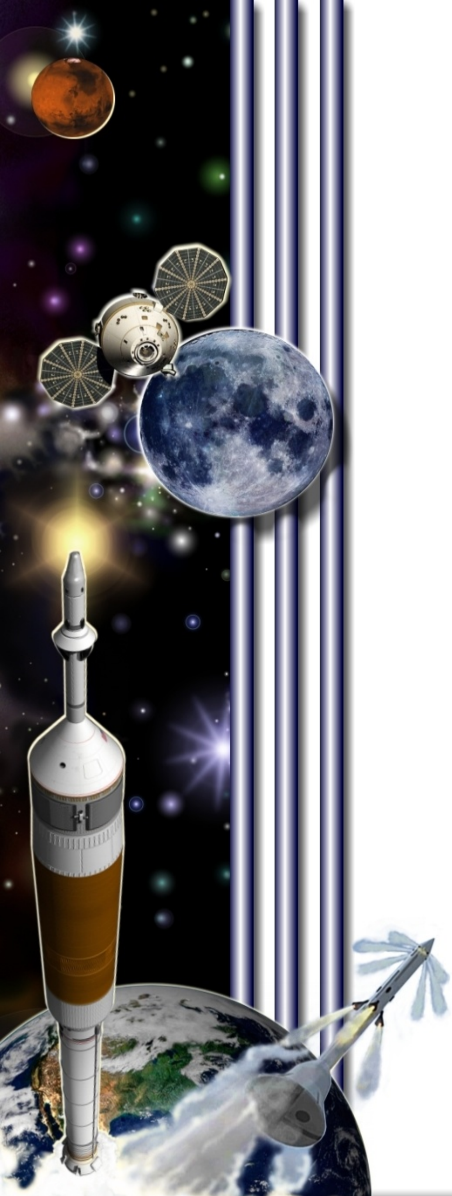


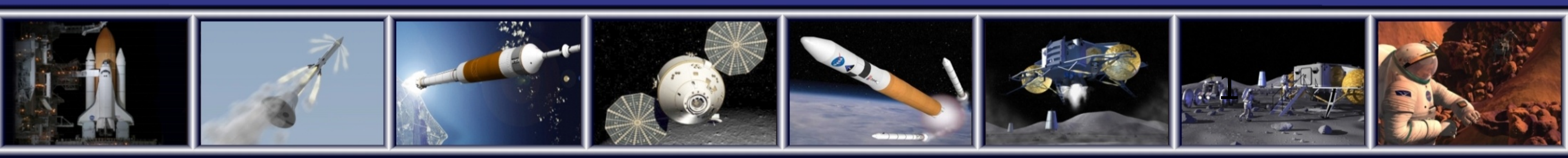
Groundwater Remediation and Alternate Energy at NASA White Sands Test Facility

December, 2008

Holger Fischer

Facility Operations

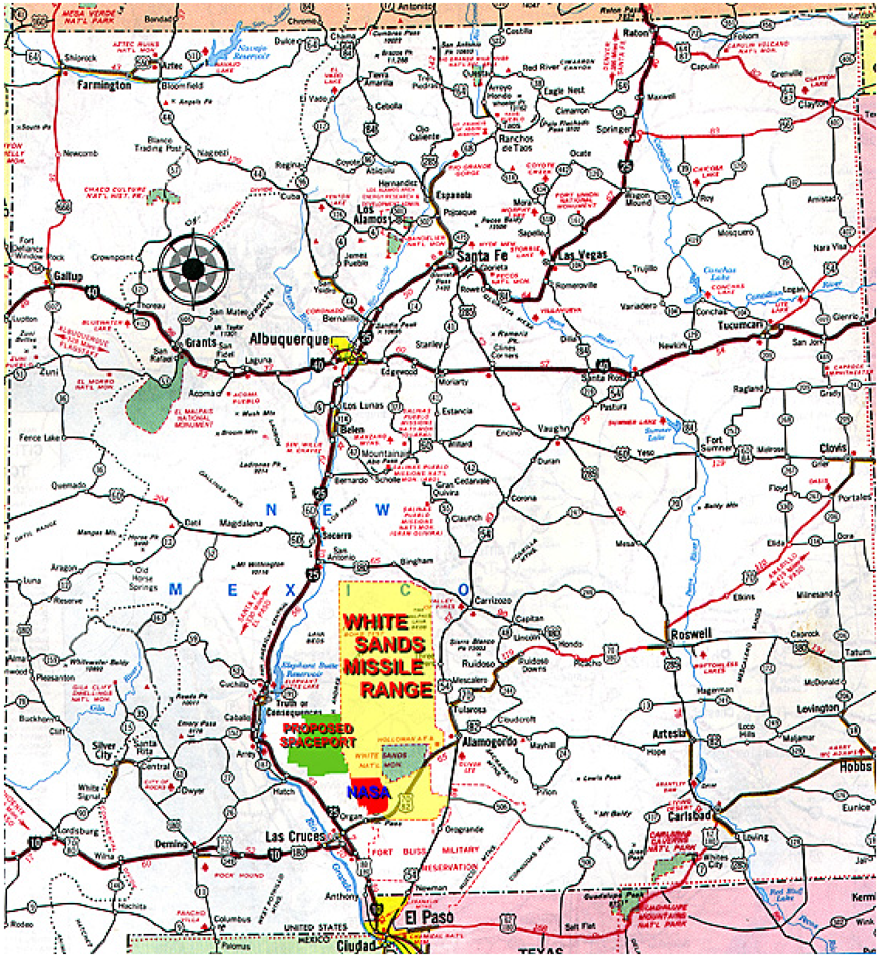
NASA White Sands Test Facility



Content

- White Sands Test Facility (WSTF) Overview and Core Capabilities
- WSTF Groundwater Remediation Program
- Alternate Energy Programs
  - Wind Energy
  - Solar- Energy Storage Testbed
    - Solar
    - Vehicle Plug-in
    - Flow Battery Energy Storage
  - Utility-Size Peak Shaving Solar Generation Plant

WSTF



WHITE SANDS MISSILE RANGE
PROPOSED SPACEPORT
NASA
N E W M E X I C O
Albuquerque
Santa Fe
Las Vegas
Los Alamos
Farmington
Gallup
Grants
Socorro
Las Cruces
El Paso
Alamogordo
Roswell
Carlsbad
Hobbs
Clovis
Tucumcari
Deming
Lordsburg
Silver City
Truth or Consequences
Raton
Artesia
Ruidoso
Espanola
Belen
Los Lunas
Santa Rosa

WSTF Core Capabilities

- Remote Hazardous Testing of Reactive, Explosive, and Toxic Materials and Fluids
- Hypergolic Fluids, Materials, and Systems Testing
- Oxygen Materials and System Testing
- Hypervelocity Impact Testing
- Flight Hardware Processing
- Propulsion Testing

