DIOXIN IN THE BAY ENVIRONMENT—A REVIEW OF THE ENVIRONMENTAL CONCERNS, REGULATORY HISTORY, CURRENT STATUS, AND POSSIBLE REGULATORY OPTIONS

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Presented to the

California Regional Water Quality Control Board
San Francisco Bay Region

on

February 1998

INTRODUCTION

Staff is seeking direction from the Board on appropriate actions to address the dioxin problem in the Bay. This report provides general background information about dioxins[1], staff's current understanding of the problem, and options for actions to address the problem.

This report summarizes much of the information that has previously been presented to the Board. One of the more significant events was a public workshop held by the Board on May 7, 1997, to receive technical information from experts recognized nationally in the field of dioxin policy and research. Following are several highlights from the workshop:

- There is general agreement that 2,3,7,8-tetrachlorinated dibenzo-p-dioxin (2,3,7,8-TCDD) is a highly toxic compound that can produce a variety of health effects in humans. Possible health effects include chloracne, developmental and reproductive effects, carcinogenesis, and immunosuppression. Formal criteria have not been adopted for other congeners, although a scheme for evaluating mixtures of congeners in comparison to the toxicity of 2,3,7,8-TCDD has been developed.

- Background or ambient levels of dioxins present in the environment are found at levels at or above those associated with human health concerns and potentially other organisms.

- U.S. EPA data show that dioxin releases to the environment have declined significantly in the last 15 years. Lake sediment cores collected by the U.S. EPA at various locations throughout the United States indicate that the concentration of dioxins in the environment appears to be decreasing. Additional data are required to see if this trend is significant and is continuing.

- Data on dioxins are relatively scarce because the analysis is very specialized and expensive.

- Human body-burden of dioxins in the United States is approaching the level where health affects may be observed. The primary pathway for dioxin exposure to humans is through dietary intake, not drinking water. For most of the population of the United States, this means that more than 90% of the dioxin exposure is from the consumption of meat and dairy products. This may not be representative for segments of the population that are dependent upon alternative sources of protein (i.e. subsistence fisher people).

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[1] There is group of compounds (coplanar polychlorinated biphenyls or PCBs) which are sometimes included in discussion of "dioxin" issues. These coplanar PCBs cause similar toxicities as dioxins, but their sources are different. Therefore, this paper addresses options for dioxins only.

- Because primary exposure to dioxin is through diet, decreasing *local* sources only may not have an impact on the body burden of dioxin for the general population in the Region.

- Sources of dioxins currently entering the environment in the Bay Area appear to be different than the national picture presented by U.S. EPA. However, both are primarily air borne sources.

- The fish tissue study (SFBRWQCB 1995) identified six chemicals or chemical groups that exceeded their respective screening values for fish tissue. These were mercury, polychlorinated biphenyls (PCBs), dieldrin, total chlordanes, total DDTs, and total dioxin/furans. However, the current fish consumption advisory is based on the quantitative risk calculated by a formal risk assessment including only mercury and PCBs.

- Concentrations of dioxins in fish from San Francisco Bay may represent a health threat to people that consume fish from the Bay. However, concentrations of dioxin within fish in the Bay Area are similar to the rest of the United States and may be representative of *background* or *ambient* conditions.

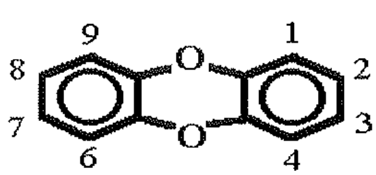
- Reductions in dioxin discharges have been demonstrated for medical waste incinerators through sorting and elimination of certain types of waste.

- Reduction in dioxin discharge for sources of direct discharge to water has been demonstrated to result in a reduction of dioxin in fish in the receiving waters. This reduction is limited by the presence of "ambient" levels of dioxin in the receiving water.

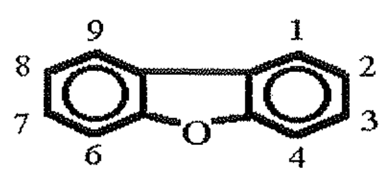
BACKGROUND

What are Dioxins?

The term "dioxin" or "dioxins" refers to a group of chlorinated compounds that share two common structures:



Dioxins



Furans

There are a total of 210 different compounds of dioxins and furans each with chlorine atoms at different locations on the structure. Those with chlorine atoms at the 2, 3, 7, and 8 positions are highly toxic, and there are seventeen of these compounds. They are called congeners of 2,3,7,8-tetrachlorinated dibenzo-p-dioxin.

