

US EPA ARCHIVE DOCUMENT

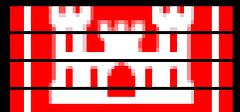
A Spill Management Information System for Freshwater Incidents

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in conjunction with

**The Nashville District and the Engineering Research and Development
Center, U.S. Army Corps of Engineers**



Presentation Outline

- Background
- Project Objectives
- Conceptual Design and System Architecture
- Water and Air Quality Models
- Model Execution
- Spill Scenario Example
- Project Accomplishments
- Current and Future Work

Background

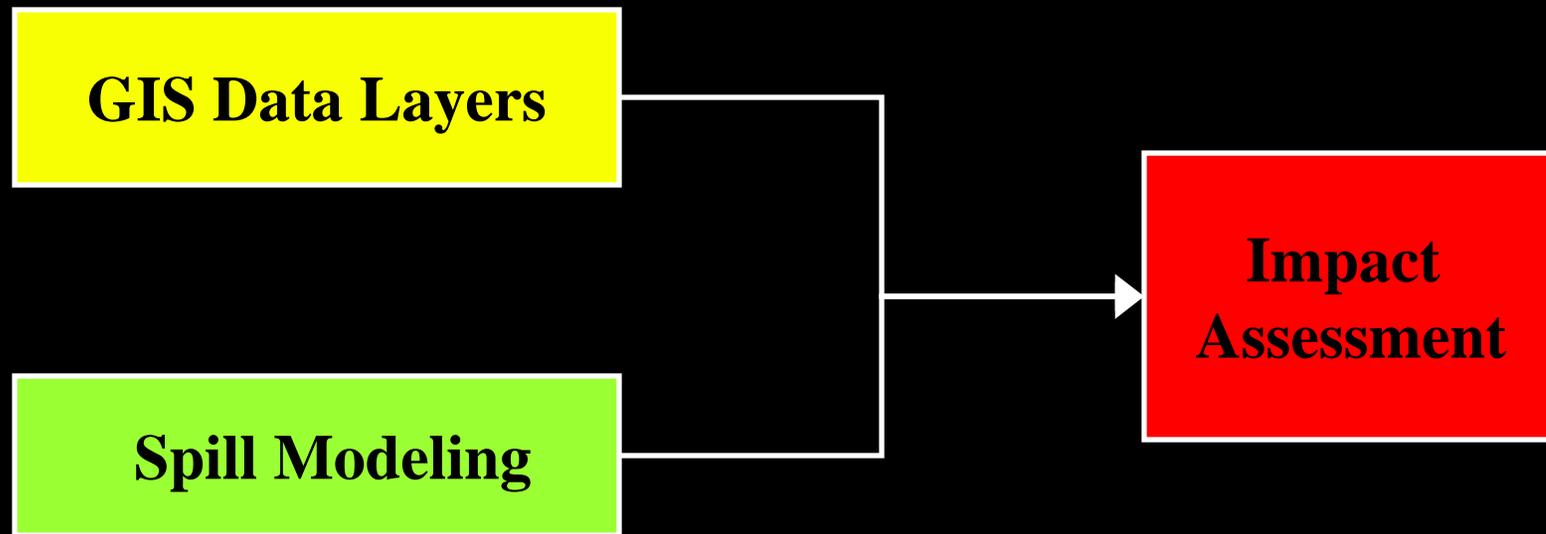
- **U.S. Army Corps of Engineers (USACE) maintains over 11,000 miles of navigable waterways which include numerous critical marine elements:**
 - **Water supply, recreation areas, and sensitive environmental areas**
- **Marine transportation is considered one of the nation's most efficient, safe, and economical modes of freight transport.**
- **Hazardous materials comprise a large portion of barge transported commodities, placing communities along navigable waterways at risk of exposure to toxic chemicals in the event of a collision, grounding, or terrorist action.**
- **Managing a navigable water body chemical spill response involves coordination and communication among numerous federal, state, and local entities posing challenges in the areas of:**
 - **Retrieving characteristic chemical data**
 - **Jurisdictional responsibility of responding agencies**
 - **Location of waterway access points**
 - **Community notification**

