



2008 INTERNATIONAL WORKSHOP ON POLLUTION
PREVENTION AND SUSTAINABLE DEVELOPMENT

AEROJET-GENERAL CORPORATION REMEDIATION ACTIVITY SACRAMENTO, CA

November 19, 2008



2008 C3P and NASA Technical Workshop

The top left of the slide features a photograph of an American flag waving on a tall pole. The Aerojet logo is overlaid on the flag. The background of the slide is a gradient from dark blue at the top to light grey at the bottom.

PRESENTATION

TOPICS

- **HISTORY OF SACRAMENTO GROWTH & THE SITE**
- **ENVIRONMENTAL REMEDIATION**
 - Goals and process
- **GREEN REMEDIATION AND SUSTAINABLE DEVELOPMENT**
 - Definitions and facility design
- **TREATMENT TECHNOLOGIES**
 - Insight into technology selection
 - Current technologies employed
 - Technology trends
- **FUTURE VISION FOR THE SITE**





History



The Aerojet Sacramento Location



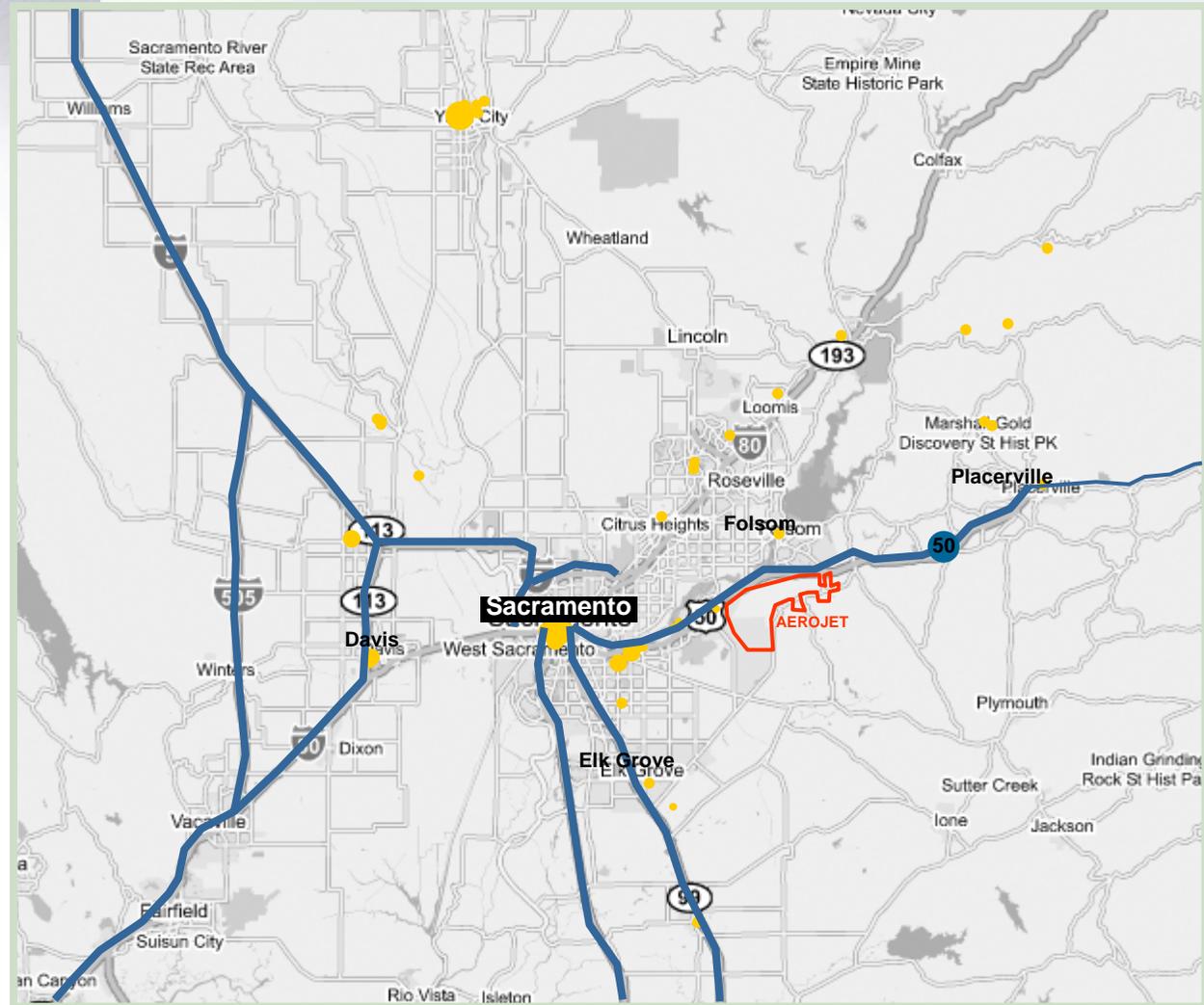
16 Miles East of Sacramento



Urbanization In The Context Of History



- 1848 Gold discovered brought flood of settlers
- 1848 Sacramento was founded
- 1854 Sacramento became state capital
- 1863 Transcontinental railroad construction began
- 1850-1900 Became a city of commercial importance



Source: SACOG (Sacramento Area Council of Governments)

Urban Areas in 1900



Site History – 1906 to late 1940's

Natomas Mining Company



- Lands were mined for gold using floating dredges
- \$100M in gold dredged From 1906-1965
- Site was left in a condition that at the time was considered unsuitable for most types of development
- Remote location and abundant supply of mine tailings for use in constructing bunkers made for an ideal rocket engine development and testing site



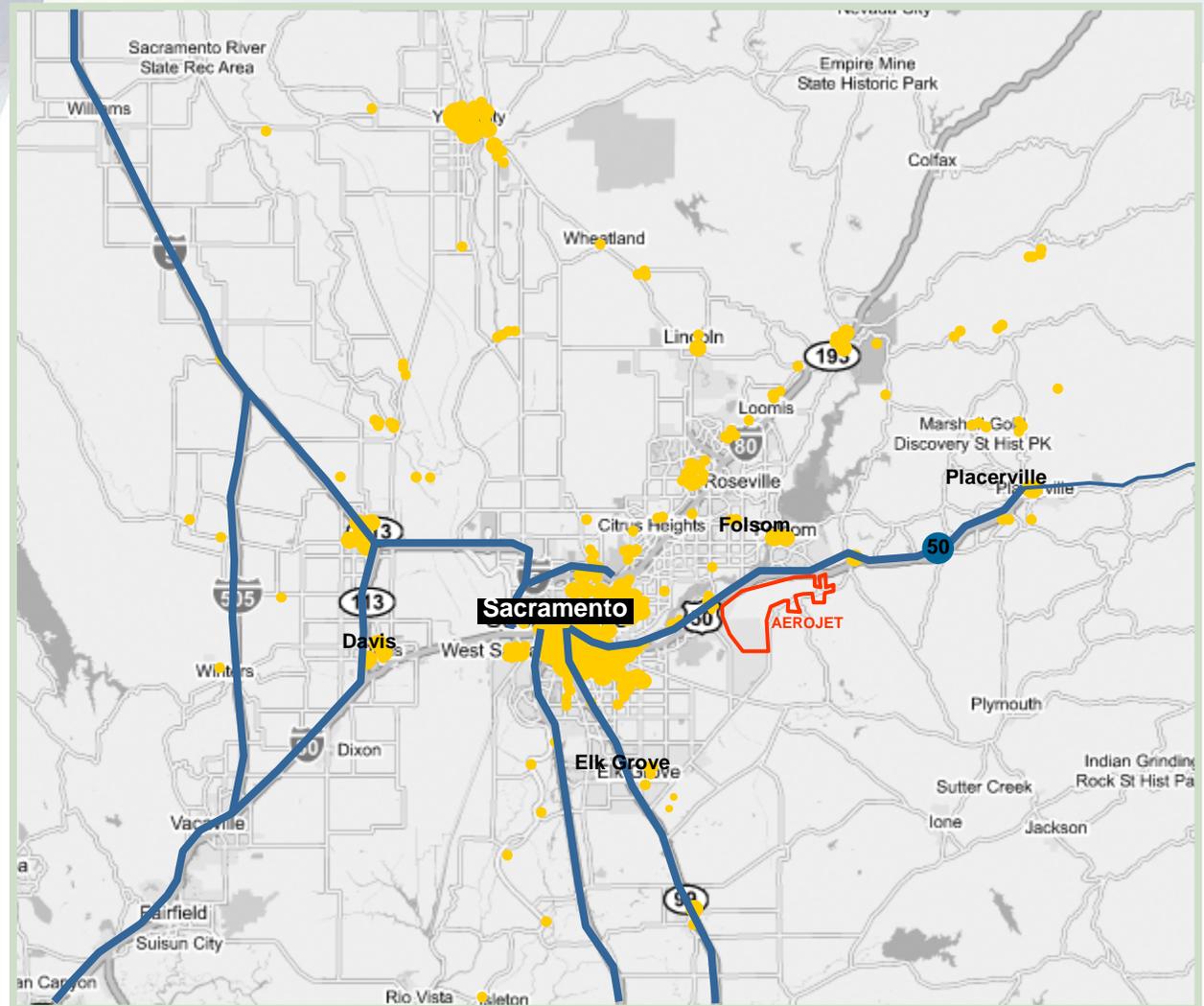
Liquid and Solid Test and Lines - 1963



Urbanization In The Context Of History



- 1916 Sacramento City College Founded
- 1923 Sacramento voters approved the creation of SMUD
- 1942 Aerojet Founded
- 1946 SMUD Began Serving Customers
- 1947 California State University Founded



