed [Tenn/Big Sandy Basin]
    - 4 TMDLs
- Scheduled for completion in 2001
- Future implementation plan initiatives limited by resources
- Approved TMDLs call for phased implementation in most cases

TMDL Costs

- TMDL Development
  - Estimate of $59 Million to complete 648 TMDLs by 2010
  - Looking to streamline process to lower costs
- TMDL Implementation
  - $150 - $300 Million [preliminary estimate]
  - does not include 260 shellfish TMDLs

Toward a Healthy Bay

Chesapeake Bay Water Quality Criteria & Tributary Strategies



DCR

Michael L. Bowman
James Watershed Manager

Chesapeake 2000

- "there can be no greater goal in this recommitment than to engage everyone – individuals, businesses, communities and governments – in our efforts; to commit all citizens of the Chesapeake Bay watershed in a shared vision."

"C2K" Commitments

- Living Resource Protection & Restoration
- Vital Habitats
- Water Quality Restoration & Protection
- Sound Land Use
- Individual Responsibility & Community Engagement

CHESAPEAKE 2000
The Renewed Agreement

Chesapeake 2000 Agreement Water Quality Goal

- Improving water quality is the most critical element in the overall restoration and protection of the Bay and its tributaries
- Achieve and maintain the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health.
- Effort to remove the Bay and tidal tributaries from the "impaired waters" list is the most comprehensive in the Program's history

Water Quality Restoration & Protection

- Continue efforts to achieve and maintain 40% nutrient reduction goals
- Define water quality conditions/set new nutrient and sediment goals
- By 2010, remove Bay and tidal tributaries from the impaired waters list

Nutrients and Sediment

What the Agreement Says.	What it Means
❖ Continue efforts to achieve and maintain the 40% N & P reduction goal set in 1987, as well as the goals set for tributaries south of the Potomac	❖ Reduced loads of N & P are critical to maintain healthy plants, fish, shellfish and waterfowl Reconfirms the original commitment with a reminder that loads are to be "capped"

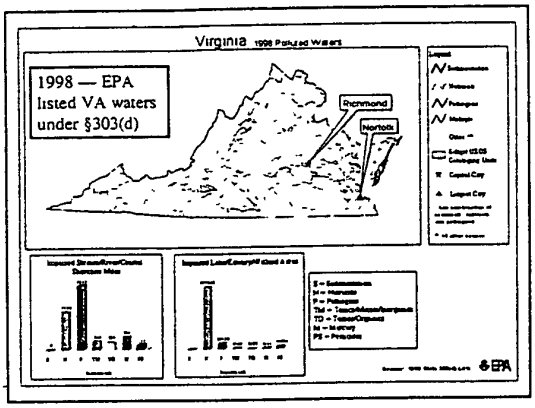
Nutrients and Sediment (cont.)

What the Agreement Says

- By 2010, correct nutrient- and sediment-related problems sufficiently to remove Bay and its tributaries from impaired waters list

What it Means

- Set specific criteria for key water quality indicators ("environmental endpoints")
- By 2001, assign tributary load reductions for N & P, and sediment needed to meet WQ conditions
- By 2002, revise tributary strategies as needed, by 2003, adopt endpoints as standards
- By 2003, adopt strategy for Susquehanna dams

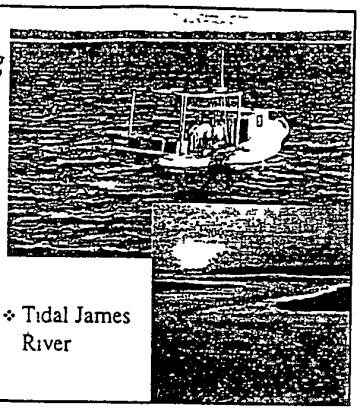


How Does This Relate to the Bay?

- EPA also identified the Chesapeake Bay and several of its tidal tributaries as impaired

Including

- Chesapeake Bay mainstem from the Maryland-Virginia state line
- Tidal James River



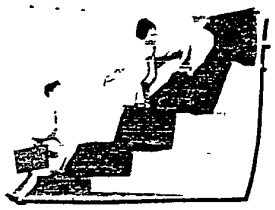
Impaired Bay Waters

Cause

- Nutrients were identified as the pollutants of concern.
- Violations of the applicable water quality standards
  - dissolved oxygen
  - use attainment for aquatic life

Schedule

2010



2000

Three Steps to "Delist" the Bay

1 Identify the water quality conditions, or *environmental endpoints*, that achieve the desired level of protection for living resources and human health in the Bay and its tidal tributaries.

"Delisting" Step 2

2 Make appropriate revisions to the state water quality standards to include the environmental endpoints for the Chesapeake Bay and its tidal rivers.

"Delisting" Step 3

Reduce the input of nutrients and sediments throughout the Bay watershed to jointly achieve the state water quality standards and other Chesapeake Bay Program goals

2001

- Define protective water quality conditions (i e "Bay Endpoints" = eventual standards)
  - Bay & tidal tributaries
  - Dissolved oxygen, water clarity, chlorophyll *a*
- Establish loading goals
  - Nitrogen, phosphorus, & sediments
- Allocate loads among tributaries

2001 - 2002

- Endpoint Completion and Adoption
  - Complete draft endpoints - June
  - Public comment on uses and criteria - July
  - Finalize uses and criteria - Sept
  - Public comment on load allocations - Oct
  - Finalize load goals/allocations - Dec
  - EPA Review/publication - Mar '02

2002

- 2002
  - Virginia to revise the Tributary Strategies
  - States (MD, VA, DE, DC) — initiate their formal water quality standards adoption process
  - Joint baywide UAA (Use Attainability Analysis) technical findings published for use by states
  - States incorporate UAA public participation into their water quality standards adoption process

James River Tributary Strategy Nutrient & Sediment Goals

- 9 % sediment reduction from the levels that existed in 1985 for the entire basin by 2010.
- Biological Nutrient Removal (BNR) at point sources & equivalent reduction in NPS for all areas draining directly to tidal fresh by 2010.
  - Results in 32% nitrogen and 39% phosphorus reduction from 1985 levels.
- Net nutrient loads to the lower estuary from all areas should not be allowed to increase & should be capped at 1996 levels.

James River Watershed Conservation Roundtables

Upper

Piedmont

Lower

Implementation Plan Development

- Identify specific actions to meet nutrient & sediment reduction goals
- Consider full range of available BMPs.
- Identify resources needed for implementation
- Practicality, implementability, & cost-effectiveness
- Participation by local stakeholders in developing implementation plan will be critical.

2003-2010

- 2002-2003 CBP WQ Standards Coordinators Team working to ensure consistent responses to comments received by individual states
- 2003 states complete adoption of Bay criteria and tidal designated uses as state water quality standards
- 2010 "Delist" Bay & tidal tributaries

Tributary Strategies and TMDLs

Implement James Strategy	2000-2010
Chesapeake 2000 Agreement	June 2000
Environmental Endpoints	2001
Revise James Strategy	2002
New Water Quality Standards	2003
Achieve Endpoints	2010
Bay and Tidal River TMDLs	2011**
Other TMDLs in James	2002 - 2010

"Delisting" Step 2

2 Make appropriate revisions to the state water quality standards to include the environmental endpoints for the Chesapeake Bay and its tidal rivers

Refined Designated Uses

- Five designated use habitat categories are proposed going beyond "fishable/swimable"
  - Migratory spawning and nursery habitat
  - Shallow water
  - Open water
  - Deepwater
  - Deep channel

Bay Specific Criteria

- Focused on three integrative criteria
  - Dissolved Oxygen
  - Water Clarity
  - Chlorophyll *a*

Bay Criteria to Protect Proposed Designated Uses

	Dissolved Oxygen	Chlorophyll *a*	Water Clarity
Migratory Spawning and Nursery	✓	✓	
Shallow Water	✓	✓	✓
Open Water	✓	✓	
Deep Water	✓		
Deep Channel	✓		

Migratory Spawning & Nursery Habitat

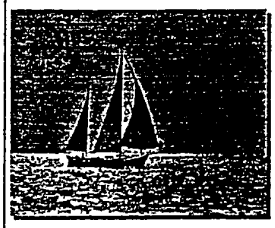
Spawning and Nursery Habitat

Shallow Water Habitat

Shallow Water Habitat

Two Meter Bathymetric Contour

Open Water Habitat

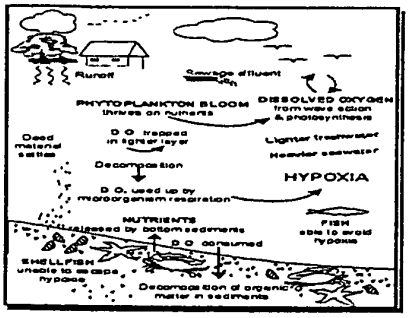


■ Ocean Water Habitat

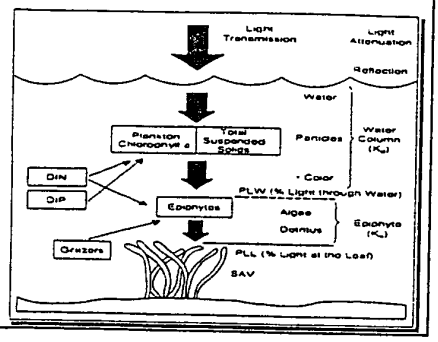
Deep Water & Deep Channel Habitats

□ Deep Water Habitat
■ Deep Channel Habitat

Dissolved Oxygen

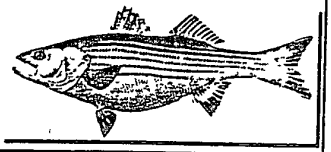


Water Clarity

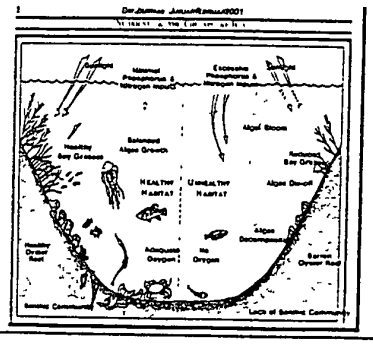


Chlorophyll

- Historical concentrations (back to 1950s)
- Contributions to reducing light penetration
- Excess algae leading to low dissolved oxygen
- Measure of health of aquatic habitats
- "Good" vs "bad" quality of fish food



Chlorophyll



Final Products

- Bay specific oxygen, chlorophyll, and clarity criteria published as EPA regional nutrient criteria
- Baywide implementation guidelines
- Consistent tidal designated uses across states

Allocation Process: Who, How And When

WHO: Six states and the District [EPA helps resolve disagreements]

HOW: Follow two step allocation process using equity and fairness options

WHEN: By December 31, 2001

Allocation Process: Who, How And When

Two Step Allocation Process:

I. Meet Bay criteria in tidal rivers first
- State develops equitable load allocation for its river basin
- Stakeholder involvement determined by state
- All states within multi-state river basins participate to develop allocation
- Where Bay impacts a tidal river, some iterative approach between steps I and II is warranted