Project Objectives

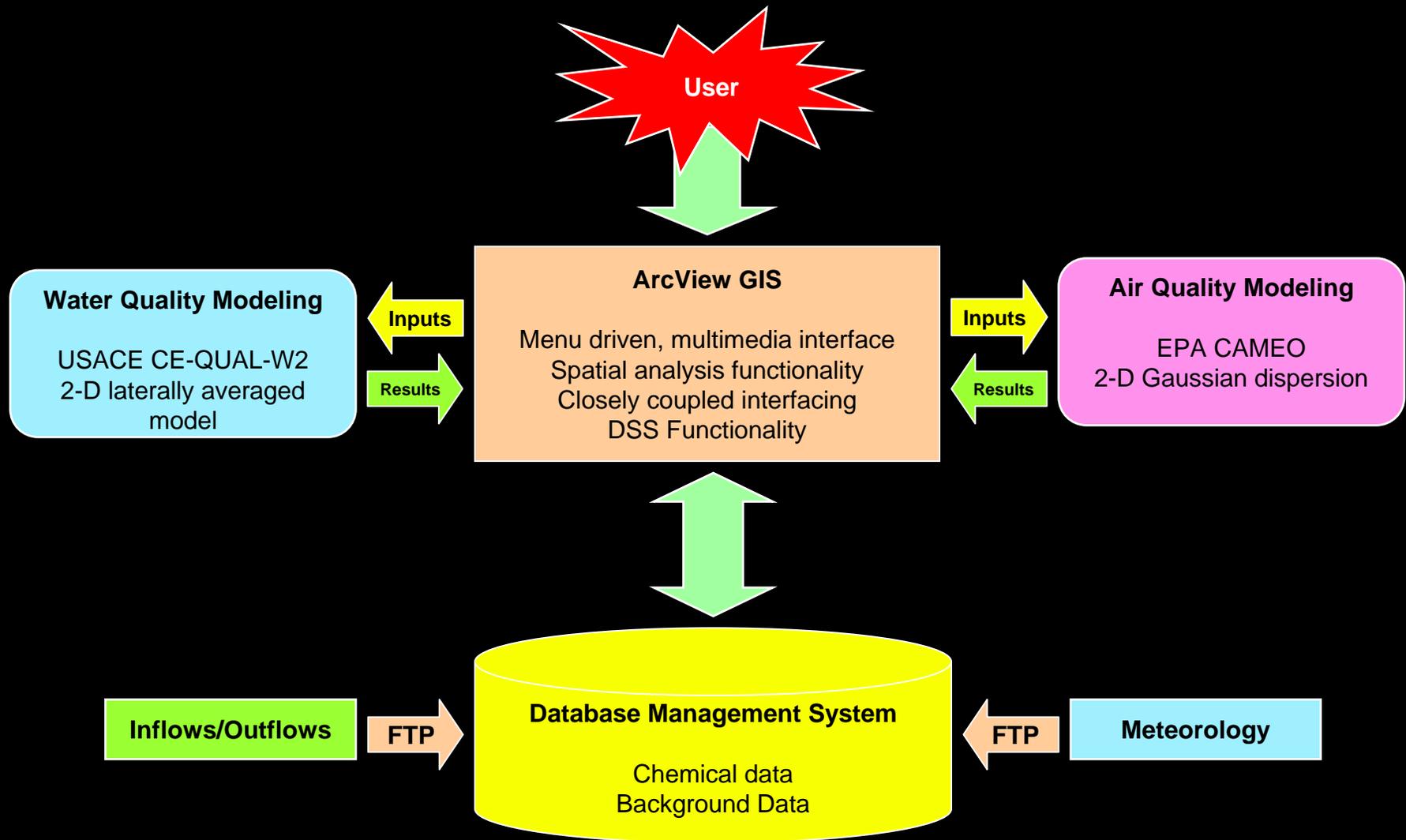
Develop a spill management information system (SMIS) that:

- **Addresses accidental releases and terrorist incidents**
- **Provides the capability to perform simulation training, contingency planning, and real-time incident management**
- **Utilizes advanced information technologies to deliver timely and accurate information in a spatial-based framework**

Conceptual Design

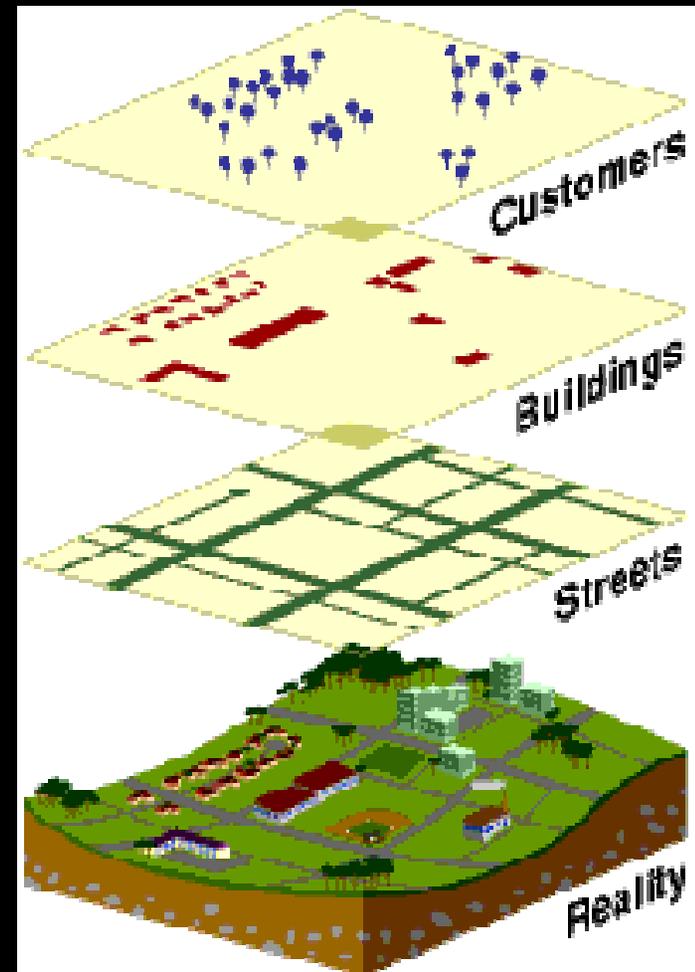


System Architecture



Geographic Information Systems

GIS is a system of computer software, hardware, and data to help manipulate, analyze, and present information that is tied to a spatial location.

