



**San Diego County Air Pollution Control District**  
**Emissions and Potential Health Risks from Welding**  
**Operations**

Allison Weller

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# Background

- **CARB's AB2588 - Air Toxics "Hot Spots" Program**
  - Requires stationary sources to report the types and quantities of TACs and ascertain health risks
- **SDAPCD Rule 1200 & 1210**
  - Requires notifying nearby residents of significant risk and reduce significant risks to acceptable levels
- **CARB's AB617**
  - Community Air Protection Program Portside Community

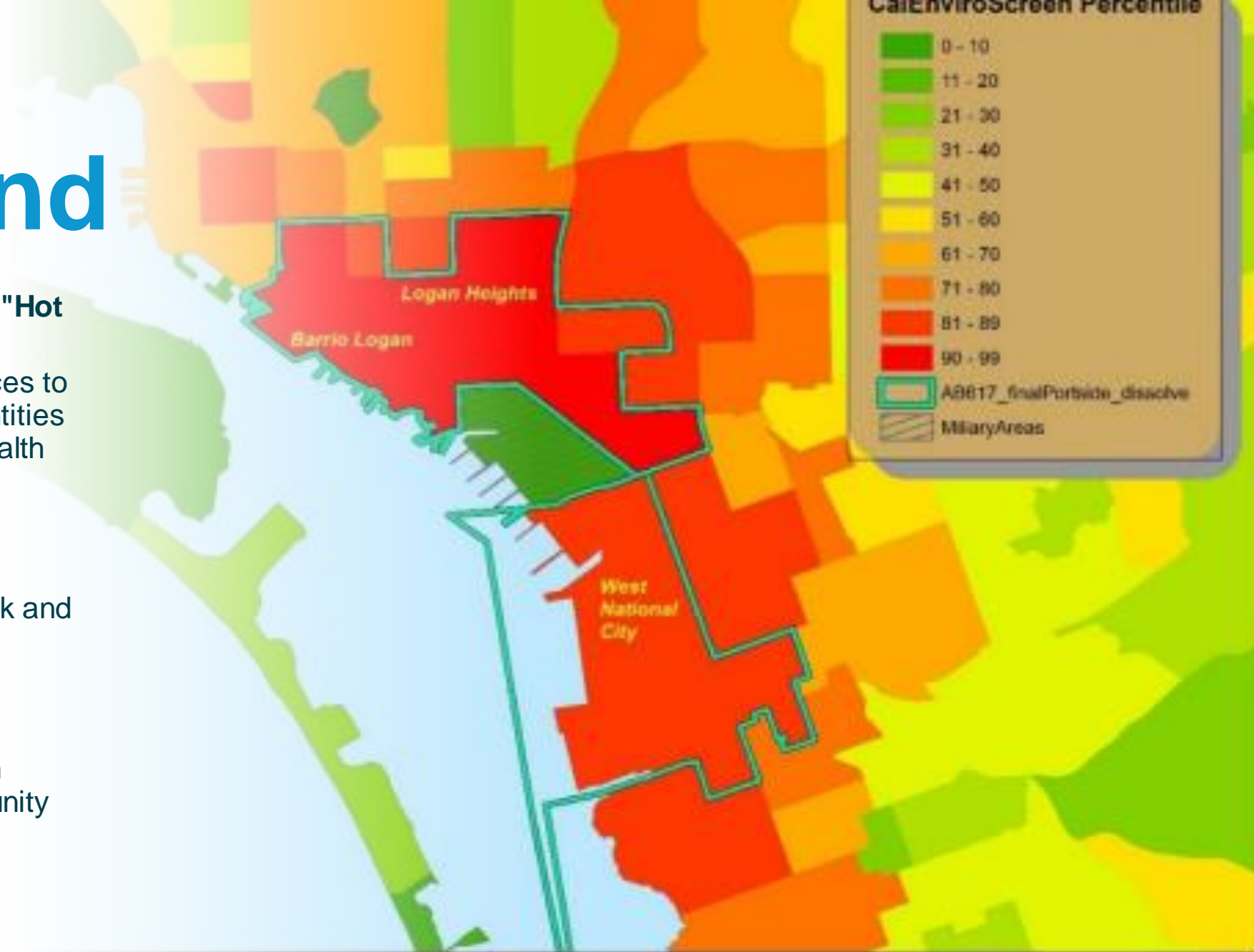


Figure 2 - CES 3.0 Map of the Portside Community

# Research Goals

- Accurately quantify emissions and risk from welding operations
  - Welding operations can emit Toxic Air Contaminants such as manganese (Mn), nickel (Ni), chromium (Cr), cobalt (Co), and lead (Pb)
  - Emissions of these metals can create elevated health risks and adverse health effects that can impact communities surrounding those operations
  - Develop methodologies and emission factors to quantify air emissions and potential health risks from welding operations



Aerial shot of BAE Systems San Diego shipyard. (Credit: BAE Systems)





# Historical

- Even though AB2588 required quantification of TAC emissions, San Diego facilities did not provide sufficient emission factors/rod speciation therefore default factors were needed
- Data required for welding emission factor development:
  - Welding emission rates
  - Fume composition
  - Process variables
  - Chromium to hexavalent chromium conversion rates
  - Control device collection efficiencies
  - Control device removal efficiencies



