

August 31, 1999

Mr. Dan Eaton, Chair
Mr. Steven R. Jones
Ms. Linda Moulton-Patterson
Mr. Daniel G. Pennington
Mr. David A. Roberti
California Integrated Waste Management Board
8800 Cal Center Drive
Sacramento, CA 95826

Dear Board Members:

I have reviewed drafts of the Board's recent report, *California Waste Tire Program: Evaluation and Recommendations [In Response to AB 117 (Escutia)]* (hereinafter referred to as the Report) and I am submitting detailed comments. I was aided in this endeavor by Robert A. McBride, post-graduate researcher at UC Davis. My comments are organized in two parts – first, the main points of my assessment, followed by attachments containing related documents cited in the main section of comments. If you would like me to elaborate on any of these comments, I may be reached by phone at (530) 752-3276 or by e-mail at: sischwartz@ucdavis.edu.

Sincerely,

Seymour I. Schwartz
Professor, Environmental Science
and Policy

cc: Sen. Tom Hayden, Chair, Senate Natural Resources Committee
Sen. Byron Sher, Chair, Senate Environmental Quality Committee
Sen. Wesley Chesbro, Senate Environmental Quality Committee
Sen. Debra Bowen, Senate Natural Resources Committee
Assemblywoman Hannah-Beth Jackson, Chair, Environmental Safety

and Toxic Materials Committee
Assemblyman Martin Gallegos, Chair, Health Committee
Assemblywoman Helen Thomson, Health Committee
Valerie Shulman, Secretary General, European Tire Recycling Association
Richard Toshiyuki Drury, Communities for A Better Environment
Bonnie Holmes, Sierra Club
Leslie Fowler, West Valley Citizens Air Watch
Leslie Byster, Silicon Valley Toxics Coalition
Johanna Wald, NRDC

**Review of the California Integrated Waste Management Board's Report:
California Waste Tire Program: Evaluation and Recommendations
*[In Response to AB 117 (Escutia)]*¹**

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Although many of the Report's recommendations are worthy of support, the Report presents no coherent or comprehensive approach to waste tire management for the long term. The Report is devoid of a vision of a future (10 to 20 years hence) that does not depend upon burning vastly greater numbers of tires as fuel (TDF) – a method that is inferior in terms of economics, energy efficiency, and health consequences.

1. The Board's vision of the future lacks vision

The Board's consultant, VITETTA, found that the Board lacks a long-term strategic plan (CIWMB, 1999; p. 27). The Report reveals more than this. It reveals that the Board has not thought about a future of waste tire management more than five years hence, and that it cannot envision a future in which source reduction and recycling – the top two levels of the waste management hierarchy – are the dominant methods for solving the tire problem. Instead, the Report's text and the graph **Current Market Status** (CIWMB, 1999; p. 51) demonstrate that the Board's short-term plan is to rely almost entirely on the combustion of waste tires (TDF) -- the next to the lowest level of the hierarchy -- by promoting an increase in this use from 10.6 million tires in 1997 to about 22 million per year within five years (CIWMB, 1999; p. 56). The Board's nearly total reliance on combustion (TDF) is disturbing in view of the potential health and environmental hazards of TDF, and its low economic value and low energy efficiency relative to recycling scrap tires into rubber products.²

The **Current Market Status** graph shows that the Board expects the "potential" annual number of tires going to cogeneration of electricity to increase from zero today to more than 10 million per year in five years, and expects the number of tires burned by the MELP waste-energy facility and by cement kilns to increase by about 2-3 million per year, for a total increase in TDF of about 12 million tires per year. In contrast to this enormous increase in the use of TDF, the Board expects modest increases in the number of tires used for RAC (from 2.1 million tires per year to 5.7 million per year), and for engineering uses of tire chips (from 1 million tires recycled to 4 million). It expects no increase in the number of tires recycled into consumer products (steady at 1 million tires per year), which reflects a very pessimistic view of the prospects for truly beneficial forms of recycling and for technology such as devulcanization, which can bring about these forms of recycling.