Remote Hazardous Testing

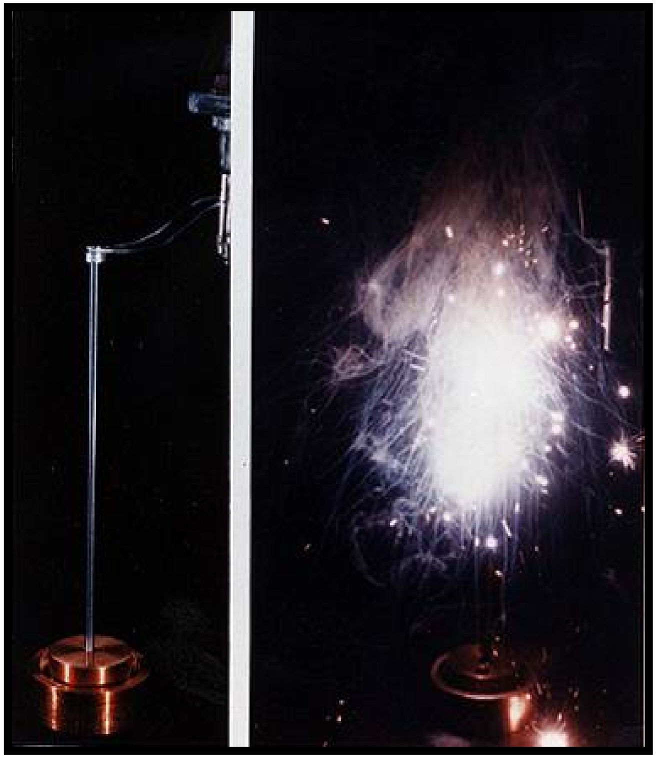
Reactive, Explosive, and Toxic Materials and Fluids

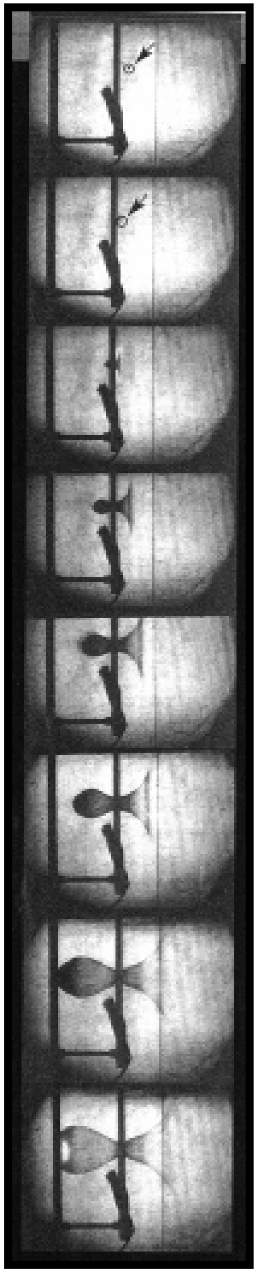
2000 lbs LH_2/LO_2 Test

Solid Propellant Test

500 lbs LH_2/LO_2 Test

Laboratories





- Micrometeoroid/Debris Hypervelocity Impact Testing
- Propellant and Explosion Hazards Assessment
- Research on Flammability of Materials including Metals in Oxygen-enriched Atmospheres

Hardware Processing

Flight Critical System Components Refurbishment

Critical Flight Hardware Assembly

Flight Hardware Production

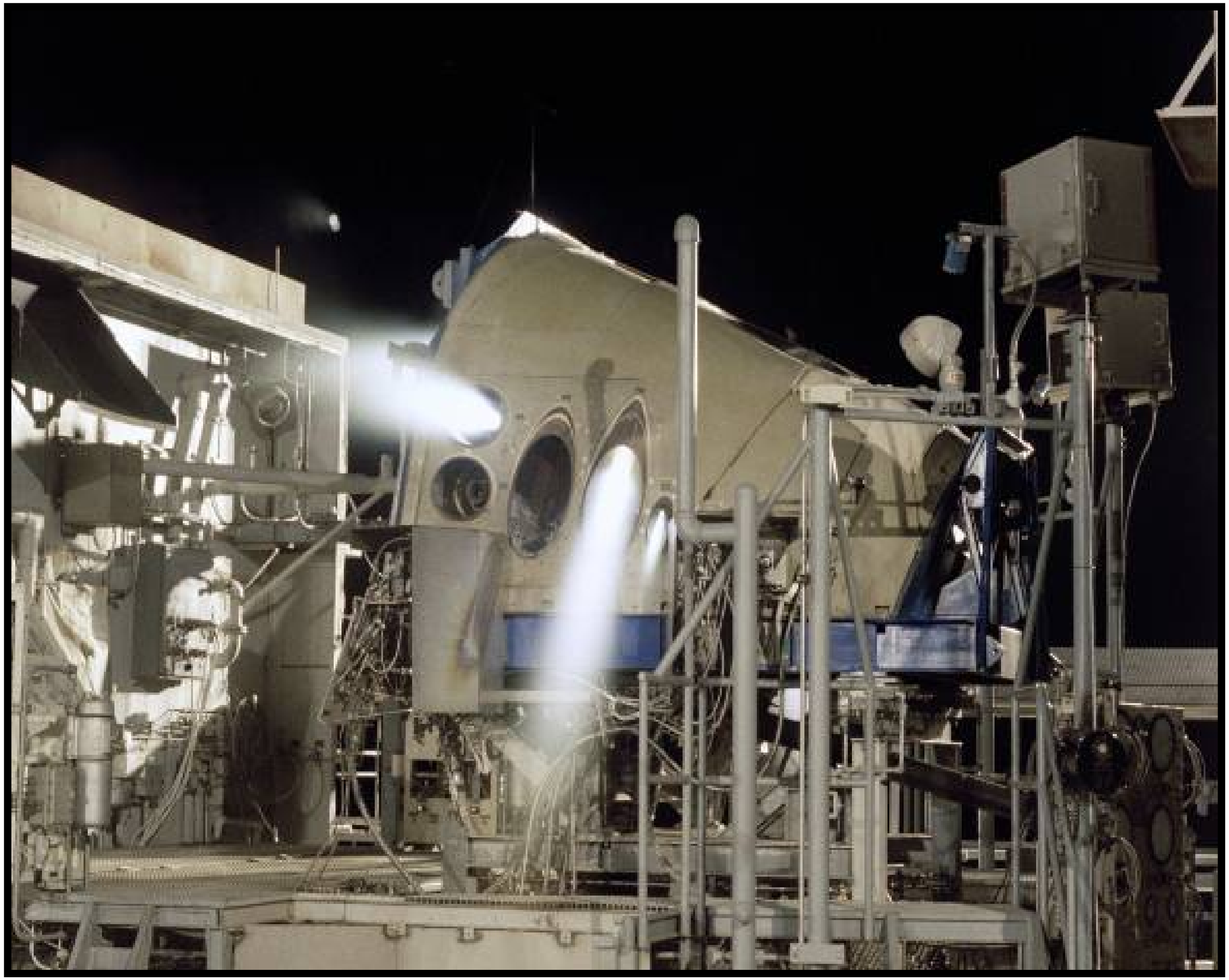
Propulsion Test

Cassini – Saturn Orbit Insertion Engine Glows during 3-h 20-min Continuous Firing

Shuttle PRCS Thruster Hot-fire Testing

Minuteman Qualification Firing inside Vacuum Test Cell

Propulsion Test



Night Firing of Shuttle Forward RCS Primary and Vernier Thrusters

Restoration Program

- Historic operations and practices in the1960s resulted in contamination of WSTF's groundwater.
  - Propulsion system testing programs:
    - N-Nitrosodimethylamine (NDMA)
    - Dimethylnitramine (DMN)
  - Component servicing and cleaning operations:
    - Trichloroethene (TCE)
    - Tetrachloroethene (PCE)
    - Freons: (11, 21, and 113)
- WSTF contaminated groundwater is NASA HQ's greatest liability (estimated at $350M).

