Comments on the NRDC Report, "A Review of Available Best Management Practices for Reducing Agricultural Discharges to Waterways in California's Central Valley"

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In January 2003 the National Resources Defense Council (NRDC) released a 45-page report, "A Review of Available Best Management Practices for Reducing Agricultural Discharges to Waterways in California's Central Valley." This review was authored by Benbrook, *et al.* (2002). This report is referred to herein as the NRDC (2002) report.

The title of this report, "…Available Best Management Practices…" is incorrect, with respect to its content and appropriate use. The title should be, "A Review of Potential Management Practices for Reducing Agricultural Discharges to Waterways in California's Central Valley." The practices discussed have not been evaluated with respect to whether they can be considered "best." They are various practices that have been claimed to be potentially useful for controlling the concentrations of potential pollutants discharged to Central Valley waterways. The US EPA (2002), in its review of agricultural water quality management practices, discussed the inappropriateness of calling the potential practices "best" management practices. Lee and Jones-Lee (2002a), in their review of water quality management practices for Central Valley agriculture, have adopted the US EPA's recommended approach.

On page 2 of the NRDC (2002) Executive Summary, first paragraph, the last sentence states,

> *"Although the myriad of identified conservation practices vary greatly – and more information is necessary to evaluate some -- numerous highly effective pollution prevention approaches can be implemented at little additional cost."*

Further, the NRDC report states,

> *"More important for policy formulation, however, is the overriding fact that many BMPs have proven records of effectiveness and, therefore, opportunities to reduce high priority pollutants are clearly at hand. There is, as a consequence, no justification for further delay in implementation. For example, in instances where priority pollutants can be reduced or eliminated, there is no justification for delaying in order to precisely quantify the water quality benefits that will accrue. The process of implementing conservation practices will itself provide additional information about the efficacy, cost and applicability of many low-impact agricultural practices."*

This is an overstatement of the current degree of understanding of many of the agricultural water quality potential management practices discussed in the NRDC report. As discussed by Lee and Jones-Lee (2002a), at this time there is limited (essentially no) information on the effectiveness and cost of various potential management practices for controlling potential pollutants in Central Valley agricultural stormwater runoff and irrigation tailwater and subsurface drain water discharges.

With reference to the statement quoted above,

> *"More important for policy formulation, however, is the overriding fact that many BMPs have proven records of effectiveness and, therefore, opportunities to reduce high priority pollutants are clearly at hand. There is, as a consequence, no justification for further delay in implementation."*

Reviewers of the NRDC (2002) and the Lee and Jones-Lee (2002a) agricultural runoff water quality management practices reports find that there is a significant difference in the approaches recommended in the two reports for implementing management practices to address water quality problems caused by irrigated agriculture stormwater runoff and tailwater/subsurface drain water discharges. NRDC advocates immediate implementation of existing conventional so-called BMPs, without further evaluation of their effectiveness and cost. Lee and Jones-Lee, on the other hand, recommend representative Central Valley site-specific evaluation of potential management practices in order to determine their efficacy and, most importantly, their cost. These comments discuss the differences in the NRDC versus Lee and Jones-Lee approaches recommended for implementation of water quality management practices for irrigated agriculture in the Central Valley.

The Lee and Jones-Lee approach considers the fact that the proper implementation of management practices has to be tied to the management practice goals and the funds available to implement the management practices to achieve these goals. If agricultural interests in the Central Valley had unlimited funds available for implementing agricultural runoff/discharge management practices, or if there were unlimited government subsidies for implementation of water quality management practices, then the NRDC statement about immediate implementation of the various management practices would have some credibility. However, the facts are that agricultural interests and the government do not have and/or have not made available funds to apply various potential water quality management practices without an understanding of what their cost-effectiveness would be in achieving the management practice goal – i.e., the desired level of water quality.

