



***Welcome***

***Approaches to  
Long-Term Monitoring / Long-Term Optimization  
Strategies, Case Studies, and Guidance***

**Session Chair  
Philip Hunter, P.G.  
AFCEE/ERS**

**2003 AFCEE Technology Transfer Workshop  
Brooks City-Base  
San Antonio, TX**

**24 Feb 2003  
800 am – 1200 pm**



# 2003 AFCEE Technology Transfer Workshop

San Antonio, Texas

*Promoting Readiness through Environmental Stewardship*

# Overview of LTM Optimization at Air Force Facilities

**Philip Hunter, P.G.  
AFCEE/ERS  
24 Feb 2003**



**Air Force Real Property Agency**



# ***Presentation Overview***

- **Optimization Overview**
- **Guidance**
- **AF Tools**
- **AFCEE Case Studies**
- **New Initiatives**
- **Validation & Effectiveness**
- **Comparison Studies of Tools**
- **Summary**

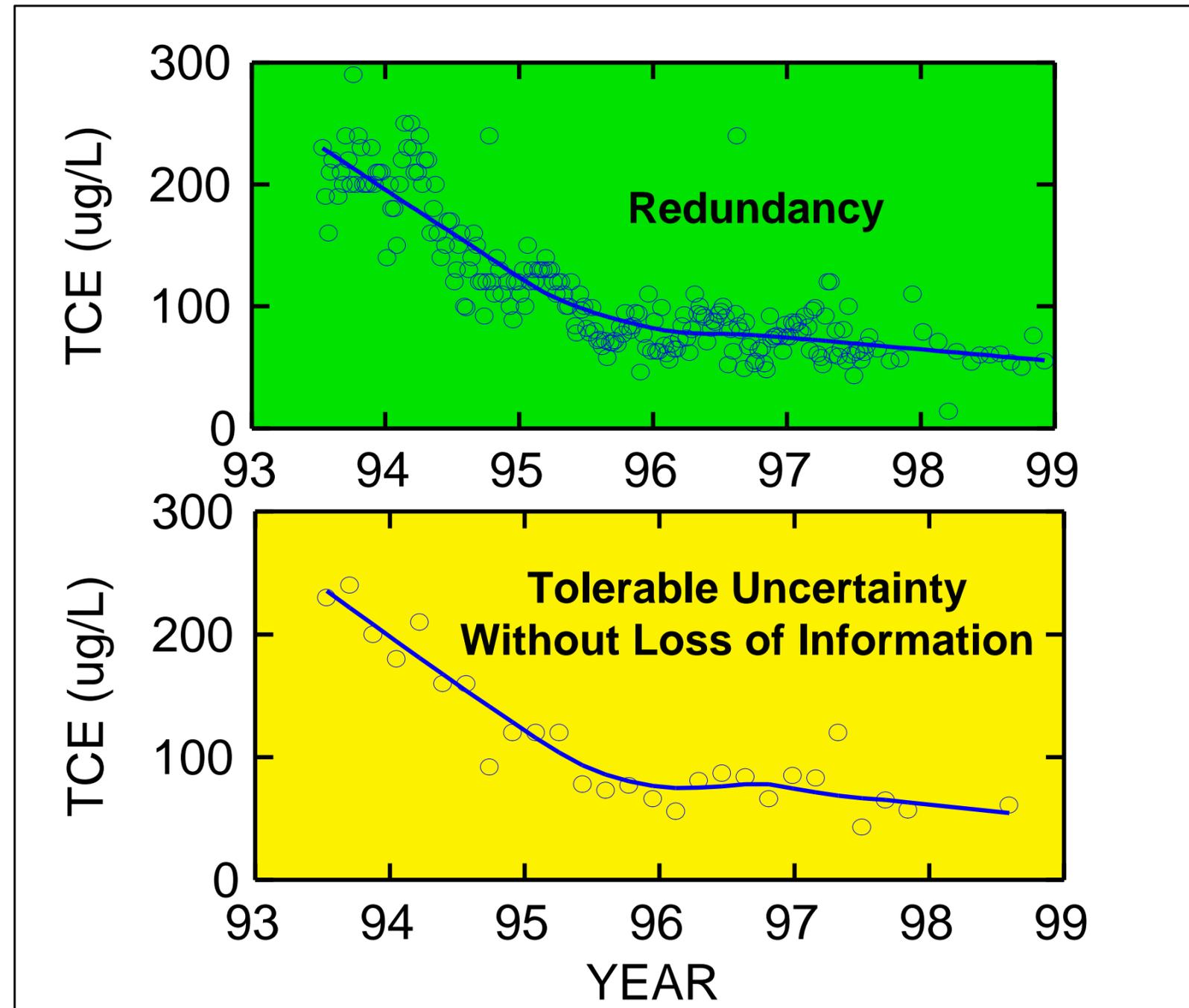


# Redundancy

Unnecessary Data

“Nice to have”  
All Data  
N = 240

“Essential”  
90% Reduction  
N = 27





# *Status*

- **Technology is relatively recent**
- **Variety of approaches**
- **Optimization case studies number < 50 across DoD, DoE, and EPA**