Source: SACOG (Sacramento Area Council of Governments)

Urban Areas in 1950



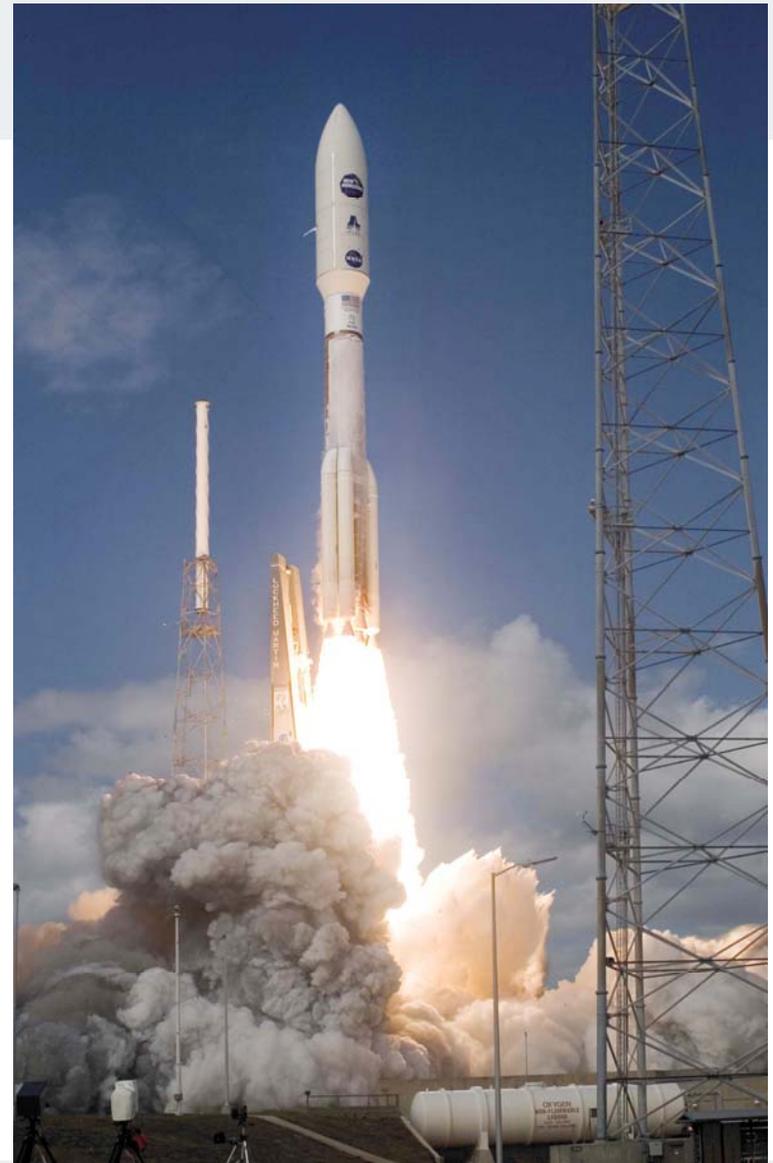
Site History – Late 1940's to Today

Aerojet General Corporation



Sacramento - home to some of the U.S.'s most important propulsion contributions to space exploration and national defense:

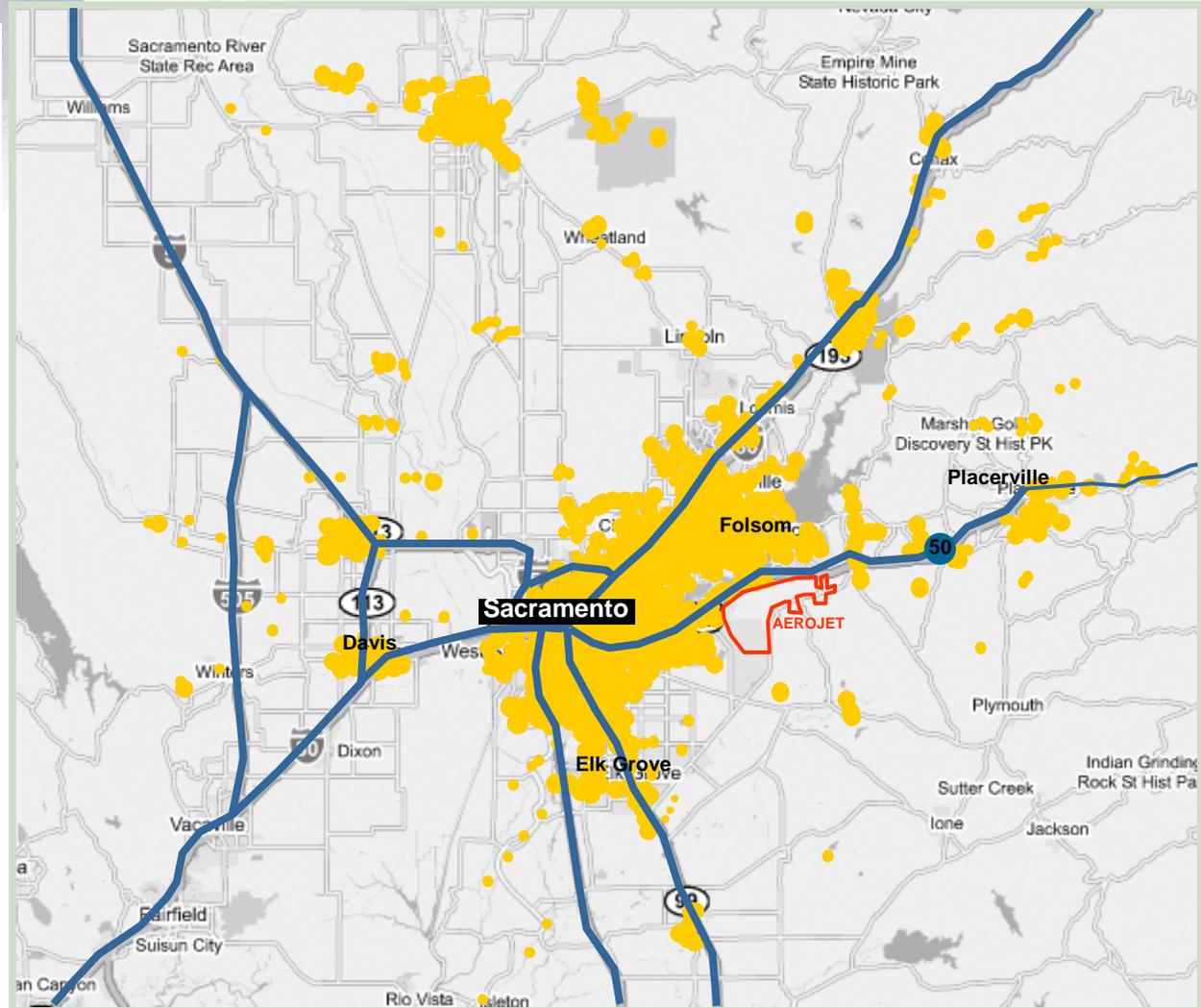
- Titan
- Polaris
- Delta
- Atlas
- Minuteman
- Apollo
- Gemini
- Space Shuttle





Urbanization In The Context Of History

- 1957 to 1975 Space Race
- Late '40s to early 90's Cold War
- 60's and 70's Aerojet employed 20K+
- 2004 Census lists Sacramento as 26 largest metropolitan area
- Aerojet's mission has evolved but still remains focused on national defense and enhancing the nation's access to space



Source: SACOG (Sacramento Area Council of Governments)