# Historical Welding Studies

- Historically the District had worked with industry groups and created best engineering estimates for welding processes

	GMAW	SMAW	Other
Fume Rate (lb fume/lb rod)	0.01	0.02	0.05
Fume Composition	Same as rod	Same as rod	Same as rod
(Cr+6/Cr total) in fume	0.05	0.63	0.10

- EPA AP-42: Compilation of Air Emissions Factors published Chapter 12.19 Electric Arc Welding Final Section in January 1995
  - Data set was limited - Generated PM-10 EFs for limited set of specific electrodes and welding processes (20 SMAW, 7 GMAW, 6 FCAW, 1 SAW) and HAP EFs (Cr, Cr(VI), Co, Mn, Ni, Pb)



# Emission Calculations

- Emissions are calculated on a per welding rod and process basis
  - $E_a$  (annual emissions) =  $U_a$  (lbs annual usage) x EF (lbs/lb rod)
  - $E_h$  (hourly emissions) =  $U_h$  (lbs hourly usage) x EF (lbs/lb rod)
- Default emission factors applied from EPA AP-42 Section 12.19, or
- Calculated using a combination of documented factors:
  - “fume generation rate” (FGR) from EPA AP-42 or CARB recommendation
  - “fume correction factor” (FCF) from NASSCO studies, and
  - hexavalent chromium conversion factor from CARB recommendation



# Emission Calculations

- Calculating an emission factor:  $EF = FGR \times FCF \times C_i$ 
  - EF = Emission Factor (lbs metal/lb rod consumed)
  - FGR = Fume Generation Rate (lbs fume/lb rod consumed)
  - FCF = Fume Correction Factor (lbs metal/lb fume)
  - $C_i$  = Concentration of listed substance in each welding rod (%)
- Additional factor is applied when calculating Hexavalent Chromium (Cr (VI)) EF
  - $EF_{Cr(VI)} = FGR \times FCF \times C_i(\text{Total Cr}) \times Cr(VI) \text{ Conversion Factor}$