In the urban stormwater runoff arena, some environmental groups hold the position that urban area and highway stormwater runoff water quality managers should immediately implement a variety of potential water quality BMPs to control to some degree the concentrations of potential pollutants in the stormwater runoff from these areas. As has been discussed by Lee and Jones-Lee (2002a) and others (see their review), adopting this approach could result in developed municipalities having to charge those in the area served by the municipal storm sewer system from $1 to $3 per person per day for construction, operation and maintenance of conventional stormwater management practices such as detention basins, grassy swales, infiltration systems, etc., only to find that these management practices are not effective in achieving the ultimate regulatory goal of eliminating violations of water quality standards (objectives) in the receiving waters for the so-called BMP-treated stormwater runoff. It has been estimated (see Lee and

Jones-Lee, 2002a) that the cost of achieving water quality standards compliance for urban area stormwater runoff for developed areas is from $5 to $10 per person per day for those in the area served by the storm sewer system. As discussed by Lee and Jones-Lee (2002a), the situation is that urban and highway stormwater managers and the public whom they serve could spend large amounts of funds in implementing the approach of installing conventional so-called "best" management practices, yet find that the discharges from the "BMP"-treated stormwater still cause violations of water quality standards in the receiving waters for the runoff, with the result that a different management practice approach would have to be adopted to achieve the water quality goal, where the funds spent for the conventional "BMPs" would have been of little value in achieving these goals.

Lee and Jones-Lee (2002a) have discussed that the approach that should be followed is to evaluate, for representative situations, the ability of various management practices (and their associated cost of construction, operation and maintenance) to achieve the degree of control of real pollutants (not potential pollutants) in the stormwater runoff from urban areas and highways.

With respect to highway stormwater runoff, Jones-Lee and Lee (1998) developed the Evaluation Monitoring approach for developing management practices for highway runoff associated with the development of the Eastern Transportation Corridor (ETC), a new 22-mile toll road that was constructed in Orange County, California, during the mid- to late 1990s. The Evaluation Monitoring approach focuses on determining whether there are real, significant water quality use impairments in the receiving waters for the stormwater runoff, which are derived from runoff-associated constituents. It also evaluates the potential benefits of controlling the runoff-associated constituents that may be causing or contributing to the beneficial use impairment of the receiving waters for the runoff. This approach carries with it a substantial commitment to conduct comprehensive studies of the receiving waters to determine the occurrence of beneficial use impairments of these waters by the discharge(s) of concern, an evaluation of the chemical(s) responsible for the use impairments, and an identification of the source of the constituent(s) responsible.

The Evaluation Monitoring approach was proposed to the regulatory agencies and others as the approach that should be followed in developing management practices to control real, significant water quality use impairments caused by pollutants in ETC runoff. This is the approach that is in place today. Based on subsequent studies, it has proven to be the approach that should be used for developing management practices for highway stormwater runoff. Further, it is the approach that should be used for urban stormwater runoff and nonpoint source runoff/discharges, such as from irrigated agriculture in the Central Valley.

As an example of the benefits of the Evaluation Monitoring approach, highways and urban streets contain elevated concentrations of several heavy metals, such as lead, copper, zinc, and sometimes cadmium. The total concentrations are above water quality objectives. Some environmental groups and others have advocated that detention basins and other management practices should be constructed to remove these heavy metals from the runoff. However, it has been well established since the late 1960s that particulate heavy metals are in nontoxic, non-available forms. Finally, the US EPA (1995) adopted ambient water dissolved heavy metals as the form of heavy metals that should be regulated. The studies in the Upper Newport Bay watershed conducted by Lee and Taylor (Lee, *et al*., 2001) as a followup to the ETC management practice development approach, found that the heavy metals in runoff from urban area streets in Orange County, as well as in stormwater runoff from other paved areas, are nontoxic. This included the total and dissolved forms. The aquatic life toxicity to *Ceriodaphnia* that was found in urban area stormwater runoff was due to the OP pesticides diazinon and chlorpyrifos and other unidentified constituents. However, toxicity identification evaluation procedures showed that this toxicity was not due to heavy metals. The construction, operation and maintenance of a detention basin or other management practice to control heavy metals in urban area and highway stormwater runoff in Orange County (or, for that matter, elsewhere where studies have been done) would produce no improvement in the beneficial uses of the receiving waters, since the BMP is directed toward controlling a non-pollutant – i.e., heavy metals that do not cause impairment of the beneficial uses of the receiving waters for the runoff.