# ***Requirement*** *from Management*

- **Mgmt Guidance for Defense Environmental Restoration Program (DERP), 2001: <https://www.denix.osd.mil/denix/Public/ES-Programs/Cleanup/guida.html>**
  - DoD umbrella **requirement**
  - Must optimize remedial actions
- **Mgmt Guidance for the AF Environmental Restoration Program (ERP), in final draft**
  - AF equivalent of DERP guidance
  - Requires **annual optimization review** for RIP sites



# ***Monitoring Goals***

- **Protect human health & the environment**
- **Achieve a better technical solution----within constraints**
- **Sufficient data**
- **Adequate decision support**
- **Reduce costs when appropriate (20-40%)**
- **Expand network if necessary**



# ***Monitoring Scenarios***

- **Passive monitoring networks; LTM**
- **Active remediation in place**
  - **Performance/effectiveness of remedial systems (e.g. pump & treat)**
  - **Monitored Natural Attenuation (MNA)**
  - **Treatment facility, e.g. influent/effluent monitoring**
- **Permit compliance**



# ***Optimization Strategies***

- ✓ **Number & location of wells**
- ✓ **Sampling frequency**
- **Analytical protocols**
- **Field procedures**
- **Data management**



# ***Monitoring Targets***

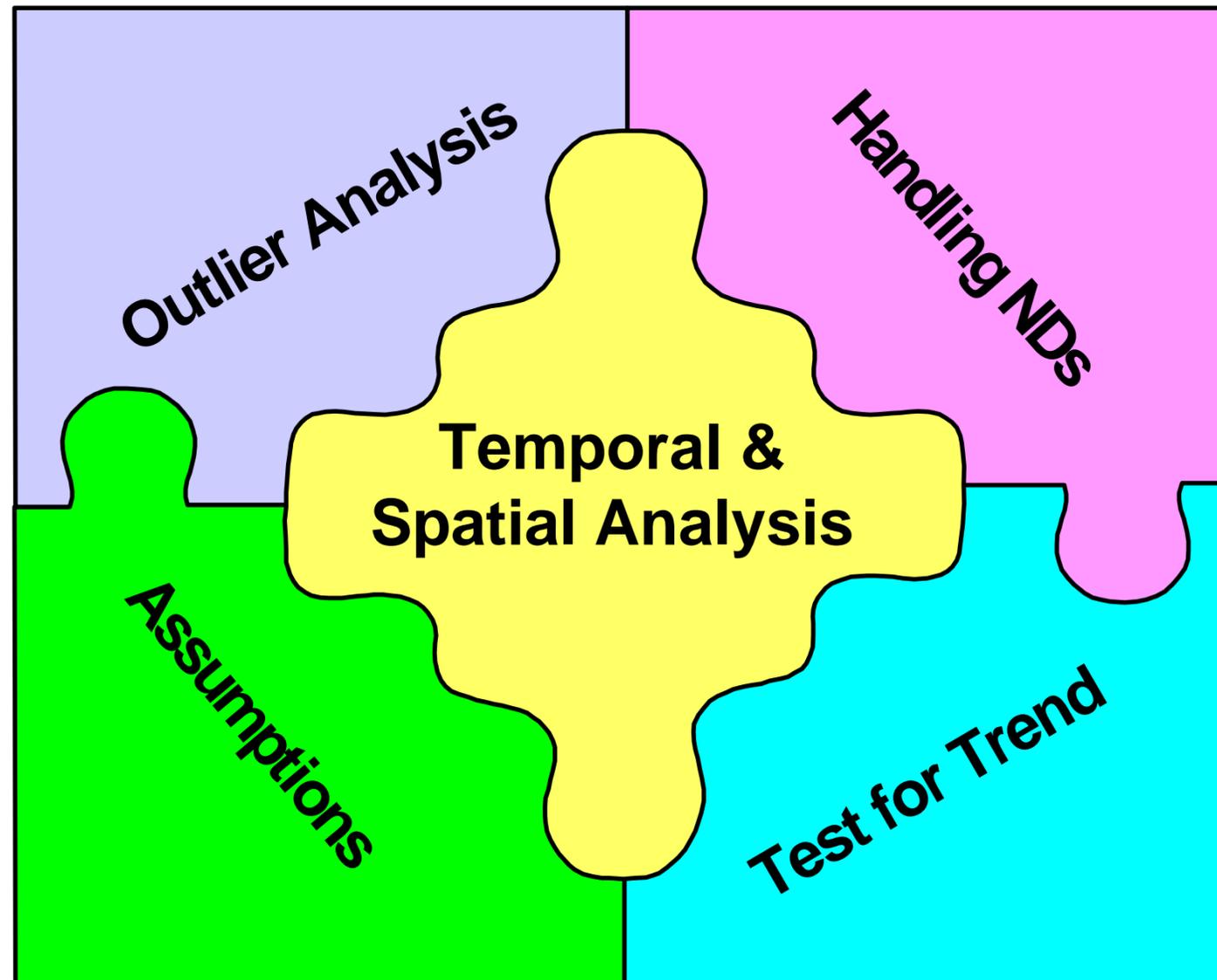
***Where is the Information?***

- **Significant trend**
- **Change in trend**
- **High variability**
- **Areas of uncertainty**
- **Threshold infringement; e.g. MCL, PRG**
- **Sentinel locations**
- **Trespass to offsite MWs**
- **Mass of contamination**
- **Process indicator**



