

## 6. Footnotes

- [1] Copper, steel and other roofs offered by a number of manufacturers are described in detail on the Sweets Catalog website at: <<http://www.sweets.com>>. Links are provided from that site to the individual home pages of each manufacturer.
- [2] Personal communication with Mr. William Good, National Roofing Contractors Association, 5/00. Also see: Kane, Karen, "Another Strong Year for the Industry", Professional Roofing Magazine, 4/99. <<http://professionalroofing.net/past/apr99/>>
- [3] Personal communication with Mr. Tyler Radonich, Roofer's Supply Co., San José, 12/99. RSC is a specialty contractor that does copper roofing projects.
- [4] Sales Literature, Copper Coats, Inc., San Diego. CCI is a manufacturer of copper patina chemical products.
- [5] Personal communication with Ms. Patrice Rose, Malarkey Roofing Company, 1999. MRC manufactures both standard and algae-resistant composition shingles.
- [6] Johnson, Bill, "Alternatives to Pentachlorophenol-Treated Utility Poles", EIP Associates, Palo Alto RWQCP, 4/99.
- [7] Chang, Mingteh, and C. Crowley, "Preliminary Observations on Water Quality of Storm Runoff from Four Selected Residential Roofs", Water Resources Bulletin, Amer. Water Res. Assoc., v29n3, 10/98.
- [8] A description of typical laminated zinc-polyester coating systems for steel roofs is available at the Vic West Steel Corporation website: <<http://www.vicwest.com/>>.
- [9] Chen, Abraham, "Evaluating ACQ as an Alternative Wood Preservative System", EPA/600/SR-94/036, 4/94. This report discusses how much ACQ leaches from preserved wood timbers exposed to rainfall.
- [10] Composition shingle roofs are described in detail on the Sweets Catalog website at: <<http://www.sweets.com>>. Links are provided to the individual home pages of each manufacturer.
- [11] Personal communications with J. Medaris and G. Hechler, ATAS International, Inc. ATAS makes both copper and steel roofing products, together with matching gutters and downspouts.

- [12] Zobrist, J., et al., "Quality of Roof Runoff for Groundwater Infiltration", Water Resources (v34,N.5,pp1455-1462), Enselvier, 2000.
- [13] Boller, Marcus, "Tracking Heavy Metals Reveals Sustainability Deficits of Urban Drainage Systems", Water Science & Technology, (v35,N.9,pp77-87), Enselvier, 1997.
- [14] Mason, Yael, et al., "Behavior of Heavy Metals, Nutrients, and Major Components During Roof Runoff Infiltration", Environmental Science & Technology, (v33, N.10,pp1588-1597), American Chemical Society, 1999.
- [15] Woodward-Clyde, "Roof Runoff Water Quality: A Literature Review", Alameda County Urban Runoff Clean Water Program, 8/94.
- [16] Tsai, Pam, "Connecting the Estuary with Its Watersheds and Airsheds", presentation to the RMPTS Annual Meeting, San Francisco Estuary Institute, 3/00.
- [17] "Metals Content of Fertilizer Products", Washington State Department of Agriculture, 2000. Available at <<http://www-app2.wa.gov/agr>>.
- [18] Bullard, Sophie, et al., "Copper Corrosion in Coastal Oregon", Corrosion Proceedings 1998 Conference, National Association of Corrosion Engineers, 1998.
- [19] Holcomb, Gordon, et al., "Microclimate Corrosion Effects in Coastal Environments", Proceedings 1996 Conference, National Association of Corrosion Engineers, 1996.
- [20] Personal communication with Dr. Stephen D. Cramer, Chemical Engineer, U.S. Department of Energy, 2/00.
- [21] Boulanger, Bryan, et al., "Evaluation of the Hydrologic and Chemical Mass Balances of Copper Within an Urban Watershed", University of Connecticut, 11/99.
- [22] Personal Communication with Bryan Boulanger, 1/00.
- [23] Nikolaidis, Nikalaos, et al., "Yearly Report: Contribution of Copper-Based Architectural Material to Copper Concentrations and Toxicity in Storm Water Runoff", International Copper Association, 11/99.