Agricultural interests in the Central Valley have limited funds available to implement water quality management practices. The profitability of many parts of Central Valley agriculture is quite low at this time, with the result that any funds spent for water quality management should be based on a proper evaluation of the ability of the management practice to achieve the desired water quality/beneficial uses in the receiving waters for the stormwater runoff/irrigation tailwater or subsurface drain water discharges.

Lee and Jones-Lee (2002b) have provided detailed guidance on how nonpoint source (NPS) water quality monitoring/assessment should be conducted as part of managing real, significant water quality impairment of the receiving waters for stormwater runoff and agricultural discharge waters. Their approach involves three components: (1) determining if there are exceedances of numeric and/or narrative water quality objectives in the runoff waters from the source, (2) evaluating the water quality/beneficial use significance of these exceedances, including adjusting the water quality standards for site-specific conditions, and (3) implementing and monitoring technically valid, cost-effective management practices to achieve the desired beneficial use improvement in the receiving waters for the runoff. This recommended approach is the approach that should be used in the Central Valley (and, for that matter, elsewhere) to develop a technically valid, cost-effective management program for all NPS sources of potential pollutants, including Central Valley agriculture.

While the NRDC (2002) and Lee and Jones-Lee (2002a) potential agricultural management practices reports both discuss various potential practices that have been identified for controlling aquatic life toxicity associated with the use of the OP pesticides diazinon and chlorpyrifos as dormant sprays in orchards, Lee and Jones-Lee point out, based on the intensive review that has been conducted by the Sacramento River Watershed Program OP Focus Group, and their own studies on OP pesticide runoff in various areas, that, at this time, information does not exist on the effectiveness, and especially the cost-effectiveness, of implementing these various management practices for OP pesticides in stormwater runoff.

The NRDC (2002) recommended approach is to implement these practices, without developing the information needed to evaluate whether expenditures for detention basins, grassy swales, etc., would be effective in reducing the OP pesticide concentrations to meet the proposed management practice goal of no more than one exceedence of the Department of Fish and Game

(Siepmann and Finlayson, 2000) water quality criteria in a three-year period for diazinon or chlorpyrifos or the sum of the two, when normalized based on their LC_{50} for *Ceriodaphnia*, at the point where the agricultural runoff enters the State's waters. Following the NRDC approach could lead to a situation where large amounts of funds would be spent by agricultural interests in developing various treatment management practices for controlling OP pesticide runoff, only to find that the only practice that can achieve the desired management goal is source control, through either adjustments in when the OP pesticides are applied, or, more likely, substitution of other pesticides for the OP pesticides.

While the substitution approach will be effective in controlling the OP pesticide-caused aquatic life toxicity, the alternative pesticide could cause even greater toxicity or other water quality problems in the receiving waters for the runoff. As discussed by Lee and Jones-Lee (2002a) and Jones-Lee and Lee (2000), the US EPA Office of Pesticide Programs and the California Department of Pesticide Regulation permitting (labeling) of pesticides for use as a dormant spray or other agricultural purposes does not include determination of whether stormwater runoff or irrigation tailwater discharges contain sufficient concentrations of these pesticides, under label use, to cause aquatic life toxicity or exceedance of water quality standards in the receiving waters for the runoff/discharges.