# **Core Strategy**

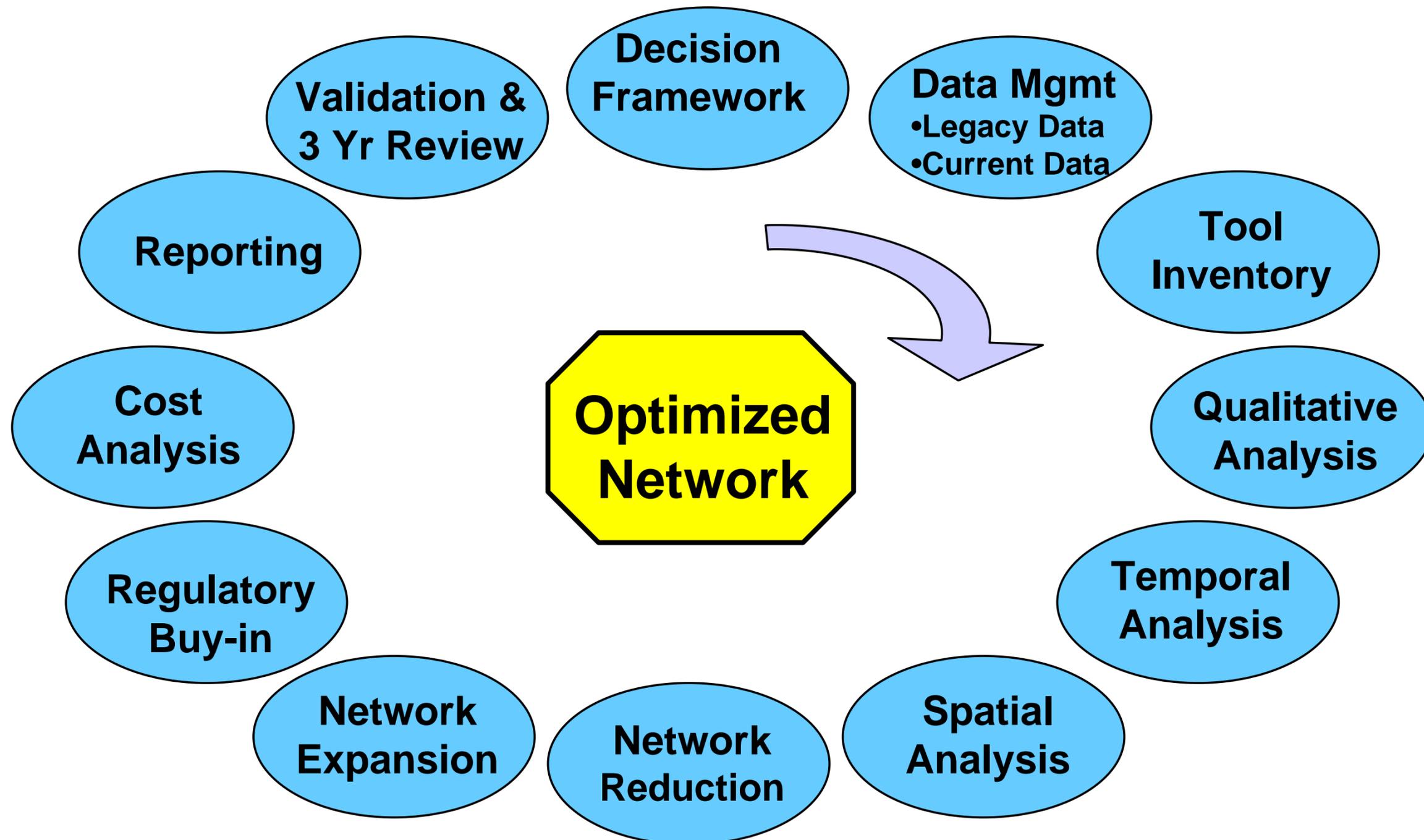
*and Technical Issues*





# ***LTM Optimization***

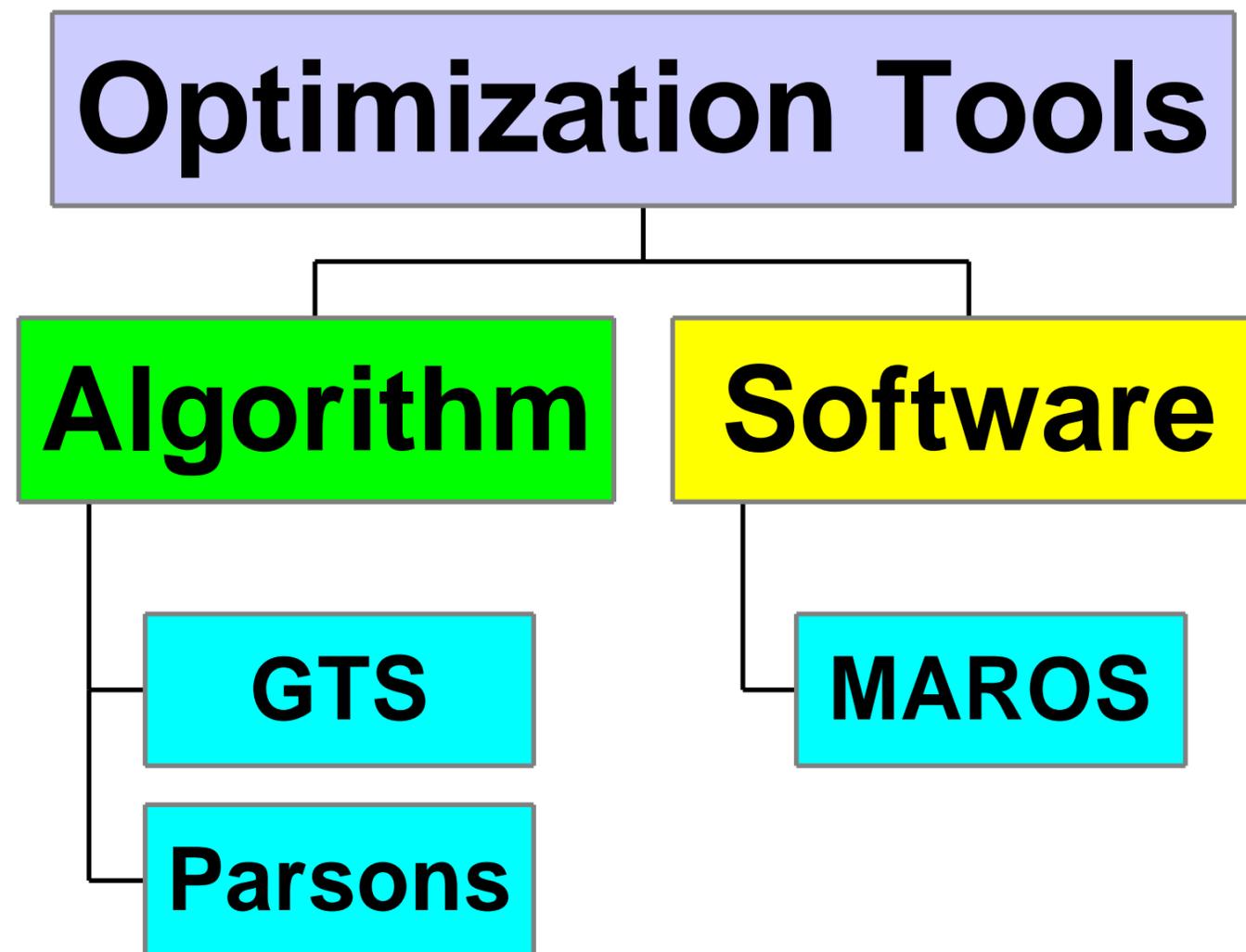
## ***Process & Components***





# Optimization Tools