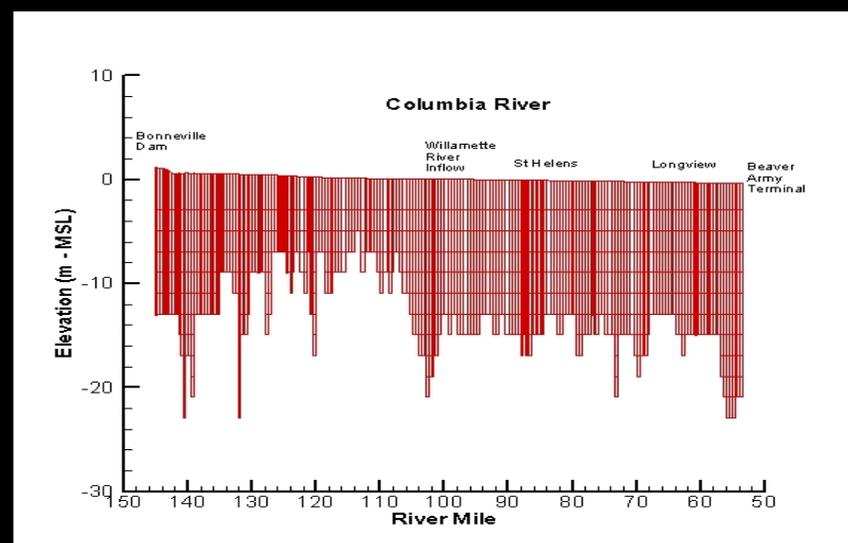
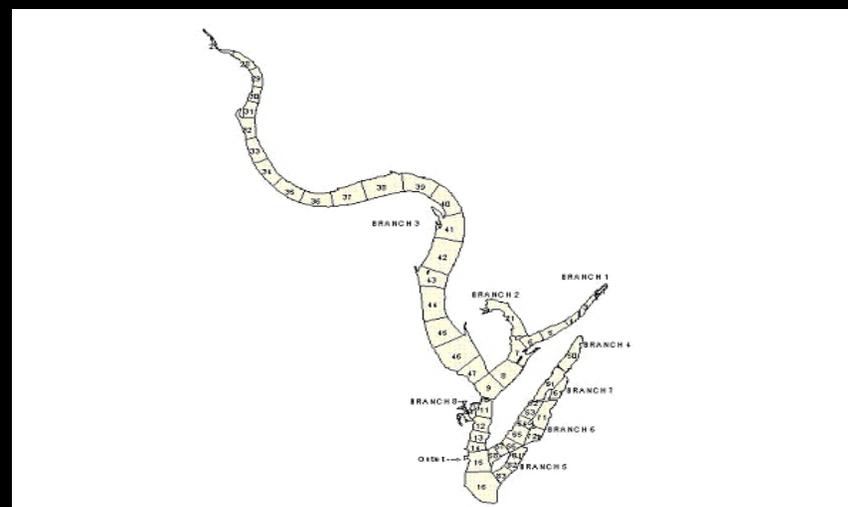


CE QUAL W2

2-D, longitudinal/vertical hydrodynamic and water quality model applicable to rivers, lakes, reservoirs, and estuaries.

Developed by Portland State University in conjunction with USACE Waterways Experiment Station (WES).

Version 3.1 developed for the Cheatham Reach of the Cumberland River.



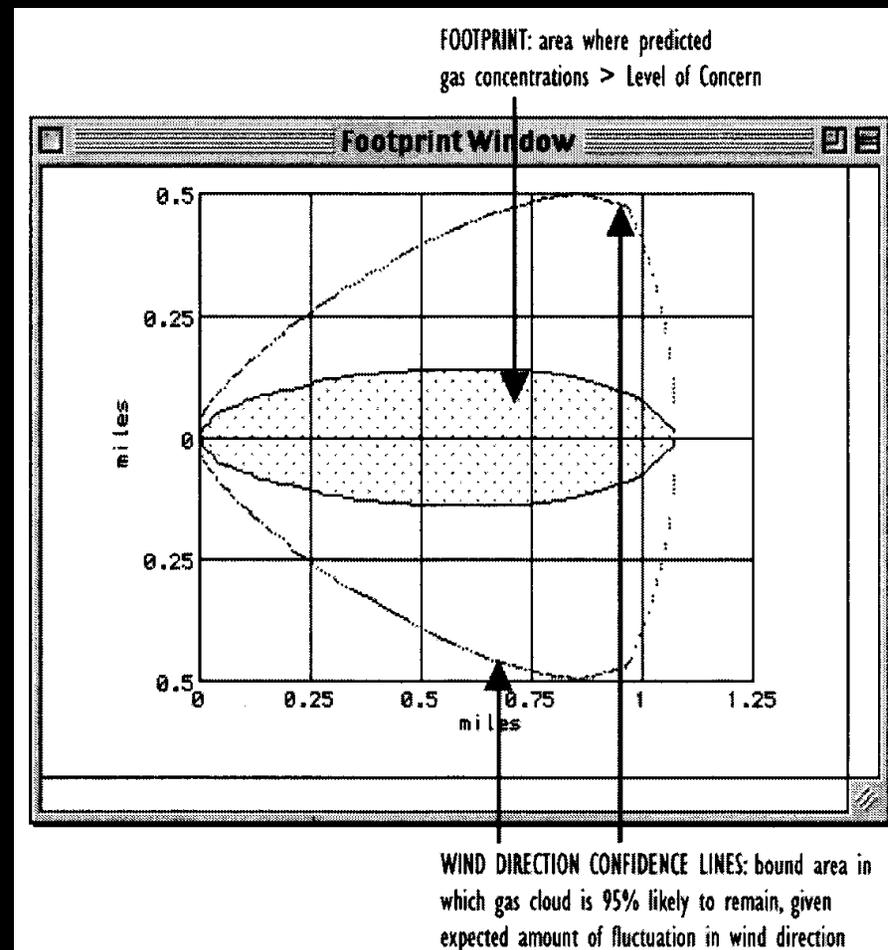
CAMEO

Computer Aided Management of Emergency Operations (CAMEO).

Suite of software programs used to plan for and respond to chemical emergencies developed by the USEPA and NOAA.

Includes a Chemical Library, Areal Location of Hazardous Atmospheres (ALOHA) and Mapping Applications for Response, Planning, and Operational Tasks (MARPLOT).