Restoration Program

- Priority: Protect the public's health and the health of our workforce.
  - Containment
    - Stop the migration of contaminated groundwater
    - Address greatest health-risk liability first, then address source areas
      - Plume front
      - Mid-plume
      - Source areas
  - Restoration
    - Clean up the environment to preexisting conditions

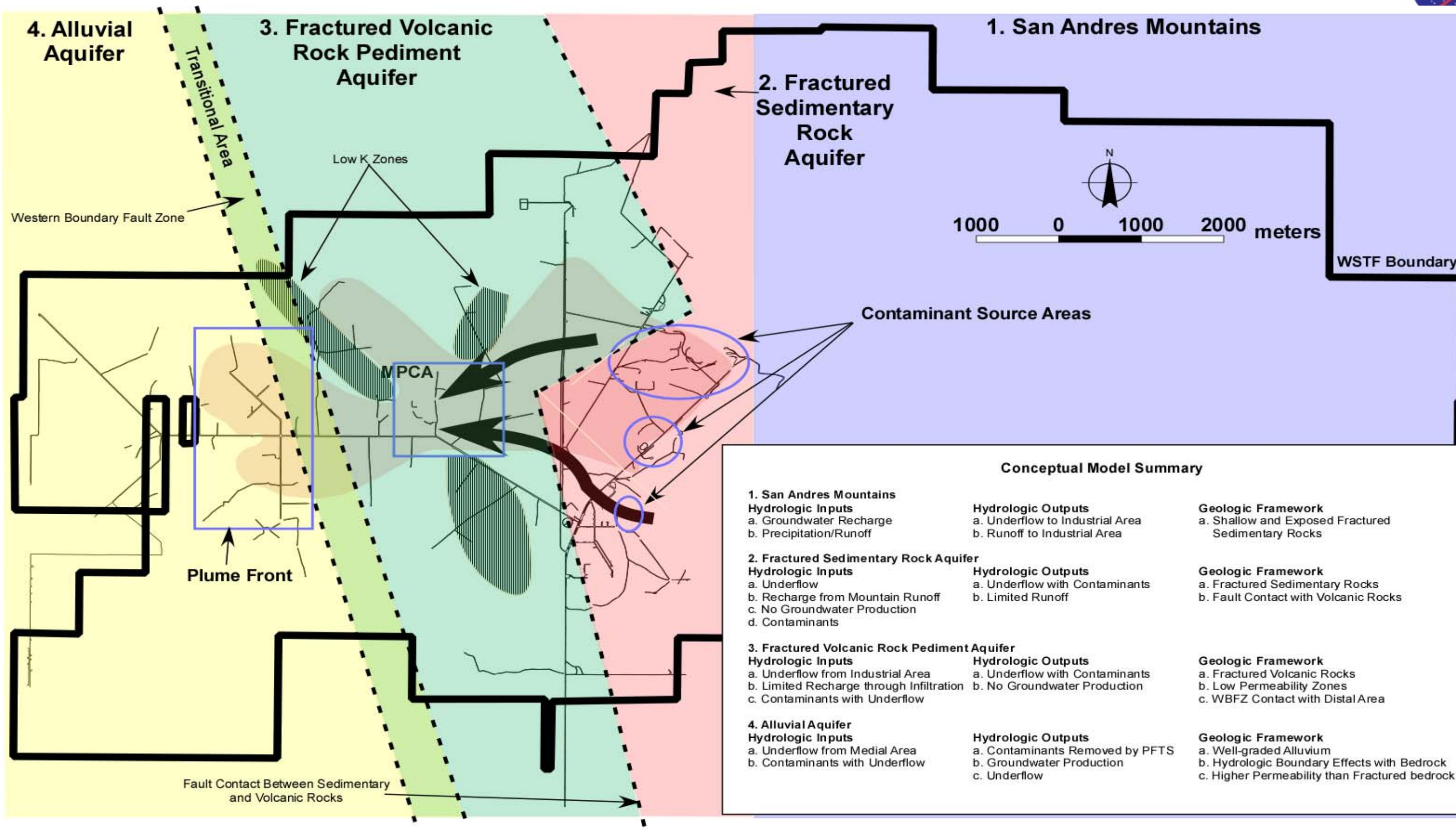
Public and Employee Assessment

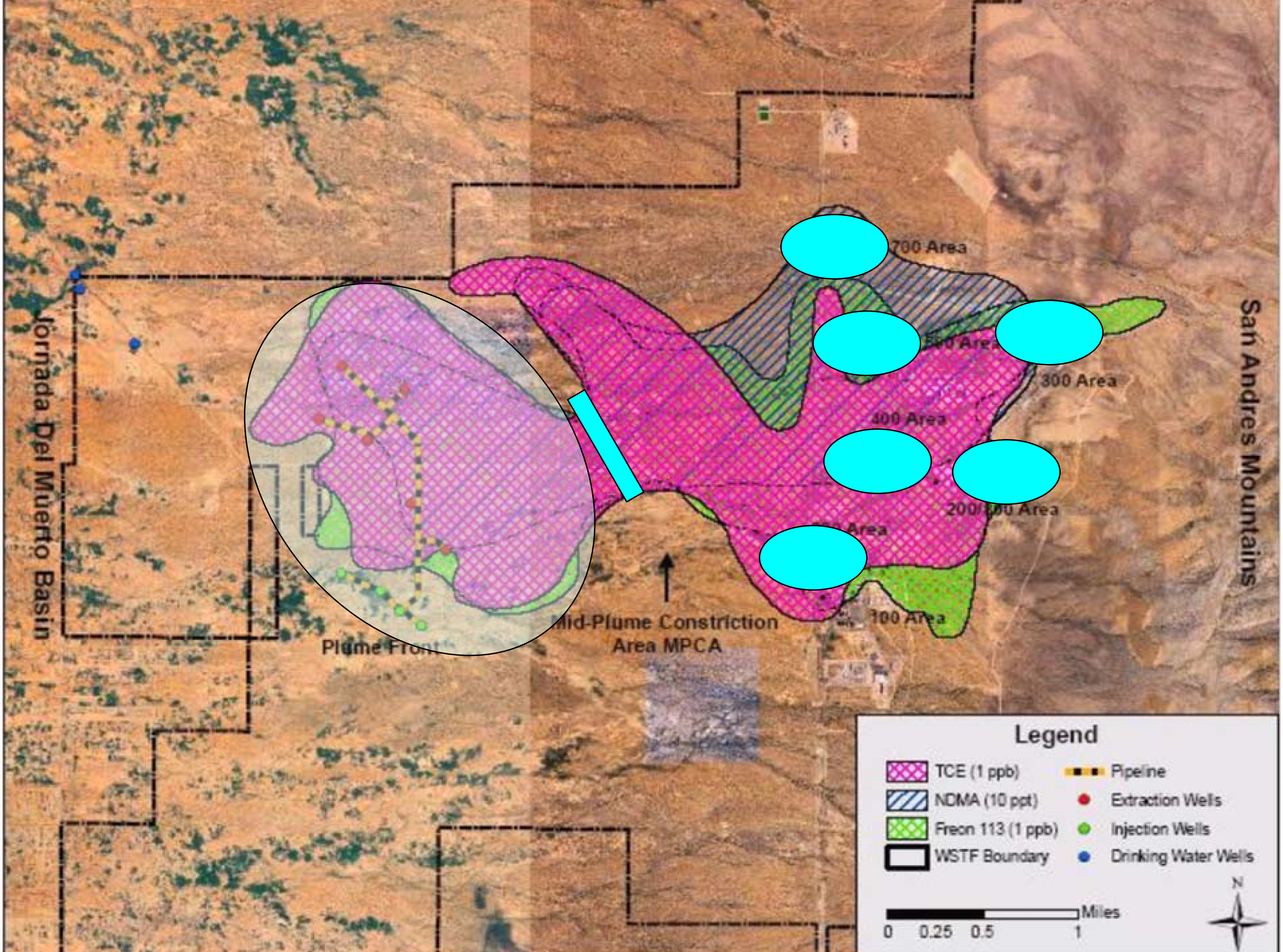
- No impact to any drinking water well
  - Includes public wells and NASA supply well
- No public exposure
  - Groundwater is several hundred feet below ground
  - No air or surface water exposure
  - Plume is moving very slowly west
    - Plume front treatment system will stop this westward movement.
- NASA performs on-going groundwater monitoring
  - More than 200 wells and zones routinely sampled
  - 850+ samples obtained monthly and analyzed for over 300 different contaminants