2. The Report's argument in support of its TDF policy is flawed and deceptive

2.1. Burying in landfills or storing in monofills. The Report states: "In effect, the options currently facing us are to either dispose of most tires through controlled burning for energy recovery or burial in landfills" (CIWMB, 1999; p. 55). This wording is inaccurate and deceptive, as it ignores legally permitted monofills, which are recognized in state law (California Public Resources Code, section 42860 et. seq.) as appropriate interim measures until all tires can be recycled. The Report's wording also implies that such monofills are no different than municipal landfills or illegal tire piles. This view of monofills contradicts what the Board's 1992 report to the legislature³ said about shredding and monofilling tires: "***Shredding reduces the volume and eliminates other problems associated with landfilling and storage***" and "***...shredding and monofilling tires is a method to safely store this valuable resource...***"⁴ (CIWMB, 1992; p. xiii; emphasis added). I add emphasis here because the Board's acknowledgment that shredded tires can be stored safely in monofills and that the stored tires are a valuable resource -- that is, they are recoverable -- undermines the Board's current argument that burning tires is their only acceptable option. Therefore, equating legal monofills with landfills or illegal tire piles is not only inaccurate, but it incorrectly eliminates monofills as an alternative to TDF.

My reading of state law (PRC section 42860 et. seq.) indicates that the legislature recognized the important distinction between a properly operated monofill storing shredded tires and either a landfill burying whole tires or an illegal tire pile. In fact, the law requires the Board to establish procedures for locating and permitting such monofills in every region of the state.

Properly managed monofills are a form of retrievable storage. Because monofills (retrievable storage) provide a resource that can be recycled, this method should be designated as a separate category in the waste management hierarchy and it should be placed higher in the hierarchy than energy recovery (TDF) and landfilling. Retrievable storage provides an essential component of a transitional strategy capable of bridging the gap between the present and a long-term future that features true recycling in an environmentally sound manner.

2.2. Dismissing concerns about environmental and health hazards from TDF. The Report's assertion that "Environmental concerns stem from on-going differences of opinion regarding the amount and types of emissions created by transformation and use of tire-derived fuel," (CIWMB, 1999; p.28) is incorrect. Emissions testing in cement kilns burning 20% waste tires instead of coal showed large percentage increases in many toxic pollutants.⁵ These data are a matter of record, not a matter of opinion. Differences of opinion do exist, however, about the hazard to human health posed by the increases of toxic pollutants and whether it is safe to use TDF in cement kilns and other facilities.

The Report claims "... that tires, in a properly run facility, generally burn cleaner than the coal fuel they usually displace"(CIWMB, 1999; p. 56). This assertion is inaccurate, even if "generally" is interpreted broadly. In my study for the Board (Schwartz, et.al., 1996), I found large percentage increases in some toxic compounds from all of the five emissions tests in California that I examined (these compounds were on the state's ***Toxic Hot Spots*** list).⁶ I also found that the Board's earlier claim that there was "***no appreciable difference in toxic air contaminant emissions***"⁷ as a result of burning waste tires ***cannot be supported by the test data*** contained in Appendix B (pages 71-72) of the Board's own 1992 report. I summarize the relevant data from the 1992 report in Attachment B of this review.

The present Report (CIWMB, 1999) states: " There are still environmental groups that express concern for the burning of tires and the current process of permitting such facilities is very rigorous"(p.

56). This sentence suggests that opponents of using TDF are misguided because emissions tests and a rigorous permit process, which involves formal risk assessment, assure that it is safe to burn tires. After examining the emission tests and the literature on health effects as part of my study (Schwartz, et.al., 1996; pp. II-45 to II-49), I concluded that there is sufficient reason to be concerned about the health hazards from burning tires as fuel in cement kilns.⁸ I recommended that the Board address these concerns by supporting research into methods for minimizing the toxic pollution generated by the use of TDF, and to establish technology and procedural requirements that implement the findings of such research. As those of you who were Board members at the time know, the Board asked me to remove the section summarizing emissions data and examining health risks from my final report, and did not accept my report after I refused to comply with their request.⁹ In response to my 1996 study and in the present Report, the Board has ignored suggestions that it attempt to minimize toxic pollution from the use of TDF.¹⁰