The most toxic of the group is 2,3,7,8-tetrachlorinated dibenzo-p-dioxin (2,3,7,8-TCDD). This is also the most studied of the congeners. Generally, as the number of chlorine atoms increases, the toxicity decreases. Toxic effects include tumor promotion, wasting syndrome (loss of body mass), alteration of immune responses, and reproductive and developmental deficits.

Dioxins are very persistent in the environment. As the number of chlorine atoms increases, the persistence also increases. The only significant breakdown process for dioxins is degradation by sunlight or gaseous dioxins. Unfortunately, most of the dioxins in the environment are not in the gaseous phase, but are adsorbed on particles or dissolved in fatty tissue of organisms where the breakdown process is minimal.

What is TEQ?

Toxicity Equivalent or TEQ is a method that the U.S. EPA and other government agencies around the world have adopted to assess the toxicity of mixtures of dioxins and furans found in the environment. It is a weighted sum of the concentrations of the seventeen congeners using Toxicity Factors that reflect the toxicity of each congener relative to 2,3,7,8-TCDD (see Appendix A for additional discussion). The idea is to generate a single number to allow comparison of the toxicity of various mixtures of congeners at different concentrations. There is not total agreement regarding the toxicity of some congeners. Some scientists believe that certain congeners are less toxic than represented by the toxicity factors and others believe that these same compounds are more toxic than represented.

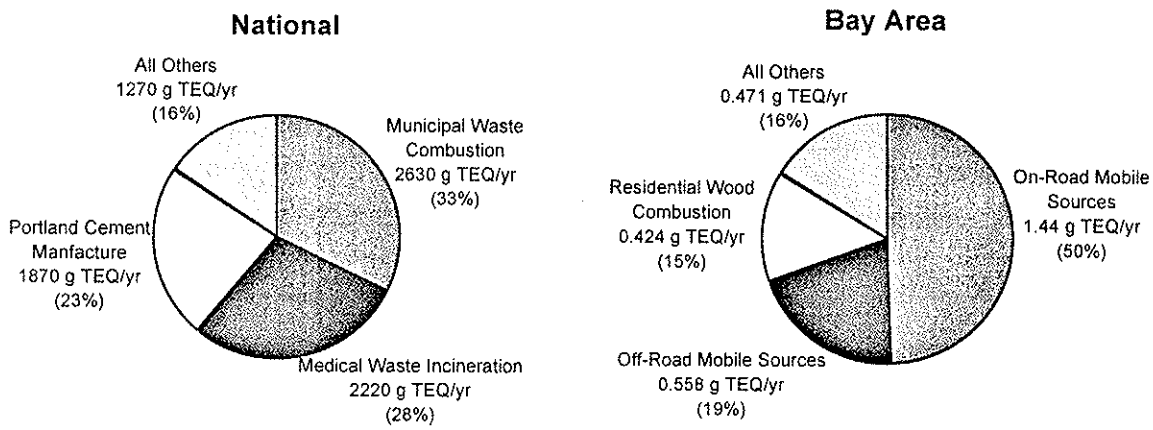
Where Do Dioxins Come From and Where Do They End Up?

Dioxins are not deliberately manufactured. Rather, they are unintentional byproducts of combustion and incineration. They are also byproducts generated from some chemical processes such as chlorine bleaching of wood pulp and paper, and chlorinated pesticide and chemical manufacturing. The primary source of dioxins from discharges directly to water is from pulp and paper mills.

The bulk of dioxins releases are to air, but much of this ultimately ends up in aquatic sediments. Sunlight degrades gaseous dioxins, but most dioxins quickly adsorb onto particles, thus inhibiting degradation. These dioxins eventually deposit on soil and surface water bodies. Storm water runoff carrying soil particles add dioxins to surface water systems. Additionally, because of dioxins' slow rate of decomposition, they can cycle from one media (air, water, soil, and animal tissue) to another.

Nationally, the primary air emission sources of dioxins are different than in the Bay Area (BAAQMD 1996). The following graphs illustrates the differences.

Dioxins Air Emission Inventories



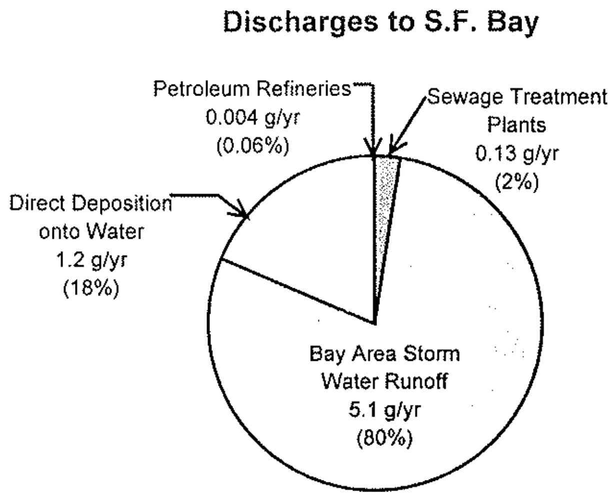
Dioxin discharges are generally higher in other parts of the country, chiefly due to more widespread use of waste incineration.