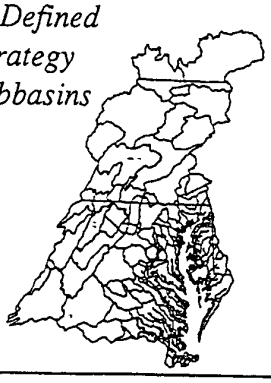
Allocation Process: Who, How And When

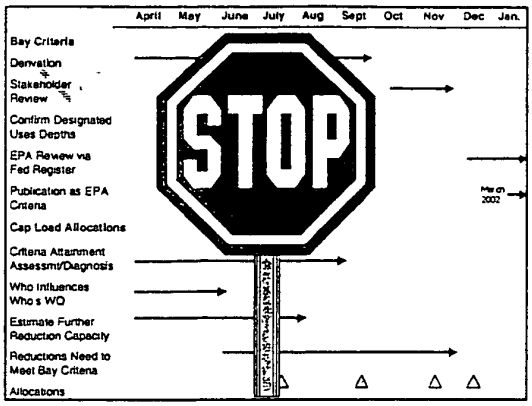
Two Step Allocation Process:

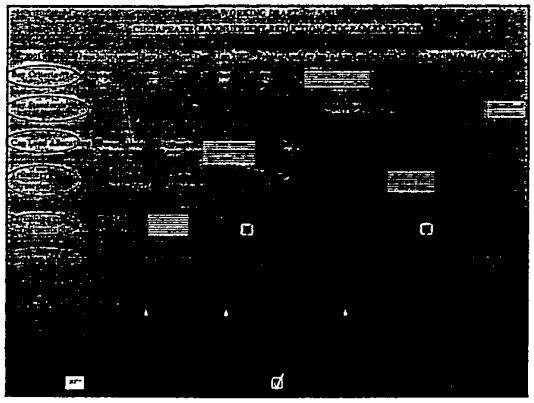
II If Bay criteria are still not achieved in mainstem equitable load reductions are needed in each major tributary basin until Bay criteria are achieved

Major Chesapeake Bay Tributary Strategy Basins

Jurisdiction Defined Tributary Strategy Basins & Subbasins







Revised James Trib Strategy

- CBP will generate new basin-level load reductions for nutrients, sediment
- State will allocate reductions within basin
- Re-form trib strategy team, Technical Review Committee
- Public meetings in 3 James regions
  - Roundtables + local gov'ts
- Revise strategy & prepare implementation plan

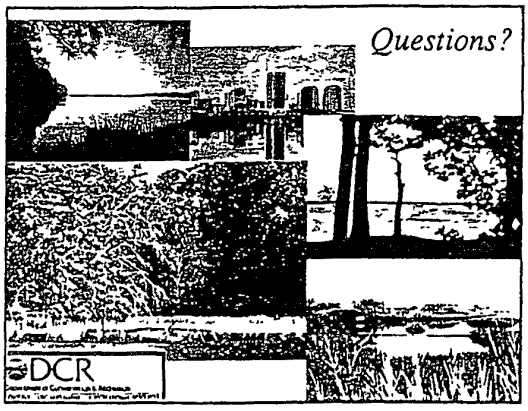
"Delisting" Step 3

Reduce the input of nutrients and sediments throughout the Bay watershed to jointly achieve the state water quality standards and other Chesapeake Bay Program goals

"Delisting"

" requiring more to be accomplished in the next nine years than was achieved in the past 14 "

Alliance for the Chesapeake Bay, *Bay Journal*, July-August 2001, p 7



Chesapeake Bay Program

A Watershed Partnership

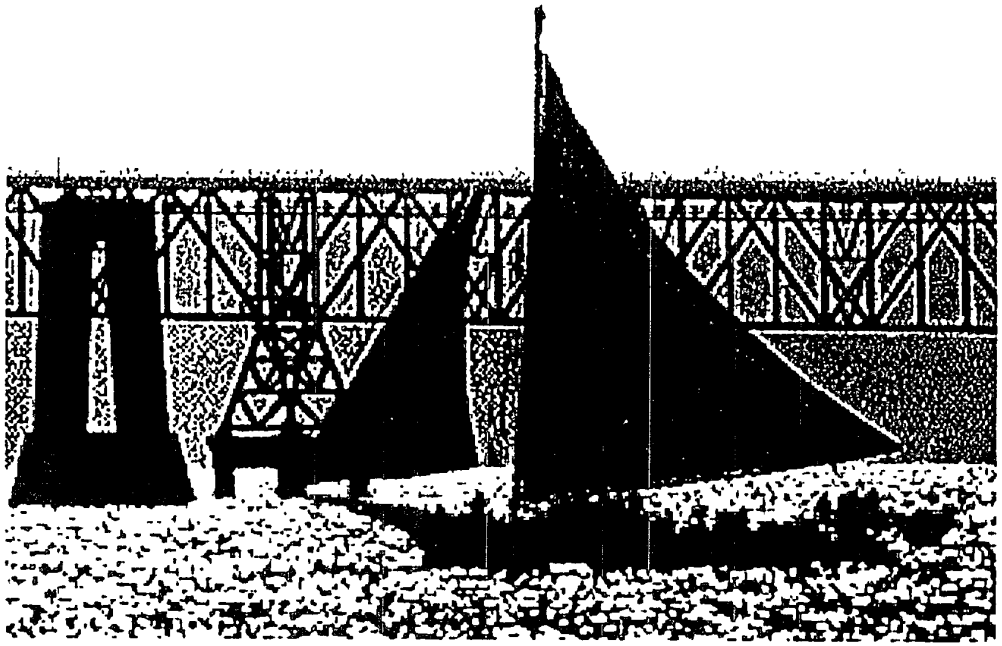
Restoring and Protecting Chesapeake Bay and River Water Quality

August 2001

The Chesapeake Bay is North America's largest and most biologically diverse estuary, home to more than 3,600 species of plants, fish and animals.

Chesapeake Bay Program

For more than 300 years, the Bay and its tributaries have sustained the region's economy and defined its traditions and culture.



Chesapeake Bay Program

It is a resource of extraordinary productivity, worthy of the highest levels of protection and restoration.

Chesapeake Bay Program

CBP 8/16/01

Purpose of This Presentation

To answer common questions about the efforts related to protecting and restoring Bay and river water quality:

- What do we want to achieve?
- How might the Bay and rivers look with restored water quality?
- How far have we come?
- How will we define restored Bay and river water quality?
- What needs to be done?
- Who is involved? What is the timeline?
- How will other Bay agreement commitments help restore the complete ecosystem?

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What Do We Want to Achieve?

DNR PHOTO BY
ANGEL BOLINGER

Achieve and maintain the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health.

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Chesapeake 2000: The New Agreement

In June 2000, the Chesapeake Bay Program partners signed a new agreement to guide the restoration and protection of the Bay through the next decade and beyond.

In *Chesapeake 2000*, the partners agreed that:

CHESAPEAKE 2000
The Renewed Agreement

Improving water quality is the most critical element in the overall protection and restoration of the Chesapeake Bay and its rivers.

Bay and River Water Quality Goal

In order to achieve and maintain the water quality necessary to support the aquatic living resources, the partners have committed to:

By 2010, correct the nutrient- and sediment- related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act.

Impaired Waters and Clean-up Plans

Placeholder for graphic showing "impaired waters" in the Bay and rivers.

- Portions of the Chesapeake Bay and its tidal rivers are listed under the Clean Water Act as "impaired waters" largely because of low dissolved oxygen levels and other problems related to nutrient pollution.
- This "listing" requires the development of a clean-up plan, known as a Total Daily Maximum Load (TMDL), for the Bay by 2011.

Regulatory vs. Cooperative Clean-up Plans

- Total Maximum Daily Load (TMDL) clean-up plans can be highly ***regulatory*** and potentially expensive and are often subject to lawsuits.
- Bay partners committed to remove Chesapeake water quality impairments before 2011, thereby, avoiding the need for regulatory TMDLs and allowing state and local partners more flexibility in crafting ***cooperative*** clean-up plans.
- If the partners are not successful in meeting their 2010 commitment to remove the Bay from the impaired waters list, then a regulatory TMDL clean-up plan covering the entire Bay watershed will be required.

What's Different About the Approach Being Taken?

- We are taking a cooperative, non-regulatory approach over the next decade.
- New York, Delaware and West Virginia are now directly involved (in addition to MD, PA, VA and DC)
- Water quality needs of the aquatic living resources of the Bay and rivers will drive necessary pollutant loading reductions.

How Might the Bay and Rivers Look with Restored Water Quality?

Bernie Fowler wades into the Patuxent River every year to test water clarity. One year he hopes to wade out up to his shoulders and still see his white sneakers.

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Restored Water Quality Means:

- Fewer algae blooms and better fish food.
- Clearer water and more underwater Bay grasses.
- More oxygen and improved habitat for more fish, crabs and oysters.

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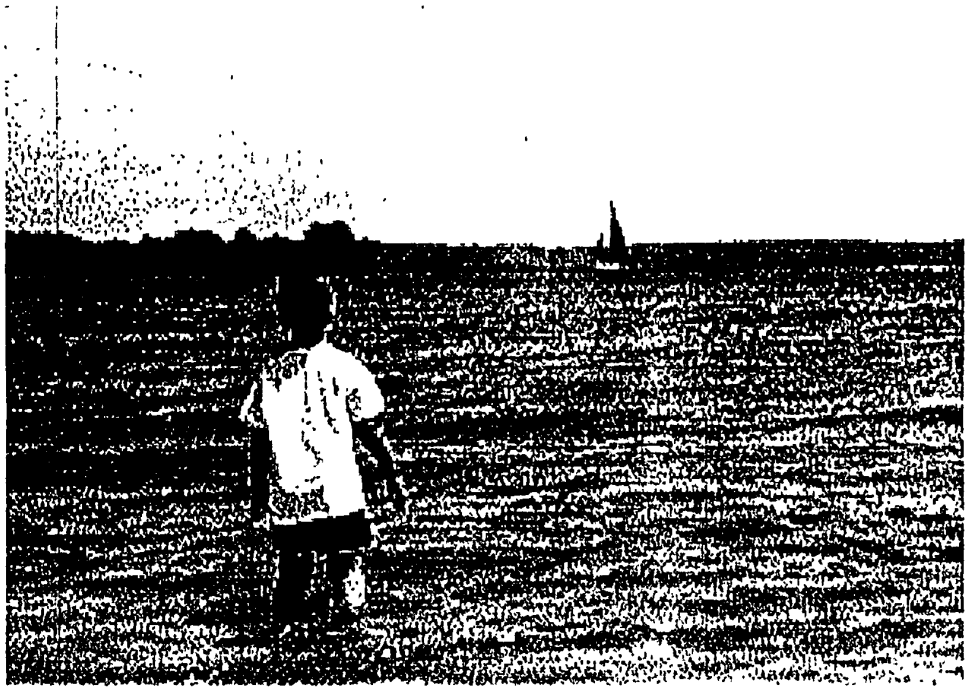
How Far Have We Come?



The Bay and its rivers are doing better but we have a long way to go.