# Information Collection Request

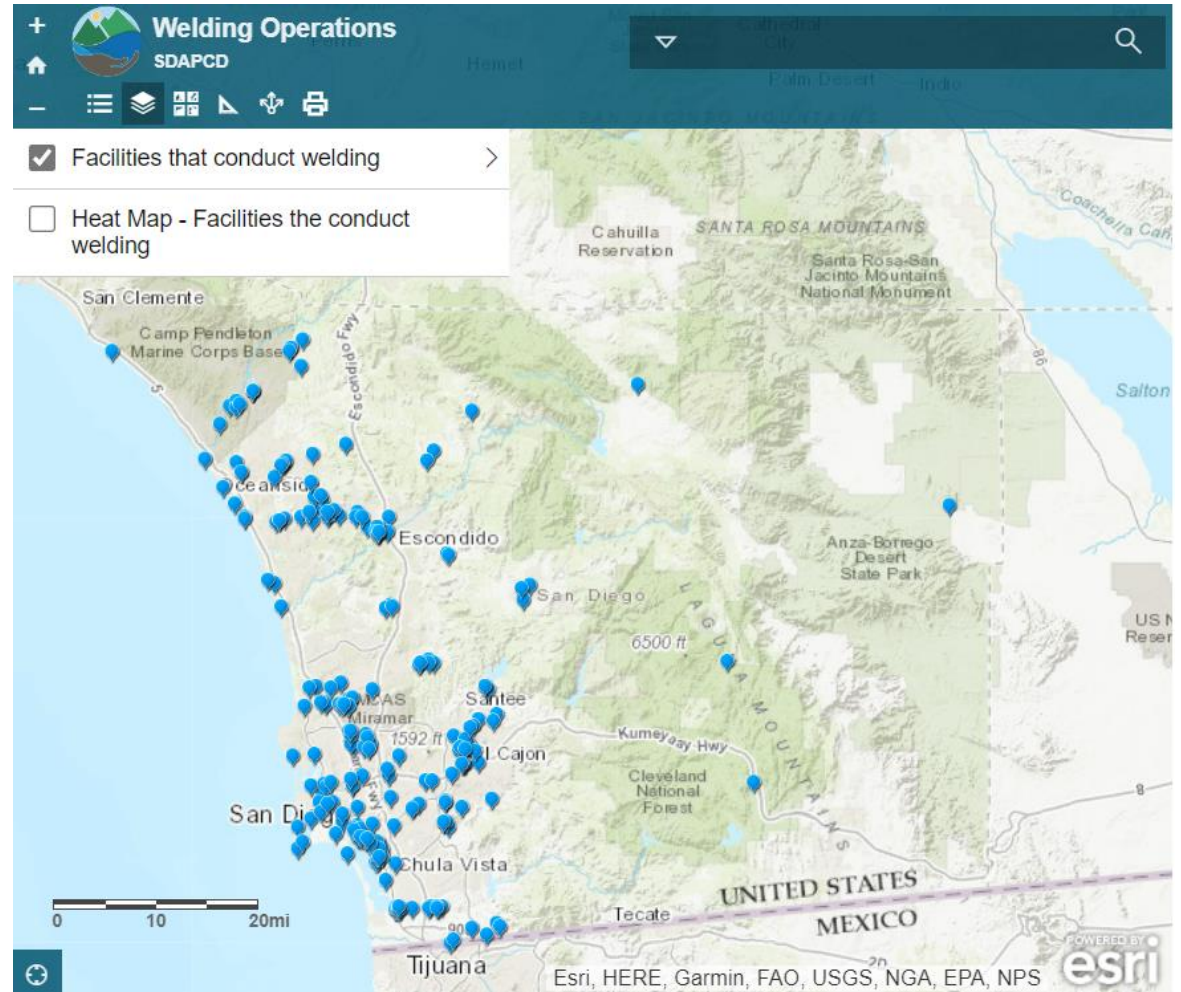
- Historical emission calculations and factors were assessed for accuracy by reviewing more recent welding studies
- Countywide Welding Operations Data Request & Advisory for operations not captured by AB2588 facilities





# Information Collection Request Results

- Identification of 200+ additional welding operations
- Seventeen (17) rods added to SDAPCD EI database
- New Cr and Cr(VI) emission factors for select SMAW/GMAW electrodes
- New PM-10 and HAP emission factors for select FCAW electrodes welded with and without shielding gas



# Findings

- Emission Factors and conversion rates are **highly** dependent on rod type
  - Previously thought certain rods were similar enough to be interchanged
- SMAW & GMAW
  - UC Davis and the Journal of Air & Waste Management (AWMA)
  - Emission factors from EPA AP-42 Section 12.19 somewhat conservative but useful for risk evaluation
- FCAW
  - FCAW can be welded with or without shielding gas (self-shielded)
  - Shielding gas affects fume generation rate (FGR) during welding
  - Rods welded without shielding gas have higher emission factors than when shielding gas is applied