Generates a 'cloud footprint', encompassing the area where ground level concentration of a pollutant gas exceeds a pre-determined Level of Concern (LOC)



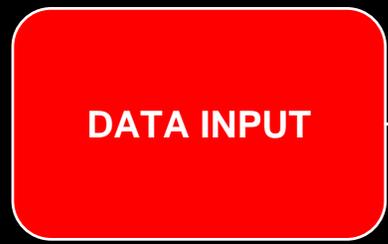
Database Management System

Database Management System stores chemical information and feeds meteorological data to the system.

The screenshot shows a database window titled 'Attributes of States.shp'. The table contains the following columns: State, Area, State_name, State_abbr, Stat_abbr, State_abbr, Pop1997, Pop1997, Pop1997, Area_sqmi, Male, Female, White, Black, Asian, and A. The data is sorted by State_name in ascending order.

State	Area	State_name	State_abbr	Stat_abbr	State_abbr	Pop1997	Pop1997	Pop1997	Area_sqmi	Male	Female	White	Black	Asian	A.
Polygon	67285.878	Washington	53	Pacific	WA	4566632	5504250	72	1872431	2413747	2452945	4308937	149803	814883	2
Polygon	147235.026	Montana	30	Mid	MT	795065	884723	5	305163	395761	403295	747111	2381	47675	
Polygon	32151.854	Maine	23	N Eng	ME	1227508	1244829	99	485012	597690	630079	1309360	5139	5999	
Polygon	78810.153	North Dakota	38	W N Cen	ND	638800	644782	8	240878	318201	320999	804142	3524	29817	
Polygon	77183.824	South Dakota	46	W N Cen	SD	1683034	1705449	9	254034	342498	353805	631515	3254	93875	
Polygon	97799.452	Wyoming	56	Mid	WY	453668	494519	5	168838	222070	225818	427061	1606	9479	
Polygon	56089.066	Wisconsin	55	E N Cen	WI	4891769	5189399	87	1822118	2352935	2498834	4512523	244529	35087	
Polygon	83340.898	Idaho	16	Mid	ID	1008748	1218819	12	380723	503896	508793	981481	3370	13780	
Polygon	9603.218	Vermont	50	N Eng	VT	562798	591859	59	210990	275492	287285	555088	1951	1636	
Polygon	94517.455	Minnesota	27	W N Cen	MN	4375099	4690417	52	1547850	2145190	2229916	4139395	94944	45086	
Polygon	97070.748	Illinois	41	Pacific	DR	2842321	3049429	29	1103313	1387073	1445248	2636787	46178	38486	
Polygon	9259.514	New Hampshire	33	N Eng	NH	1109252	1171443	130	411186	545544	585708	1007433	7198	2134	
Polygon	56257.220	Iowa	19	W N Cen	IA	2767955	2859263	45	1084325	1348002	1431953	2843000	40890	7345	
Polygon	8172.462	Massachusetts	25	N Eng	MA	6016425	6106904	796	2247110	2889745	3127680	5405394	300130	12241	1
Polygon	77328.357	Nebraska	31	W N Cen	NE	1528389	1680513	20	602363	769439	808845	1481828	57404	12410	
Polygon	48660.579	New York	36	Mid Atl	NY	17590455	18177299	370	6639322	8650701	9264782	13062555	2651055	62651	6
Polygon	45494.739	Pennsylvania	42	Mid Atl	PA	11981543	12651907	262	4409944	5946765	6187379	10510411	1088756	14732	1
Polygon	4976.434	Connecticut	09	N Eng	CT	3287116	3277113	661	1200479	1592873	1694243	2893253	274269	6854	
Polygon	1044.850	Rhode Island	44	N Eng	RI	1003464	998370	950	379377	481496	521958	917395	38861	4071	
Polygon	2517.302	New Jersey	34	Mid Atl	NJ	7730188	8018328	1030	2742711	3759005	3994503	6110465	1038825	14570	2
Polygon	36399.515	Indiana	18	E N Cen	IN	5644159	5874944	152	2085355	2690321	2859879	5203700	432052	12720	
Polygon	110667.293	Nevada	32	Mid	NV	1201833	1820383	11	486297	611880	588953	1012695	79771	19637	
Polygon	84870.185	Utah	49	Mid	UT	1722890	2034167	20	537273	665769	687091	1615945	11576	24283	
Polygon	15774.182	California	06	Pacific	CA	29780021	32197302	189	10381204	14876727	16342384	28524227	2208801	242164	29
Polygon	41192.852	Ohio	39	E N Cen	OH	10647119	11202691	263	4087546	5265340	5520775	9521795	1154826	20398	
Polygon	56297.954	Illinois	17	E N Cen	IL	11430602	11890919	203	4202240	5552231	5878369	8952578	1694273	21836	2
Polygon	66.063	District of Columbia	11	S Atl	DC	689900	539027	9187	269634	282970	323930	179667	399604	1466	
Polygon	2054.906	Delaware	10	S Atl	DE	686168	737219	324	247487	322098	342000	639004	112460	2019	
Polygon	24238.213	West Virginia	54	S Atl	WV	1793477	1828832	74	688267	861936	891941	1729523	56290	2458	
Polygon	9731.753	Maryland	24	S Atl	MD	4701948	5100819	491	1748351	2306071	2482197	3393564	1108169	12972	1
Polygon	104089.108	Colorado	08	Mid	CO	3294394	3886615	32	1262688	1671205	1643089	2905474	131146	27776	
Polygon	40218.777	Kentucky	21	E S Cen	KY	3605296	3904965	91	1399392	1785205	1900051	2916222	262007	5769	
Polygon	82195.436	Kansas	20	W N Cen	KS	2477974	2962933	30	944726	1214649	1262929	2231886	143076	21828	
Polygon	39819.194	Virginia	51	S Atl	VA	6187398	6726895	195	2291830	3033874	3183384	4791793	1162954	15282	1
Polygon	69831.624	Missouri	29	W N Cen	MO	5117073	5367753	73	1961206	2464315	2552780	4486228	540288	15836	
Polygon	113711.522	Arizona	04	Mid	AZ	3005220	4520066	32	1000000	1010000	1025437	2001000	110524	20000	
Polygon	70002.352	Oklahoma	40	W S Cen	OK	3145595	3318622	45	1205135	1530819	1614785	2503512	230801	252420	
Polygon	49046.813	North Carolina	37	S Atl	NC	6628637	7411219	135	2517026	3214920	3414347	5008491	1456323	80195	