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Problem Defined and Solutions Implemented

The nutrients nitrogen and phosphorus,

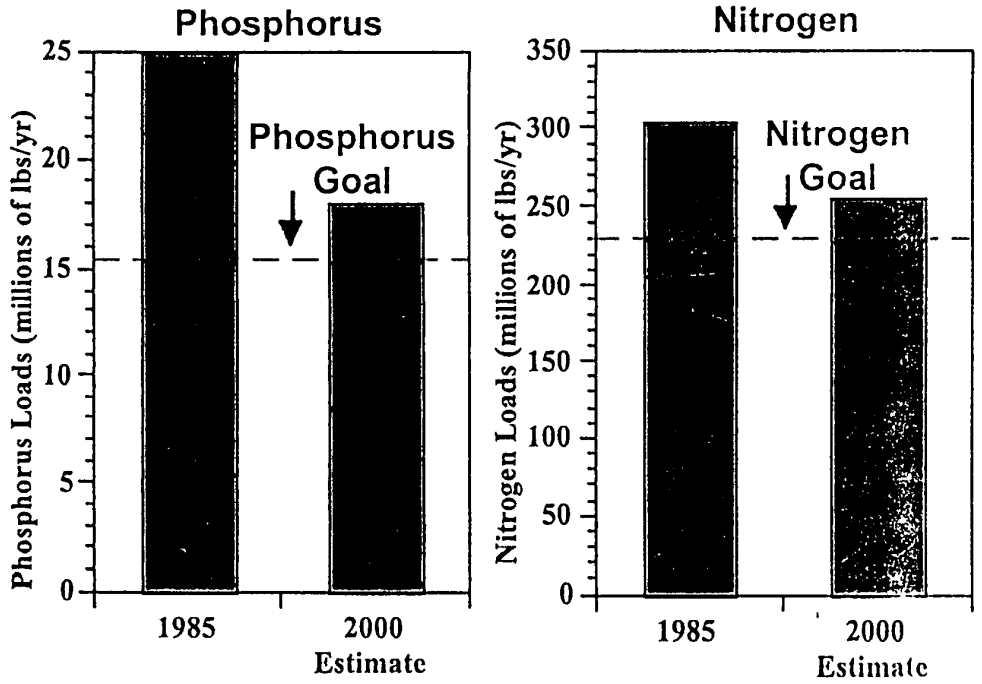
as well as sediment...

...are the root of most water quality problems in the Bay.

- *In 1987, Chesapeake Bay Program partners committed to achieving a 40 percent reduction in controllable nutrient loads to the Bay by 2000...*
- *and in 1992, agreed to stay at or below these nutrient loads once attained.*

Nutrient Pollution Declining, but We Still Need to Do More

Total Nutrient Loads Delivered to the Bay from All Bay Tributaries (MD, PA, VA, DC).

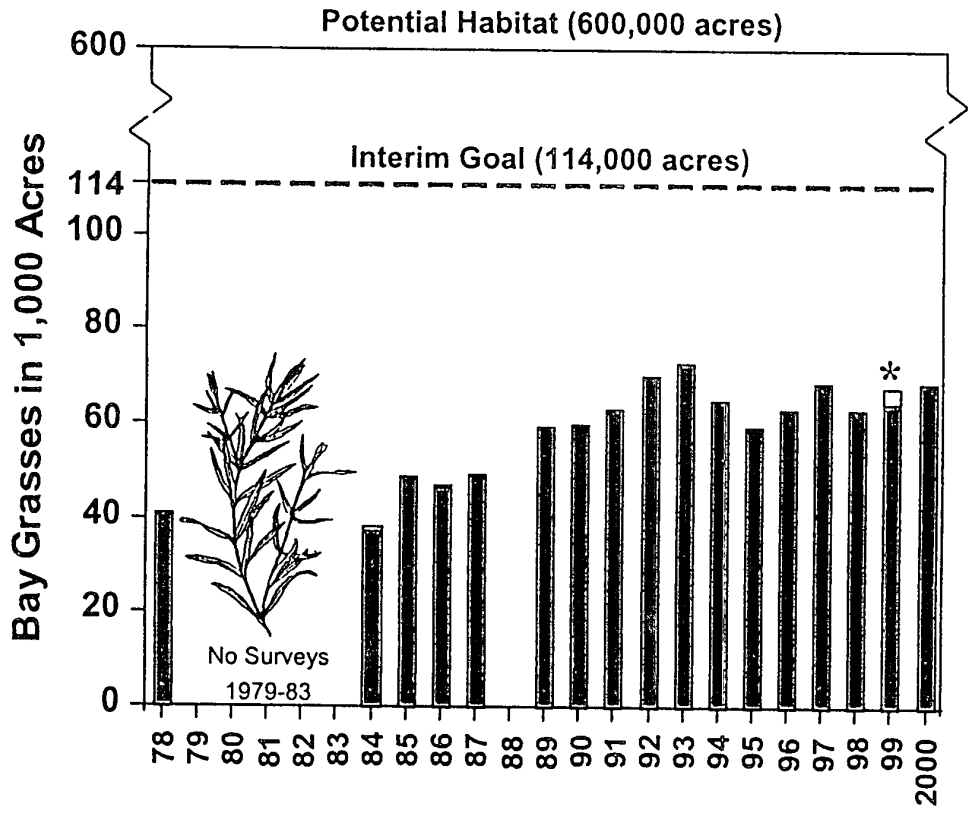


Source. Chesapeake Bay Program Phase 4.3 Watershed Model
Data include total nutrient loads delivered to the Bay, from point and nonpoint sources, from Chesapeake Bay Agreement jurisdictions : MD, PA, VA and DC

The partners have made measurable reductions in pollution loading despite continuing growth and development.

Still, more needs to be done.

Bay Grasses Have Increased Since 1984...



...But we are only at 60% of the interim restoration goal.

Underwater Bay grass beds are vital habitat for fish and crabs.

Bay grasses need clear water in order to get enough light to grow.

*Note – Hatched area of bar includes estimated additional acreage.

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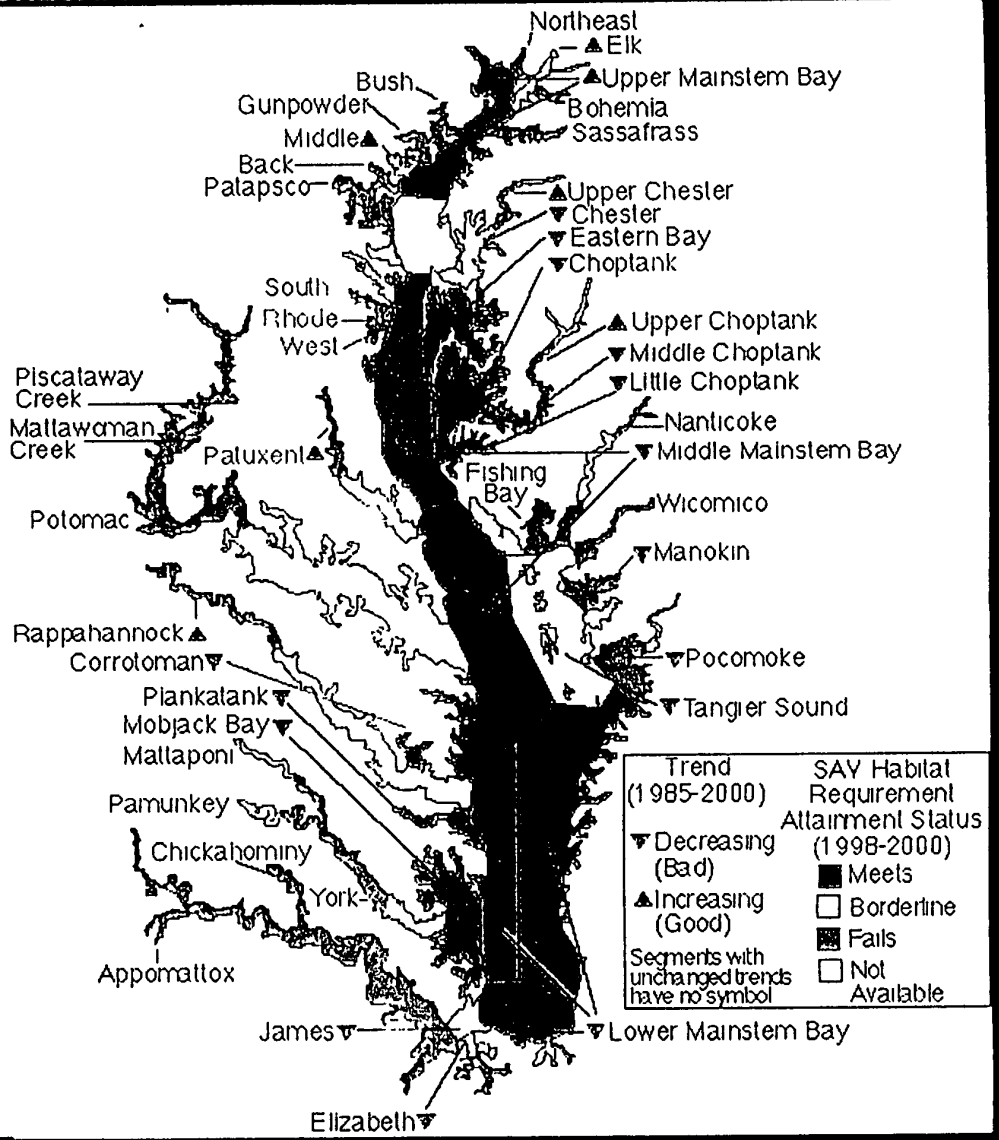
Some Waters Still Not Clear Enough for Bay Grasses

Water clarity is affected by the amount of sediment and algae in the water.

Water clarity is degrading in many parts of the basin.

While most of the main Bay and larger embayments meet the minimum light requirement for Bay grasses, almost all of the tributaries are borderline or failing.



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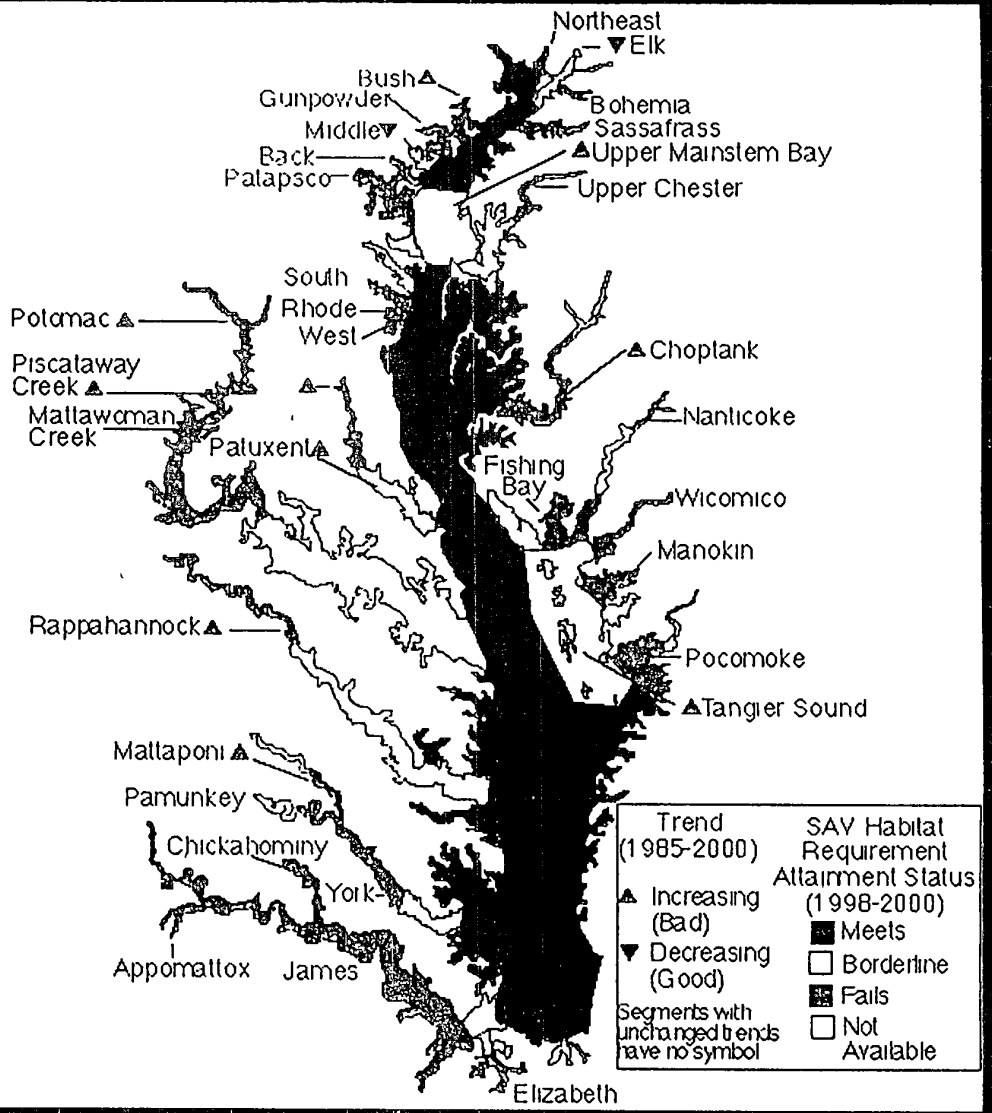
Some Waters Still Have Too Much Algae