With the exception of areas near known point sources (paper and pulp mills, etc.), the principal contribution to water is through primary or secondary deposition from the air. Primary deposition involves dioxins falling directly on to water surfaces. Secondary deposition involves deposition on to the ground followed by soil erosion by runoff that carries contaminated particles into water.

Once in the aquatic food web, dioxins accumulate in the tissue of higher organisms like fish and birds. Dioxins also deposit on crops and vegetation that are eaten by livestock and other animals. U.S. EPA estimates that about 96% of human exposure to dioxins occur through ingestion of meat, dairy, and fish.

Sources of Wastewater Discharge to San Francisco Bay

The following graph shows our estimate of the mass contribution from direct discharges to the Bay. The categories shown are petroleum refineries and municipal wastewater discharges, and direct atmospheric deposition (primary deposition), and storm water runoff (secondary deposition). These estimates are preliminary and may change in regard to the primary and secondary deposition rates if new data become available. It should be noted that mass contribution from upstream of the Bay Area (central valley and the delta) are not included in the graph.



The following discussion explains our current understanding of the sources to each of the above categories of dioxin discharges.

For the largest categories of direct deposition and storm water runoff, we believe the sources are air emissions from disperse sources or from reservoir sources. Reservoir sources are historic releases that are still in the environment because of the persistence of dioxins. We suspect this because the concentrations and characteristics were similar throughout the region (SFBRWQCB 1997), independent of industrial activity. The current significant sources are on- and off-road mobile sources, and residential wood combustion (BAAQMD 1996). Dioxin is also present from historic discharges. These may include over 20 medical waste incinerators and other combustion sources that operated historically in the Bay Area. Currently, there are two sewage sludge incinerators (Central Contra Costa County Sanitary District and Palo Alto's sewage treatment plant) and one medical waste incinerator (Integrated Environmental Systems in Oakland) in the Bay Area.

For the sewage treatment plants, the sources may also be diffuse. Possible sources are laundry gray-water, storm water inflow, shower water, human waste, bleached toilet paper, food waste, and industrial sources. Of these, the predominant one appears to be laundry gray-water (EIP 1997). Dioxins in gray-water may come from pentachlorophenol treated cotton from overseas, chloranil-based dyes in the fabric, fabric bleaching, soil and human skin.

For the industrial category, the only documented source of dioxins in the Bay Area is from petroleum refineries. The specific source is the wash waters from catalyst regeneration of reformers. Further studies have shown that the refineries' treatment systems remove these dioxins to below detection limits prior to discharge (Tosco Corporation 1997). These studies also suggest that the dioxins that remain in the discharge are primarily due to storm water runoff from areas surrounding the refineries. This runoff is comparable to the urban runoff from areas far away from any refinery (SFBRWQCB 1997).

Dioxins Problem in San Francisco Bay

In December 1994, the Office of Environmental Health Hazard Assessment (OEHHA) issued an interim health advisory for consumption of fish from San Francisco Bay. OEHHA issued the advisory because of high concentrations of polychlorinated biphenyls and mercury found in the fish tissue during a recent study conducted by the Regional Board (SFBRWQCB 1995). The quantitative risk that was calculated for this data only included PCBs and mercury. This is not intended to indicate that mercury and PCBs were the only chemicals of concern identified by the study. All chemicals that exceeded the screening values are of concern; however, the quantitative risk due to PCBs and mercury is much greater than the other four chemicals.

Dioxins were also listed as a contaminant of concern because they exceeded the screening value used in the study. It is important to note that the dioxin concentrations found were within the range considered by the U.S. EPA as background based on a national study (U.S. EPA, 1992). The U. S. EPA uses a fish consumption rate of 6.5 grams of fish per day in evaluating potential risks related to fish consumption. The screening value established by Board staff was based on U.S. EPA guidance with a consumption rate adjusted to 30 grams of fish per day to be more representative of the Bay area. Fish consumption surveys in the Bay Area have indicated that some individuals may consume as much as 450 grams of Bay fish per day. Since the concentrations of dioxin detected from Bay fish are similar to concentrations detected nationally, this variation in consumption rate is one of the primary differences in risk estimates.

Board staff initiated the fish tissue contamination study. This is one of only two such studies completed in California. As follow up to the first fish tissue study, additional fish were collected in 1997 and we are awaiting analytical results. Currently, this is the only study in California that has been repeated. Additional collection is planned on a periodic basis. This is funded by all major Bay Area dischargers through the Regional Monitoring Program.