SMIS Data Input



Location of Spill Injection on Waterway
Select injection point by mouse click or river segment

Selection of Spill Contaminant
Select contaminant from database of 1300+ common marine transported chemicals

Quantification of Spill
Input spill volume in units of volume or mass

Time Interval Selection
Select injection time of spill
Select required overall simulation time

Inflows/Outflows
'Current' flowrates (automatic transfer from FTP site)
User-specified flowrates for scenario evaluation

SMIS Data Input

QUALW2- INPUT PARAMETERS [X]

CONSTITUENT

Name: [Select Constituent]

Volume [Enter Spill Volume] [Cu. Feet]

Mass [Enter Spill Mass] [Kg]

SPILL DURATION

Start Date(MM:DD)/Time(HR:MIN)

End Date(MM:DD)/Time(HR:MIN)

LOCATION OF SPILL INCIDENT

Waterway Name: [Cumberland River]

Segment ID: [86] [Zoom to Segment]

SIMULATION

Start Date(MM:DD)/Time(HR:MIN)

[] [] / [] [] []

[Same as Spill Start Date/Time]

Duration: 1 2 3 4 5 days

[Run] [Map Output] [Close] [Help]

SMIS Data Input

Dam Flow Settings ✕

Change Live Dam Flow and Weather File

OLD HICKORY DAM FLOW

Live Connection FLOWRATE: 424.755 Cu. Meters/sec ▾

Enter Flow

DURATION: Start(MM:DD:HR) End(MM:DD:HR)

Same as Simulation Duration 1 1 0  1 2 0 

PERCY PRIEST DAM FLOW

Live Connection FLOWRATE: 0.28317 Cu. Meters/sec ▾

Enter Flow

DURATION: Start(MM:DD:HR) End(MM:DD:HR)

Same as Simulation Duration 1 1 0  1 2 0 

CHEATHAM DAM FLOW

Live Connection FLOWRATE: 396.438 Cu. Meters/sec ▾

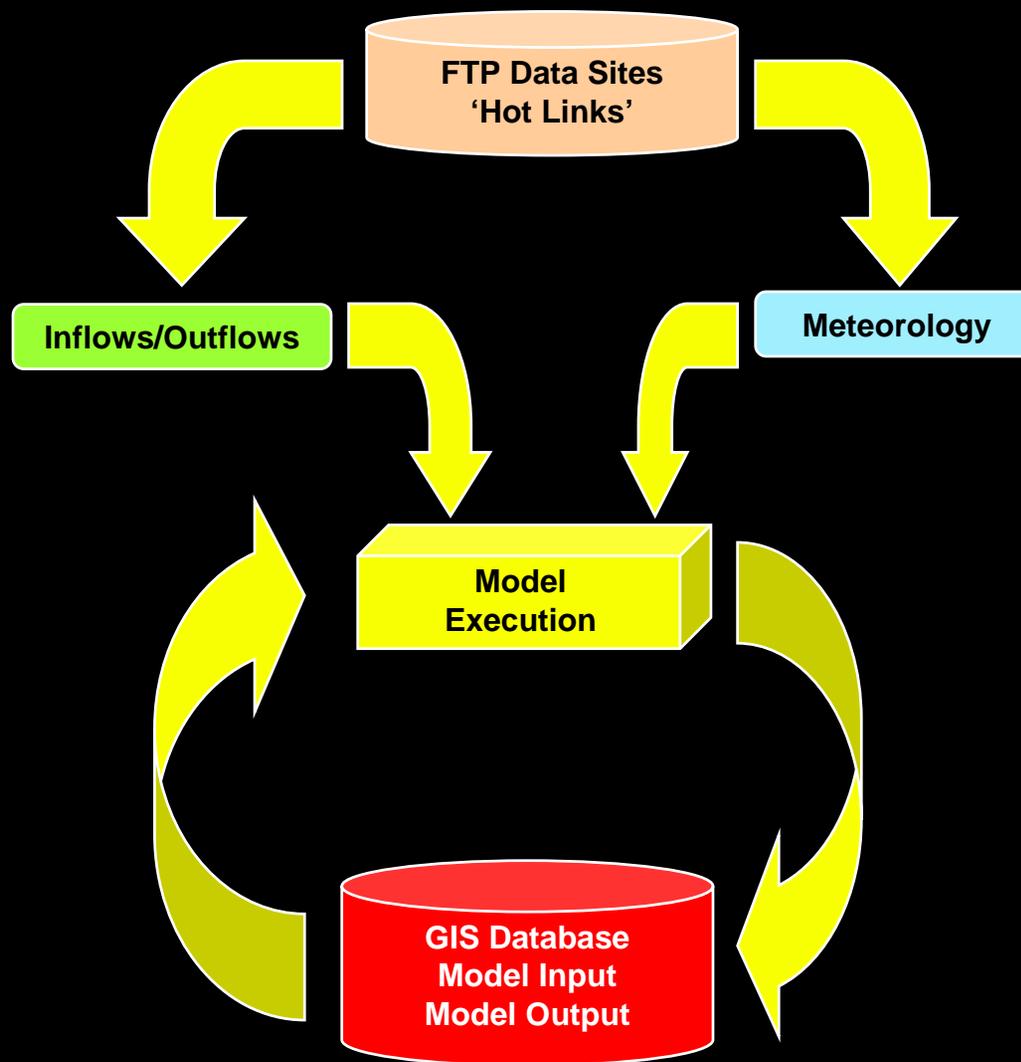
Enter Flow

DURATION: Start(MM:DD:HR) End(MM:DD:HR)