3. The Report ignores innovative technology that could produce dramatic long-term results

Promoting the development and adoption of innovative technology, particularly devulcanization, appears to offer tremendous long-term potential for recycling millions of tires per year, yet the Report is silent about such technology. Two processes for devulcanizing granulated tire rubber are currently available: the De-Link™ process, which uses chemicals commonly used in the rubber industry to break the sulfur bonds in the molecular structure,¹¹ and ultrasound, which may be more attractive to rubber compounders since it adds no new ingredients,¹² hence it does not affect quality; ultrasound devulcanization is also less expensive.¹³ Devulcanized rubber using the De-Link additive is already in commercial use, whereas ultrasound devulcanization has successfully produced rubber sheets but the method is still in a development stage.¹⁴

Economically, the market potential of devulcanized rubber should be strong because it is capable of replacing virgin rubber and polypropylene in high-value products at a recycled content of up to 40 percent.¹⁵ Thus, markets will come to it – to the high quality recycled rubber – rather than needing market development efforts to create or promote end uses that often must be subsidized. Natural rubber imports and polypropylene production are each multi-billion dollar components of the U. S. economy, suggesting that the market potential for substitute devulcanized tire rubber products is huge. Perhaps the most immediate uses for devulcanized rubber are in asphalt formulations and in passenger tires.¹⁶

4. Cleanup of existing tire piles, enforcement, and illegal disposal

Proposed enforcement efforts in cooperation with local governments to identify and remove illegal tire piles are a welcome initiative. As the Report notes, local governments can help to locate small or medium-sized piles, upon which the Board can then take enforcement action. However, as my research on enforcement of illegal disposal of hazardous waste indicates,¹⁷ enforcement actions are usually time consuming and expensive, so using legal tools to clean up small or medium-sized illegal piles would rapidly stretch the Board's resources in this program area.

The Report's proposal to make the manifest system more comprehensive could make enforcement more effective against illegal haulers and facility operators (storage), but it does not address the illegal disposal that results when buyers of replacement tires dispose illegally rather than pay the dealer a disposal fee.¹⁸ The Board's proposal of a \$2 per tire front-end fee will do nothing to prevent this sort of illegal disposal. A potentially effective method for preventing illegal disposal at the point of purchase is a *deposit-rebate system*. In outline form, a deposit is levied on a tire at the time of purchase (including at

purchase of a new car), and when the tire is turned in to a dealer at replacement, the buyer receives a rebate, which need not be as large as the deposit.¹⁹ At present, the tire dealer would take part of the rebate to cover the cost of disposal; if tires become more highly valued as a resource in the future, the disposal charge could disappear. In order to make the rebate more attractive as an incentive to dispose of the old tire legally, it might be better for the state to levy a fee on annual registration to raise revenue for the Tire Fund, rather than at the time of purchase.

Legacy piles and number of tires “on the ground.” Finding #2 (CIWMB, 1999; p. 25) focuses on the number of tires cleaned up from the “legacy piles” that existed at the time of legislation (1990). The Report (in Finding #2, p. 25) claims that the “**number of tires on the ground**” has been reduced from 45 million in 1990 to 15 million today, a 67% reduction.²⁰ However, Finding #9 (CIWMB, 1999; p. 27) raises the “16 million tire question” – where are the 16 million tires per year that are not put to “productive end use” going? The Report states that they must be going into monofills, landfills, or illegal piles. I added the annual number of tires listed in Table 3-4 as *stockpiled/landfilled* in years 1990 through 1997 and obtained a total of 115.2 million tires stockpiled or landfilled since 1990. But the Report claims that there are only 15 million tires on the ground in need of remediation. Where are the 115 million accounted for? Isn’t it true that many of them – certainly those disposed illegally – are in need of remediation? Even if the tires going into legal monofills are not counted as “on the ground” – a position that is reasonable if tires in monofills are considered in a new category of retrievable storage – the number disposed illegally since 1990 must have added millions of tires to the 15 million estimate. The Report’s focus on legacy piles also diverts attention away from the difficult problems caused by illegal disposal.

5. Rubberized asphalt concrete (RAC)

I agree with the Report that RAC “... is a technology of special interest because it has the potential of diverting a large volume of tires to a very beneficial end use” (CIWMB, 1999; p. 52). My research found that, despite its appeal, neither CalTrans nor local governments were using RAC at anywhere near its potential. Reasons for this shortfall are that the paving industry is generally opposed to RAC, and there were few firms in the industry qualified to use it. The opposition claimed that RAC was more difficult to apply than conventional asphalt, and that roads using it could fail early if the RAC were not applied properly. CalTrans confirmed that these claims are valid. Paving contractors also have an obvious economic reason for opposing longer-lived materials in roadways.