Also, a fish consumption study is underway to determine the degree of exposure of Bay Area residents who fish and consume fish from San Francisco Bay. The consumption study is being completed under contract by the Department of Health Services. Funding for this contract is also provided by dischargers through the Regional Monitoring Program. This will be a large-scale study and should provide more reasonable estimates of fish consumption rates of Bay fish. Board staff initiated and is actively involved in both projects.

Regional Board Regulatory History

The Regional Board began adopting dioxin limits in NPDES permits for point source discharges in 1992. The legal basis for inclusion of limits for dioxins in these permits is the narrative standard in the Basin Plan. The narrative prohibition, "All conservative toxic and deleterious substances, above those levels which can be achieved by a program acceptable to the Regional Board, to waters of the Basin" is the standard that is applied. The development of actual effluent limitations followed the procedure specified in the Basin Plan. This included the best professional judgment of Board staff that there was reasonable potential for exceedances of standards. Since there was concern regarding potential water quality problems in the receiving waters, staff acted in a protective manner, and included limits for dioxins. These water quality based effluent limits were developed based on available technical information.

The limits vary from facility to facility based on best professional judgment. However, the primary question in each case was whether to establish dioxin limits for 2,3,7,8-TCDD only or to establish a TEQ based limit for all of the dioxin congeners. In 1992, U.S. EPA had established criteria for 2,3,7,8-TCDD and the criteria document included a discussion of the use of toxicity equivalence factors and TEQ. However, U.S. EPA declined to promulgate TEQ standards in its 1992 National Toxic Rule. The California Ocean Plan, and the now invalid Enclosed Bays and Estuaries Plan established by the California State Water Resources Control Board, included TEQ limits for dioxin.

The first discharges regulated by the Regional Board were petroleum refineries. Catalytic reformers used as part of the oil refining process are a source of dioxins documented in the literature. Currently, all the refineries in the Bay Area have a limit of 0.14 picogram per liter (pg/l)[2] as TEQ. Only the Tosco Avon facility has violated this limit. The Pacific Refinery also recently violated its dioxin limit. Under the terms of the Cease and Desist Order issued by this Board in 1995, Tosco has further characterized dioxins in their discharge. Based on the data, staff has come to several conclusions:

- The mass of dioxins discharged from the Tosco Avon facility is less than the mass that would be discharged from a catchment area of approximate equal size anywhere in the Bay Area. This is based on estimates of average aerial deposition of dioxin and transport by storm water to surface water.

- The catalytic reformer does not appear to be a significant source of dioxins in the waste stream. This conclusion is based on comparison of the mass

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[2] 1 pg/l is approximately 1 part per quadrillion or ppq. One ppq is 1/1000ths of a part per trillion or ppt. One ppt is 1/1000ths of a part per billion or ppb.

discharge of dioxin and profiles of dioxins that were detected after a carbon unit was added to treat the reformer wash water.

Large municipal discharges also have dioxins permit limits. Nineteen out of forty-one sewage treatment plants, amounting to 87% of the sewage discharge to the Bay, are regulated with a limit for dioxins. The limits range from 0.01 to 120 pg/l as TEQ. Five out of the nineteen are not in compliance with their limit.

Several recent developments may have an impact on the future of dioxin regulation in this region and within California. First, the U.S. EPA published proposed standards for regulating toxic compounds in California, the California Toxics Rule (CTR), in August 1997. This rule proposed to promulgate standards only for 2,3,7,8-TCDD at 0.014 pg/l, like the National Toxics Rule. The State Water Resource Control Board published its draft Inland Surface Waters and Enclosed Bays and Estuaries Plan in September 1997. This plan is intended to be California's implementation of the CTR. Like the previous state plans, this plan proposes the use of TEQ for dioxins. It proposes limits on 2,3,7,8-TCDD only, but requires monitoring for TEQ and source investigations if the TEQ value exceeds the limit for 2,3,7,8-TCDD.

U.S. EPA has convened a Science Advisory Board (SAB) to provide a scientific review and critique of scientific documents pertaining to dioxin. The SAB is continuing its evaluation of the existing criteria document and risk assessment documents for dioxin. However, controversy over the assessment and criteria development for congeners of dioxins other than 2,3,7,8-TCDD continues. Recent developments include:

- recognition by the World Health Organization (WHO) and U.S. EPA that other forms of dioxin, along with 2,3,7,8-TCDD, are carcinogens.
- proposal of revised toxicity factors used to calculating TEQs for dioxins by the WHO, and
- proposal of toxicity factors for co-planar polychlorinated biphenyls (PCBs) for wildlife by the U.S. EPA. Co-planar PCBs are a subset of total PCBs and exhibit similar toxicity effects as dioxins.