Urban Areas in 2000



Environmental History



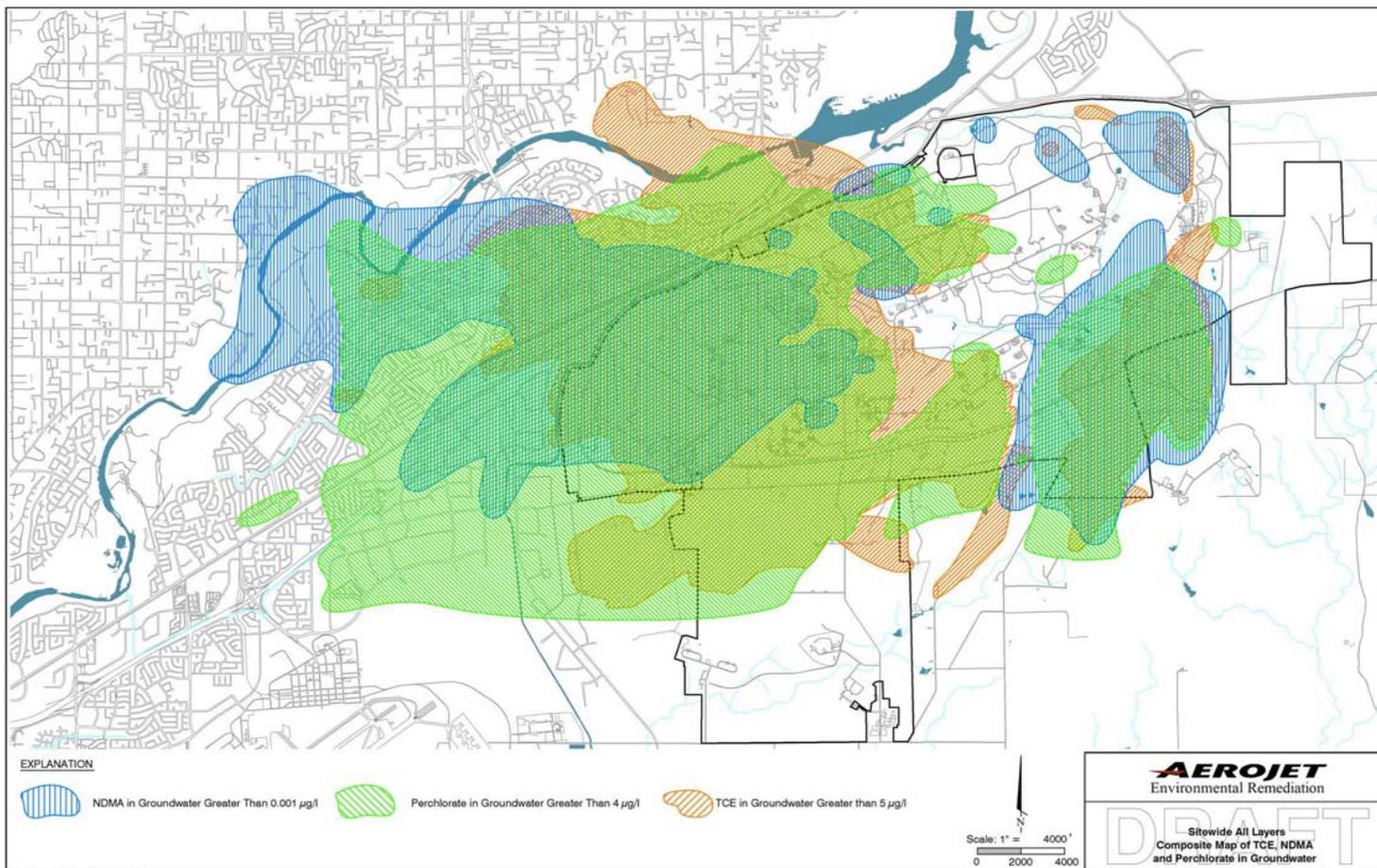
- Discovered VOCs (primarily TCE) in groundwater
- Named a Superfund site in 1984
- Groundwater Extraction and Treatment (GET) facilities began treating groundwater round-the-clock operations
- Entered Partial Consent Decree in 1989 with U.S. EPA and State of California
- Perchlorate & NDMA issues emerged
- Today, the GET's treat more than 22 million gallons of contaminated groundwater every day
- Treated water meets or exceeds drinking water standards.



- **Solvents** –
 - Trichloroethylene (TCE)
 - PCE
 - Freon
 - Chloroform
- **Perchlorate** – component of solid rocket propellant
- **N-Nitrosodimethylamine (NDMA)** – associated with liquid rocket fuel
- **1,4 Dioxane** – stabilizer in solvents



Site-Wide Groundwater Plumes





Environmental Remediation:

-The Goals and the Process



The image shows a large American flag waving in the wind. The Aerojet logo is superimposed on the flag's stripes. The background of the slide is a gradient from light blue to white.

Aerojet's Goals for Remedial Action

- Protect human health and environment
- Protect threatened drinking water wells
- Halt migration of chemicals and start restoration of the aquifer
- Perform work with minimal disruption to the community
- Partnership with regulators, water purveyors, local government and the community



Remediation Process

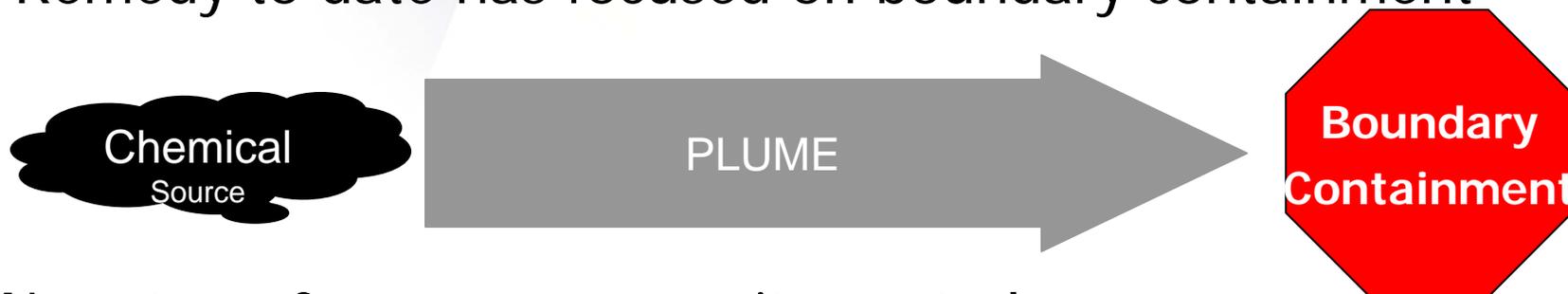
- Conduct remedial investigation (RI)
- Prepare feasibility study (FS)
- USEPA prepares proposed plan – public meeting
- USEPA issues a Record of Decision (ROD)
- Consent or unilateral order issued
- Design remedy
- Implement and monitor remedy



Sacramento Approach To Chemical Plume



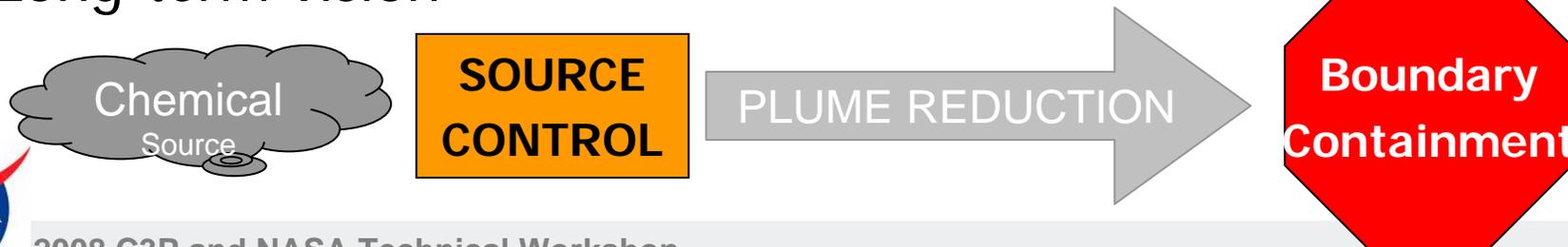
- Remedy to date has focused on boundary containment



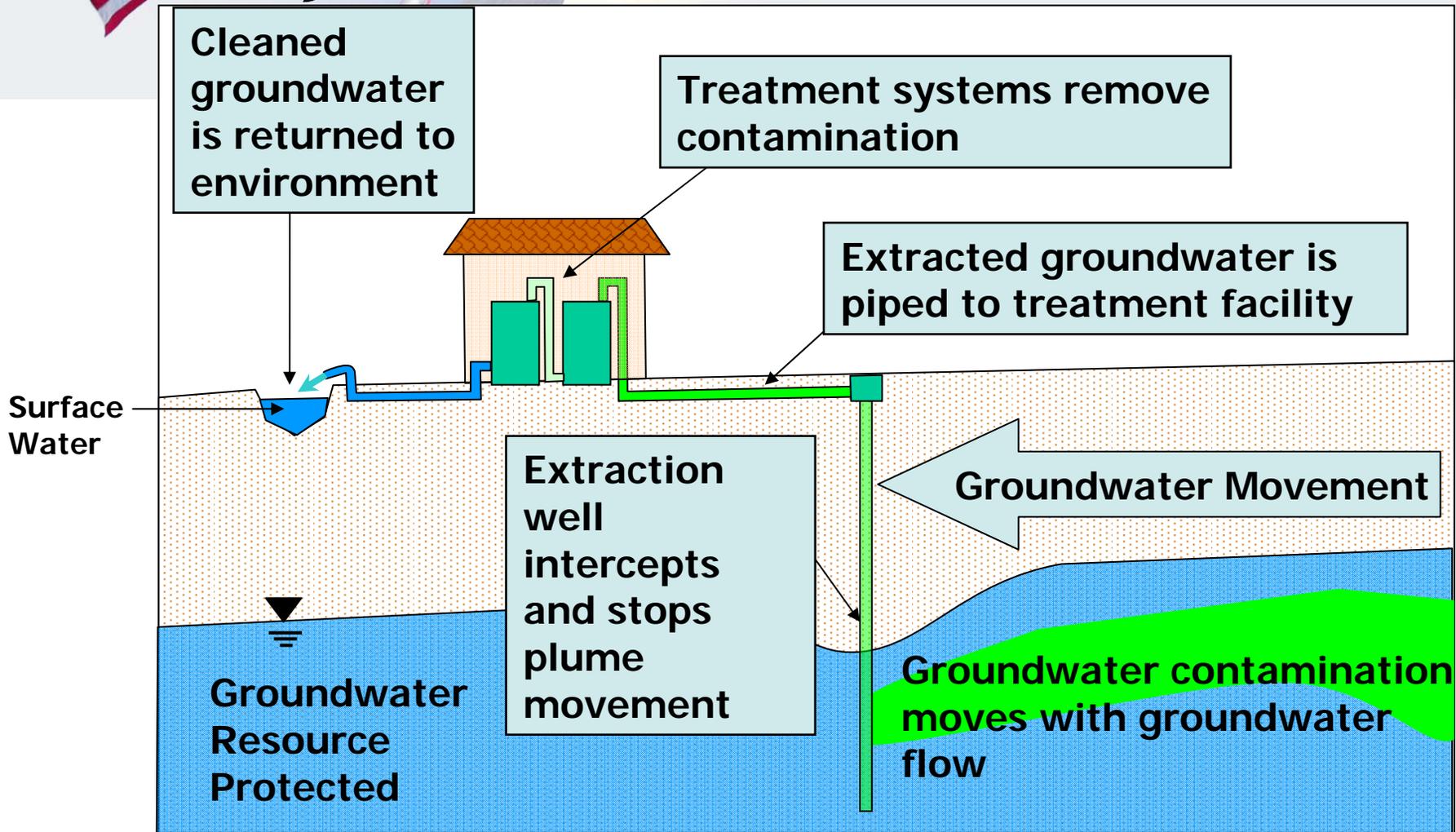
- Near-term focus on source site control