Mandating RAC use is a policy option for realizing its potential for recycling millions of tires per year in California. The federal Intermodal Surface Transportation Efficiency Act (ISTEA, 1991) contained a mandate for increasing use of RAC, but political opposition from the paving industry and state highway departments forced Congress to repeal this mandate in 1995. As the current Report notes (CIWMB, 1999; p. 52) the Rubber Pavements Association and CalTrans oppose mandating RAC use in California. An advocate of RAC I interviewed at CalTrans in 1995²¹ explained that highway departments oppose the mandate because their engineers consider themselves the experts on what materials should be used in pavements, and they object to having a specific additive mandated as the only acceptable one. Mr. Van Kirk said that his enthusiasm for RAC was based on its performance, but if another additive, for example, a polymer, proved to be better, he would favor the better additive. Thus, it is clear that efforts to mandate RAC use will encounter political opposition in California. There are also occupational health concerns arising from RAC use – paving workers have reported adverse reactions to fumes from the rubberized asphalt mix. These health concerns should be examined more fully to establish if the rubber additive is capable of causing serious health problems.

The Report's recommended goal for RAC use by CalTrans – a minimum of 40% by 2003 and beyond – is both optimistic in view of the political obstacles and pessimistic in terms of what is possible if, as the report says, "...they [CalTrans and the Rubber Pavements Association] believe that rubberized asphalt is a good product and should be accepted on its own merits" (CIWMB, 1999; p. 52). Of course, both of these organizations opposed to mandating RAC say it should be accepted on its merits, but they are using their political muscle to prevent that from happening.

The Report also devotes only one sentence to RAC use by local governments – stating that the goal is 4 million tons per year by the end of 2002.²² Because the potential for RAC use at the local level is even greater than at the state level, the Board should provide incentives and technical assistance to local governments to increase their use of RAC.

Recommendations 13 and 14, which direct other organizations to take action on RAC are reasonable, but they require little effort from the Board. The Board could promote RAC more vigorously by providing grants for training of contractors to use RAC properly, and offering grants to local governments to speed up their acceptance of RAC.

6. Source reduction

Source reduction is at the top of the waste management hierarchy, yet the Report devotes only a few brief paragraphs and one weak recommendation to this approach (CIWMB, 1999; p. 55). That recommendation would have the Board spend \$6 million per year on an information/education program to convince consumers to purchase long-lived replacement tires. This seems to be an extraordinarily ineffective way to spend an amount that is greater than the current Tire Fund and would be 15% of the "optimum" funding of \$40 million per year the Board hopes to obtain to fund all its waste tire programs.

Michelin and Yokohama already sell tires with a treadwear rating of 620, which translates to approximately 124,000 miles of expected use, and Goodyear sells a tire with a rating of 540 (approximately 108,000 miles) so there is no question about the necessary technology being available.²³ The only question is how to get the largest number of long-lived tires on vehicles as quickly as possible. Educating consumers to buy long-lived replacement tires at a premium price is the wrong answer. These tires must be installed on new cars as original equipment, so it will only be necessary to convince *or require* auto makers to install them. The extra cost relative to today's original equipment tires is small, probably less than \$100 per car – a relatively insignificant amount on the average \$20,000 price of a new car. Furthermore, the buyer does not see the cost of tires itemized, so the extra cost will not be a factor in the consumer's decision or cause a problem for the auto maker. Driving their new cars more than 100,000 miles on a single set of tires will be the best marketing device to convince vehicle owners to buy long-lived replacement tires.²⁴

I believe that state law should mandate that all new cars sold in California be equipped with tires that have a minimum treadwear rating of 500 (equivalent to 100,000 miles of expected wear). Surely, if the Board can make the case on public health grounds that it is necessary to burn 22 million tires per year as fuel (CIWMB, 1999; p. 56), it can make the case that new passenger vehicles be equipped with long-lived tires in order to reduce the negative health impacts of both uncontrolled fires and controlled burning using TDF.²⁵

7. A different vision of the future

My scenario for waste tire management in the future (10- 20 years hence) contains the following elements:

7.1. Long-lived tires, capable of more than 120,000 miles of use, as original equipment on new passenger vehicles, and as replacement tires for a large percentage of used vehicles. The widespread use of long-lived tires will dramatically reduce the number of waste tires generated, thus making it much easier to recycle the flow of new waste tires by environmentally and economically more desirable methods than using tires as fuel.