Basically, the NRDC (2002) approach, of first implement and then find out what was accomplished, is not a technically valid approach. This approach is also out of sync with respect to the Central Valley Regional Water Quality Control Board's approach for implementing the new conditional waiver of waste discharge requirements for discharges from irrigated lands policy (agricultural waiver policy – CVRWQCB, 2002) which involves a several-year period of monitoring and evaluation. The NRDC approach could result in substantial expenditures of already limited funding available for implementing water quality management practices only to find that the cost-effectiveness of these expenditures is quite limited in achieving the desired water quality management goal.

In footnote 4 on the bottom of page 10 of the NRDC report, the statement is made:

> *"Past monitoring sheds no light on the risks stemming from the use of recently registered, new pesticides, but such risks are less likely to be significant compared to risks from older products, because of the stricter standards applied by regulators today and the much more complete ecotoxicological datasets they evaluate prior to product approvals."*

This statement is misleading. While current pesticide registration requires development of a large ecotoxicological dataset, this dataset does not result in the restriction the use of pesticides which are highly toxic to aquatic life. A critical review of the US EPA Office of Pesticide Programs (OPP) pesticide registration process shows that the Agency is not requiring that an evaluation be made of the potential for stormwater runoff or irrigation water discharges to contain sufficient concentrations of pesticides to be toxic to aquatic life and/or to violate narrative water quality standards for protection of aquatic life.

On page 14, in the next to last paragraph, the statement is made, *"In general, for every OP insecticide use in California – from controlling budworms in cotton to aphids in alfalfa or tomato fields – there are one to three registered carbamate and at least three synthetic pyrethroid alternatives that can be applied in about the same way, achieving comparable results."*

No mention is made about the problems that are emerging with respect to insects showing an ability to develop a resistance to the pyrethroid pesticides. This is a growing problem that needs to be properly evaluated in any attempt to substitute pyrethroid-based pesticides for OP pesticides. Further, no mention is made that carbamate pesticides can cause significant aquatic life toxicity. In the Lee and Taylor (Lee, *et al.*, 2001) studies in Orange County, among the highest aquatic life toxicity found in stormwater runoff in a tributary stream of Upper Newport Bay was due to the use of carbamate pesticides on strawberries.

On page 25, mid-page, it is stated that,

"No synthetic pyrethroids were detected in runoff from any of the treated alfalfa fields, down to a limit of detection of 50 parts per trillion, and there were no adverse impacts on water fleas from exposure to the water."

It should be noted that the detection limit for pyrethroids used in this study was well above the concentration of the pyrethroid that could be toxic to some forms of aquatic life, and the toxicity test did not include fish as a test species. It is known that pyrethroids tend to be highly toxic to some fish species. This is one of the significant differences between pyrethroid pesticides and OP pesticides, which, while toxic to *Ceriodaphnia* (water flea), have relatively low toxicity to fish.

Overall, the NRDC discussion of the potential management practices to control pesticide-caused water quality impairment lists a variety of management practices that have the potential to be effective. However, as discussed by Lee and Jones-Lee and as concluded by the Sacramento River Watershed Program OP Focus Group (see Lee and Jones-Lee, 2002a), there is need to evaluate the effectiveness of these various potential management practices in the various agricultural settings within the Central Valley, to evaluate the proper approach/mix of the various programs to achieve the most technically valid, cost-effective management of pests, while controlling pesticide runoff/infiltration to achieve the management goal set forth in the agricultural waiver policy, and as required by Porter-Cologne.

On page 29, mid-page, the statement is made,

"EPA's review of other programs and case studies provide similar findings:

- *The State of Maryland estimates that average reductions of 34 pounds of nitrogen and 41 pounds of phosphorus per acre can be achieved through the implementation of nutrient management plans."*

With respect to the situation in the State of Maryland, Lee and Jones-Lee (2002a) discuss the fact that the Chesapeake Bay watershed has had a requirement for over 15 years to substantially reduce the nitrogen and phosphorus content of agricultural runoff to Chesapeake Bay. As Lee and Jones-Lee point out, a recent review by Sharpley (2000) of what has been accomplished has shown that little progress has been made during this period in achieving these regulatory requirements. Where progress has been made, it is largely due to retirement of agricultural lands.