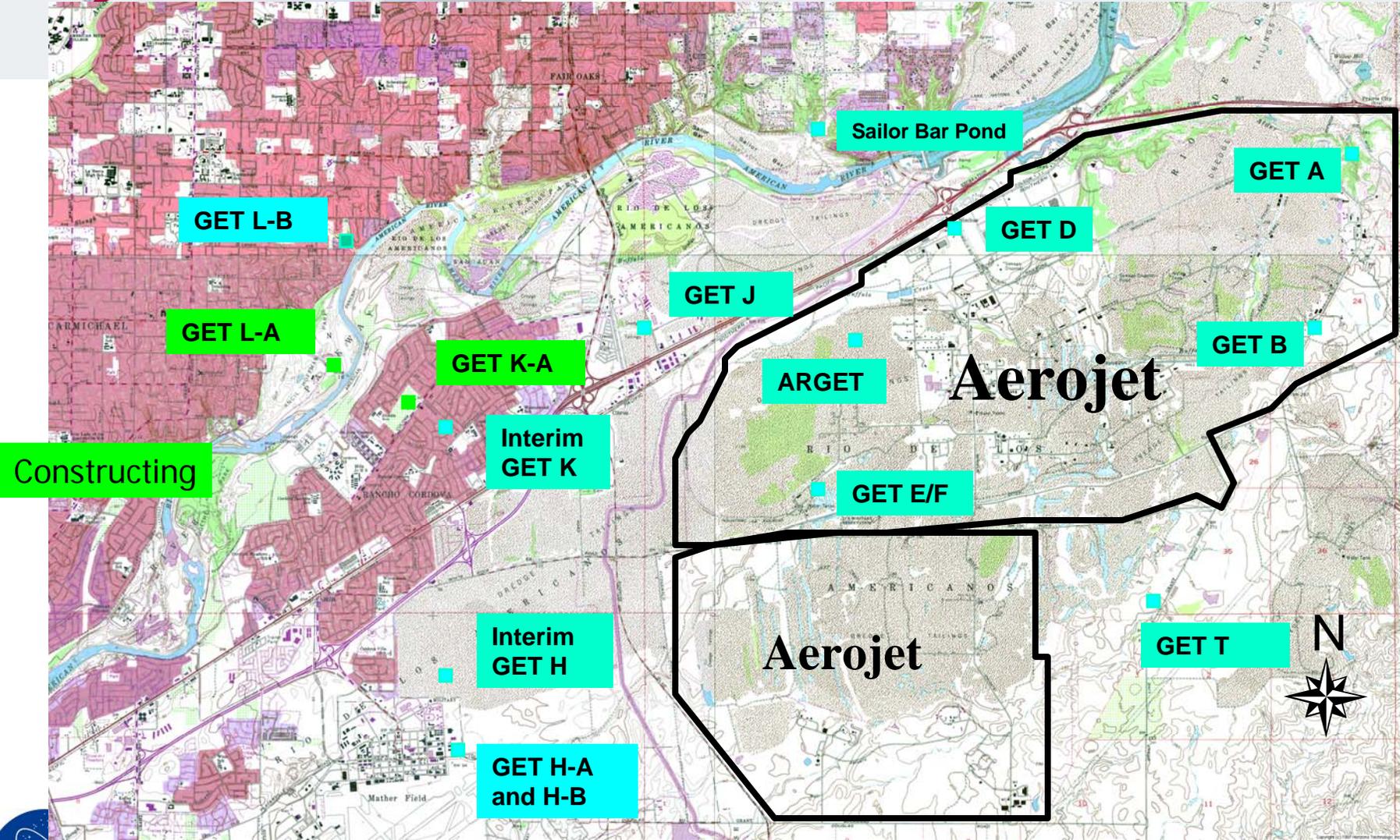
- Long-term vision



How The Cleanup Process Works



GET Facilities





GREEN REMEDIATION AND SUSTAINABLE DEVELOPMENT:

- Definitions
- Aerojet Facility Design



The top left of the slide features a photograph of an American flag waving on a tall pole. The Aerojet logo is overlaid on the flag. The background of the slide is a gradient of blue and white.

US EPA Definitions

PER EPA 542-R-08-002

RELEASED APRIL 2008

- **Green Remediation:** The practice of considering all environmental effects of remedy implementation and incorporating options to maximize net benefit of cleanup actions.
- **Sustainable Development:** Meets the need of the present without compromising the need of future generations, while minimizing overall burdens to society.



- A major element of remediation design is reduction of the impacts on surrounding areas.
- Aerojet invests large amounts of time and money with communities to design treatment solutions that are minimally intrusive and blend with surroundings.



Remediation Design GET J Treatment Facility





Remediation Design

GET J - Interior View





Remediation Design GET K Treatment Facility





Remediation Design

Site of GET K-A Treatment Facility





Remediation Design

GET K-A Treatment Facility

(Conceptual Drawing)



Remediation Design GET L-B Treatment Facility





Remediation Design

GET L-A Treatment Plant

(Conceptual Drawing)



Remediation Design

GET E/F – Industrial Setting





TREATMENT TECHNOLOGY

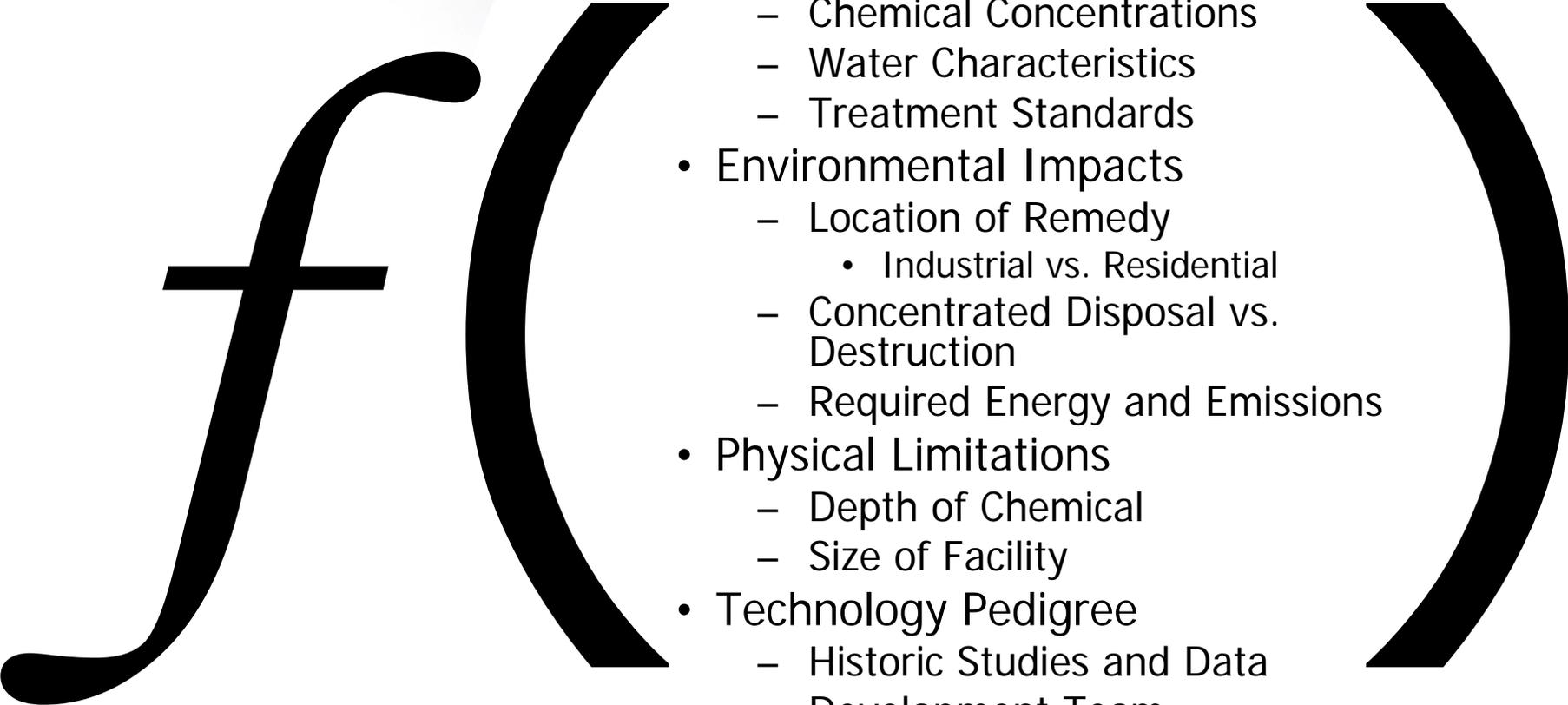
- Insight Into Technology Selection
- Current Technologies Employed
- Technology Trends Are Green