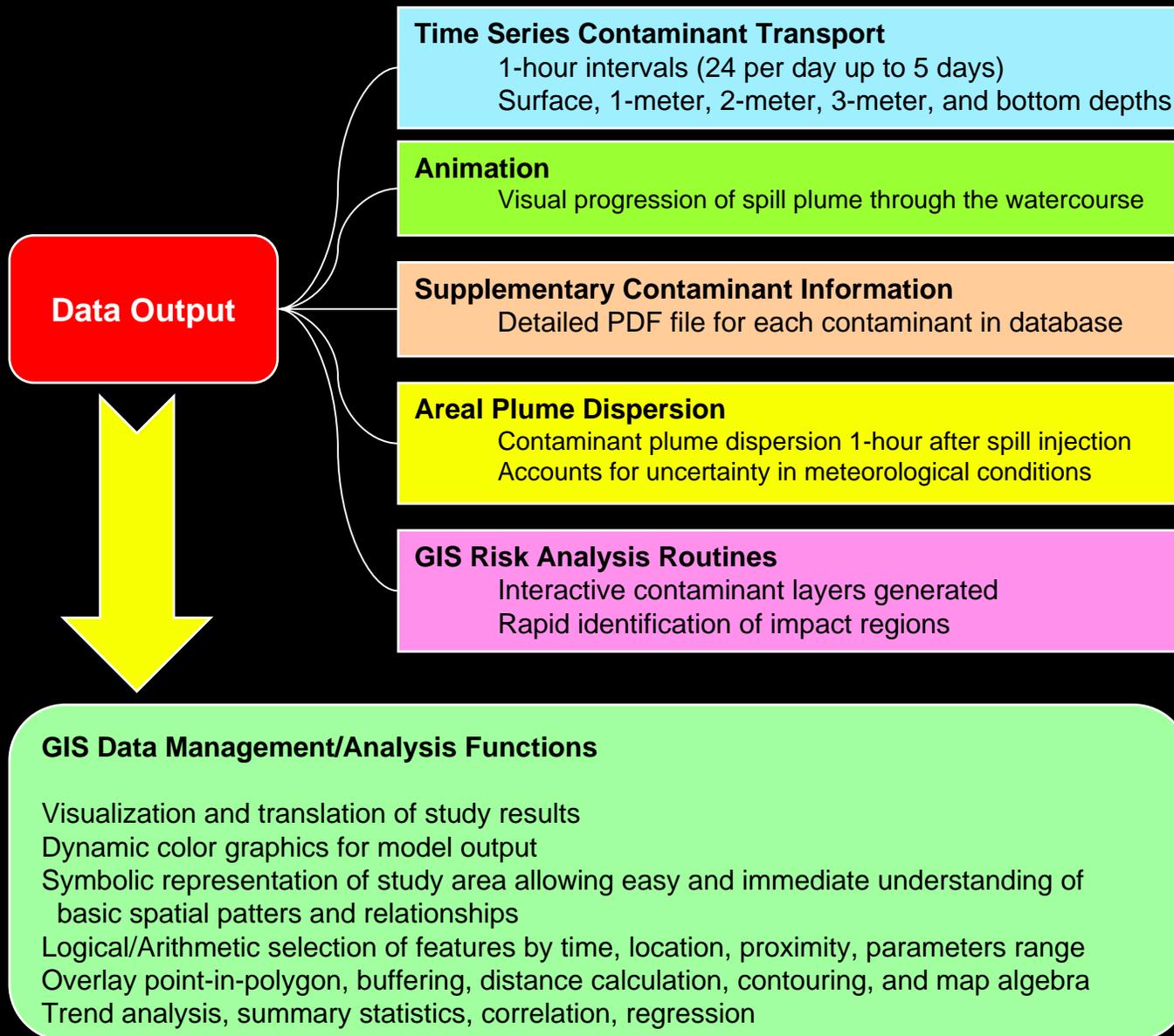
Same as Simulation Duration 1 1 0  1 2 0 