7.2. Innovative technology, most likely some form of devulcanization, will convert a large percentage of waste tires into a high quality rubber that will be used in new tires and a wide variety of other rubber products, as well as in RAC. Development of this technology constitutes a key element of my scenario. I believe that innovative technology will provide the means to use waste tire resources in economically and environmentally more beneficial ways than as fuel.

7.3. Recovery of shredded tire rubber from retrievable storage monofills. Devulcanization will create the demand for retrieving many millions of shredded tires, which will be stored in monofills during the transitional period (2000- 2020).

7.4. Granulated tire rubber, chips and shredded tires will be used in civil engineering projects and in low-value consumer products during the transitional period until higher-value uses take all of the supply of waste tires. Buyers of replacement tires who are unwilling to pay the premium for long-lived replacement tires will purchase more retreaded tires.

7.5. Tires will no longer be used as fuel as demand for higher-value, environmentally superior uses, will make tire rubber more valuable for those uses.

8. Comments on specific recommendations

I comment on some of the Report's recommendations and add several of my own at the end.

Recs #2 and #3: I support these recommendations.

Rec #4: Expanding the manifest system is appealing if it creates a deterrent to law breaking haulers and facility operators, which is likely if the Board uses the manifest data to improve enforcement. The Report correctly emphasizes the importance of enforcement in creating a level playing field; allowing illegal disposal to be widespread puts law abiding firms at a disadvantage to law breakers or those firms doing business with law breakers. However, a more comprehensive manifest system also has a downside -- there will be an enormous amount of additional paper and data generated, it will be expensive to process these data, and it may be difficult and expensive to use the data for enforcement. However, I think the potential benefits from improving enforcement or creating an effective deterrent to illegal disposal outweigh the negatives.

Recs #8 and #10: The rationale for making permitting easier for waste-energy facilities to store

tires, namely that there should be special consideration given to facilities using tires for fuel (p. 46), reflects the Board's position about favoring TDF but it is unrelated to any reasons for requiring storage facilities to have permits. It seems to me that the appropriate criterion is the degree of fire danger from storage of tire shreds. It is also irrelevant whether tire shreds at the facility burning tires are defined as feedstock or waste.

Rec #12: *Evaluating* whether a Northern California center for RAC is needed is a weak recommendation. Since the Southern California center is doing good things but serves a limited geographic area, its activities should be expanded to the northern part of the state.

Recs #13 and #14: It is useful to provide guidelines for RAC use, but stronger steps to promote RAC use are also necessary.

Recs #16, 17, 18: I support these efforts to promote the purchase of recycled rubber products among governmental and industry organizations.

Rec #19: As I note above, I don't believe it will be cost-effective to spend \$6 million per year on an information/education program to promote the desirability of purchasing long-wearing tires, and to inform the public about proper tire maintenance and disposal. A much greater payoff for source reduction by the use of long-lived tires can be obtained by requiring all tires sold on new vehicles in California to have a minimum treadwear rating of 500 (100,000 miles). A partnership with tire manufacturers with substantial funding for research to obtain higher recycled content in tires is a good idea if it can push recycled content beyond what tire manufacturers are already doing on their own. Michelin successfully tested tires with 10% recycled content several years ago and indicated in 1996 that they intended to push the recycled content to at least 20%.

Rec #20: In view of the Board's commitment to promoting TDF and my experience of the Board's rejection of my effort to summarize emissions data in my 1996 report, I am skeptical about the recommendation to "partner with interested industry segments to assist in examining environmental aspects (air emissions and ash characteristics) [from use of tires as fuel]."

Rec #21: I agree strongly that existing incentives to end users of waste tires should be discontinued.

My Recommendations

In addition to recommendations of the Report that I support, I offer the following recommendations:

- 1.** Propose to the legislature a bill requiring auto manufacturers to equip new passenger vehicles with tires that have a minimum treadwear rating of 500 (100,000 miles of expected use).
- 2.** Promote the development of innovative technologies for rubber recycling, particularly devulcanization, with much larger amounts of grant funds than the Board now offers; these grants should be large enough to help firms bring technologies that are promising at laboratory or R&D scale to commercial scale, and to speed adoption of these technologies.