Detection Limits

The detection limits from commercially available analytical methods are not low enough to assure compliance with effluent limits based on U.S. EPA criteria. These criteria are 0.014 pg/l for salt water and 0.013 pg/l for fresh water, and are for the most toxic of the seventeen congeners: 2,3,7,8-TCDD. U.S. EPA recognizes 10 pg/l as the standard detection limit achievable by most commercial analytical laboratories for 2,3,7,8-TCDD. This 10 pg/l is significantly greater than the water quality criteria for 2,3,7,8-TCDD. This creates a problem when determining compliance with an effluent limit set based on the criteria for 2,3,7,8-TCDD or for any of the other congeners.

Currently, we assume a value of zero when a congener is below detection. Different conventions can be used such as assuming the value is at the limit of detection, or one half the detection limit. These are all commonly acceptable approaches for studies. However, for permit compliance determination, we believe using zero is the most defensible approach at this time.

Methods are available to improve analytical sensitivity. These involve concentrating a larger volume of the sample onto a solid absorbent and extracting the dioxins from the absorbent before analysis. Researchers have used these methods successfully on relatively clean environmental samples, but these methods have not been used on effluent samples which may be considerably more complex chemically. Data validation would be necessary before using these methods for compliance determination.

Current detection limits have already shown that dioxins are a widespread problem. Improved detection limits are not likely to change our overall understanding of the problem, but it will be useful for assuring permit compliance.

ACTIONS TAKEN OR IN PROGRESS

In addition to the regulatory action taken on discharges from petroleum refineries and sewage treatment plants, we have taken steps in response to the health advisory on consumption of fish from the Bay. Warning signs, in multiple languages, are posted at fishing piers throughout the Bay Area. We helped prepare and distribute brochures describing preparation methods for seafood that will minimize exposure to contaminants. We are also working in conjunction with other State and Federal agencies to prepare an educational program regarding consumption of seafood from the Bay.

Staff has played a large part in collecting data from storm water and some specific industrial discharges to help try to understand the problem. Staff has analyzed this data and data from treatment plants within the Region. A study of air deposition of a number of compounds, including dioxins, was included in the Regional Monitoring Program, but is not yet complete. This study will include the deployment of specialized sampling equipment to provide more accurate measurements of the rate of air deposition of selected compounds, including dioxins.

Additional fish tissue has been collected and is undergoing chemical analysis. Future studies will also include shellfish and crabs. It is probable that tissue samples of Bay organisms will be collected on a recurring basis. A consumption study is also in progress to determine relative levels of consumption of seafood from within the Bay. Several studies are underway in California to obtain data on the body burden of dioxins in local human populations.

ISSUES AND OPTIONS FOR FUTURE ACTION

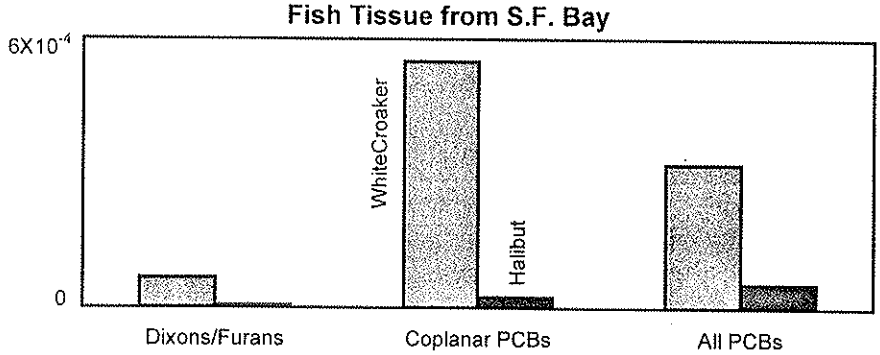
Issues

There are two related issues before the Board: 1) what is the relative magnitude of the problem with dioxins levels in the Bay? and based on this assessment, 2) which of a number of possible actions seem worthwhile in terms of effectiveness and resources available. An understanding of the magnitude of the dioxin problem relative to other areas and to other problems in the Bay is necessary to make decisions about what are appropriate actions to address the problem.

Relative to other areas, our fish data show that the fish in the Bay are within national background levels. Background levels are defined as areas with no known discharge sources. Based on U.S. EPA's assessment, background levels in the environment are at or approaching levels which may cause human health effects. So for people in the Bay Area who consume fish at rates greater than what the U.S. EPA considers to be average, these people may be at greater risk.

Relative to other problems in the Bay, the fish tissue data show that the health risks from polychlorinated biphenyls (PCBs) are substantially higher than from dioxins (Pollock 1997). This is shown in the following graph.