Ok

SMIS Model Execution



SMIS Output



CONSTITUENT PROPERTIES

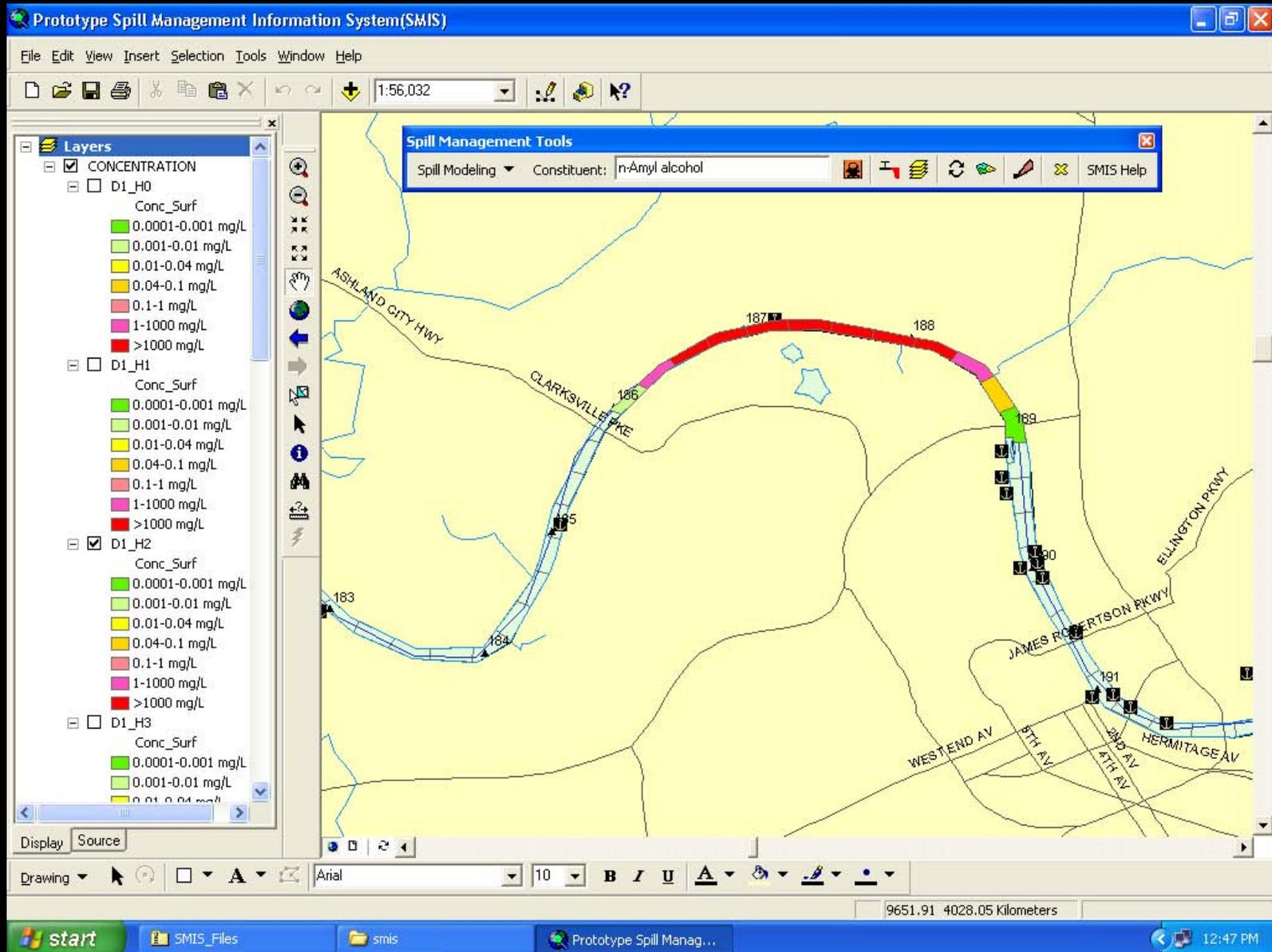
**GIS LAYERS
W2 MODEL INPUT INTERFACE**

MAP W2 OUTPUT

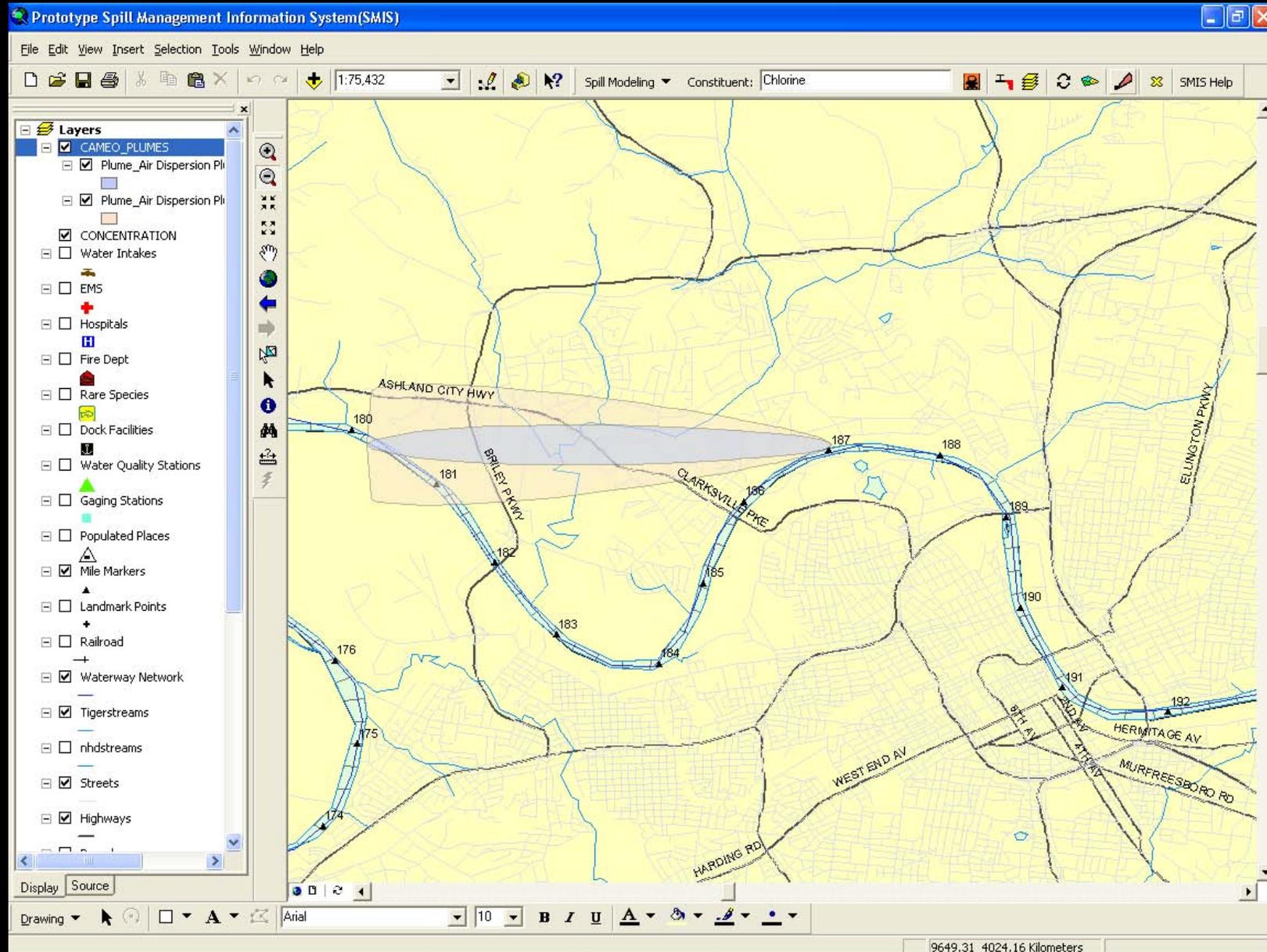
SPILL ANIMATION

CHANGE DEPTH

Sample Output – Surface Water Contaminant Dispersion



Sample Output – Air Dispersion



Functionality Summary

• Simulate Release

- Location by mouse click
- Select chemical (1300+)
- Enter quantity (mass or volume)
- Enter spill duration
- Specify simulation duration

• Run Water/Air Quality Models

- CE-QUAL W2
- CAMEO
- Started from GIS interface
- Model fed from chemical database and weather data

• Import and Display Model Results

- Multiple CE-QUALW2 model outputs
 - GIS layers depict stages of spill
 - Animate spill progression
 - Display output at surface, bottom, 1, 2, and 3 meter depths
- Detailed GIS layers for reference, routing, mitigation, and protection

• Perform Mitigation

- Locate nearest responders and facilities (using GIS layer contact information)
- Predict where spill will be in future
- Estimate population and ecological exposure
- Perform “what-if” scenarios (e.g., increase/decrease water release from upstream/downstream flow control structures)

Scenario Demonstration

Scenario

- **Location:** Cheatham Reach - RM 194
- **Incident:** Barge Grounding
- **Release:** 25,000 barrels (1.05×10^6 gallons) over 30 minutes
- **Chemical:** ethylene glycol
- **Meteorology:** 10 mph easterly wind, 70° F, partly cloudy

SMIS Input

QUALW2- INPUT PARAMETERS

CONSTITUENT

Name: Ethylene glycol

Volume 1050000 Gallons

Mass Enter Spill Mass Kg

LOCATION OF SPILL INCIDENT

Waterway Name: Cumberland River

Segment ID: 87 Zoom to Segment

SIMULATION