Containment and Restoration

- A Staged Approach over 60 years:
  - Attack the greatest risk to public health first
    - Stabilize the plume front (in progress)
  - Stop migration of contaminant into the plume front
    - Extraction and treatment at the Mid-Plume Constriction Area (~2009)
    - 100% design review completed, Construction start January 2009
  - Stop migration into the Mid-Plume Constriction Area
    - Clean up the source areas (~2012-2015)

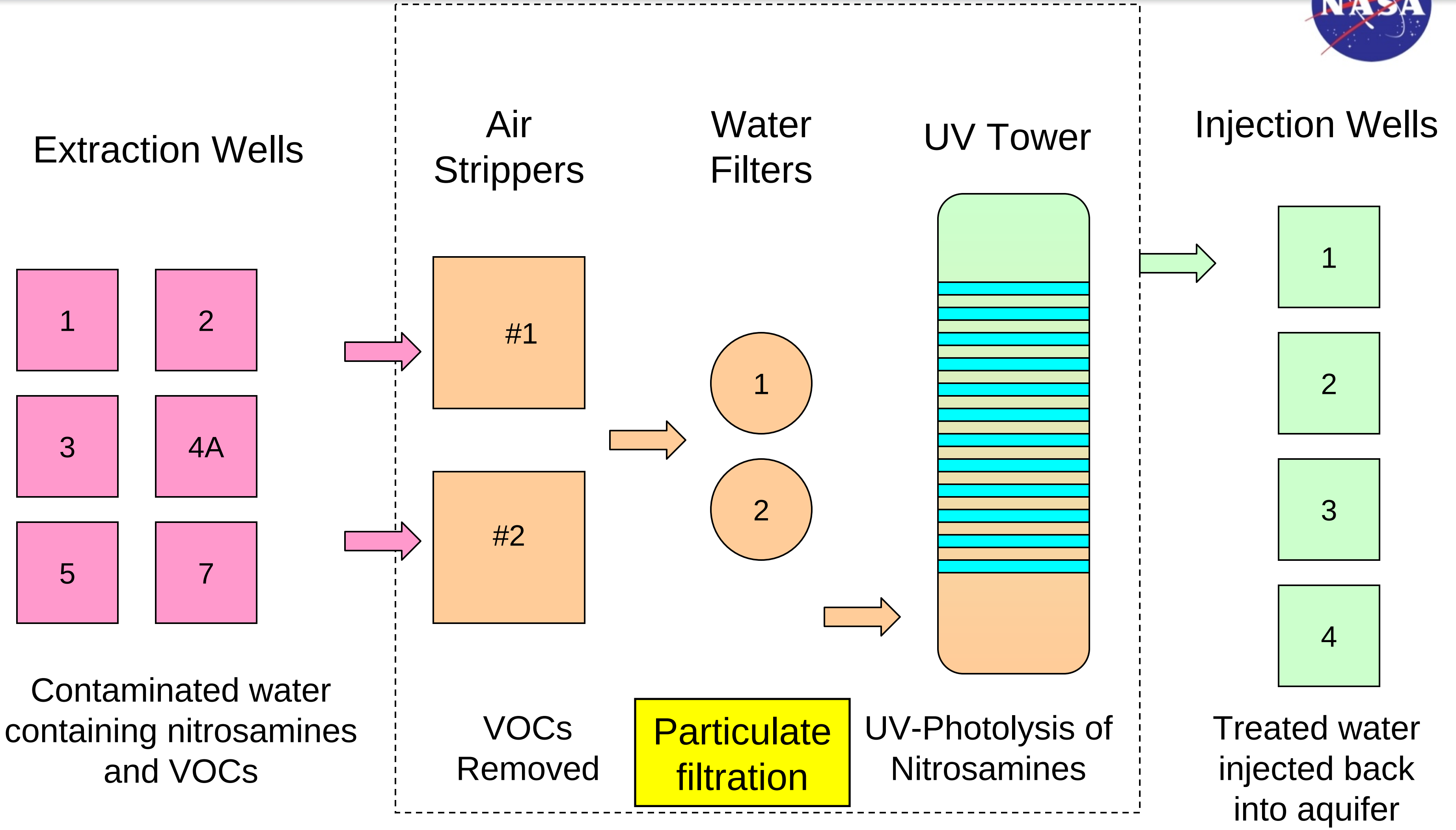
Containment and Restoration