3. Propose to the legislature a bill that: a). defines legally permitted monofills storing waste tire shreds or chips as *retrievable storage*; and, b). defines a new category for retrievable storage in the waste management hierarchy, placing it above energy recovery and landfilling. Doing so identifies this category as a potential resource and distinguishes it from old-style landfills and illegal piles. Designating retrievable storage as a new category in the waste management hierarchy will also enable the Board to receive credit for reducing landfilling by the amounts stored in retrievable storage.
4. Support research whose goal is to enhance the duration of storage and the quality of tire rubber to be retrieved from monofills.
5. Support research to identify procedures and technology for minimizing toxic emissions from burning tires as fuel, and establish regulations to implement desirable measures. This action is essential so long as large amounts of TDF are in use. Relatively simple operating changes may be able to reduce toxic emissions, and these methods should be required.
6. Offer grants for RAC research that study methods for enhancing the granulated rubber's effectiveness as an asphalt modifier, and the health effects on workers paving roads. Offer other grants to train paving contractors and workers in appropriate application methods, and to provide an incentive to local governments to use RAC.
7. Create a deposit-rebate system on tires to eliminate the illegal disposal that results from buyers of replacement tires being unwilling to pay a disposal fee to the tire dealer.
8. Sponsor a high-profile international technology competition with a large prize (at least \$1 million) for firms demonstrating technologies (not including combustion) capable of recycling a large percentage of the annual waste tire flow.

Notes

1. I refer to this report in the text at "the Report" and cite it as (CIWMB, 1999); page numbers cited are for the May 25, 1999 draft. The full citation for the report is: CIWMB, *California Waste Tire Program: Evaluation and Recommendations [In Response to AB 117 (Escutia)]*. Sacramento: California Integrated Waste Management Board, May 25, 1999 (draft); available on the Internet at: <www.ciwmb.ca.gov/tires/ab117rpt/>

2. Kurt Reschner comments that proponents of using tires as fuel (TDF) cite its energy content of approximately 13,000 - 14,000 BTU per pound of rubber burned as a benefit. However, they usually ignore the fact that it takes approximately 55,000 BTU to produce a pound of rubber and less than 1,000 BTU to convert a pound of waste tire rubber into good quality granulated (crumb) rubber (also referred to as GTR). Tom Faust states that it requires only 3,000 BTU to devulcanize a pound of ground rubber by the ultrasound method, thus yielding a form of rubber that can be used in new tires and other high-value rubber products. As Reschner puts the question, "Why 'recover' 13,000 BTU per pound of rubber in a cement kiln or power plant if one can preserve 54,000 BTUs by recycling" or save 52,000 BTUs by devulcanization, which creates the potential for higher-value products than are possible from granulated rubber that is not devulcanized. (See Reschner, *The Scrap Tire Recycling Page*, <www.inx.de/~kurtr/> February 26, 1998; data on devulcanization from Tom Faust, President, Redwood Rubber LLC., Corte Madera, CA;

personal communication, June 1998.) Reschner's economic analysis of the use of granulated tire rubber devulcanized by the De-Link™ process shows a 24% savings in cost, assuming a manufacturer uses 40% recycled content in its rubber compounds. Faust states that ultrasound is capable of producing devulcanized rubber at a substantially lower cost than De-Link, so the cost savings using ultrasound could be more than 30%. (See Kurt Reschner, "The Economics of Ground Tire Rubber in the Rubber Manufacturing Industry," *Scrap Tire News*, vol. 10, n.10, October 1996, pp. 12-14.) See Attachment A of this review for a discussion of potential environmental and health hazards from using TDF.

3. California Integrated Waste Management Board, *Tires as a Fuel Supplement: Feasibility Study*, Sacramento, CA, January 1992, p. xiii (Executive Summary).

4. The Board's 1992 report, *Tires as a Fuel Supplement*, also states that it is doubtful that the shredded tires in monofills would ever be economically recovered (p. xiii). Only time will tell whether that opinion is borne out by events.