\*Summary of Emission Factors found on our website - <https://www.sdapcd.org/content/sdapcd/permits/toxics-emissions/calculation-procedures.html>\*



# Determinations & Discussions

- Welding emissions and emission factors dependent on multiple factors that are not easily ratioed
- Nickel (Ni) and Chromium (Cr) welding emissions exceeding acute and cancer health risk thresholds even in low usage scenarios
- Limited test data available for welding operations other than shipyards
- Straight averages sufficient for limited dataset(s) available
- Chrome conversion emission factors favored over limited data until more representative Cr(VI) data becomes available
- Misalignment between data sources
  - Some AWS certified FCAW rod TAC content does align with test results of the National Shipbuilding Research Program (NSRP) Study, "*Emission Factors for Flux Cored Rod Used in Gas Shielding Processes*"(2000)



# Current Emission Factor Methodology

1. AP-42 Section 12.19 Electric Arc Welding: Emission factors reviewed and published as described in AP-42 Section 12.19.
2. Welding Specific Studies: Emission factors from studies specific to welding processes, including those completed with industry in San Diego County (NASSCO / NSRP), by professional organizations (AWMA), and government agencies (CARB).
3. Safety Data Sheets (SDS): If emission factors were not available from AP-42 Section 12.19 or welding specific studies, then SDS were used to quantify emission factors. This is the least favorable method, as SDS can vary by manufacturer.





# Welding Study Outcomes

- Welding Operations Permit Screening Tool
- Public and Industry meetings
- Risk Reduction and Audit Plans through AB2588 “Hot Spots”
- Welding Operation Air Quality Permits to Operate
- New AB2588 Facilities

Exempt	Permit Required	Application Submitted
200	51	17



# Risk Identification & Reduction

- AB2588 “Hot Spots” HRA
- High risk found from welding activities
  - Risk driving pollutant – Nickel
  - Acute health hazard index greater than 1.0
- Public & Community Notification Requirements
- Required Risk Reduction & Audit Plan
- Enforceable risk reduction through permitting conditions



(Credit: BAE Systems Ship Repair – 2017, Risk Isopleth Maps)





# Future Work

- Explore options to control toxic air emissions from welding operations
- Additional emission factor testing data (FCAW and TIG)
- New calculation methods
- Air Quality Permitting and Risk Reduction & Audit Plans



# Resources

- [Compliance Programs - Welding \(sdapcd.org\)](http://sdapcd.org)
- [Calculation Procedures \(sdapcd.org\)](http://sdapcd.org)
- [Permits - Welding Operations \(sdapcd.org\)](http://sdapcd.org)
- [Air Toxics "Hot Spots" Program \(sdapcd.org\)](http://sdapcd.org)





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# Questions?

Allison Weller

Senior APC Engineering

San Diego Air Pollution Control  
District

[Allison.Weller@sdapcd.org](mailto:Allison.Weller@sdapcd.org) or  
[APCDEngineering@sdapcd.org](mailto:APCDEngineering@sdapcd.org)



# References

- *Welding Fume Analysis Study*; ESAB Welding and Cutting Products; National Steel and Shipbuilding Company: San Diego, CA, 2000
- *Emission Factors for Flux Cored Rod Used in Gas Shielding Processes*; NSRP 0587, NI-98-1, Subtask 43; National Shipbuilding Research Program: 2000
- *Improving Welding Toxic Metal Emission Estimates in California*, Final Report; Prepared for the California Air Resources Board, Sacramento, CA, by University of California–Davis; Department of Civil and Environmental Engineering: Davis, CA, 2004
- *Developing Emissions Factors for Electrodes Commonly used within the Shipbuilding Industry for use in Regulator Reporting Procedures*, Final Project Technical Report; Prepared for the NSRP Environmental Technology Panel, by Concurrent Technologies Corporation (CTC): Johnstown, PA, 2009
- *Development of Welding Emission Factors for Cr and Cr(VI) with a Confidence Level*, Journal of the Air & Waste Management Association (AWMA), 59:5, 619-626, 2009