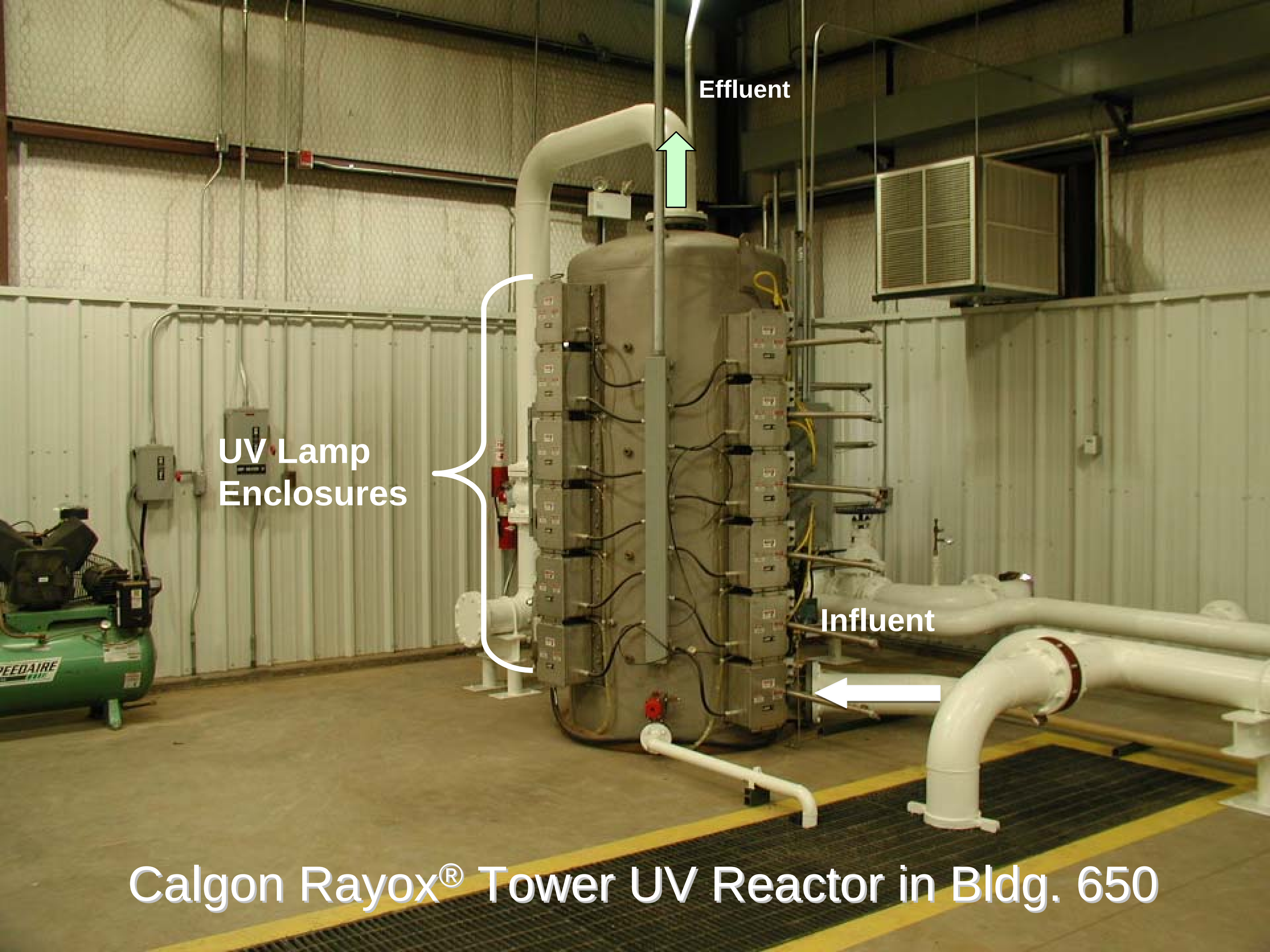




700 Area
300 Area
400 Area
200/600 Area
100 Area
Mid-Plume Constriction
Area MPCA
Plume Front
Jornada Del Muerto Basin
San Andres Mountains
Legend
TCE (1 ppb)
NDMA (10 ppt)
Freon 113 (1 ppb)
WSTF Boundary
Pipeline
Extraction Wells
Injection Wells
Drinking Water Wells
N
Miles
0
0.25
0.5
1

Plume Front Treatment System

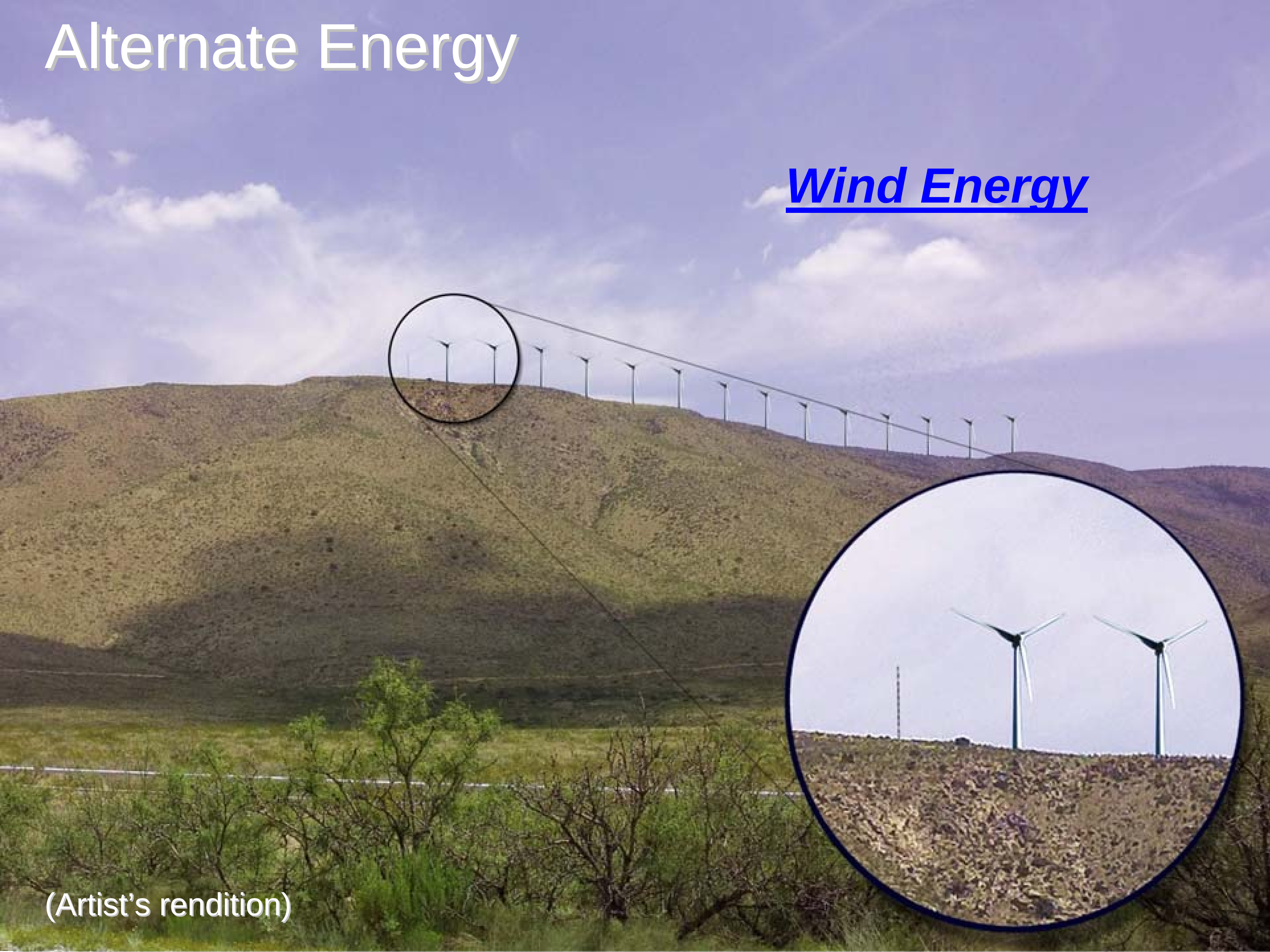




Calgon Rayox® Tower UV Reactor in Bldg. 650

Alternate Energy

Wind Energy



(Artist's rendition)