Remediation Technology Selection Considerations

Understanding the nature of individual, organizational behavior and decision making

- 
- Chemical Limitations
 - Mix of Chemicals
 - Chemical Concentrations
 - Water Characteristics
 - Treatment Standards
 - Environmental Impacts
 - Location of Remedy
 - Industrial vs. Residential
 - Concentrated Disposal vs. Destruction
 - Required Energy and Emissions
 - Physical Limitations
 - Depth of Chemical
 - Size of Facility
 - Technology Pedigree
 - Historic Studies and Data
 - Development Team
 - Cost

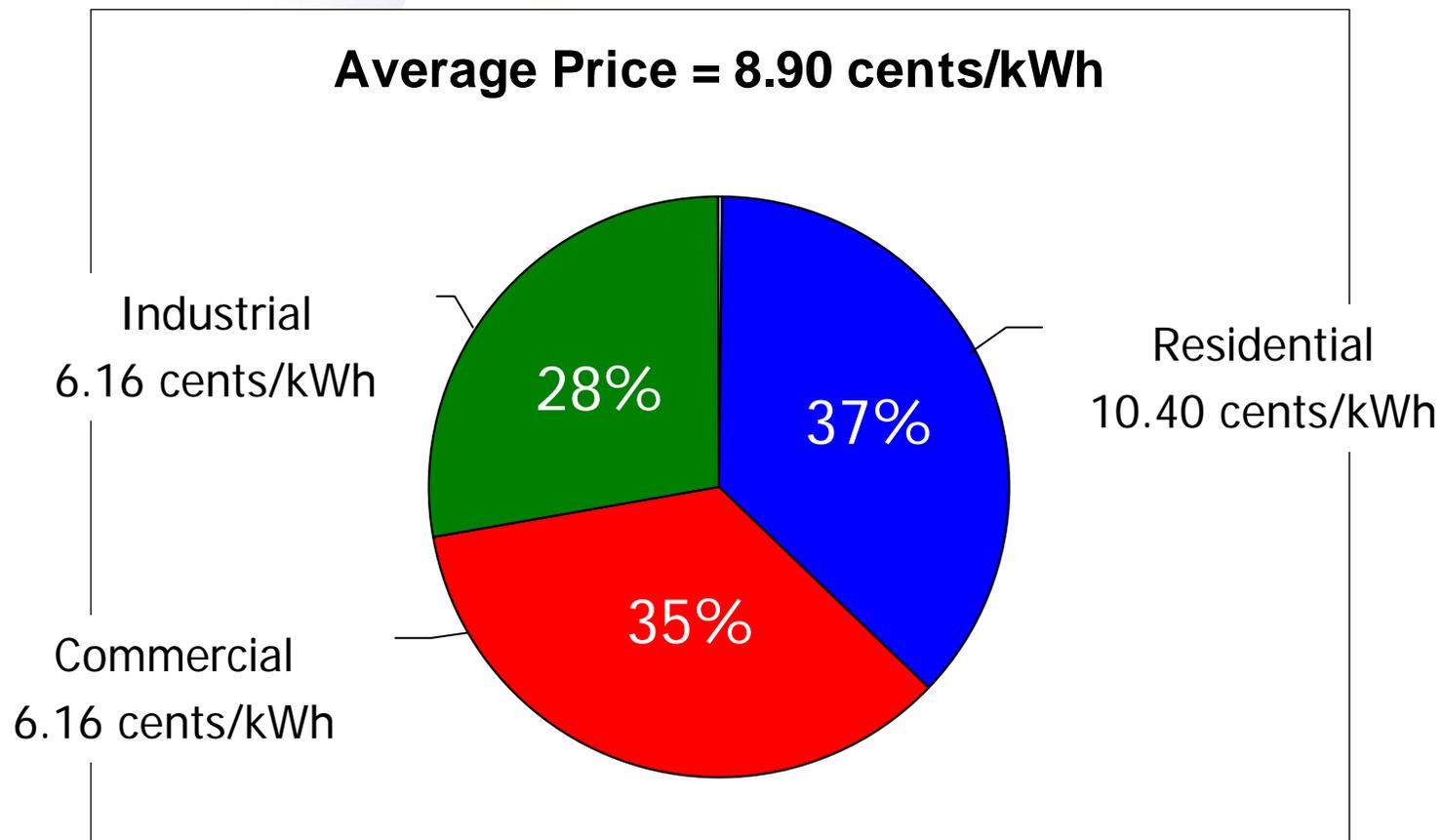


Energy Consumption and Cost



Price of energy is an important consideration but only one of many

U.S. Electricity Sales by Sector, 2006



Source: Energy Information Administration, *Electric Power Annual, 2006*

Evaluating Alternative Sources

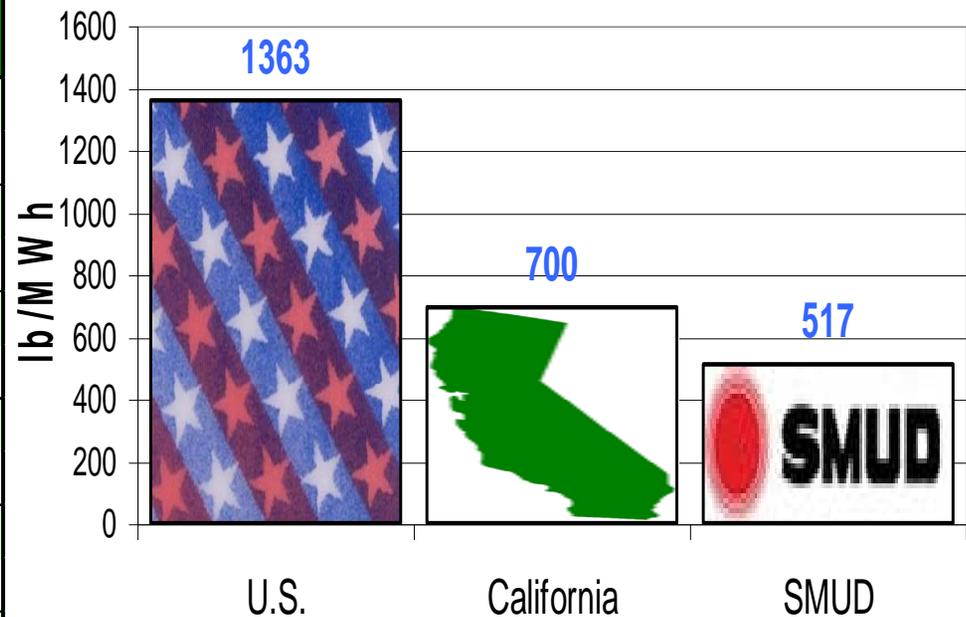


Energy emissions vary regionally

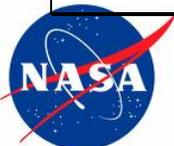
POWER CONTENT LABEL		
ENERGY RESOURCES	2008 SMUD Power Mix (projected)	2007 CA Power Mix (for comparison)
Eligible Renewable	20%	10%
-Biomass & waste	7%	<1%
-Geothermal	4%	2%
-Small Hydroelectric	2%	6%
-Solar	<1%	<1%
-Wind	6%	2%
Coal	1%	32%
Large Hydroelectric	17%	24%
Natural Gas	62%	31%
Nuclear	<1%	4%
Other	0%	0%
Total	100%	100%

Source: SMUD

2004 CO2 EMISSIONS LBS/MWh



Source: eGRID2006 Version 2.1, April 2007





Current Treatment Technologies

Compound	Treatment Technology						
	Air Stripper	Granular Activated Carbon	HiPOx	Ultra Violet Oxidation	Ultra Violet light	Ion Exchange Resin	Fluidized Bed Reactor
NDMA							
Perchlorate							
VOC - Chlorinated Ethenes							
VOC - Other							
- 1,2-dichloroethane							
- 1,2,3-trichloropropane							
- chloroform							
- carbon tetrachloride							
- freon							





VOC Treatment Technologies

Air Stripping

UV/H₂O₂ AOP

HiPox – O₃ AOP



 **SMUD May 2007 COMMUNITY ENERGY AWARD**

- 90% energy reduction
- 1.4M lbs of CO₂ emissions avoided



2008 C3P and NASA Technical Workshop



Perchlorate Treatment Technologies

ION EXCHANGE

Single-Pass Resin Technology



Resin Regeneration Technology

Concentrated
Waste Disposal



Developed by Oak Ridge National Laboratory & Calgon Carbon Tech

Tech evaluation, pilot and full-scale demo in conjunction w/ Aerojet

Waste minimization:
Resin only. Projected at 80% vs. single pass





Perchlorate

Treatment Technologies Cont.

Biological Destruction Process = Waste minimization (organic sludge)



TECHNOLOGY NEWS AND TRENDS

A newsletter about soil, sediment, and ground-water characterization and remediation technologies



Fluidized Bed Reactor and Ion Exchange Systems Added for Perchlorate Removal

Ground water beneath the GenCorp Aerojet facility in Rancho Cordova, CA, is actively treated by multiple-technology, ex-situ treatment systems, three of which are designed to remove commingled perchlorate and trichloroethene (TCE). Perchlorate removal is achieved through use of either a fluidized bed reactor (FBR) or an ion exchange unit. The first perchlorate-specific technology to be implemented was the FBR, which was added to an existing ground-water extraction and treatment system in 1998 shortly after perchlorate was

discovered in the western portion of the site. In 2002, the ion exchange unit was added to a separate treatment system to address perchlorate in another TCE plume located in the northern portion of the site. Both perchlorate treatment components consistently have achieved perchlorate concentrations below the 4 µg/L detection limit in post-treatment effluent.