Chlorophyll *a* is a measure of the amount of algae in the water.

Excessive nutrients can stimulate algae blooms resulting in reduced water clarity.

While most of the main Bay and larger embayments meet the requirement for Bay grasses, almost all of the tributaries are borderline or failing.



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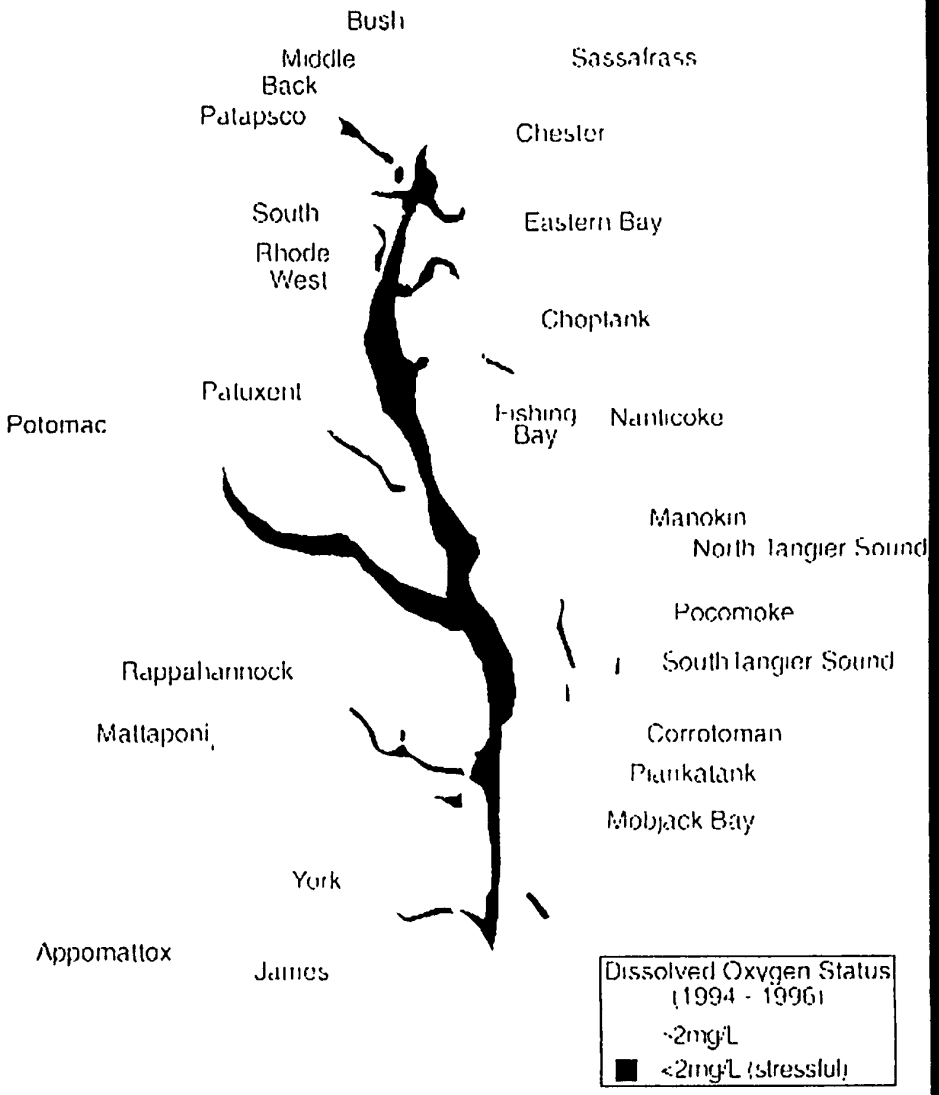
Many Water Habitats Still Lack Sufficient Oxygen

Excessive nutrients can stimulate algae blooms resulting in reduced oxygen levels in the water.

Stressful dissolved oxygen conditions occur during summer months throughout much of the deeper waters of the mainstem Bay and up into the Patapsco, Chester, Patuxent, Potomac, Rappahannock, and York Rivers, and Eastern Bay.



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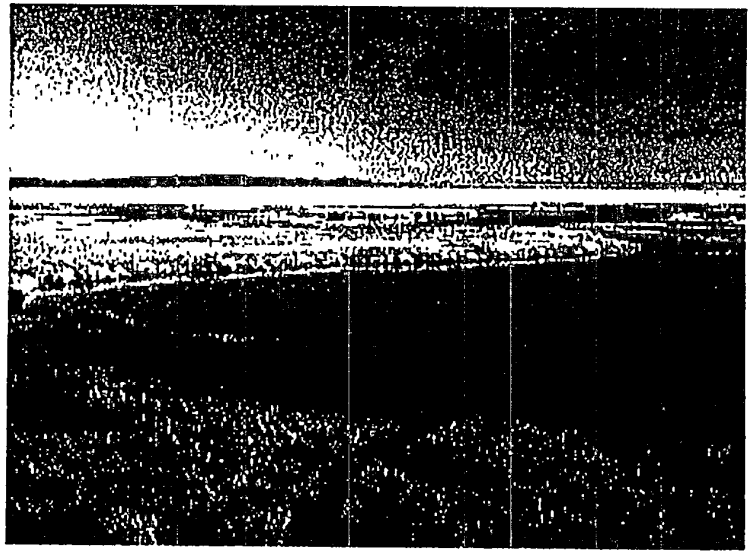
How Will We Define Restored Water Quality?



- *Map out the "designated uses" (habitat zones) of for the Bay's different living resource communities.*
- *Determine the water quality conditions or "criteria" necessary to protect those "uses".*

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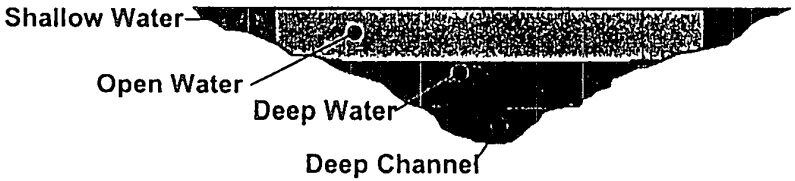
Designated Uses of Bay and Tidal River Waters

The uses (habitat zones) are based on the habitat needs of the Bay's living resources:

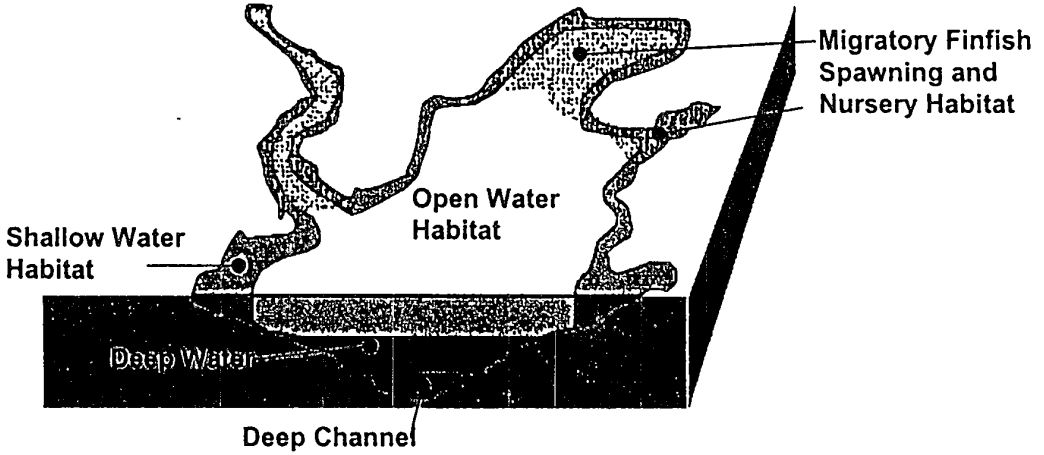
- Migratory Spawning and Nursery Habitat
- Shallow Water Habitat
- Open Water Habitat
- Deep Water Habitat
- Deep Channel Habitat

Refined Designated Uses for Chesapeake Bay and Tidal Tributary Waters

A. Cross Section of Chesapeake Bay or Tidal Tributary



B. Oblique View of the "Chesapeake Bay" and its Tidal Tributaries



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Migratory Fish Spawning and Nursery Habitat

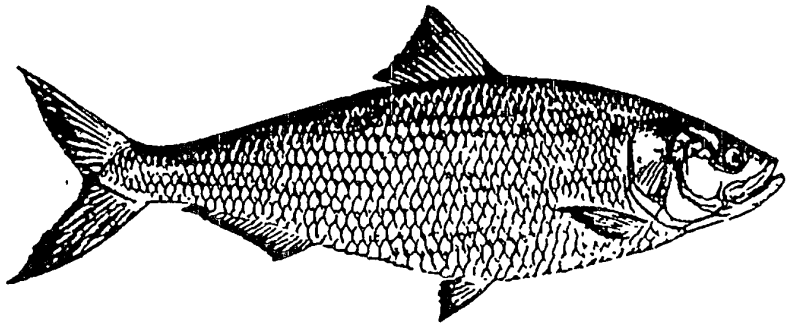
The upper extent of tidal waters used as spawning and nursery grounds by striped bass, shad, perch and other fish from February 15 to June 10.

■ Spawning and Nursery Habitat

Chesapeake Bay Program

Migratory Fish Spawning and Nursery Habitat

- Designated Use: Promote the growth of balanced, populations of migratory fish.
- Target species: Striped bass, American shad, hickory shad, alewife, blueback herring, white perch, and yellow perch.



Shallow Water Habitat

Tidal waters to a 2-meter depth (~6 feet).