Significantly Higher Cancer Risk from PCBs in Fish Tissue from S.F. Bay



The graph also shows the risk due to a subset of PCBs, called coplanar PCBs or dioxin-like PCBs which, because of their chemical structure, exhibit toxicity effects similar to dioxins. It should be noted that although these compounds exhibit similar toxicity effects, the generation sources of coplanar PCBs are different than for dioxins and furans.

Options

The remainder of this section contains different options for Board consideration. The actions are summarized in two categories: actions to improve understanding of the problem, and actions that might reduce discharge to the Bay. Following each option is a short discussion of the action's purpose or possible effects, and the positive and negative points.

There is possibly a third category of action that might assist with risk reduction and risk management for exposed populations. One example is to educate and assist people on alternative food sources. These types of actions would require participation by numerous other agencies involved in human health protection and improvement.

Several presumptions are embedded in the options outlined below: the Regional Board does not have the ability to change the criteria adopted by U.S. EPA; and the Regional Board must include limits in NPDES permits for pollutants that have a reasonable potential to exceed water quality criteria.

A. Actions to improve understanding of the problem

1a. Action – Implement a dioxin limit for just 2,3,7,8-TCDD for all point source dischargers, such as petroleum refineries and sewage treatment plants. Require these dischargers to continue monitoring for all other dioxin and furan congeners. If detected levels expressed as TEQ are greater than the permit limit for 2,3,7,8-TCDD, require the discharger to conduct source audits.

Purpose – The monitoring aspect of this action will confirm and refine staff's current assessment with respect to the importance of local wastewater discharge sources relative to observed environmental levels. This will result in elimination of effluent limits for the other sixteen congeners of dioxins and furans in NPDES permits. Based on current data, assuming non-detects are zero, all point sources would be in compliance with a limit for 2,3,7,8-TCDD.

Positive – This is similar to the approach proposed in the draft Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California so no new policy would have to be established by the Board. Also, if lower detection limits methods are developed, the source audits would allow identification of actual sources that could be controlled.

Negative – This action will provide additional information on potentially less than 5% of the total dioxins currently discharged into the Bay. This may have large monetary impacts on publicly owned treatment works because dioxins analyses are expensive and currently available in only five commercial laboratories in the country. Also, unless alternative analytical methods with lower detection limits are developed, it will be difficult to separate any contribution from these point sources from impacts of air borne sources. There may be legal obstacles with changing existing permit limits for dioxins expressed as TEQs to just 2,3,7,8-TCDD.

1b. Action - Similar to 1a but implement a dioxin limit for just major point source dischargers, and require source audits only when the dioxins detected have different profiles from the profiles found in the storm runoff throughout the region.

Purpose: Similar to 1a. This option would address only major dischargers who comprise of about 99% of the total discharge flow volume from point sources to the Bay. Additionally, this option would eliminate concern regarding permit compliance when the source is not process related but from other unrelated air sources.

Positive: Similar to 1a but is refined slightly to focus on just major dischargers and circumvent the influence from atmospheric sources that are beyond the direct control of our dischargers.

Negative: Similar to 1a, but would affect just the major dischargers who may be more able to bear the costs involved.

1c. Action: Similar to 1a, but implement a limit for 2,3,7,8-TCDD for only those dischargers who discharge wastewaters from known dioxins generation sources. These include petroleum refineries, and sewage treatment plants with sludge incinerators or industrial users who are known dioxin generators. Known generation sources will be based on the information available in the literature. Unlike Option 1a, these dischargers will be required to determine whether all reasonable controls are in place for their dioxin generation sources, irrespective of whether these sources are contributing to exceedance of the effluent limit. If the discharger is above the dioxin limit using TEQ values, the discharger will be required to implement other programs aimed at reducing dioxins in the discharge. These programs may include public education about what individuals can do to minimize dioxins in the environment. Compliance with the limit will be measured by the concentration in the discharge and by the discharger's diligence in pursuing reasonable control measures.

Purpose: This option is designed to focus on just those sources that are controllable by the discharger.

Positive: Focusing on generation sources is a more efficient expenditure of resources. Also, the requirement for reasonable control measures at the source minimizes the need to lower detection limits. One of the concerns with current detection limits is the fear that there are discharges occurring above the effluent limit that go undetected. This concern is minimized if the dioxin sources are controlled at the source and not simply diluted by other wastewaters to the point where it is below the detection limit.

Negative: In addition to those listed for 1a, it is possible that some generation sources will not be regulated. This can happen if an incomplete literature search is conducted or because some sources are not currently documented in the literature. Also, there are currently no guidelines or consensus regarding reasonable source control measures.