Alternate Energy

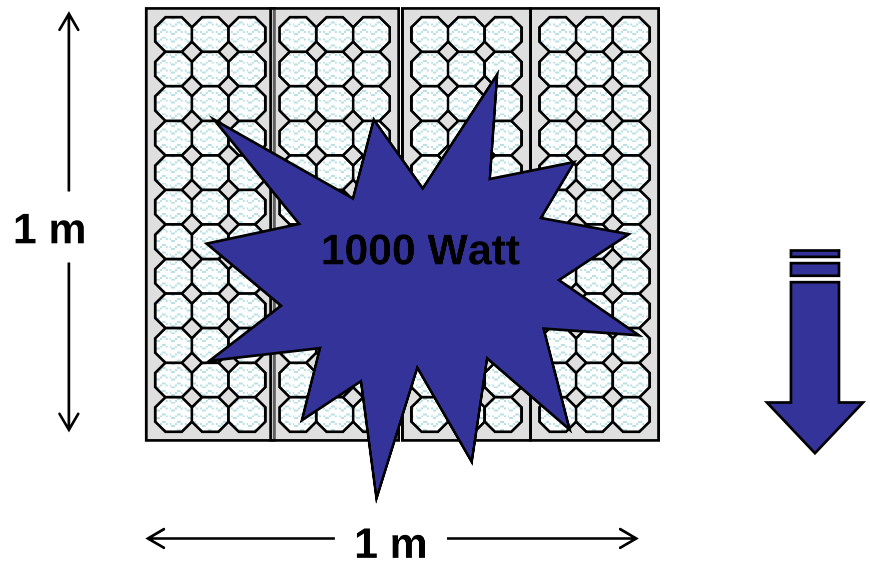
- **Wind Energy**
  - Quartzite Mountain monitored since 2005
  - Determined to be a class 4 to class 5 wind site
  - Initial Environmental Assessment (EA) performed by WSTF Environmental
  - Issues associated with EA:
    - Bat study (Fall 2007/Spring 2009)
    - Radar issues with WSMR (formed working group with WSMR test operations)
    - Cost for road to access planned wind farm about $5-6 M
  - Developers interested in constructing wind and solar
  - El Paso Electric Company (EPEC) interested in future wind project

Photovoltaic System

- Photovoltaic (PV) system will provide peak shaving during daylight hours
- Test bed for Plumefront energy storage (flow battery technology)
- Charge storage batteries
- Provide peak shaving
- Provide shading for vehicles in parking lot
- Provide plug-in for autos
- Could be used for PV test bed
  – Installation of separate modules (different technologies)