- [24] Boulanger, Bryan, and N. Nikolaidis, "Mobility and Aquatic Toxicity of Copper in an Urban Watershed", University of Connecticut, 5/00.
- [25] Wallinder, Odenevall, and C. Leygraf, "A Study of Copper Runoff in an Urban Atmosphere", Corrosion Science (v39,N.12,pp2039-2052), Elsevier, 1997.
- [26] Rainwater and runoff data from tests conducted April - June, 2000, upon two roofing panels (each 1.14 sqm). The first panel is algae-resistant, while the other is a standard composition shingle. Both are located at the Palo Alto RWQCP. See Appendix for photo.
- [27] Uribe & Associates, Copper Roof and Gutter Runoff Study, Palo Alto RWQCP, 8/99.
- [28] Donley, Michael, et al., Atlas of California, Pacific Book Center, Culver City, CA, 1979.
- [29] The conversion from rainfall intensity to runoff is 1mm/hr = 1 liter/sqm/hr.
- [30] VicWest Steel product literature and personal communication with sales representatives, 5/00.
- [31] RWQCP tests indicate the following bulk copper contents and release rates for ordinary and algae-resist composition shingles:

	Ordinary Shingles	Algae-Resist Shingles
Bulk Copper Content (mg/kg)	12.7	24.5
Copper Release via Rainfall (g/sqm/yr)	0.009	0.13

Additional tests are planned to refine upon these release rates.

- [32] Weather data for California is available at <<http://cdec.water.ca.gov>>. The station ID for Palo Alto is "PAA".
- [33] The key value of 1.0 g/sqm/yr for copper release from roofs is conservatively adapted from the tests made in Connecticut, Oregon, Sweden, and Switzerland. Tests conducted on gutters of uncertain age indicate somewhat higher values.

- [34] Annual wet and dry copper deposition rates in Stockholm are 1.2 mg/sqm/yr and 1.4 mg/sqm/yr, respectively. Local rainfall is 0.5 m/yr. Personal e-mail communication with U. Mohlander, Env. Health Protection, City of Stockholm, 9/26/00.
- [35] He, W., et al., "Comparison Between Corrosion Rates and Runoff Rates From New And Aged Copper And Zinc As Roofing Material", Department of Materials Science & Engineering, Royal Institute of Technology, Stockholm, 2000.
- [36] He, W., et al., "A Laboratory Study Of Copper And Zinc Runoff During First Flush And Steady State Conditions", Department of Materials Science & Engineering, Royal Institute of Technology, Stockholm, 2000.
- [37] He, W., et al., "Effects Of Exposure Direction On The Runoff Rates Of Copper And Zinc Roofs", Department of Materials Science & Engineering, Royal Institute of Technology, Stockholm, 2000.
- [38] This and other satellite photos of the San Francisco Bay area are available from a project website sponsored jointly by the US Geological Survey and Pacific Gas and Electric Company. The internet address is: <<http://www.sqftbayquakes.org-thumbnails.html>>.
- [39] "Metal Control Measures Plan", Santa Clara Valley Runoff Pollution Prevention Program, 2/12/97. Table 4-3 presents data on metals loading measured in local creeks. The MCMP report is available at: <<http://www.city.palo-alto.ca.us/cleanbay/publications.html>>.
- [40] Ekstrand, E., et al., "Digital Air Photo Processing For Mapping of Copper Roof Distribution And Estimation Of Related Copper Pollution, Swedish Environmental Protection Agency, 1999.
- [41] Appreciation and thanks to these individuals who provided comments and suggestions for improving this report.

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- [42] Ghaffari, Javad, "Pretreatment Program Annual Report 1999", City of Palo Alto RWQCP.

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Coated Steel Shingle Roof On A Home
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- Page 21 Coated Steel Roof • School, Redwood City CA
- Page A4 Algae-Resist Shingle Test Stand at RWQCP