1d. Action -- No new action. Continue to impose dioxins limits as TEQ in permits as they come up for reissuance or new issuance. Continue to enforce permit limit violations and required source audits for these violations.

Purpose - This option fully utilizes the regulatory authority of the Board under the current permitting program.

Positive - The Board would not need to set a new policy.

Negative - Similar to 1a, source audits would be economically burdensome for many dischargers. Additionally, based on current data, about 9 out of 25 dischargers would be unable to consistently comply with the limit as TEQ. The Board has enforced against one of these dischargers and may enforce against another in the near future. Because permit exceedances may be caused by diffuse sources, compliance with the limit would required substantial upgrading of the end-of-pipe treatment systems for removal of solids, possibly costing on the order of $10's of million per facility. Control of these discharges would impact less than 5% of the dioxins load to the Bay. Another draw back is additional Board staff resources that would be diverted from other problems to pursue enforcement items.

2. Action – Require all storm water runoff and non-point source discharges to monitor for dioxins.

Purpose - Based on current data and staff interpretation of that data, the primary source of dioxins is mobile and stationary combustion sources. While the absolute magnitude of this contribution may be questioned, staff believes that regardless of the total, this source still represents the primary ongoing source of dioxins to surface water. This occurs both as direct deposition from air and through secondary transport of dioxin attached to material, such as sediment, that enters surface water as runoff. As with most diffuse sources, this is very difficult to control. The purpose of this action would be to more accurately quantify the contribution of dioxins to the Bay from secondary sources.

Positive – This would be easy to implement since existing permits require that storm water dischargers monitor for chemicals of concern. We can administratively add dioxins to the list of chemicals of concern.

Negative - This action would have a significant monetary impact on dischargers, particularly those small facilities regulated under general permits for non-point or storm water discharges. Detection limits would be a concern similar to the point source dischargers. While this would provide more accurate data, it would not necessarily result in any reduction of dioxin discharge since the majority of discharges do not represent generators of dioxin, only conveyors of dioxins from other sources.

3. Action - Require all dischargers to begin a study to develop and evaluate methods for obtaining lower detection limits for dioxins in water.

   Purpose - No method currently available will provide detection limits near the effluent limit (0.14 pg/l) that is currently most commonly applied in permits within the region. The U.S. EPA has selected a practical quantification limit of 10 pg/l for dioxin based on the standard method. Once completed, this would provide more precise information about the mass of dioxins entering the Bay and the individual congeners.

   Positive - This would provide information on congeners of dioxin that may be present below the current detection limits. This would provide a more accurate method of determining permit compliance.

   Negative - Estimated cost for method development starts at $100,000. Method validation may require significantly more money. Method validation is necessary before any results can be used for compliance purposes. There is no guarantee that an improved method can be developed that will work for all matrices. Current cost of analysis for dioxins is about $1200 per sample and it is probable that the cost of an alternative analytical method would be higher. Also, the relative contribution of dioxin loading to the bay from different sources may not change significantly compared to our current estimates.

4. Action – Refine current understanding of risk by collecting data from blood or tissue of marine organisms at higher tropic levels in future sampling.

   Purpose - This would provide additional information on possible bioaccumulation effects up the food chain and a possible surrogate for data from the human population.

   Positive – Data would provide a good estimate of the bioaccumulation potential. This may represent a worst case scenario since these organisms would have an extremely high consumption rate. Archived blood or tissue samples may already exist.

Negative – Sample collection from live organisms would require a special permit. Sample collection would require special equipment and expertise. The translation of the data to human receptors may be problematic.

5. Action: Establish a regional reasonable potential analysis to assess which category of discharge is having the most significant impact on dioxins in the Bay. This would be performed based on currently available data.

   Purpose: This would provide the legal vehicle for deleting dioxins limits from point source discharge permits which account for less than 5% of the total dioxin input to the Bay. This option would allow regional board staff to devote resources on options involving only storm water runoff discharges. These options include further monitoring and working with CalEPA to address the cross-media problem of dioxins.

   Positive: Devotes resources on the area that has the most impact to the Bay.

   Negative: The Board will have only indirect authority over any source reductions that are needed.

B. Actions to limit dioxin discharge to the environment

1. Action – Request that Cal/EPA direct its agencies to assess dioxin as a cross-media issue to identify sources of dioxin, the best potential control strategies, and impacts to public health and aquatic life.

   Purpose - This would help to identify sources that eventually enter storm water from the air and would provide better discrimination for potentially controllable sources.

   Positive – This would involve all of the appropriate agencies in identifying sources and formulating a cost effective control strategy. It would foster a cross media approach and help agency personnel to focus on the root causes of the problem.