Efficiency of PV modules

- Commercial modules: 10-22 %

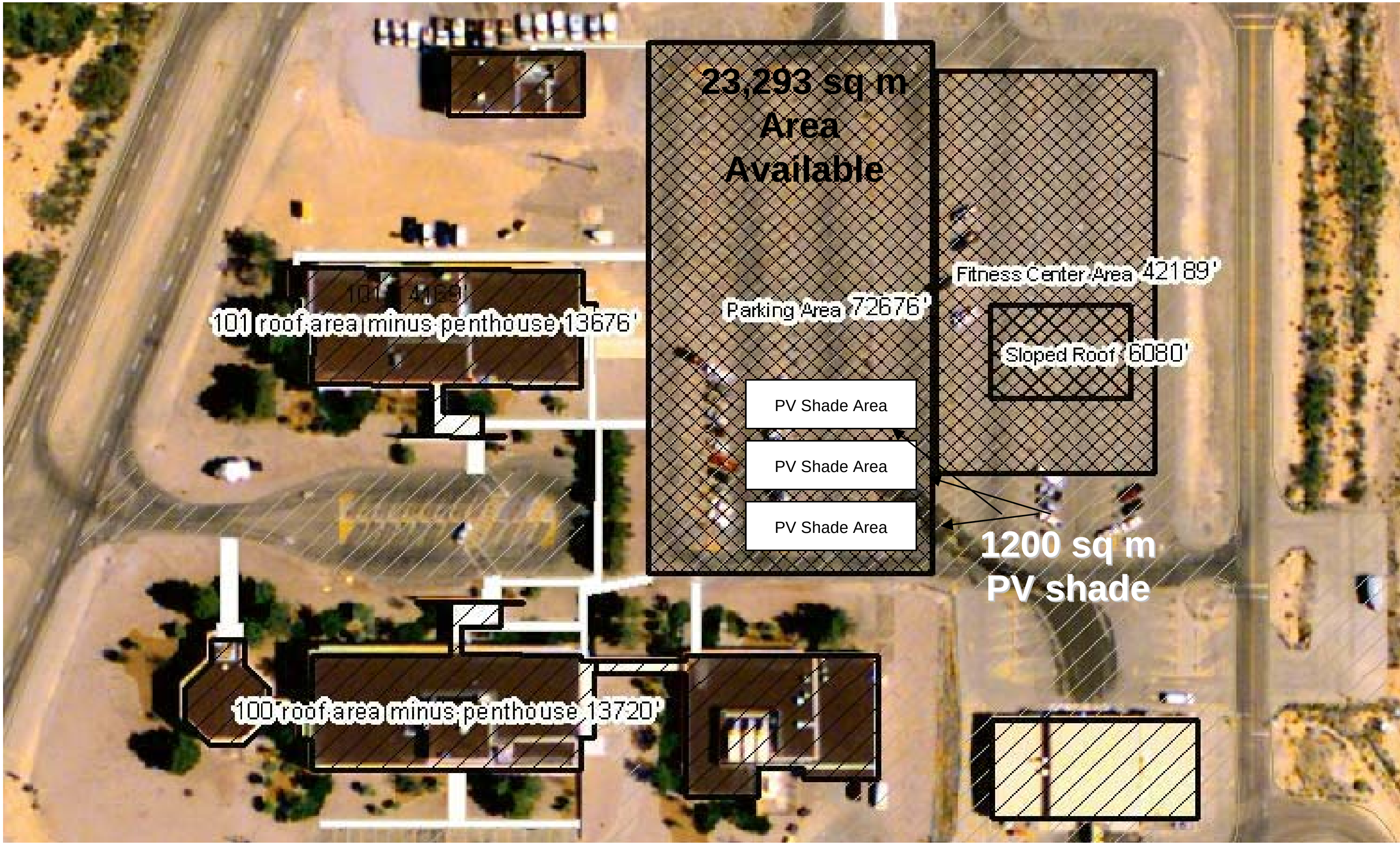


Irradiance = 1000 Watt/m^2

100 - 220 Watts Electrical power

Shaded PV Structure Plan View

N



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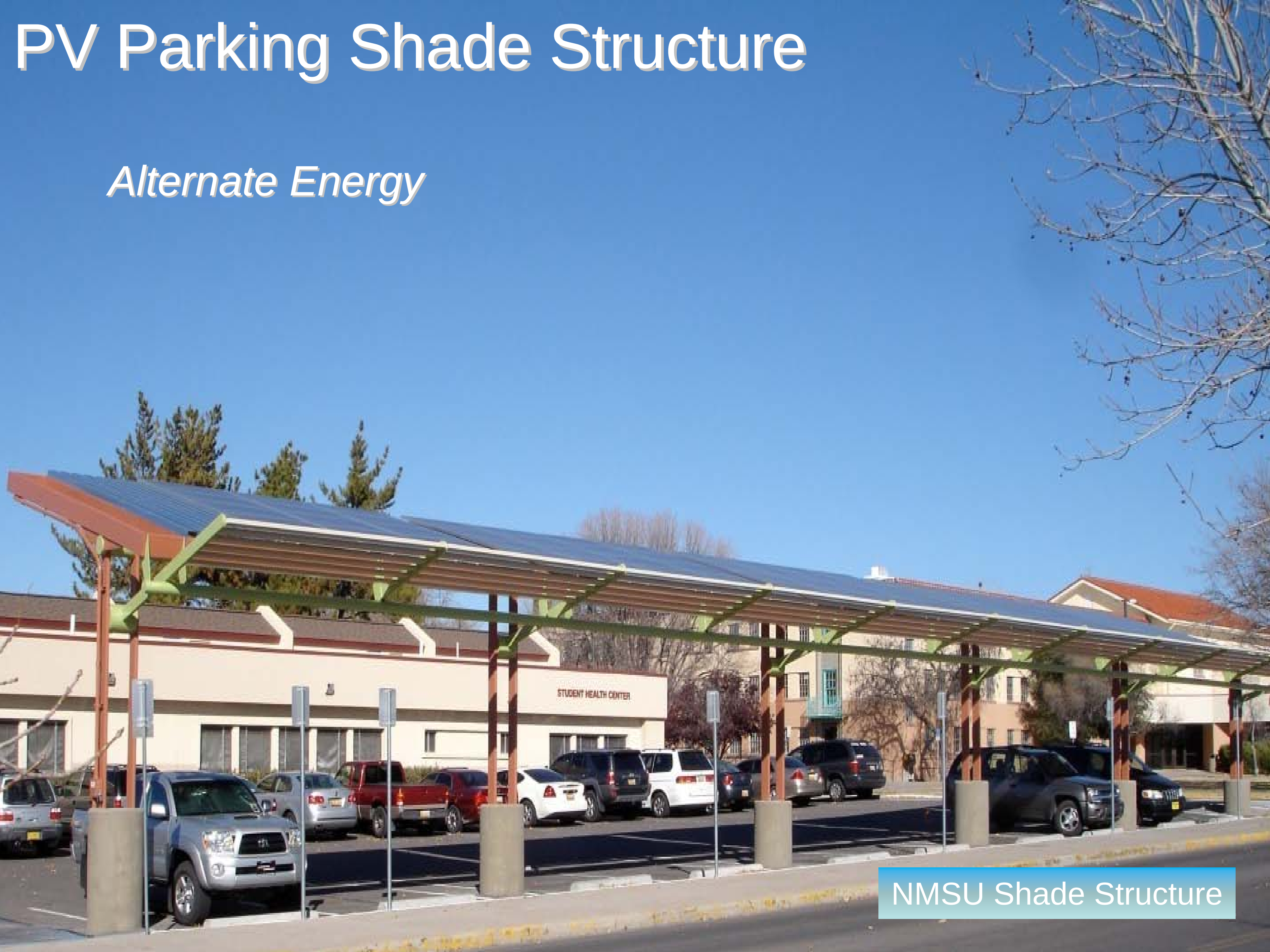
PV Parking Shade Structure

Alternate Energy



NMSU Shade Structure

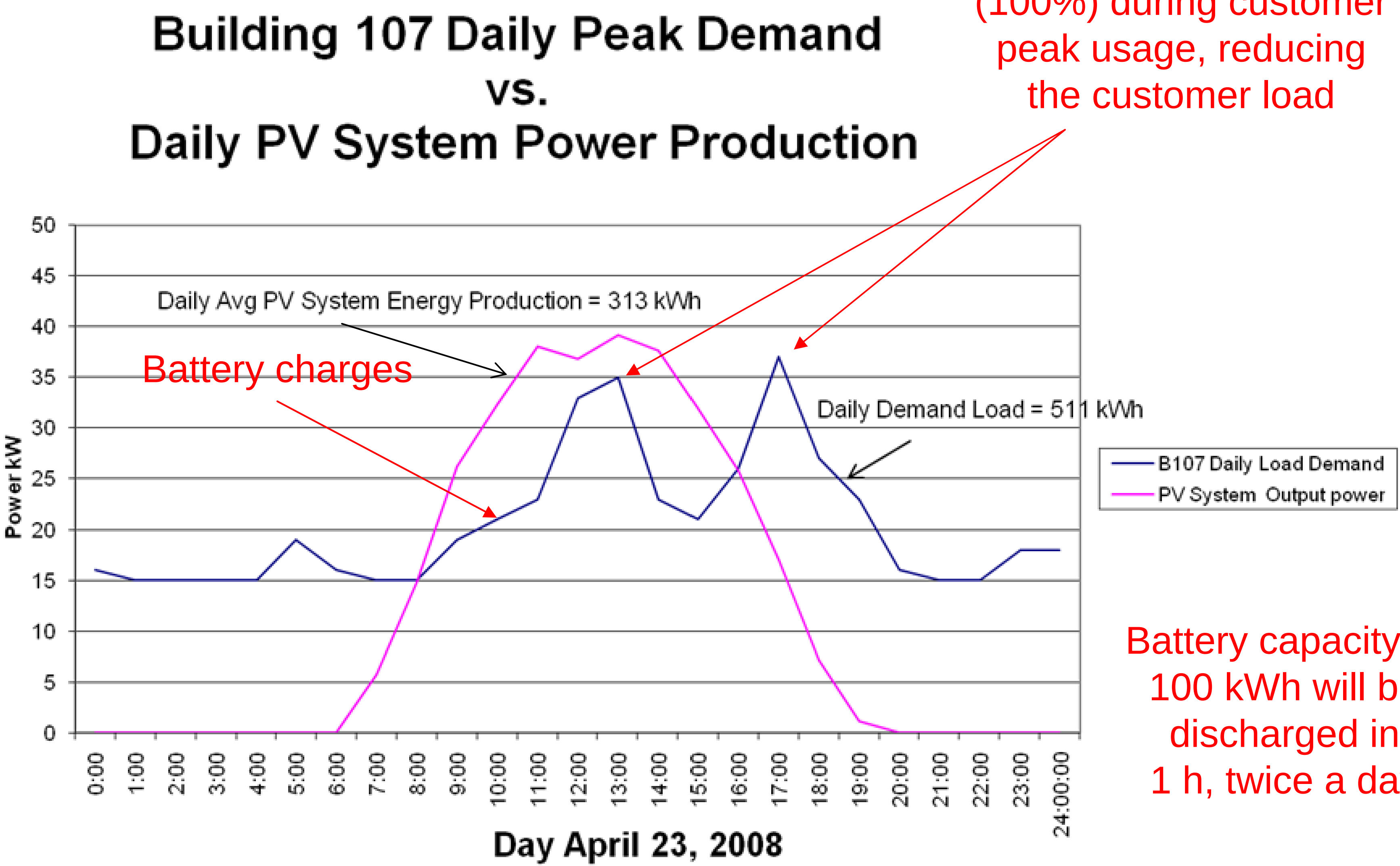
PV/Battery Hybrid System

Test Bed Renewable System

- Charges batteries throughout the day during off-peak load demand
- Discharges batteries during peak load demand
  - Determines benefits of using Flow batteries as energy storage for plume front system (discharge in solar off-peak hours or at night)
  - Evaluates the economic benefits of the system and monitoring the operation and performance of the PV and batteries (Zinc-Bromine/Vanadium)
  - Collects data to evaluate overall system performance, and to verify the storage system operates when necessary and provides necessary power required