On the bottom of page 31, NRDC (2000) states,

> *"According to the National Research Council (NRC), eroding sediment from land producing row crops tends to be the most common agricultural source of phosphorous runoff, especially from fields with fine-textured soils near watercourses. Reducing erosion losses, then, is a primary method to limit phosphorous runoff (reducing P losses by reducing the flow of sediment off farm fields has the added advantage of also keeping pesticides that commonly bind to soil particles out of water)."*

While this statement is correct, there is need to consider the situation discussed by Lee and Jones-Lee (2002a) and Lee, *et al*. (1980), that much of the particulate phosphorus present in agricultural land stormwater runoff has been found by a number of investigators to be in non-algal-available forms, and does not convert to algal-available forms in the receiving waters for the agricultural runoff. Large amounts of agricultural funds could be spent trying to control particulate phosphorus from agricultural lands and have little or no impact on the receiving water excessive fertilization situation.

Excessive fertilization situations where phosphorus is the key element must focus on available (soluble) forms of phosphorus – not total phosphorus, which is normally largely dominated by particulate forms. The same situation applies to pesticides associated with particulates. There are some pesticides, such as some of the pyrethroid pesticides, that are not toxic to aquatic life in the attached-to-soil-particle form. As discussed by Lee and Jones-Lee, it is important that the aqueous environmental chemistry/toxicology of the potential pollutants be understood, in order to develop technically valid, cost-effective management practices. Without this understanding, large amounts of funds could be spent inappropriately in controlling concentrations of non-pollutants.

Overall, the nutrient section of the NRDC "BMP" report discusses a number of potential nutrient management programs. However, this report is significantly deficient in addressing the most important issues in nutrient management – namely, a clear, explicit definition of the purpose of nutrient management, on a fairly site-specific basis. Nutrients cause problems in waterbodies at specific locations downstream of the discharge point. As discussed by Lee and Jones-Lee, these problems are highly dependent on the characteristics of the receiving waters. Nutrient reduction, just to have nutrient reduction, is not a technically valid approach. The implementation plan for nutrient reduction must be properly mated to receiving water characteristics, and the desired goal. Once this is done, then appropriate management practices can be implemented to achieve that goal. It should also be noted, as discussed by Lee and Jones-Lee (2002a), that nutrient reduction, *per se*, can be strongly contrary to the aquatic life resources of a waterbody, since these resources and fish production are dependent on nutrients. Reducing nutrients can be detrimental to the waterbody's aquatic life-related beneficial uses.

Page 39, second paragraph states,

> *"In addition, sediment often carries with it potentially harmful pollutants such as phosphorous and nitrogen, certain pesticides, and minerals. When normal biological processes degrade the organic material in sediment deposited in water bodies, these pollutants can be released and lead to impairment of ecosystem function. Dredging or major storm events and flooding can greatly increase the rate of biologically degradation of sediment, leading to spikes in the release of nutrients and pollutants that were once immobile and largely inaccessible to organisms within aquatic ecosystems."*

There are a number of statements in this quote that are incorrect. As discussed above, and as is well known in the aquatic chemistry literature, particulate adsorbed potential pollutants – such as nutrients, pesticides – often are not available to be adverse to aquatic life. Lee and Jones-Lee (2002a) discuss this issue, pointing out that the US EPA (1995), after about a 20-year delay, finally adopted this approach for addressing heavy metals. Exactly the same situation applies for many other potential pollutants.