Shallow Water Habitat

- Designated Use: Promote the growth of balanced, native populations of fish, shellfish and underwater Bay grasses.
- Target species: Largemouth bass, pickerel, speckled sea trout (juvenile), blue crabs.

Chesapeake Bay Program

Open Waters

Need photo of open water (does anyone have one?)

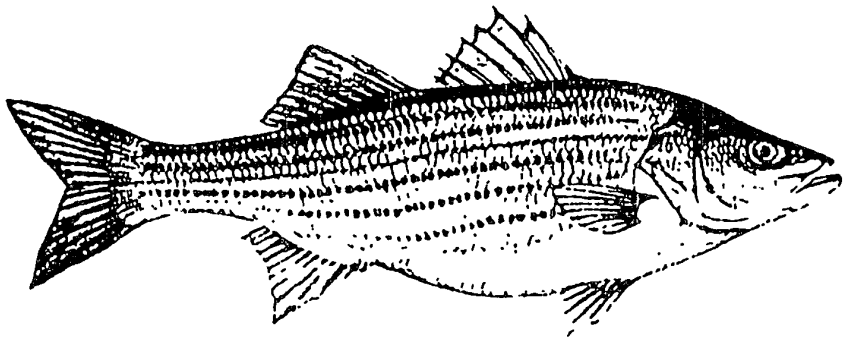
Tidal waters extending out from a 2-meter depth (~6 feet) into the water to the bottom, or to the top of the pycnocline* in areas where it exists.

* **Pycnocline** marks a density change in the water column due to a transition from the warm, freshwater layer on the surface to the relatively cold, salty water at the Bay's bottom.

■ Open Water Habitat

Open Waters

- Designated Use: Promote the growth of balanced populations of fish and shellfish inhabiting open water habitats.
- Target species: Menhaden, Bay anchovy, striped bass, aquatic reef communities.



Chesapeake Bay Program

Deep Water Habitat

Need photo of deep water
(does anyone have one?)

Placeholder for map of deep water habitat

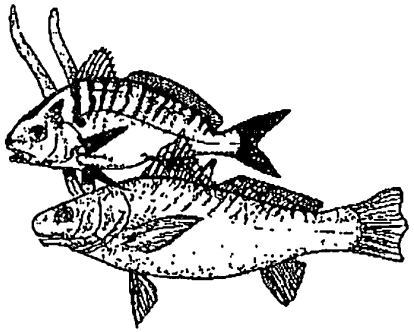
Tidal waters below the depth of the pycnocline* or, in its absence, below a certain depth that varies based on geographic conditions. Critical timeframe is mid-May through early October.

* **Pycnocline** marks a density change in the water column due to a transition from the warm, freshwater layer on the surface to the relatively cold, salty water at the Bay's bottom.

- ☐ Deep Water Habitat
- ▩ Deep Channel Habitat

Deep Water Habitat

- Designated Use: Protect the propagation and growth of balanced populations of fish and shellfish inhabiting deep water habitats.
- Target species: Blue crab, oyster, softshell clam, hard clam, spot, croaker, flounder, catfish.



Deep Channel Habitat

Need photo of deep channel
(does anyone have one?)

Very deep water and adjacent bottom sediment located in the channels at the lower reaches of major tidal rivers and along the spine of the upper and middle mainstem Bay.

Placeholder for map of deep water habitat

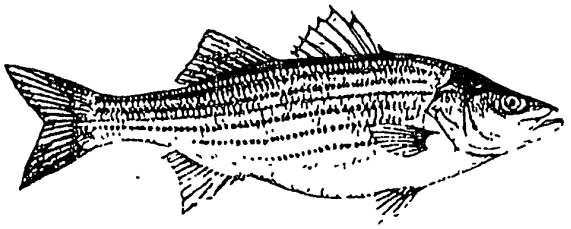
* **Pycnocline** marks a density change in the water column due to a transition from the warm, freshwater layer on the surface to the relatively cold, salty water at the Bay's bottom.

☐ Deep Water Habitat

■ Deep Channel Habitat

Deep Channel Habitat

- Designated Use: Refuge for balanced populations of fish species that overwinter in deep channel habitats from October - April; and the propagation and growth of benthic worms and clams that provide food for bottom-feeding fish and crabs from May - September.
- Target species: Blue crabs, migrating adult striped bass.



Chesapeake Bay Program

Water Quality Criteria

- **Water Clarity** – light for underwater Bay grasses
- **Dissolved Oxygen** – for fish, crabs and oysters
- **Chlorophyll *a*** – base of the Bay food chain

Together, these three criteria define the conditions necessary to protect the wide variety of the Bay's living resources and their habitats.

Water Clarity

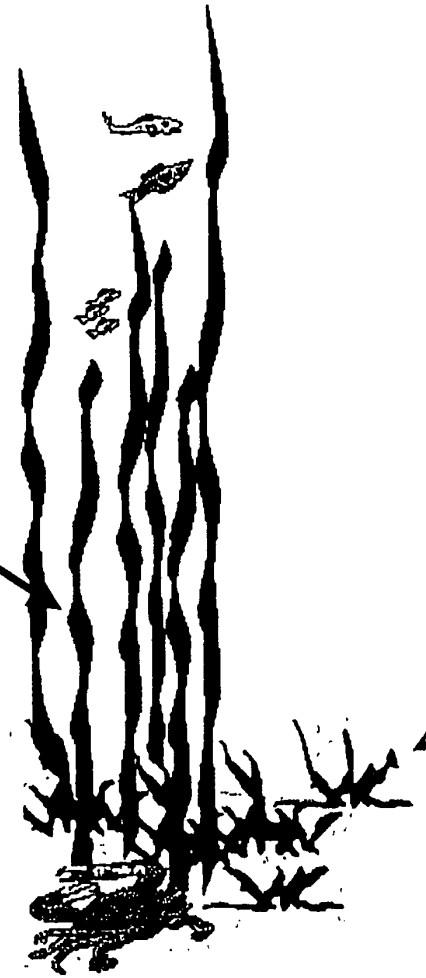
- All plants--even those underwater--need light!
- Water clarity is a measure of the amount of sunlight that penetrates the Bay's waters and reaches the surface of underwater Bay grass leaves.
- The amount needed is determined by the specific underwater grasses which grow in different areas of the Bay.

What's Blocking the Light?

Good Water Clarity

Percent of sunlight reaching leaves:

- 9% in low salinity waters
- 15% in high salinity waters



Poor Water Clarity

← Sediment and other particles in the water

+

← Algae in the water

+

Algae on the leaves

equals

Very low percentage of sunlight reaching leaves – Bay grasses grow poorly or die.

Dissolved Oxygen

- Living things--even those underwater--need oxygen!
- The amount of oxygen needed in the water depends on the specific needs of the Bay's living resources.
- The amounts depend on where and when certain areas are used by different living resources.

Dissolved Oxygen Criteria

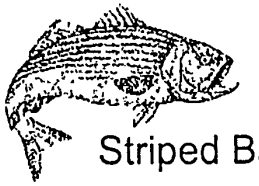
Migratory Spawning & Nursery Areas

Shallow and Open Water Areas

Deep Water

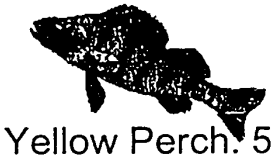
Deep Channel

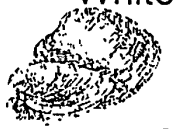
Minimum Amount of Oxygen (mg/L) Needed to Survive by Species


Striped Bass: 5-6


American Shad: 5


White Perch: 5


Yellow Perch: 5


Hard Clams: 5


Alewife: 3.6


Crabs: 3


Bay Anchovy: 3


Spot: 2


Worms: 1

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Chlorophyll *a*

- Chlorophyll *a* is a measure of the amount of algae in the water.
- Some algae are good sources of fish food and others are poor sources.
- Excessive nutrients can stimulate nuisance algae blooms resulting in reduced water clarity, reduced amounts of "good fish food", and depleted oxygen levels in deeper waters.

Chesapeake Bay Criteria Needed for Protection of the Proposed Tidal Waters Designated Uses

	Dissolved Oxygen	Chlorophyll *a*	Water Clarity
Migratory Spawning and Nursery	☐	☐	
Shallow Water	☐	☐	☐
Open Water	☐	☐	
Deep Water	☐		
Deep Channel	☐		

Working Draft Chesapeake Bay Water Quality Criteria

	Dissolved Oxygen (milligrams per liter)	Chlorophyll a (micrograms per liter)	Water Clarity (% surface light)
Migratory Spawning and Nursery	6 mg/L (7 day mean) 5 mg/L (1 day instantaneous minimum)	Spring/Summer Tidal fresh: 7-15/13-15 Low salt: 12-15/6-15 Med. Salt: 8-12/7-8 High salt: 3-7/5-7	
Shallow Water	5 mg/L (30 day mean) 4 mg/L (7 day mean) 3.5 mg/L (1 day in. min.)	Same as above	Low salt: 9% Higher salt: 15%
Open Water	Same as above	Same as above	
Deep Water	3 mg/L (30 day mean) 1.7 mg/L (1 day in. min.)		
Deep Channel	1 mg/L (1 in. day min.)		

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What needs to be done?

Once restored water quality has been defined what actions will need to be taken to remove the Bay from the impaired waters list by 2010?

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Adopting Water Quality Standards

- The Bay watershed partners are working to establish new state water quality standards that would more realistically reflect the needs of fish and other aquatic life.
- Once the water quality conditions (criteria and designated uses) have been finalized, jurisdictions with tidal waters – DE, MD, VA, and DC -- will use their best efforts to adopt new or revised water quality standards consistent with the defined water quality conditions by 2003.

Assign Load Reductions for Nutrient and Sediment Pollution

In order to achieve the needed water quality conditions, certain amounts of nitrogen, phosphorus and sediment reductions need to occur.

Pollutant Load Reductions → **Water Quality Condition Achievement**

Place holder for graphic to depict this relationship

Allocating Load Reductions for Nutrient and Sediment Pollution

- After the overall amounts of needed pollutant reductions have been determined,
- Then each of the 9 major watershed basins will be allocated maximum loads or "caps".

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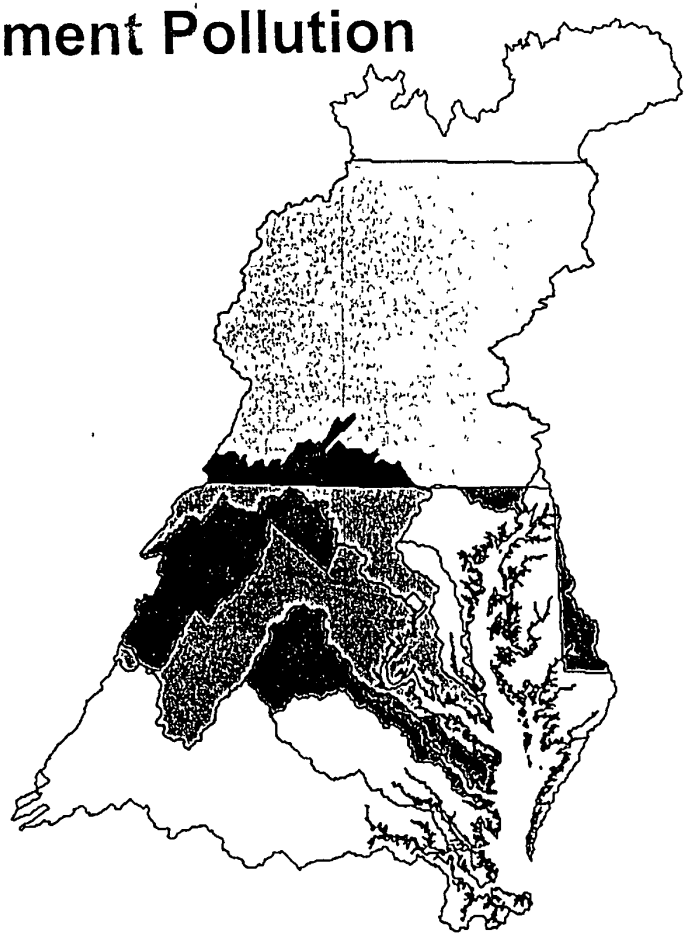
Allocating Load Reductions for Nutrient and Sediment Pollution

- Further allocations will be made to each jurisdiction within the 9 major watershed basins.