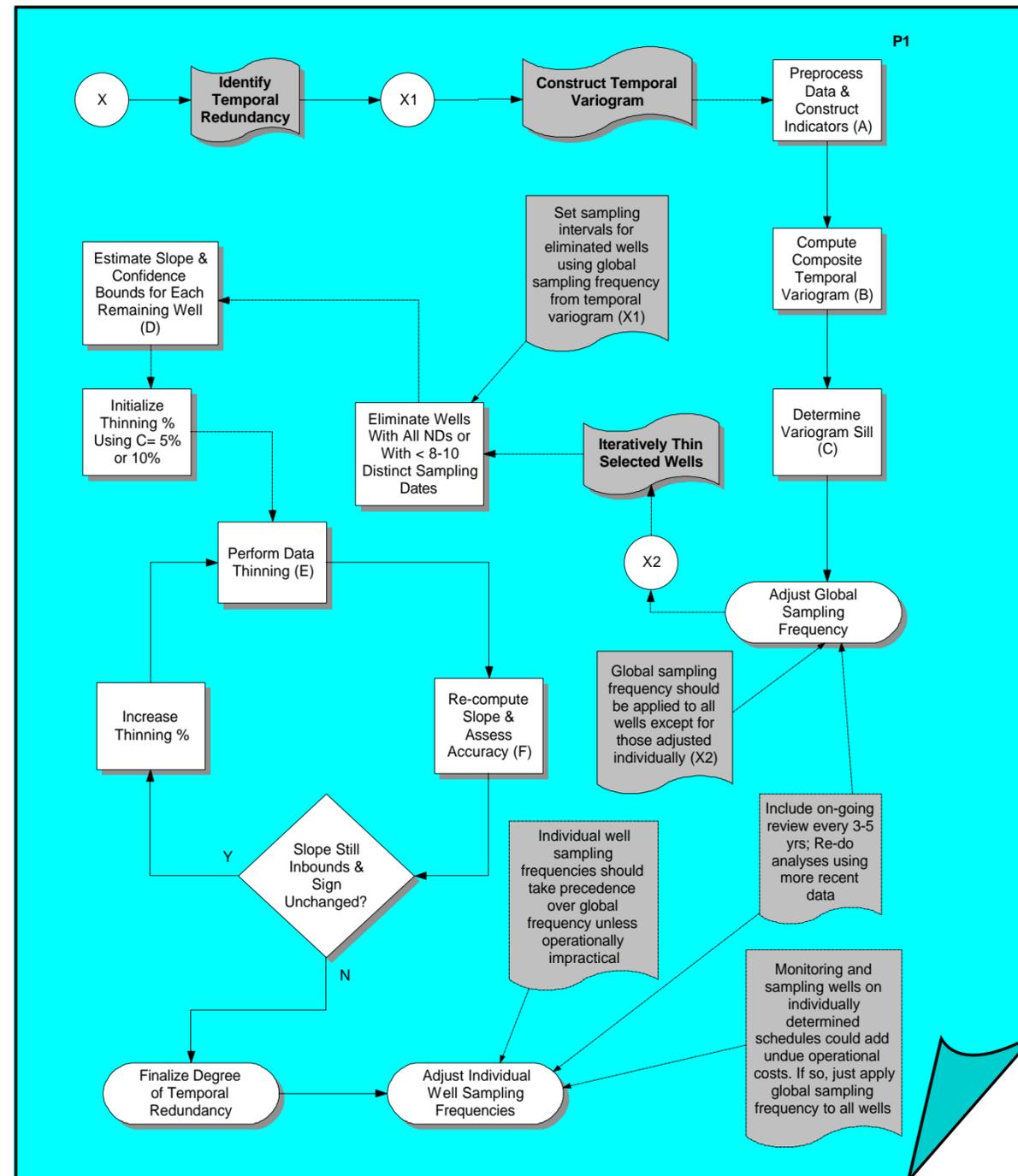
*General Categories*





# Decision-Path Framework

Essential & Detailed





# ***Challenges***

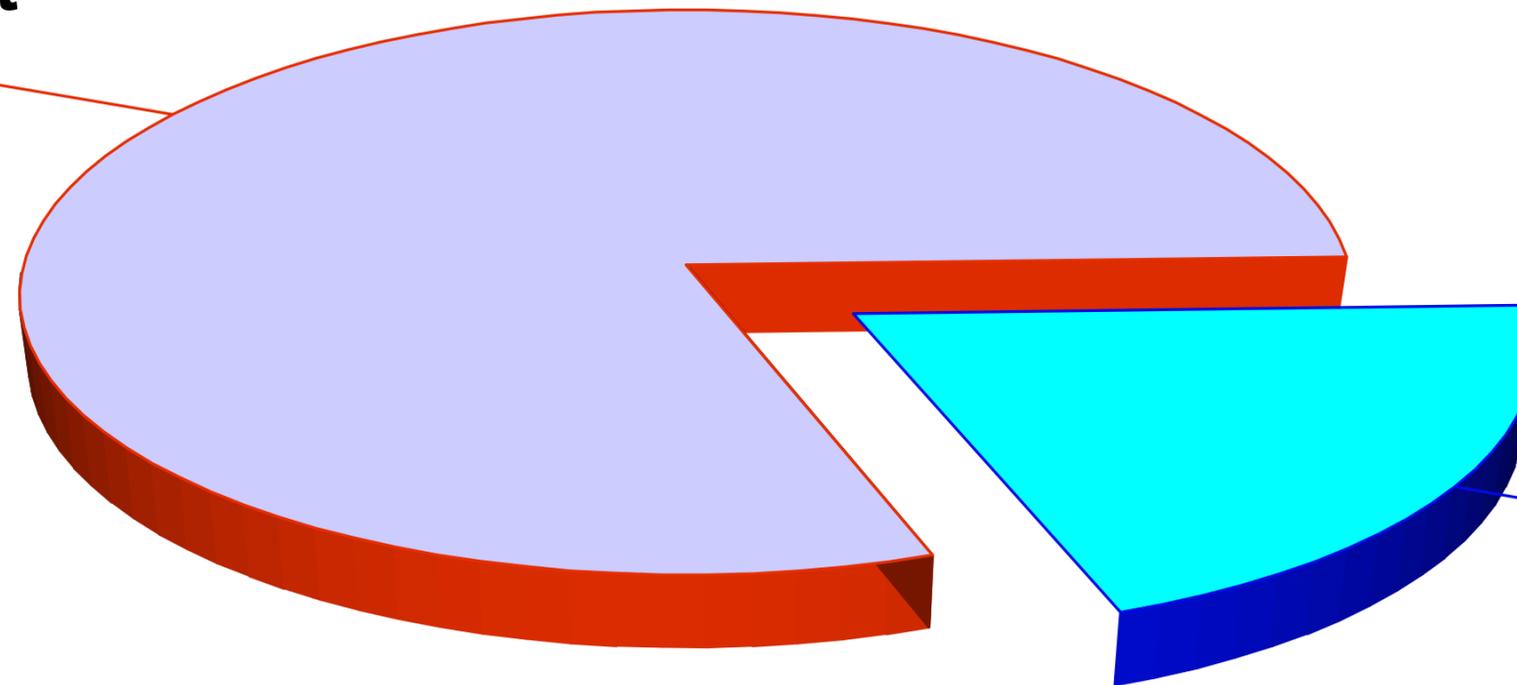
- **Disparate Data Management Systems**
- **Flow systems**
  - **Fractured media**
  - **Multiple aquifer systems**
- **Complex contaminant hydrogeology**
  - **Variety of sites & constituents**
  - **Mixed waste**
- **3-D geostatistical analysis**