An FBR is a columnar reactor that optimizes biological treatment of ground water through use of

activated carbon or sand serving as a medium for biological growth. Water flows upward through the reactor at a sufficient velocity to expand and fluidize the bed. The design allows for a large inventory of biomass to be maintained within the reactor while maximizing contact between microorganisms and contaminants. Additional components of the system include continuous sand filters to remove solids (primarily waste biomass) and equipment to handle solids.

[continued on page 3]

FBR is Industrial Treatment Application

Sustainable Technology Does Not Always Harmonize With Surroundings

FBR Not Welcome In Residential Neighborhoods



Perchlorate Treatment Technologies Cont.

- ZVI PRB - Field-scale pilot has shown destruction of perchlorate from >10ppm to less than 4ppb
- No energy, no waste



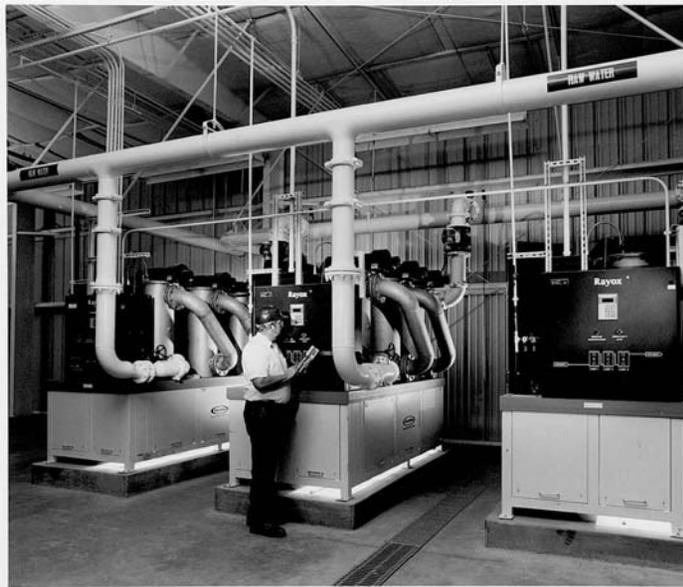
- In-well bioreactor - Pilot-scale has shown significant reduction of perchlorate and nitrate
- Minimal energy, no waste





NDMA Treatment Technologies

UltraViolet Photolysis and AOP



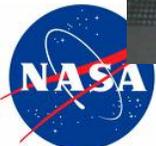
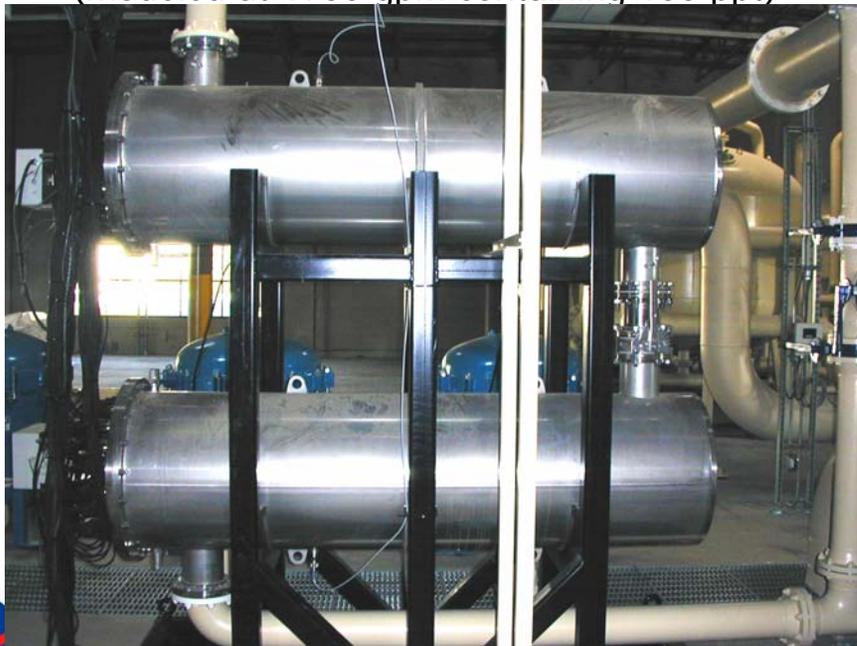
High Watt UV is
energy intensive





Low Watt UV

- Cost effective treatment down to 10s of ppt
- Approx 85% lower energy consumption than High Watt UV (modeled at 1700 gpm containing 100 ppt)





- Solar Ponds
 - Effective treatment during sunlight hours
 - Land intensive
 - Algal bloom issues



Innovative Technology Evaluation On The Horizon

The Trend Is Sustainably Oriented

Perchlorate

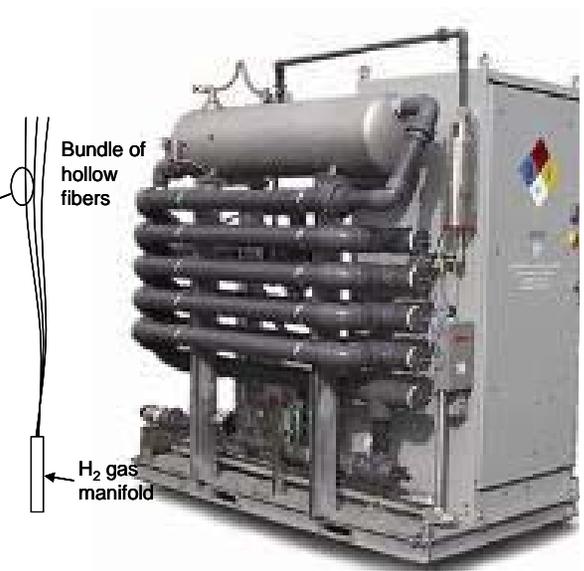
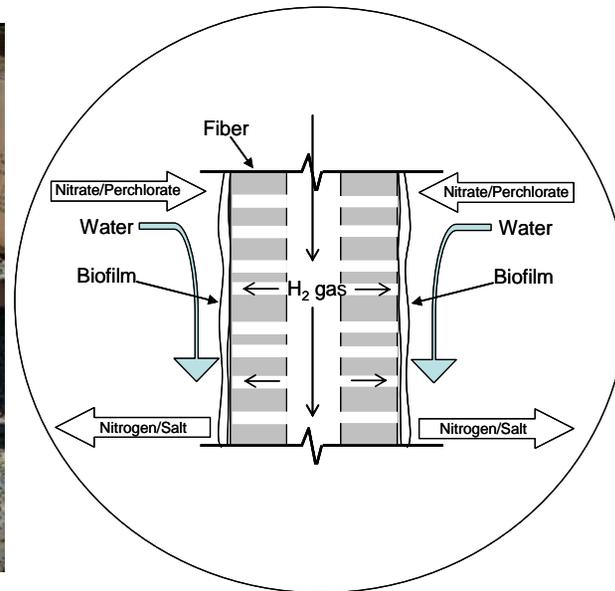
- Phytoremediation
- IX Regeneration
- In-situ Bioreactor
- ZVI
- APT MBfR