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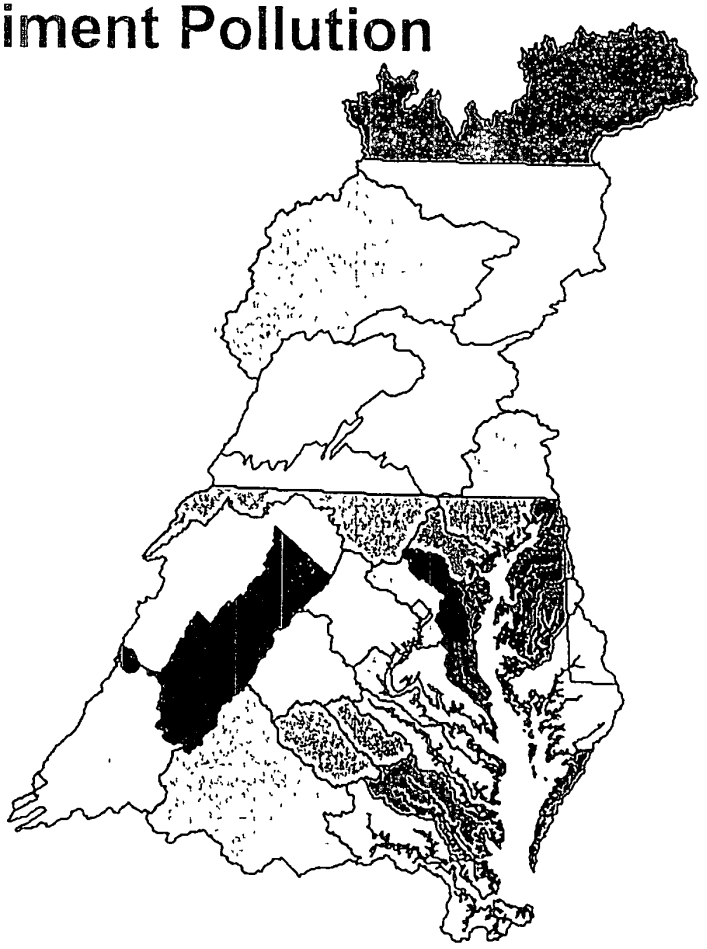
Allocating Load Reductions for Nutrient and Sediment Pollution

- Finally, the loading caps will be allocated to 37 tributary strategy sub-basins.
- Tributary strategies will be based on these allocations.



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Developing and Implementing Strategies

- Tributary strategies will be developed to achieve and maintain the allocated nutrient and sediment pollutant loading caps in each basin.
- The strategies will be developed in each jurisdiction with extensive local government and public involvement.
- Achieving the reductions and maintaining the loading caps will result in the achievement of the water quality conditions needed for aquatic living resources.

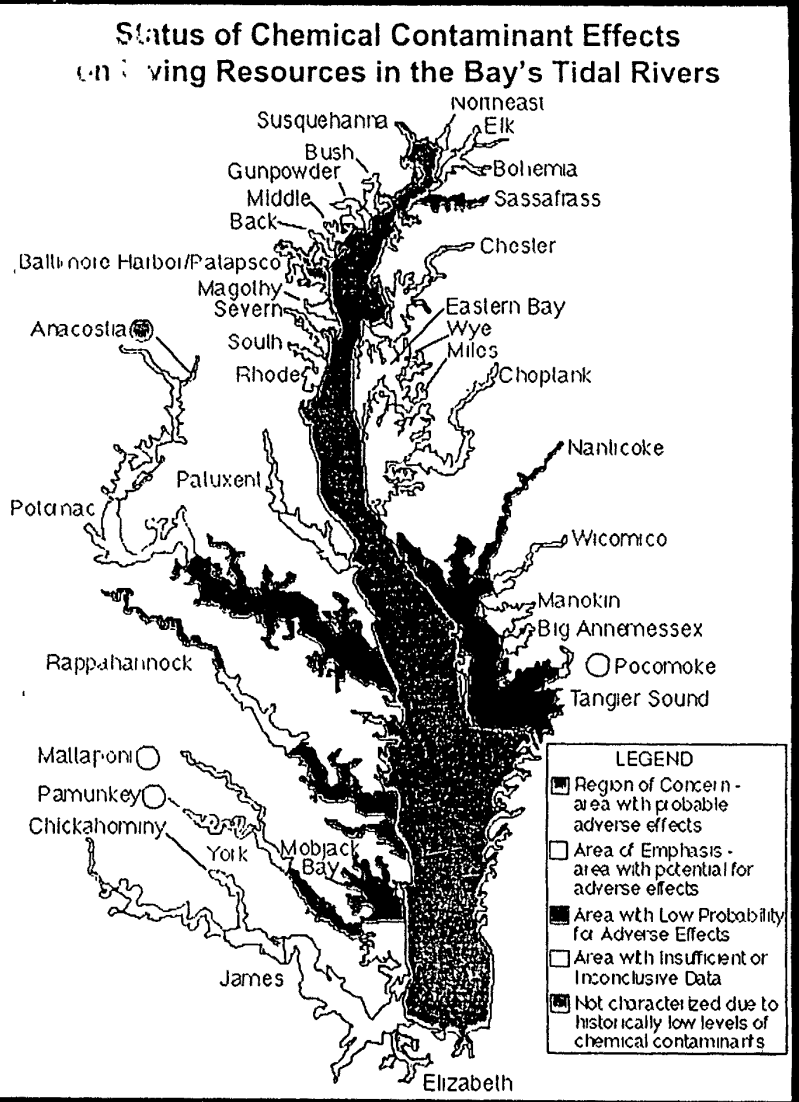
Inclusive and Innovative Strategies

- Strategies will need to involve everyone as personal responsibility and life style change may become components.
- Strategies will encompass complete watersheds.
- Strategies may include new ideas/new technologies (BNR to 3mg/L; nutrient trading; more wetlands, forest buffers, oyster reefs; innovative management of filter feeders; low impact development).

Additional Water Quality Restoration Efforts

The *Chespeake 2000* agreement also commits to reduce or eliminate chemical contaminants to levels that result in no toxic or bioaccumulative impact on living resources that inhabit the Bay or on human health.

Many of the efforts necessary to reach the chemical contaminant reduction goal will also help to reach the nutrient and sediment reduction goals (and visa versa).



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Timeline from the *Chesapeake 2000* Agreement

- By 2001, define the water quality conditions.
- By 2001, assign pollutant load reductions to each major tributary.
- By 2002, complete development and begin implementation of revised Tributary Strategies.
- By 2003, jurisdictions with tidal waters will adopt new or revised water quality standards.

What Will be Accomplished In the Coming Months?

- Fall 2001:
  Complete initial review of draft water quality criteria and designated uses.
- Winter 2001:
  Develop range of loading caps that will achieve water quality conditions (criteria and uses).
- Spring 2002:
  Complete 1st draft of cap allocations for 9 major basins.
- Summer 2002:
  - EPA will publish Bay water quality criteria.
  - Complete 1st draft of cap allocations for each jurisdiction within the 9 major basins.

Who's involved?

- Bay Program partners in this effort include the signatories to the Chesapeake Bay agreement -- EPA (representing the Federal government), the jurisdictions of MD, PA, VA and DC, and the Chesapeake Bay Commission.
- The partnership for this effort was expanded, through a Memorandum of Understanding to include the jurisdictions of DE, NY and WV.

Who Else Needs to be Involved?

- Local governments and citizens and…
- YOU need to become informed and get involved:
  - Participate in Tributary Teams – contact your watershed's tributary team coordinator.
  - Hold Bay Program partners accountable!

We are all a part of the problem –
All of us need to become part of the solution.
WE ARE ALL IN THIS TOGETHER

Key Opportunities for Citizen Involvement

- Summer/Fall 2001 – review draft criteria and designated uses
- Winter 2002 – review final criteria and uses published in the Federal Register
- Spring/Summer 2002 – review draft cap allocations
- 2002 – Get involved with teams developing tributary strategies
- From now until 2010 – Hold Bay Program partners accountable!

How Will Other Bay Agreement Commitments Help Restore the Complete Ecosystem?

We must encourage all citizens of the Chesapeake Bay watershed to work toward a shared vision – a system with abundant, diverse populations of living resources, fed by healthy streams and rivers, sustaining strong local and regional economies, and our unique quality of life.

Chesapeake Bay Program

Water Quality Improvements Alone Will Not "Restore the Bay"

If we do not manage fisheries, no matter how clean the water becomes, we still may not have sustainable populations.

Water Quality Improvements and Fisheries Management Are Still Not Enough

We need to restore all habitats, not just water habitats.

Chesapeake Bay Program

Water Quality Improvements, Fisheries Management and Habitat Protection Are Still Not Enough

We need to manage the way we use the land in watersheds.

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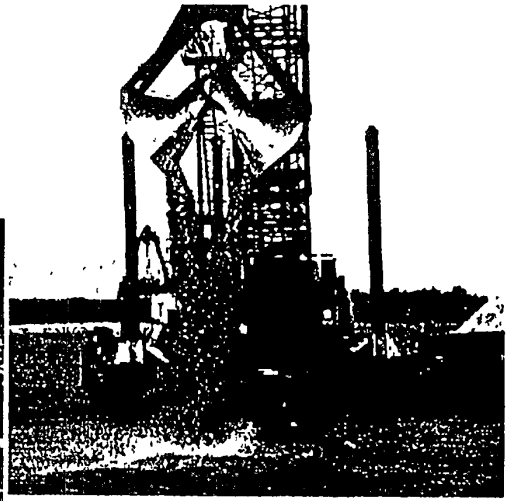
Water Quality Improvements, Fisheries Management, Habitat Protection and Sound Land Use are Still Not Enough

We need to engage everyone to become better stewards of the watershed.

Only By Integrating ALL Components of *Chesapeake 2000* Can We Expect to Restore the Bay

The agreement reflects the Bay's complexity in that each action taken, like the elements of the Bay itself, is connected to all the others.