The statement about dredging causing releases of nutrients and other pollutants reflects a lack of familiarity with the dredging literature. During the 1970s I conducted over $1 million in research on behalf of the US Army Corps of Engineers, devoted to investigating about 100 sites across the US, for the purpose of examining the release of contaminants from dredged sediments upon their suspension in the water column. Thirty parameters were measured, including a suite of heavy metals, a suite of organochlorine pesticides and PCBs, nutrients, and several other potential pollutants. As reported by Lee and Jones-Lee (2000), this study found that there were only two constituents released. These were ammonia and manganese. The organochlorine pesticides, PCBs, heavy metals, other forms of nutrients, etc., were not released. The focus of the above-quoted paragraph is on organic materials in sediments. Many of the potential pollutants present in sediments, especially those that are derived from agricultural lands, are associated with inorganic particles, where there is no degradation of the particle possible. Also, much of even the organic particles that are present in agricultural runoff are refractory, and do not degrade to any significant extent.

Page 40 contains a discussion on approaches that have been used in west Stanislaus County to help growers control erosion. No mention is made, however, in the NRDC report of the use of polyacrylamide (PAM) as a means of accomplishing erosion control. These issues are discussed by Lee and Jones-Lee (2002a).

Page 44 states,

> *"For example, the Yolo County Resource Conservation District evaluated the efficacy of winter cover cropping, sediment traps and tailwater ponds for tomatoes to reduced sediment losses and improve water quality from runoff."*

The NRDC report, however, does not discuss the fact that, while there was sediment trapping under certain conditions, there was also significant sediment release from these traps. At this point, the development of such sediment traps is being investigated, in order to prevent the release situation.

On the bottom of page 44, reference 141 cites a US EPA publication, "National Management Measures to Control Nonpoint Source Pollution from Agriculture (Draft)," with a date of August 2000. The US EPA finalized that document this past fall. Lee and Jones-Lee have provided information from the final document in their management measures report. There are some differences between the draft document and the final version of the US EPA report.

On page 45 of the NRDC report, there is another statement about how vegetative buffer strips can trap particulate pesticides:

> *"NRCS has reviewed the efficacy of vegetative buffer strips for trapping pesticides in runoff water. The agency concludes that that a variety of buffer strips have worked well to trap a wide range of pesticides in many states and crops and frequently found that vegetative buffers trapped 50% or more of the pesticides in runoff. In some studies, up to 100% of the pesticide was trapped in by the buffer strip."*

Again, as discussed by Lee and Jones-Lee, it is important to evaluate, on a site-specific basis, under the variety of climatic and flow regimes, where there is interest in controlling toxic-available forms of pesticides in runoff from agricultural lands, whether vegetative buffer strips are effective in achieving the management goal. As discussed by NRDC, vegetative buffer strips often take crop land out of production. They will need water to maintain the vegetation. Also, many of the particulate constituents that are removed are in nontoxic and non-available forms.

Overall

NRDC is to be complimented on its conducting this literature review on Central Valley irrigated agriculture potential water quality management practices. Overall, this report is a valuable addition to the literature in its providing specific examples of agricultural water quality management practices that could and should be evaluated in the Central Valley agricultural setting. Some of the references in the NRDC report had also been provided by Lee and Jones-Lee (2002a). NRDC has provided some examples of potential management practices that were not mentioned in the Lee and Jones-Lee report.

The NRDC report, however, failed to properly present the course of action that should be followed from the current state of knowledge and experience to develop a technically valid, cost-effective approach for managing real, significant pollutants in stormwater runoff and irrigation tailwater/subsurface drain water discharges. It is inappropriate to recommend, as NRDC has done, that farmers immediately implement one or more of these management practices. As discussed by Lee and Jones-Lee (2002a), the current state of knowledge on the efficacy and cost of potential water quality management practices is such that there is need for a comprehensive, systematic evaluation of practices that may improve water quality, to determine which practice(s) should be implemented to achieve the desired water quality management goals in a cost-effective manner.