DNAPL

- ZVI
- Phytoremediation
- In-well Advanced Oxidation
- APT MBfR

NDMA

- Advanced Oxidation
- APT MBfR



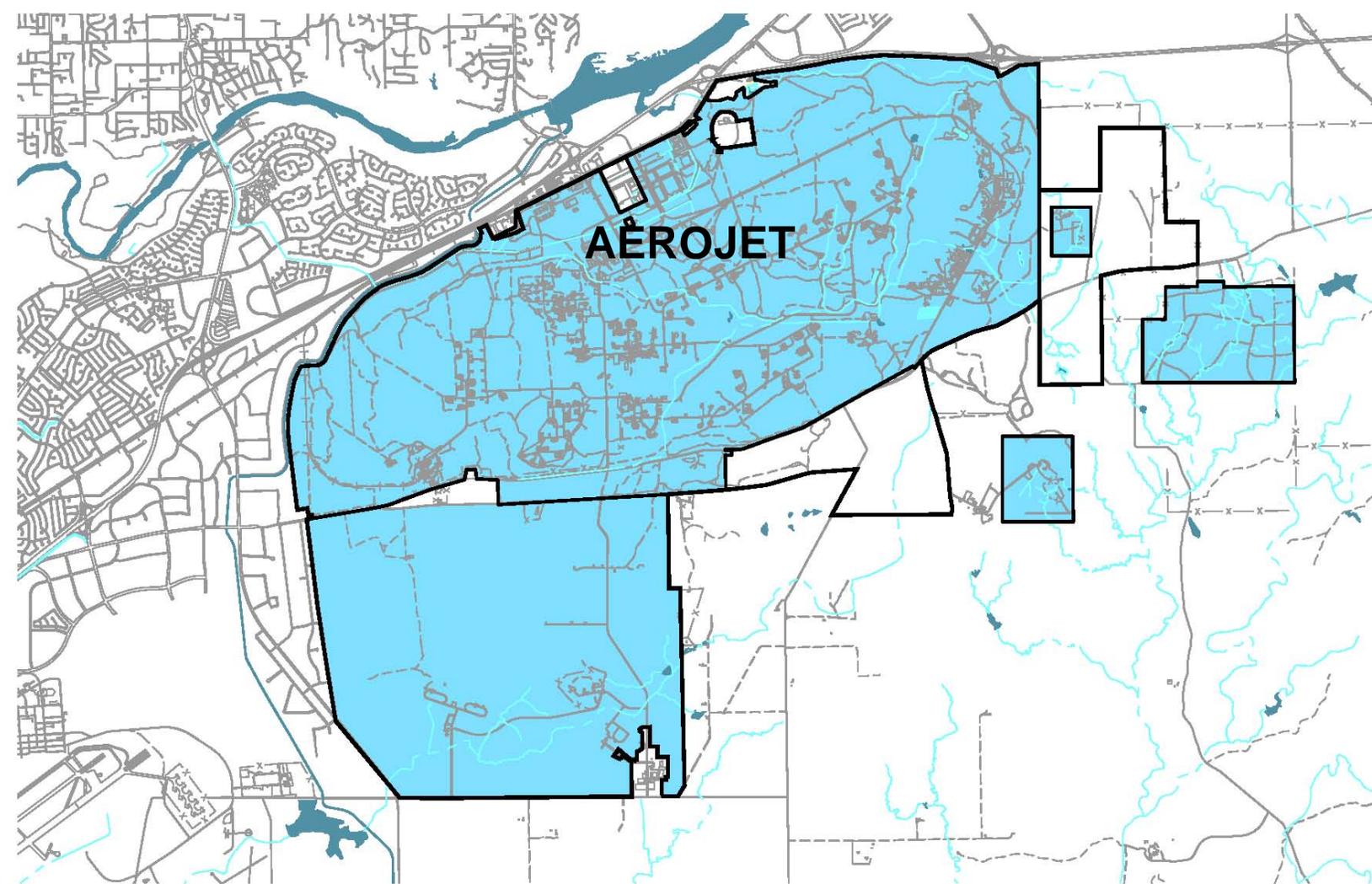


FUTURE VISION FOR THE SITE:

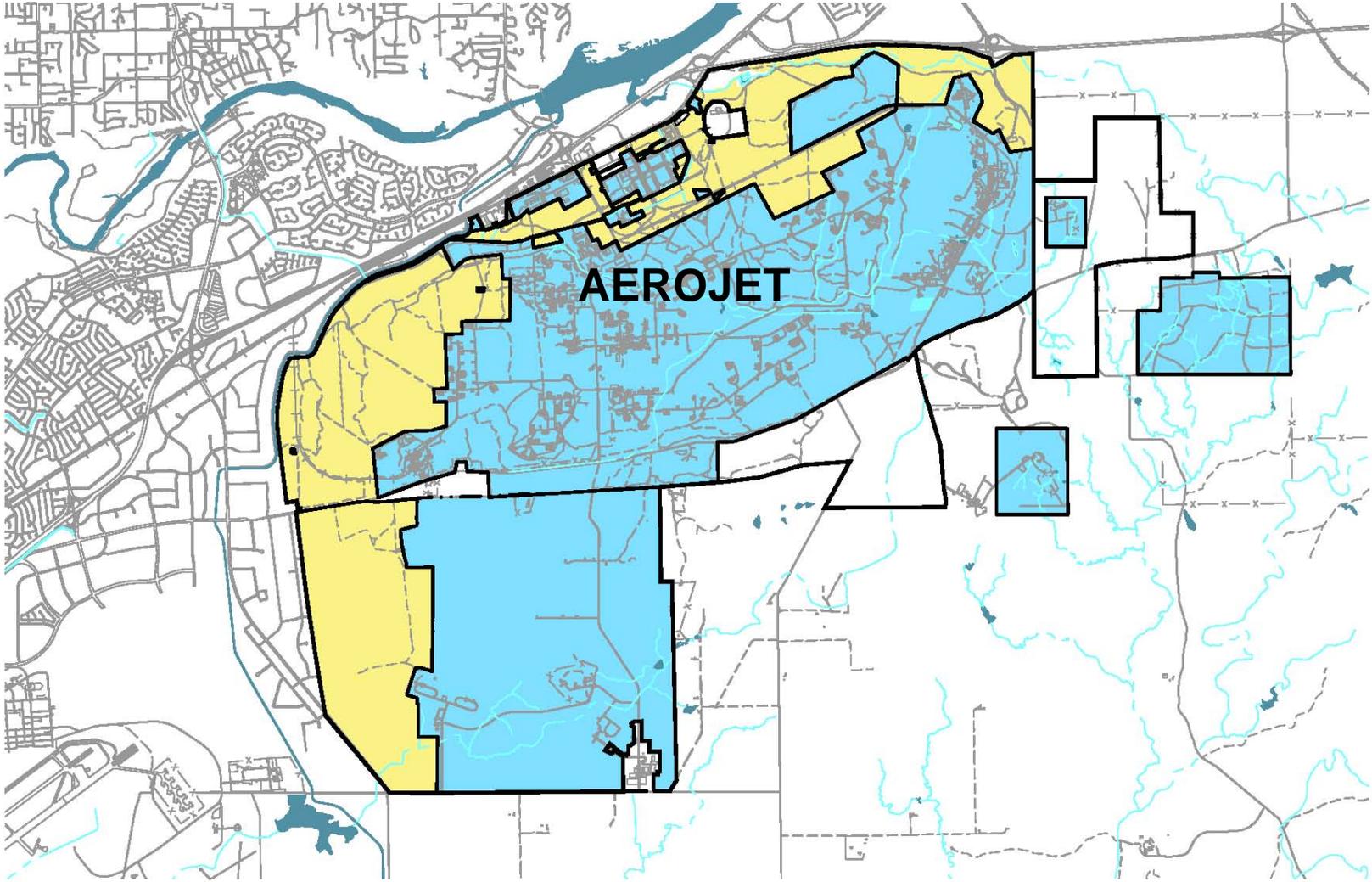
- Beneficial Reuse of Land
- Sustainability



Aerojet Federal and State Superfund Designation (Pre-delisting)

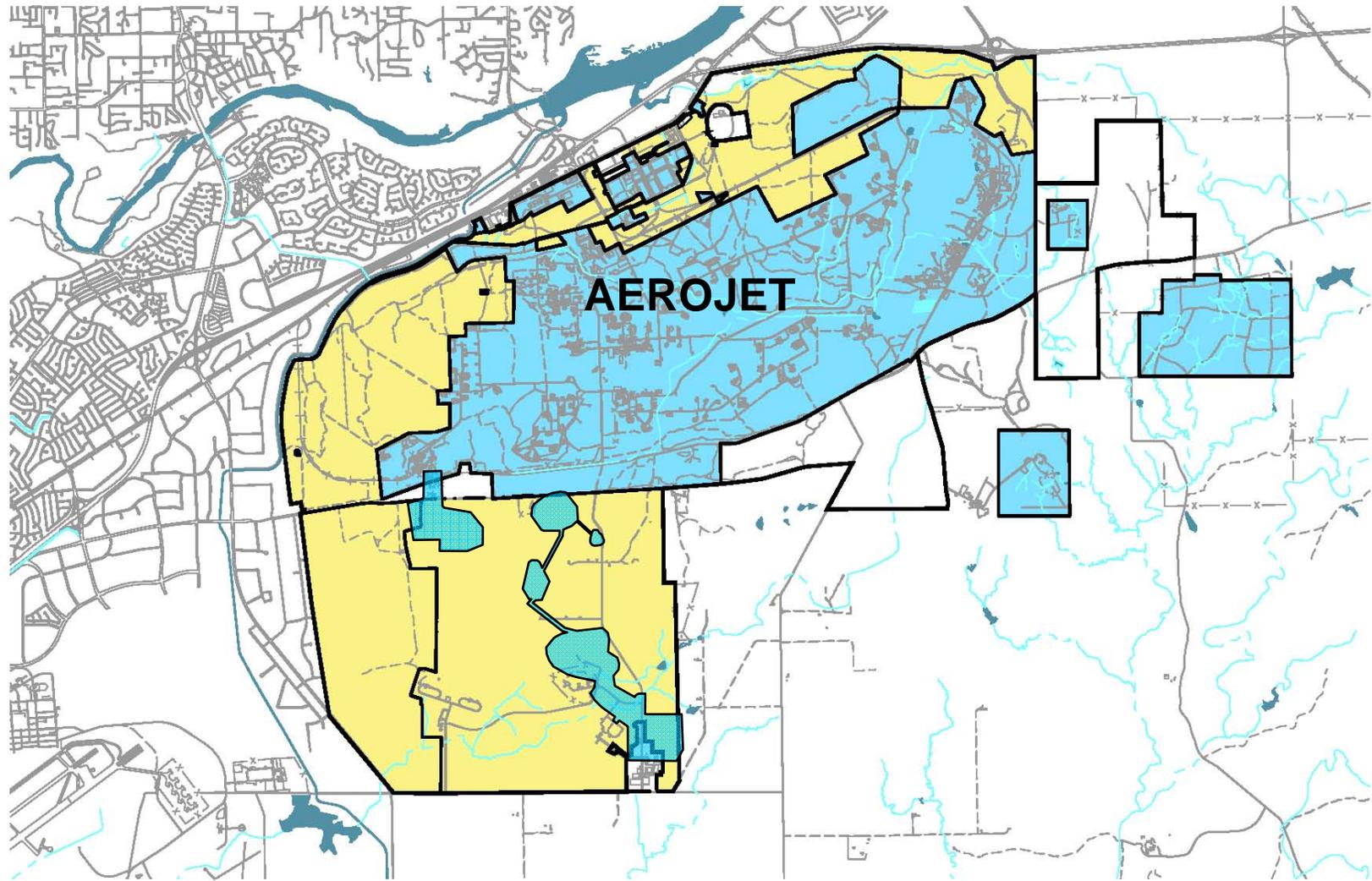


Lands De-Listed (2002)