5. For a summary of emissions from test burns, see Attachment A and the full report from which it is summarized: Schwartz, Seymour I., et al., *Domestic Markets for California's Used and Waste Tires*, Davis, CA: University of California, Davis, Department of Environmental Science and Policy, October 1996. To request a copy of the report, send e-mail to: sischwartz@ucdavis.edu.

6. See Schwartz, et al., *Domestic Markets for California's Used and Waste Tires*; summary of emissions data in Attachment A.

7. Data from the Board's 1992 report to the legislature *Tires as a Fuel Supplement: Feasibility Study*, pp. 71-72.

8. Schwartz et al., *Domestic Markets for California's Used and Waste Tires*. See Attachments A and C for a discussion of the flaws in risk assessment and reasons why claims that burning tires is safe cannot be supported on rigorous scientific grounds.

9. Attachment A of this review contains the section of my report (*Domestic Markets for California's Used and Waste Tires*) to which the Board objected.

10. Possibilities exist for greatly reducing toxic emissions from cement kilns burning TDF, both by using crumb rubber introduced at the hottest part of the kiln rather than introducing whole tires into a cooler part of the kiln, and by adding emission control devices.

11. Kurt Reschner, "The Economics of Ground Tire Rubber in the Rubber Manufacturing Industry," *Scrap Tire News*, vol. 10, n.10, October 1996, pp. 12-14). The De-Link process is a product of STI-K Polymers, Inc.

12. The ultrasound devulcanization process is licensed to Ultramer, Inc. of Masillon, Ohio.

13. Data from Tom Faust, personal communication, June 1998.

14. Tom Faust (personal communication, June, 1998) reports having successfully devulcanized rubber at laboratory scale using the ultrasound method. The Board has awarded only one small grant for a devulcanization project, to US Century LLC (\$80,000). Perhaps the most publicized group developing ultrasound devulcanization is Ultramer, Inc., of Masillon, Ohio. Ultramer is commercializing the work of Dr. D. Isayev of the University of Akron. Other innovative devulcanization methods, including biological breakdown of the sulfur bond, are being researched.

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15. Reschner, "The Economics of Ground Tire Rubber..." p. 13.
 16. Michelin has successfully tested tires with 10% granulated rubber added, but in order to raise the recycled content to 20% or more, they will need to use devulcanized rubber. Schwartz, et. al., 1996.
 17. Schwartz, Seymour I., and Wendy Pratt, *Hazardous Waste from Small Quantity Generators*. Washington, D.C., Island Press, 1990.
 18. My study of waste tires found that buyers of new tires will often keep their old tires and dispose of them illegally, rather than pay the tire dealer a disposal fee.
 19. For discussion and analysis of how deposit-rebate systems work, see Schwartz and Pratt, *Hazardous Waste from Small Quantity Generators*, pp. 218-227.
 20. Reschner (*The Scrap Tire Recycling Page*, <www.inx.de/~kurtr/> February 26, 1998) stated that there are at least 1 billion scrap tires stored in illegal piles in the U.S. If California has a proportional share, it would have more than 100 million illegal waste tires. Reschner does not provide documentation for his estimate, however.
 21. Personal communication with Jack Van Kirk, May 1995; see Schwartz, et al. *Domestic Markets for California's Used and Waste Tires*, Ch. II-B.3. on RAC (pp. II-20-II-32). Modified granulated tire rubber (crumb) using methods such as Tyreplex or Xcetera as well as devulcanization, would likely produce an asphalt modifier superior to the present crumb.
 22. The 4 million tons refers to the total amount of asphalt paving used, and needs to be converted to the number of waste tires going into the asphalt mix.
 23. We recognize that the relationship between treadwear rating and actual miles of use might differ among manufacturers. If a law is passed mandating minimum treadwear rating, it might be necessary to standardize the rating process.
 24. Drivers whose decision about replacement tires is dictated by low first-cost (rather than life-cycle cost) might not want to buy long-lived replacement tires for a car with more than 100,000 miles on the odometer. However, drivers who are concerned about life-cycle cost and own a vehicle capable of lasting 200,000 miles (not unusual in high quality vehicles), might very well buy long-lived tires as replacements.
 25. A mandate for long-lived tires would produce major health benefits by greatly reducing the amount of small particles that enter the atmosphere as a result of normal tire wear on the road. This particulate matter is a contributor to lung cancer and a variety of respiratory illnesses.