Chesapeake Bay Program

Nutrient Criteria for California

Management Coordinating Committee

Sacramento, CA
October 2, 2001

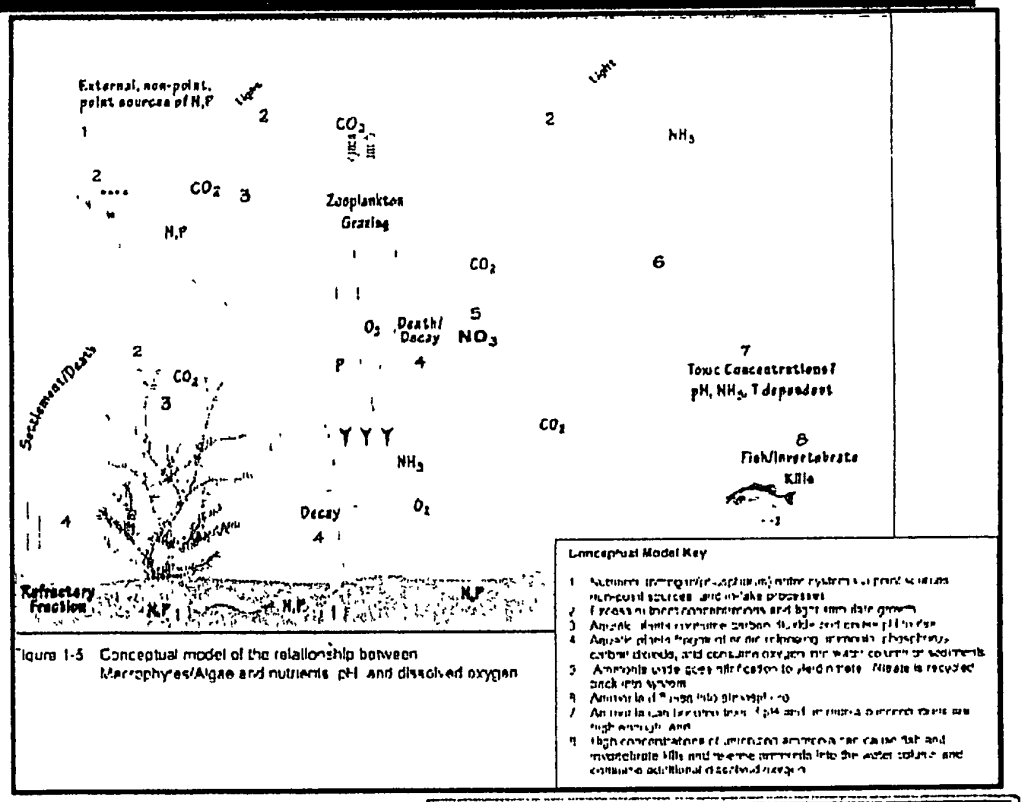


Figure 1-5 Conceptual model of the relationship between Macrophytes/Algae and nutrients, pH, and dissolved oxygen

Freshwater Standards Unit

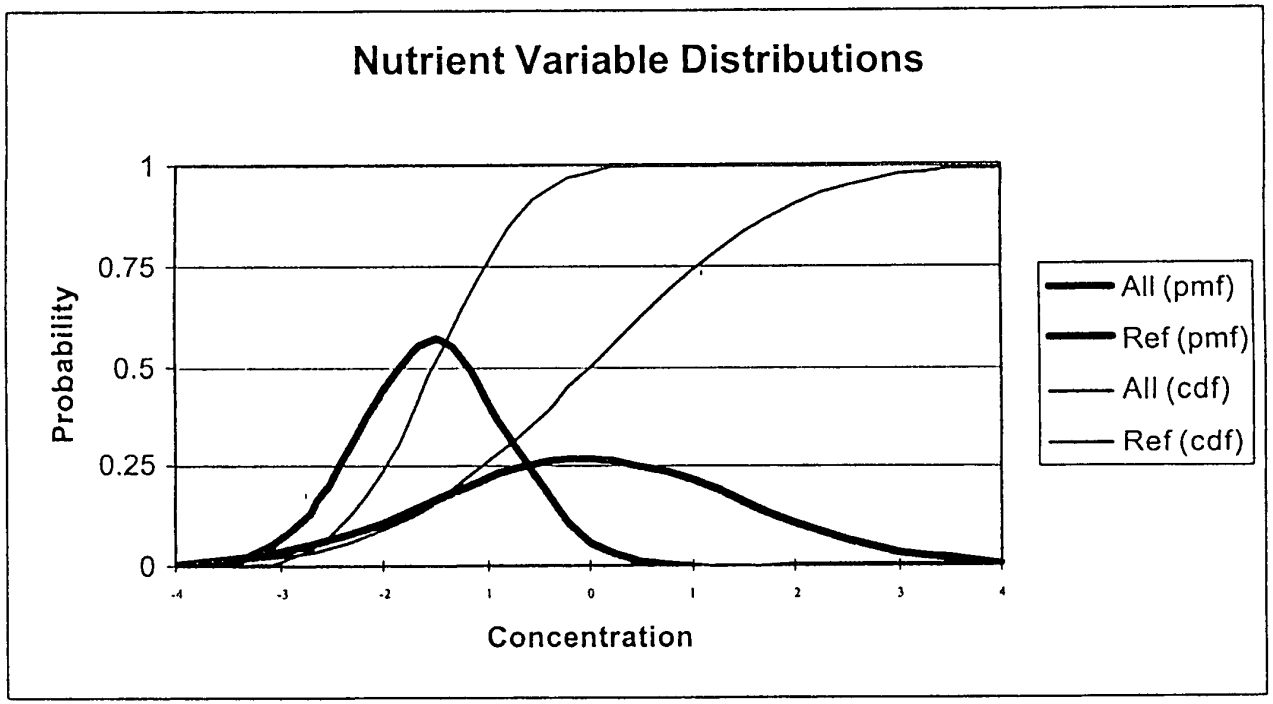
USEPA's Strategy for Reducing Cultural Eutrophication

- Nutrient criteria established by region for various water body types
- USEPA has completed guidance for establishing criteria on a water body- type and ecoregional basis
- USEPA Regional Nutrient Coordinators (Region IX – Suesan Saucerman) and Regional Technical Advisory Groups

USEPA's Strategy for Reducing Cultural Eutrophication

- USEPA is developing ecoregional criteria for water body types – can be used by states as guidance or promulgated as criteria for states
- USEPA will provide sufficient information to start adopting criteria by the end of 2004
- States are expected to monitor and evaluate effectiveness of nutrient management programs – criteria are to reflect minimally impaired trophic condition for ecoregion / water body type

USEPA Method Summary



- **Based on comparison of reference population with general population**

Timetable for Criteria Development

- 1998: National Nutrient Strategy
- 1999: USEPA RTAG Formed
- March of 2001: USEPA notifies states of the water body types and ecoregions expected to be addressed in Section 304(a); criteria to be published by December 2001.

Timetable for Criteria Development

- End of 2001: States complete plan to develop and adopt nutrient criteria into WQS, including a description of how and when nutrient criteria will be adopted.
- Early 2004: USEPA completes the process of providing sufficient information for the states to begin adopting nutrient standards.
- End of 2004: States should begin adoption of nutrient criteria for the water body types and ecoregions associated with Section 304 (a) water quality criteria; USEPA publishes nutrient standards for states that have not developed their own.

Freshwater Standards Unit

Status of USEPA Guidance

- **Ecoregion I** (Sacramento and Willamette Valleys): Guidance for lakes/reservoirs and rivers/streams not yet been published; expected later this year.
- **Ecoregion II** (Western Forested Mountains): Guidance for lakes/reservoirs and rivers/streams published December 2000.
- **Ecoregion III** (Xeric West): Guidance for rivers/streams published December 2000. Guidance for lakes/reservoirs expected later this year.

Status of USEPA Guidance (continued)

- The Guidance for Estuarine and Marine Coastal Waters does not use the ecoregional approach, so USEPA will not be publishing specific guidance for sub-areas of coastal California. A site-specific approach will be used for these waters.

RTAG / STRTAG

- RTAG has wide range of stakeholders from USEPA Region IX states – including WQ programs
- Active since 1998 - has sponsored two pilot studies to evaluate USEPA guidance for nutrient criteria development
- STRTAG formed in 2001 to focus on CA issues related to nutrient criteria development
- Operating cooperatively / jointly with Region IX RTAG

The Importance of "getting it right"

- ~ 150 CA water bodies impaired (1998 303(d) list) for nutrients and nutrient related parameters (DO, pH)
- Once established, nutrient criteria will be incorporated into state standards
- Are the 304(a) criteria correctly specified? Misspecification could lead to a large number of 303(d) listings

The Importance of "getting it right"

Ecoregion 2 - Rivers and Streams

	304(a)	Storet (25%)	Reference (25%)	Storet (75%)	Reference (75%)
TP ug/L	10.00	13	22	36	60
TN mg/L	0.12	0.09	0.125	0.24	

Freshwater Standards Unit

Three Approaches to Develop Criteria

- Use methods proposed in USEPA's Technical Guidance Manuals
- Adopt USEPA's Section 304(a) criteria (previous slide)
- Use other scientifically defensible methods

Confounding Factors to be Considered in Alternate Approach

- Size of ecoregion / regional unit used in analysis
- Additional classification / stratfication criteria (e.g., structural characteristics, physical habitat condition)
- Effect of large water transfers from one ecoregion to another
- Effluent-dominated and ephemeral waters
- Better established reference conditions for CA waters

Issues to be Addressed In Work Plans

- What approach will you take to establish criteria?
- If you are considering different approaches what is your preference?
- How will you relate criteria to use classifications?
- How will you group state waters (physical classification)?
- What data will you rely on?

Issues to be Addressed in Work Plans (cont.)

- What new data will you collect?
- How will you analyze the data?
- How will compliance be determined?
- What staffing / resources will you need?
- What administrative procedures will you need to go through?

Issues to be Addressed in Work Plans (cont.)

- Who is involved in critical decision making?
- How will you solicit public participation and stakeholder involvement?
- How will you utilize outside expertise?
- What are the major milestones and schedule for completion?