Total Lands De-Listed (2008) Now Available for Reuse and in Entitlement



Urbanization In The Context Of The Future



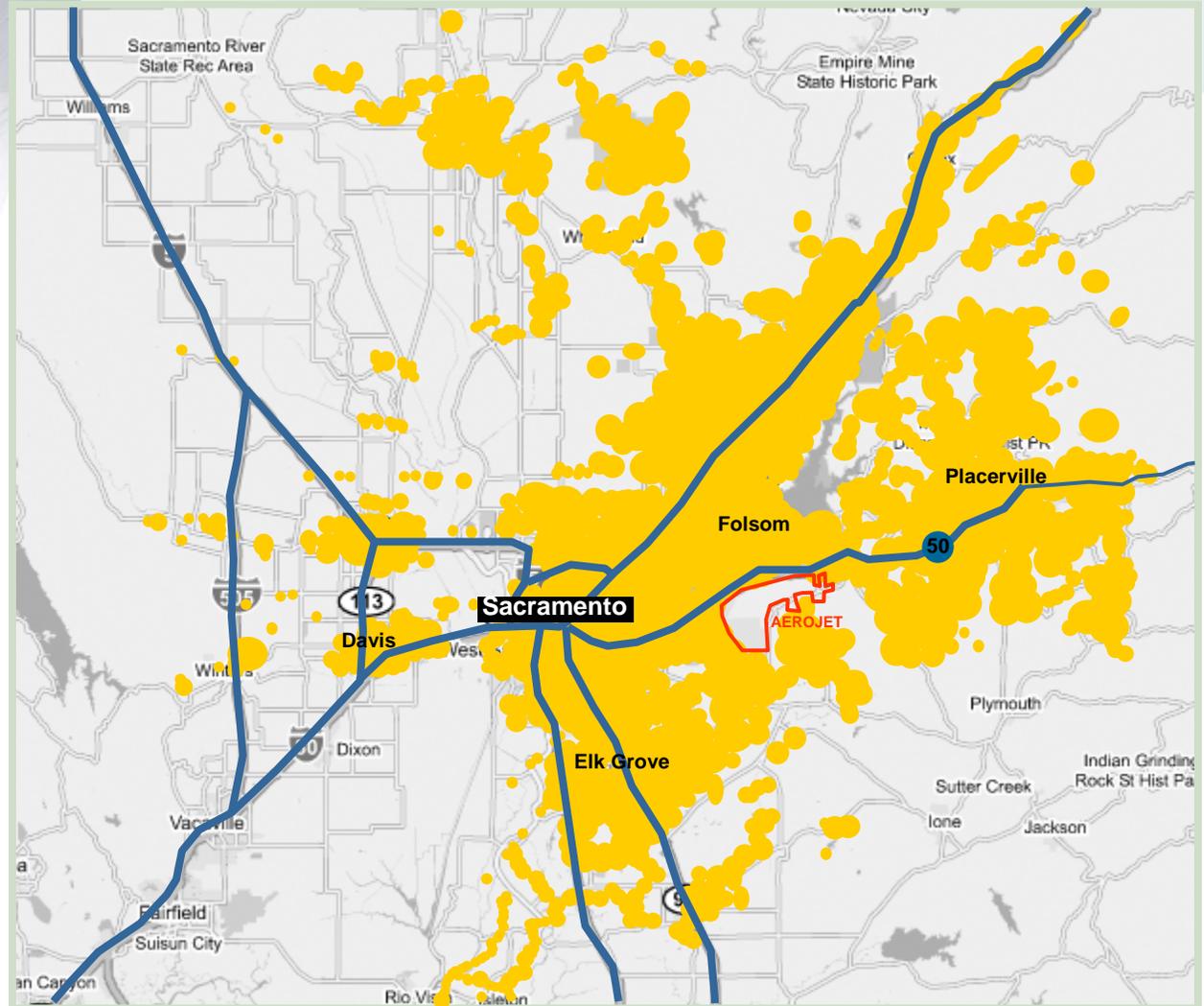
- 2020 GHG emissions match those of 1990

Source: AB32

2050 Issues

- More than 1.7 million additional people will live in the Sacramento Region
- Housing needs will more than double
- Land use decisions made during the next decade will guide our future quality of life

Source: Valley Vision



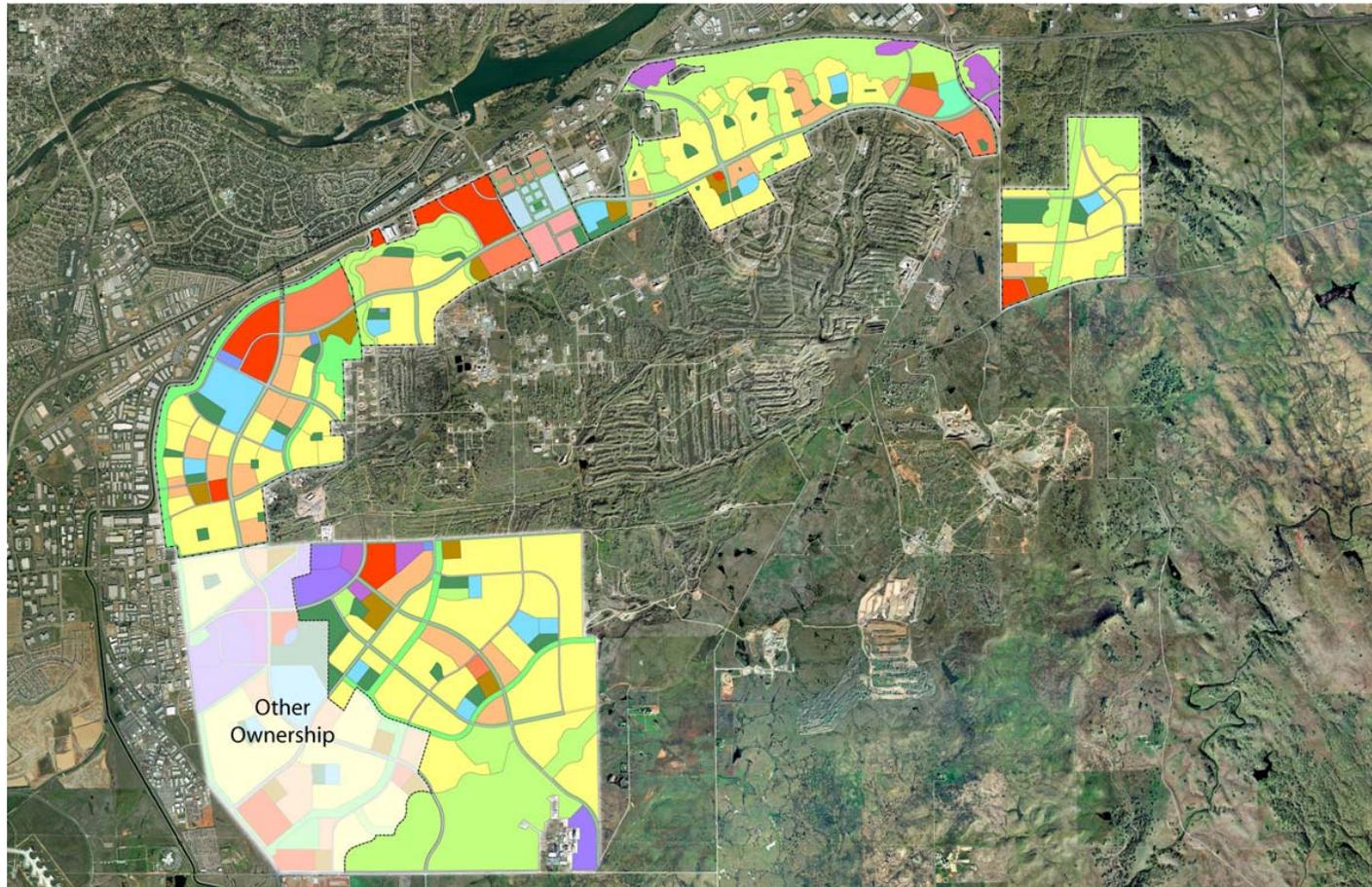
Urban Areas in 2050 (projected)





Vision of The Future

Balanced Mix of Land Uses



Land Uses

- Low Density Residential
- Medium Density Residential
- High Density Residential
- Mixed-Use
- Commercial
- Office/Business Park
- Industrial Park
- Public/Quasi Public
- Schools
- Community Resource Area
- Parks
- Parkways/Drainage Corridors
- Open Space/Preserves
- Roadways
- Easton Place – Transit District
- Easton Place – Central District
- Easton Place – Market District

Source: GenCorp Realty Investments





- **Restore**
 - Beneficial reuse of land
- **Conserve**
 - Existing assets
 - Natural resources
- **Provide**
 - Housing choices
 - Transportation options
- Consistent with “smart growth” principles identified by SACOG’s *Sacramento Region Blueprint* and Urban Land Institute
- Submitted Application For LEED Neighborhood Development Pilot Program