   Negative – Resources for agency staffing and any contract dollars needed may be limited.

2. Action – Require treatment of all storm water to remove dioxin. This would probably require sediment removal from all storm water outfalls.

Purpose – This would limit the largest input of dioxins entering the waters of the Bay.

Positive – Permits in place could be modified to require this action. Responsible parties for most discharge points are known.

Negative – The technical and economic feasibility is questionable. Cost would potentially be in the range of $10's of millions for each creek. Sediment traps are the most probable control technology. Their effectiveness under high flow conditions is uncertain. Also, because of where they may have to be constructed (near the Bay rim), other considerations come into play such as availability of space or augmentation of existing wetlands to accomodate the extra flow. Finally, treating storm runoff would not address dioxins which deposit directly onto surface waters, or that flow into the Bay from the central valley.

3. Action - Require reasonable control of known dioxin generation sources to point source discharges (See option A.1.c.), or control of all wastewater discharges above permit limits for TEQ (option A.1.d.).

References

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Appendix A

Dioxin Toxicity Equivalence

As stated above, 2,3,7,8-TCDD is the most widely studied of the forms of dioxin. This is also the most toxic of the dioxin compounds. Consequently, standards for the discharge to water have been established for 2,3,7,8-TCDD. Standards have not been established for the other congeners. The use of toxicity equivalence factors (TEFs) to calculate a TEQ is one method to assess the toxicity of mixtures of dioxins and furans.

Toxicologists establish a TEF for each congener. For many of the congeners, the TEFs are often based on very limited toxicological data. The establishment of these TEFs is a source of open debate within the toxicology community. The U.S. EPA and the World Health Organization have each adopted this approach for risk assessment, though each organization uses different TEF values for some congeners. The key point is that most of the controversy surrounds the TEFs for OCDD and HpCDD. These congeners are the most commonly detected and usually detected at the highest concentration in our samples of storm water, sewage effluent and refinery effluents.

For a given sample the concentration of each congener is multiplied by the TEF for that congener, with the TEF for 2,3,7,8-TCDD being one. These TEF values are then summed to equal the TEQ for that sample. The concept is that the TEQ represents the toxicity of the mixture as if only 2,3,7,8-TCDD had been detected. A calculation example is shown in the table below. This is the calculation of TEQ for a storm water sample from the Bay Area. For this calculation, congeners that are not detected (ND) are assigned a value of zero.

Several points about this example are of note:

- This is typical of samples of storm water from the Bay Area.
- 2,3,7,8-TCDD is not detected.
- The dominant congeners detected are OCDD and HpCDD the least toxic congeners.
- Assuming that the TEQ limit of 0.014 pg/L was applicable, this sample would represent an instance of non-compliance.
- If the limit for this sample had been based solely on 2,3,7,8-TCDD, not TEQ for dioxins, it would have been in compliance.

CONGENER	Toxicity Equivalence Factor	Concentration (pg/l)	Detection Limit	TEQ
2,3,7,8-TCDD	1	ND	0.9	0
Total TCDD		ND	0.9	
1,2,3,7,8-PeCDD	0.5	ND	2.5	0
Total PeCDD		ND	2.5	
1,2,3,4,7,8-HxCDD	0.1	4.5		0.45
1,2,3,6,7,8-HxCDD	0.1	14		1.4
1,2,3,7,8,9-HxCDD	0.1	9.4		0.94
Total HxCDD		75		
1,2,3,4,6,7,8-HpCDD	0.01	230		2.3
Total HpCDD		420		
OCDD	0.001	1700		1.7
2,3,7,8-TCDF	0.1	1.2		0.12
Total TCDF		17		
1,2,3,7,8-PeCDF	0.05	1.8		0.09
2,3,4,7,8-PeCDF	0.5	3.2		1.6
Total PeCDF		60		
1,2,3,4,7,8-HxCDF	0.1	3.8		0.38
1,2,3,6,7,8-HxCDF	0.1	5.3		0.53
2,3,4,6,7,8-HxCDF	0.1	6.4		0.64
1,2,3,7,8,9-HxCDF	0.1	ND	0.98	0
Total HxCDF		75		
1,2,3,4,6,7,8-HpCDF	0.01	46		0.46
1,2,3,4,7,8,9-HpCDF	0.01	2.4		0.02
Total HpCDF		110		
OCDF	0.001	88		0.09
SUM OF 2,3,7,8-TCDD Toxicity Equivalents			11	

Toxicity equivalence factors and TEQ were developed for the evaluation and comparison of mixtures of congeners. Most samples from the storm water study (RWQCB 1997) are dominated by two congeners of dioxin. In this case, where a mixture is limited, the use of TEQ may not be an appropriate measure of compliance.