Schedule of Completion for Alternate Development

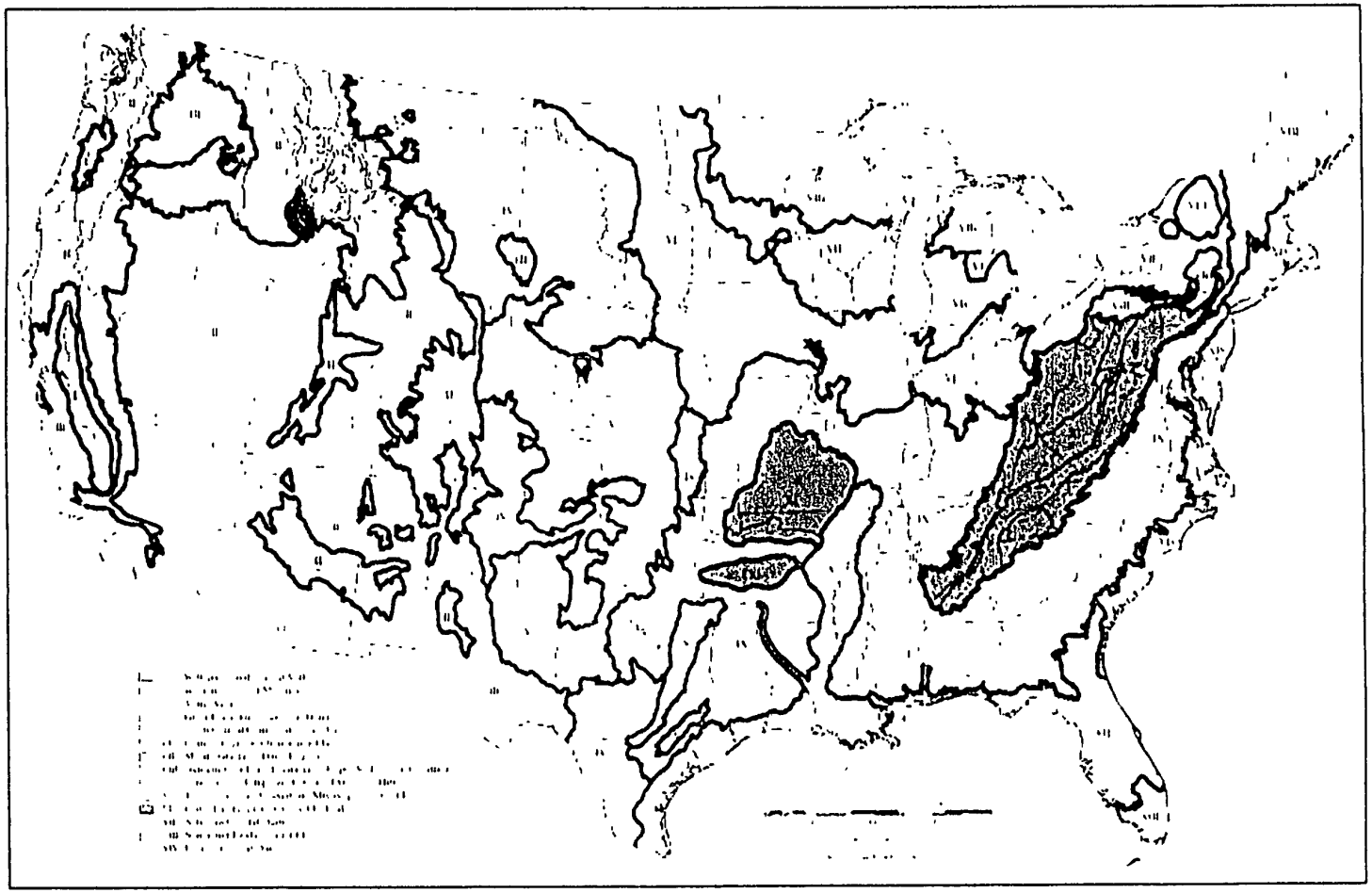
- Establish Ecoregion Workgroups: Fall 2001
- Completion of Work Plans: 12/2001
- Data Collection and Analysis: 9/2004
- Criteria Recommendations: 10/2004
- Administrative Process: 12/2004
- Formally adopt into water quality standards: 1/2005 (process initiated)

Freshwater Standards Unit

Recommendations

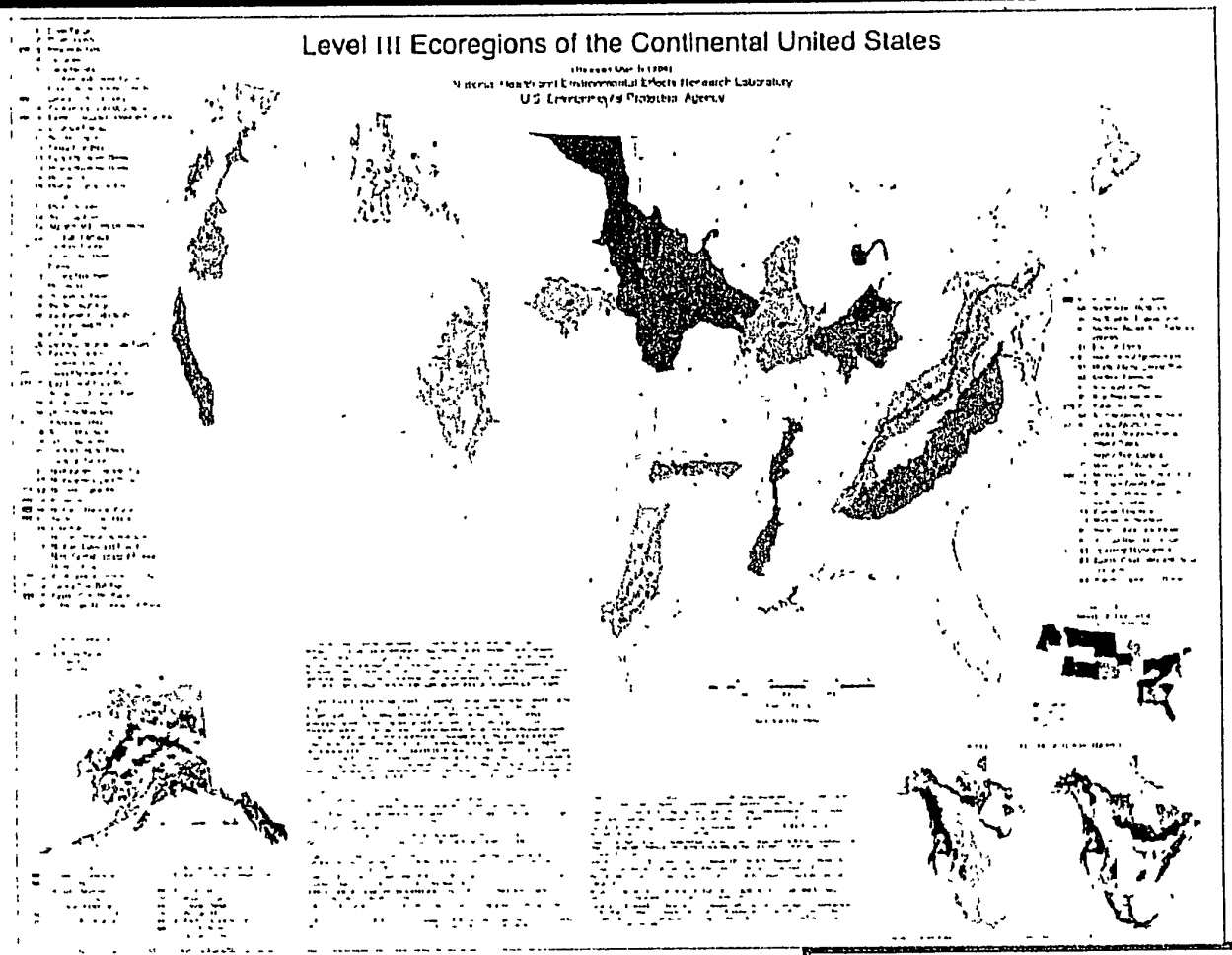
1) STRTAG / RTAG adopt the alternate approach
2) Develop conceptual design for alternate approach and work plans
3) Acquire additional resources to support alternate approach
4) Secure services of technical support contractor to develop and undertake nutrient criteria development work plans

Aggregated Ecoregions for National Nutrient Criteria

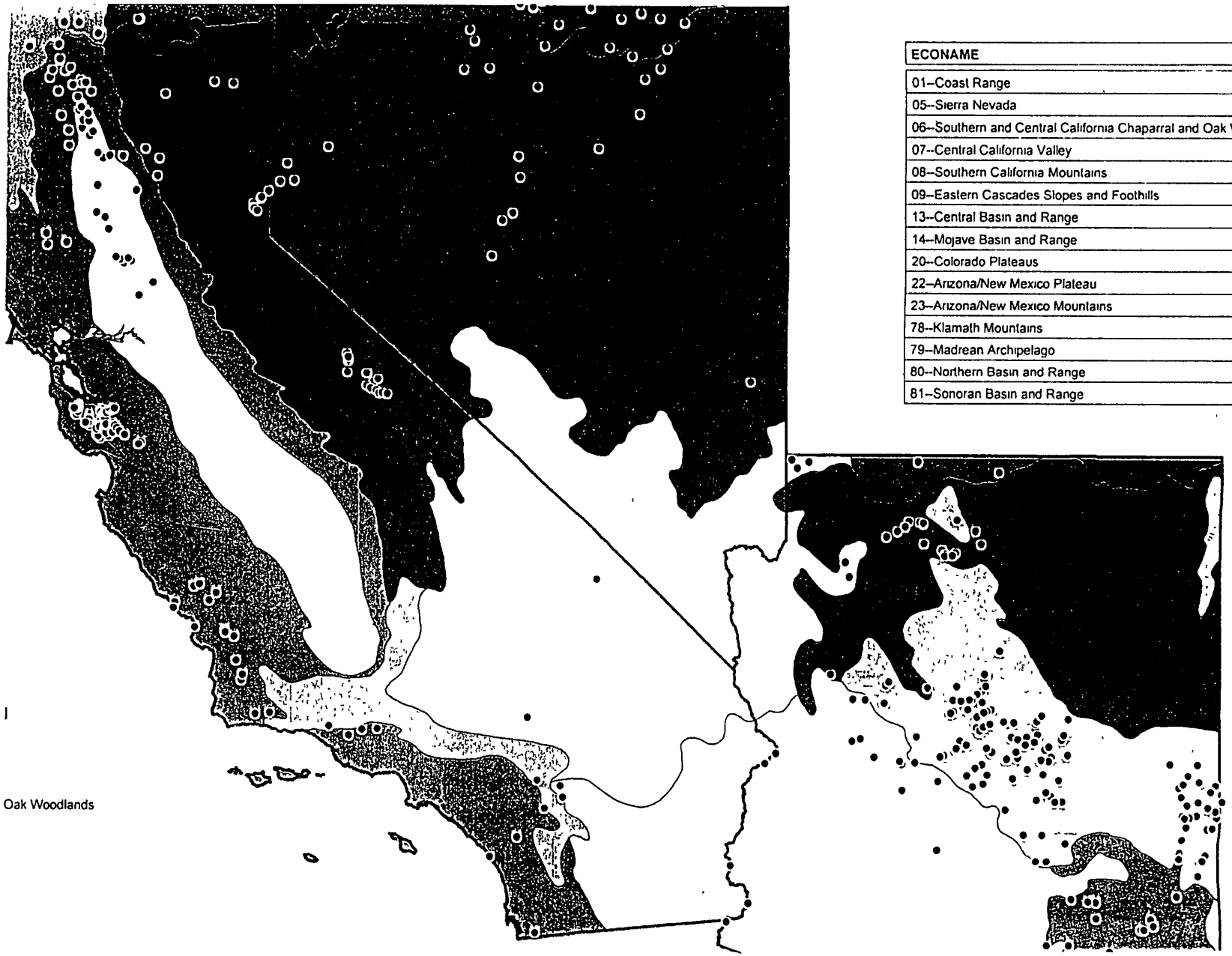


Freshwater Standards Unit

"Original" Level III Ecoregions



Freshwater Standards Unit



ECONAME
01--Coast Range
05--Sierra Nevada
06--Southern and Central California Chaparral and Oak Wood
07--Central California Valley
08--Southern California Mountains
09--Eastern Cascades Slopes and Foothills
13--Central Basin and Range
14--Mojave Basin and Range
20--Colorado Plateaus
22--Arizona/New Mexico Plateau
23--Arizona/New Mexico Mountains
78--Klamath Mountains
79--Madrean Archipelago
80--Northern Basin and Range
81--Sonoran Basin and Range

Oak Woodlands