# Optimization

*Level of Effort – Edata is Important*

**Data Mgmt  
80%**



**Analysis &  
Reporting  
20%**



# ***Data Resources***

- **ERPIMS**
- **Resident installation databases**
- **Disparate data sources**



# ***Products and Deliverables***

- **Independent analysis**
- **Decision framework**
- **Essential monitoring locations**
- **Redundant monitoring locations**
- **Optimized sampling frequency, duration**
- **Need for new monitoring locations**
- **Cost benefit analysis**



# ***What's New***

- **Case studies**
  - **More complex sites**
  - **Variety of contaminants & remedial systems**
- **GTS Algorithm modification & software conversion**
- **MAROS Vers 2.0 beta (Oct 2002)**
- **Comparison studies of tools**



# Case Studies

2002

- **Air Force**
  - Hill AFB, UT
  - MMR, MA
  - AFP6, GA
  - McClellan AFB, CA
- **Defense Logistics Agency (DLA)**
  - Defense Depot (DD) San Joaquin, Tracy, CA
  - DD Memphis, TN
  - DD Susquehanna, PA
- **Navy**
  - Marine Corps Logistic Base, Albany, GA
  - Naval Air Station (NAS), Brunswick, ME
  - Marine Corp Base Camp Lejeune, NC
- **Army; Ft Lewis, WA**
- **DoE**
  - Lawrence Livermore National Lab (LLNL), CA
  - Savannah River Site (SRS), SC
- **Norton AFB, CA**
- **Mather AFB, CA**
- **DD Sharpe, CA**
- **Defense Service Center, Richmond, VA**
- **Former DD Ogden, UT**
- **Arctic Surplus Supply, Fairbanks, AK**
- **NAS Patauxent River, MD**
- **NAS Ft. Worth, TX**
- **Naval Weapons Industrial Reserve, Dallas, TX**



# ***Case Studies***

## ***Recent***

- **Loring AFB, ME**
- **Pease AFB, NH**
- **Edwards AFB, CA**
- **Bolling AFB, MD**
- **Columbus AFB, OH**
- **Dover AFB, DE**
- **Keesler AFB, MS**
- **McClellan AFB, CA**
- **Shaw AFB, SC**
- **Vandenberg AFB, CA**
- **Williams AFB, AZ**



# ***AFP 6***

## ***Interim Corrective Measures (ICM) & LTM Case Study***

- **Wells:**
  - **ICM extraction 16 (3 dual-phase)**
  - **ICM monitoring 14**
  - **LTM monitoring 40**
- **Contaminants of concern**
  - **Solvents (TCE and daughter products)**
  - **Fuel-related (BTEX)**
  - **Metals**



# ***AFP 6***

## ***Interim Corrective Measures (ICM) Case Study***

- **Hydrogeology**
  - **Fractured metamorphic bedrock**
  - **Partially weathered bedrock**
  - **Saprolite (decomposed rock, residual structure)**
- **Remedial system: Pump & Treat and SVE**
  - **Influent/effluent sampling frequency**



# ***Loring AFB***

***OU-12 Case Study***

- **Monitoring wells: 165**
- **Contaminants of concern**
  - **Fuel-related (BTEX)**
  - **Solvents (TCE, PCE, trans 1,2-DCE, 1,1,1-TCA)**



- **Hydrogeology**
  - **Fractured carbonate bedrock**
  - **Glacial till overburden**
- **Remedial systems (6 GW monitoring zones)**
  - **Bioventing**
  - **SVE**
  - **Dewatering trench**



# **Pease AFB**

## **Site 49 Case Study**

- **Monitoring wells: 80**
- **Contaminants of concern**
  - **Solvents (TCE and daughter products)**
  - **Fuel-related (BTEX)**
  - **Naphthalene**
  - **Monitored natural attenuation (MNA) parameters**



- **Hydrogeology**
  - **Fractured metamorphic bedrock**
  - **Glacial till**
  - **Unconsolidated material**
- **Remedial system: Permeable Reactive Barrier**



- **Monitoring wells: 130**
- **Contaminants of concern**
  - **Solvents (TCE and daughter products)**
  - **Perchlorate**
  - **NDMA – *N*-nitrosodimethylamine**
  - **Fuel related (benzene, MTBE)**
  - **Metals (Cr, Ni, As, Se, Mn, Fe, Tl)**



- **Hydrogeology**
  - **Fractured granitic bedrock**
  - **Weathered bedrock**
  - **Unconsolidated alluvium (gravel - clay)**
- **Remedial system: Pump & Treat**



# *Lessons Learned*

- **Independent analysis**
- **Essential features & deliverables**
- **Disparate databases**
- **Regulator buy-in**