The specific comments provided above focus on those technical areas in which the author, Dr. G. Fred Lee, has specific expertise, with particular reference to those statements made in the NRDC report that are either not in accord with, or do not adequately cover, the information available on the topic. It is expected that others familiar with a number of the topics covered in the NRDC report will be providing additional comments.

References

Benbrook, C.; Kaplan, J.; Solomon, G. and Chan, E., "A Review of Available Best Management Practices for Reducing Agricultural Discharges to Waterways in California's Central Valley," National Resources Defense Council, December (2002).

CVRWQCB, "Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands," Resolution No. R5-2002-0201, Central Valley Regional Water Quality Control Board, Sacramento, CA, December (2002).

Jones-Lee, A. and Lee, G. F., "Evaluation Monitoring as an Alternative to Conventional Water Quality Monitoring for Water Quality Characterization/Management," Proc. of the NWQMC National Conference "Monitoring: Critical Foundations to Protect Our Waters," US Environmental Protection Agency, Washington, D.C., pp. 499-512, (1998).

Jones-Lee, A. and Lee, G. F. , "Proactive Approach for Managing Pesticide-Caused Aquatic Life Toxicity," Report of G. Fred Lee & Associates, El Macero , CA, October (2000).

Lee, G. F.; Jones, R. A. and Rast, W. (1980), "Availability of Phosphorus to Phytoplankton and its Implication for Phosphorus Management Strategies," In: *Phosphorus Management Strategies for Lakes*, Ann Arbor Press, Ann Arbor, MI, pp 259-308.

Lee, G. F. and Jones-Lee, A., "Water Quality Aspects of Dredging and Dredged Sediment Disposal," In: Handbook of Dredging Engineering, Second Edition, McGraw Hill, pp. 14-1 to 14-42 (2000).

Lee, G. F. and Jones-Lee, A., "Review of Management Practices for Controlling the Water Quality Impacts of Potential Pollutants in Irrigated Agriculture Stormwater Runoff and Tailwater Discharges," California Water Institute Report TP 02-05 to California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 128 pp, California State University Fresno, Fresno, CA, December (2002a).

Lee, G. F. and Jones-Lee, A., "Issues in Developing a Water Quality Monitoring Program for Evaluation of the Water Quality - Beneficial Use Impacts of Stormwater Runoff and Irrigation Water Discharges from Irrigated Agriculture in the Central Valley, CA," California Water Institute Report TP 02-07 to the California Water Resources Control Board/ Central Valley Regional Water Quality Control Board, 157 pp, California State University Fresno, Fresno, CA, December (2002b).

Lee, G. F., Taylor, S., and County of Orange Public Facilities and Resources Department, "Upper Newport Bay Water Quality Enhancement Project, Final Report," Agreement Nos. 8-023-258-0 and 8-174-250-0, submitted to State Water Resources Control Board, Santa Ana Regional Water Quality Control Board and Orange County Public Facilities and Resources Department to meet the requirements of the US EPA 319(h) Project, G. Fred Lee & Associates, El Macero, CA and RBF Consulting, Irvine, CA, May (2001).

NRDC (2002). See Benbrook, *et al*. (2002).

Sharpley, A. N. (ed), Agricultural and Phosphorus Management - The Chesapeake Bay, CRC Press, Boca Raton, FL (2000).

Siepmann, S. and Finlayson, B., "Water Quality Criteria for Diazinon and Chlorpyrifos," California Department of Fish and Game, Administrative Report 00-3, Rancho Cordova, CA (2000).

US EPA, "Stay of Federal Water Quality Criteria for Metals; Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance—Revision of Metals Criteria; Final Rules," US Environmental Protection Agency, *Federal Register*, 60(86):22228-22237 (1995).

US EPA, "National Management Measures for the Control of Nonpoint Pollution from Agriculture," Nonpoint Source Control Branch, Office of Water, US Environmental Protection Agency, Washington, D.C. (2002). http://www.epa.gov/owow/nps/agmm