PV Power Coincides with Peak Demand Load

Battery discharges (100%) during customer peak usage, reducing the customer load



Battery capacity of 100 kWh will be discharged in 1 h, twice a day

Energy Storage Unit

50 kWh Zinc Bromine Battery Module

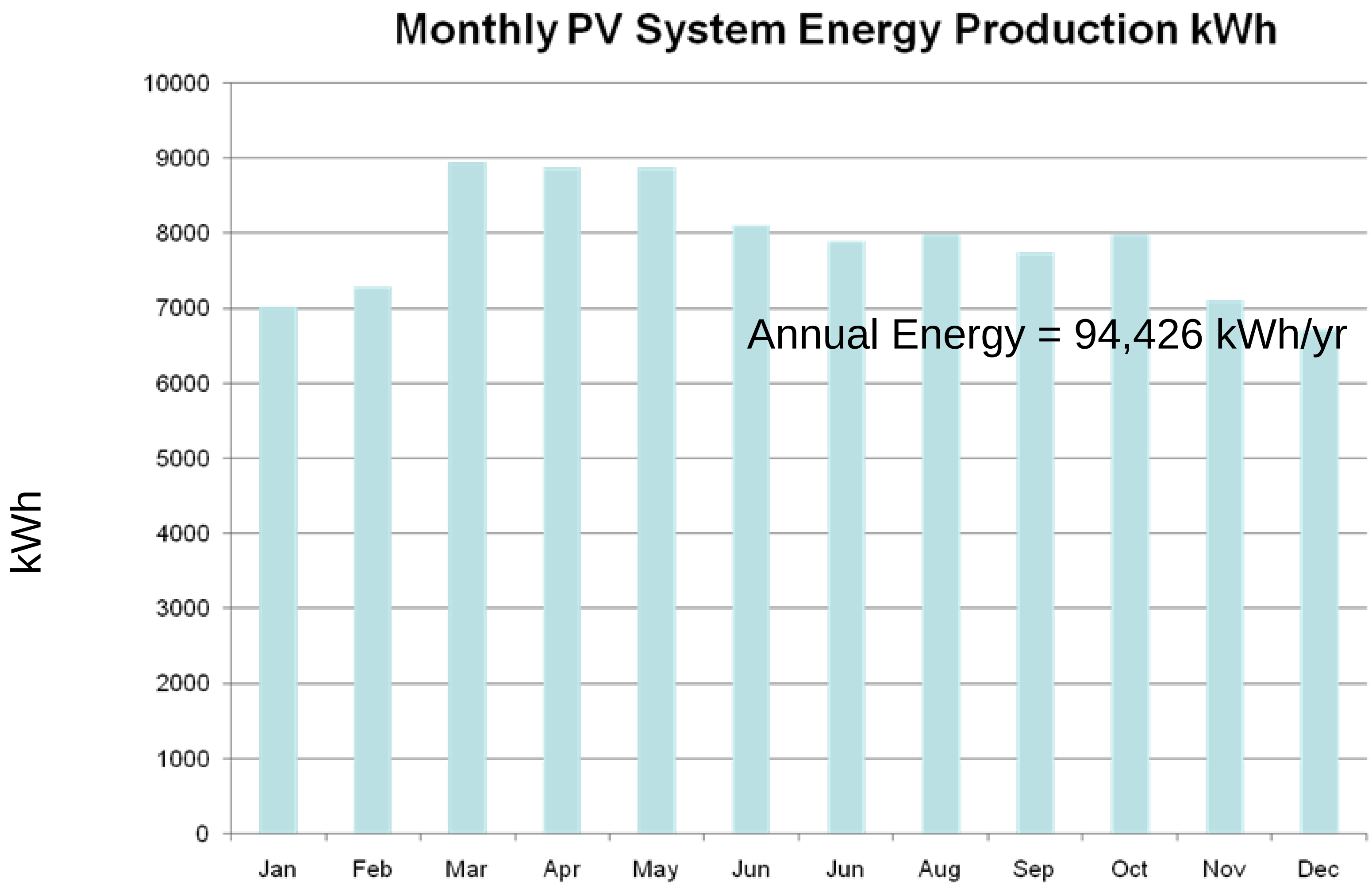
Battery Bank

- Two 50 kWh battery modules connected electrically in parallel
- A control system (Power Conversion System (PCS) inverter)
- A pair of electrolyte storage tanks
- Electrolyte circulation equipment

Advantages

- Uses electrodes that do not take part in the reactions, consequently there is no material deterioration that would cause long term loss performance
- Rapid recharge (2-4 hours)
- Deep discharge capability (100%)
- Built-in thermal management system
- Can be used for large scale application

System Energy Production



Alternate Energy

Utility-size Solar Peak Shaving

Nevada Solar One

Peak Shaving Solar Plant

- NASA-owned land at WSTF considered for a solar-power generation plant
  - Approximately 400 acres
- Plant will be built and operated by the developer
- Developer is responsible for <u>ALL</u> financing of design, construction, and operation

Peak Shaving Solar Plant

- Current Electrical Power to WSTF
  - 69kV Transmission line to Apollo Substation from El Paso Electric Company
  - Substation rated for 15 MW (reached capacity in June 2006)
  - 24kV distribution line down to NASA land area
- NASA needs power to support site
  - Currently NASA has a ~5.5 MW peak load
  - DOD installation on site also interested in renewable energy

Peak Shaving Solar Plant

- Preliminary Environmental Assessment (EA) has been completed, but a complete EA is required prior to construction start
- NASA facility-type support is available, but cost is associated

Peak Shaving Solar Plant

- RFI on GovBiz (14 responses)
  - Number: 2008LUA
  - Posted Date: May 14, 2008
  - Response Date: May 27, 2008
  - 14 responses received
- Industry Day on Aug 12, 2008
  - MMA Renewable Ventures, LLC
  - Abencs/Abengoa
  - Acciona
  - International Power America
  - EverGuard Roofing, LLC
  - Greenlight Sunstream Holdings, LLC (dba Helios Energy)
  - Consolidated Solar Technologies
  - North Wind, Inc.
  - Juwi Solar

Peak Shaving Solar Plant

- New website for vendors generated
- In process of posting project information and Q&A
- Working with National Renewable Energy Laboratory (NREL) and New Mexico State University (NMSU) on the Request for Proposal (RFP)
- Options:
  - Provide land to El Paso Electric Company for 92 MW Concentrating Solar Power (CSP) plant
  - Sell power to Public Service Company of New Mexico (PNM) or other New Mexico utilities
  - Sell power out-of-state
  - Use power only behind the meter (NASA, White Sands Missile Range (WSMR), Holloman Air Force Base (HAFB), Fort Bliss)

Questions?