# ***Validation***

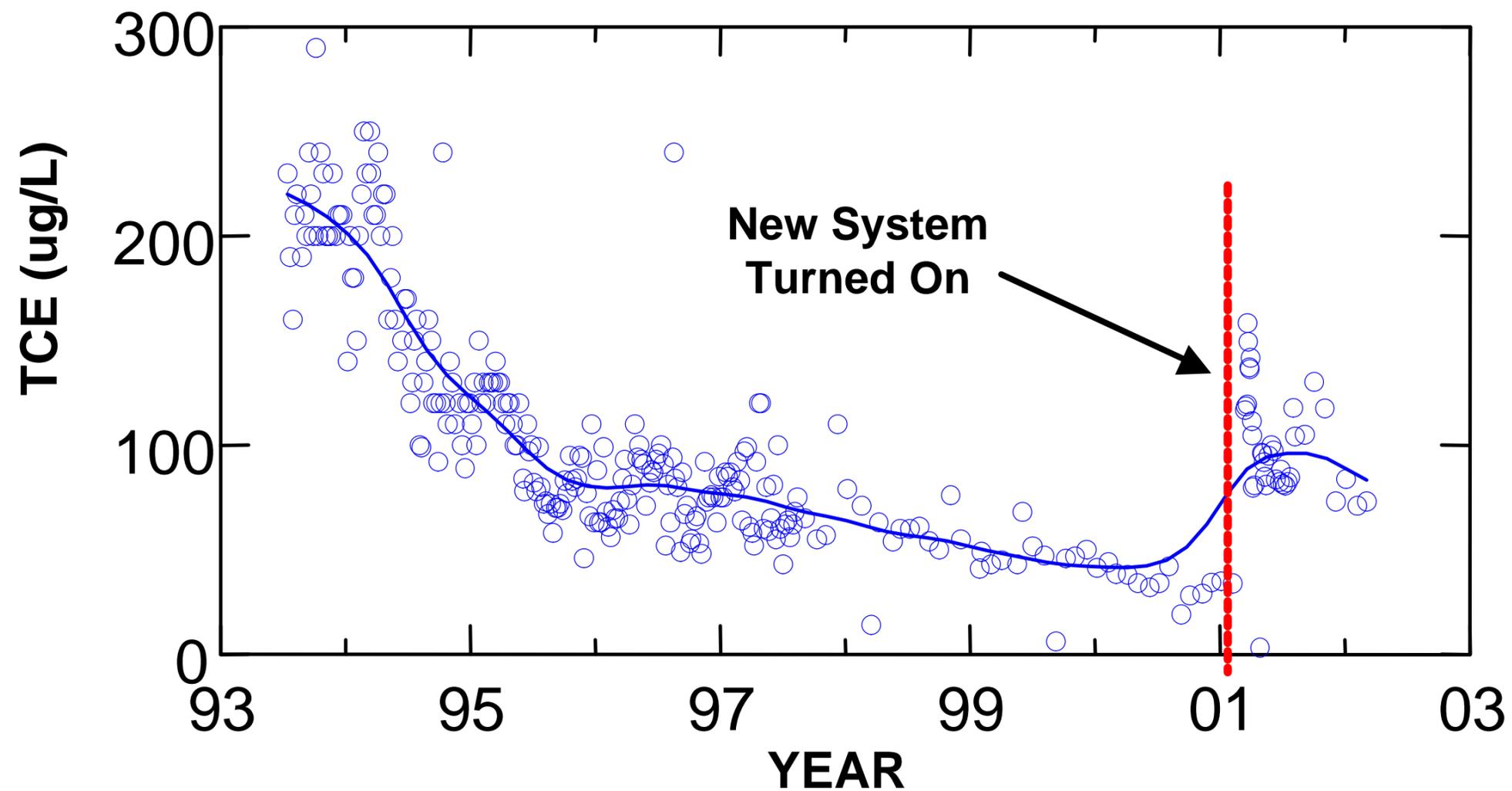
## ***Optimized Network***

- **Periodic review 3 – 5 years**
- **Selective sampling of redundant MWs**
- **Sample small percentage (<5%) of MWs**
  - **Random assignment (over time and space)**
  - **Judgmental assignment**
- **Reproducibility of predicted vs actual**
  - **Relative percent difference**  $(RPD) = \frac{|x_1 - x_2|}{x_{avg}} \times 100$
  - **Violation of local kriging confidence limits**
- **Confirmation sampling**



# ***TCE Influent***

***Mission St System***

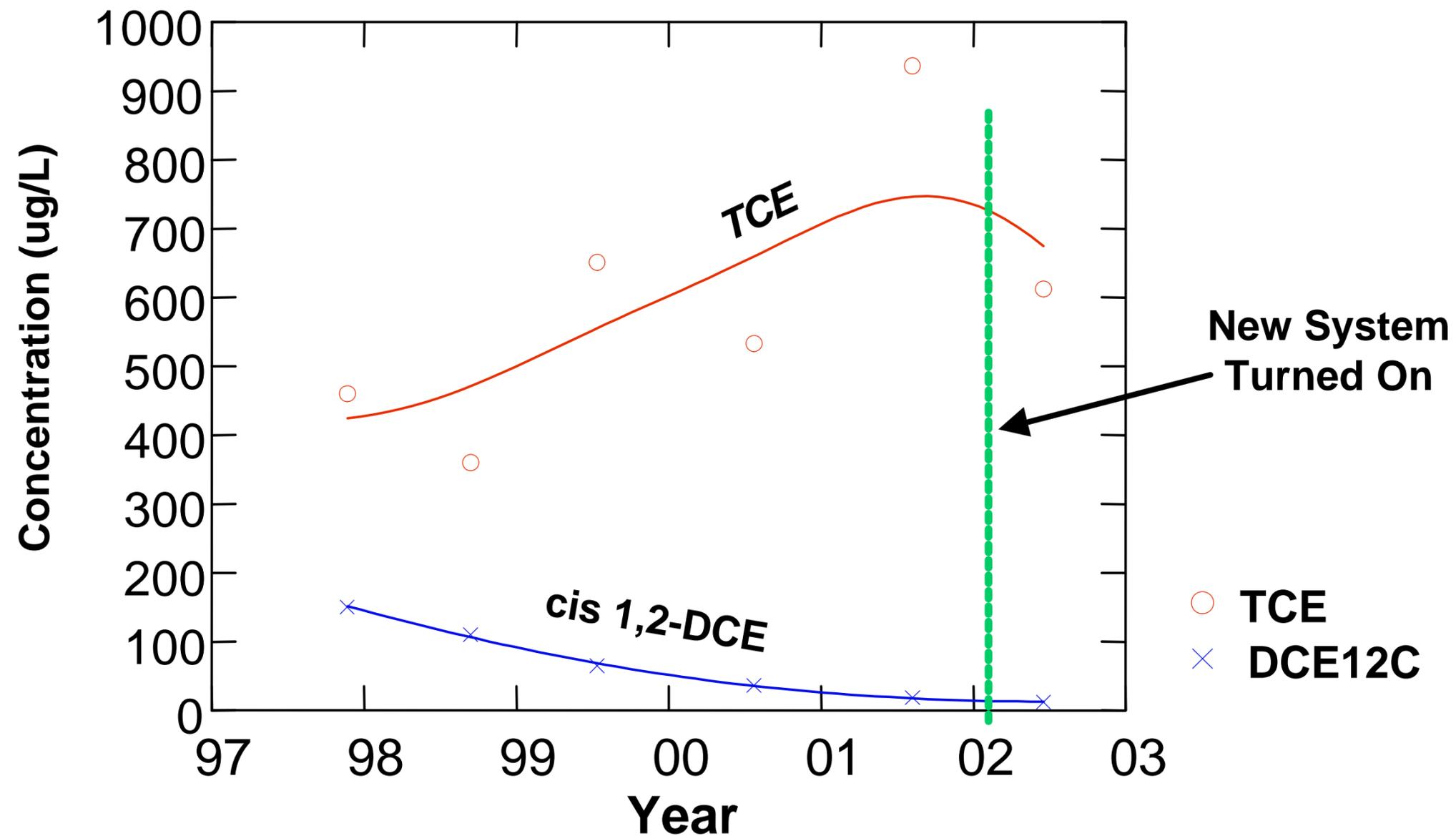




# Downgradient Well

Mission St P&T System

## Time Series MW64D





# ***Comparison Studies***

## ***Optimization Tools***

### **Metrics**

- **Essential MWs (location)**
- **Number of essential MWs**
- **Sampling frequency**
- **Statistical comparison of plume concentrations**
- **Cost analysis**



# ***Comparison Studies***

## ***Optimization Methods***

### **MAROS VS Parson's Approach**

- **McClellan AFB, CA**
- **Fort Lewis (Army), WA**
- **Long Prairie (Superfund site), MN**



# ***Comparison Studies***

## ***Optimization Methods***

### **GTS Algorithm vs MAROS**

- **Loring AFB, ME**
- **Pease AFB, NH**
- **Edwards AFB, CA**



# ***What's To Come***

- **More challenging sites**
  - **Fractured media**
  - **Complex hydrogeology, multiple aquifers**
- **More refinement and integration of temporal and spatial components**
- **Standardization of Reporting, Validation, & Periodic Review**
- **Reproducibility; Comparison of tool approaches and costs**



# ***How to Get Involved***

## ***Resources***

- **AFCEE website: <http://www.afcee.brooks.af.mil/er/rpo.htm>**
  - **Tools & guidance**
  - **Remedial Process Optimization**
  - **AFCEE LTM Optimization Guide**
  - **Geostatistical Temporal/Spatial (GTS) Optimization Algorithm Vers 1.0**
  - **Monitoring and Remediation Optimization System (MAROS) Vers 1.0**
- **AFCEE RPO Outreach Office (new):**  
**<http://www.afcee.brooks.af.mil/er/rpo/rpooutreach/rpo.asp>**
  - **Management assistance**
  - **Service center to facilitate RPO process**
- **EPA Technology Innovation Office (EPA TIO), Kathleen Yager;**  
**<http://www.clu-in.org/>**
- **Interstate Technology Regulatory Council (ITRC); <http://www.itrcweb.org/>**
- **Federal Remediation Technologies Roundtable (FRTR);**  
**<http://www.frtr.gov/optimization.htm>**



# *Summary*

- **Opportunity to significantly reduce monitoring**
- **Management requirement & guidance exists**
- **Capture sufficient data, reduce “nice to have”**
- **Innovative approaches and case studies are maturing technology**
- **Importance of electronic data**
- **Need validation protocol for 3-5 yr review**
- **Comparison studies of tools are ongoing**



***Thanks***



**Phil Hunter, P.G.  
AFCEE/ERS  
Tel 210 536-5281  
DSN 240-5281  
philip.hunter@brooks.af.mil**