Start Date(MM:DD)/Time(HR:MIN)

12 / 1 / 12 / 0

Same as Spill Start Date/Time

Select constituent

Duration: 1 2 3 4 5 days

Run Map Output Close Help

SMIS Flow Settings (Live)

Dam Flow Settings [Close]

Change Live Dam Flow and Weather File

OLD HICKORY DAM FLOW

Live Connection FLOWRATE: 12200 Cu, Feet/sec

Enter Flow

DURATION: Start(MM:DD:HR) End(MM:DD:HR)

Same as Simulation Duration 12 1 12 [Calendar] 12 2 12 [Calendar]

PERCY PRIEST DAM FLOW

Live Connection FLOWRATE: 500 Cu, Feet/sec

Enter Flow

DURATION: Start(MM:DD:HR) End(MM:DD:HR)

Same as Simulation Duration 12 1 12 [Calendar] 12 2 12 [Calendar]

CHEATHAM DAM FLOW

Live Connection FLOWRATE: 13800 Cu, Feet/sec

Enter Flow

DURATION: Start(MM:DD:HR) End(MM:DD:HR)

Same as Simulation Duration 12 1 12 [Calendar] 12 2 12 [Calendar]

Ok

CE-QUAL-W2 Model Execution

Prototype Spill Management Information System(SMIS)

w2_cvf - [CE-QUAL-W2 V3.1 - Run parameters for waterbody 1]

File Edit View State Window Help

Time Parameters		Meteorology		Run times	
[GDAY]	= December 2, 2003	[TAIR]	= 25.56 °C	Start	= 19:26:44
[JDAY]	= 336 days 0.08 hrs	[TDEW]	= 20.64 °C	Current	= 19:27:03
[ELTM]	= 0 days 12.08 hrs	[WIND]	= 0.00 m/s		
[DLT]	= 285 sec at (6,7)	[PHI]	= 6.00 rad	Water surface	
[MINDLT]	= 276 sec at (6,7)	[CLOUD]	= 49.15	[KT]	= 5
at	= 335 days 16.20 hrs	[ET]	= 20.21 °C	[ELKT]	= 117.34 m
[DLTAV]	= 287 sec	[CSHE]	= 0.4E-05 m/s	[ZMIN]	= -0.34 m
[NIT]	= 151	[SRO]	= 0.00 W/m ²	[IZMIN]	= 262
[NV]	= 1 = 0.7 %				

Inflow/Outflow (m³/s)

[QIN]	= 345.46						
[TIN]	= 9.10						
[QTR]	= 0.00	0.30	14.16	1.20	4.00	0.90	3.54 3.30
[TTR]	= 9.70	15.00	9.70	9.70	15.00	15.00	9.10 9.70
[QDTR]	= 0.00						
[TDTR]	= 9.70						
[QOUT]	= 390.77						

Running

Dissolved oxygen

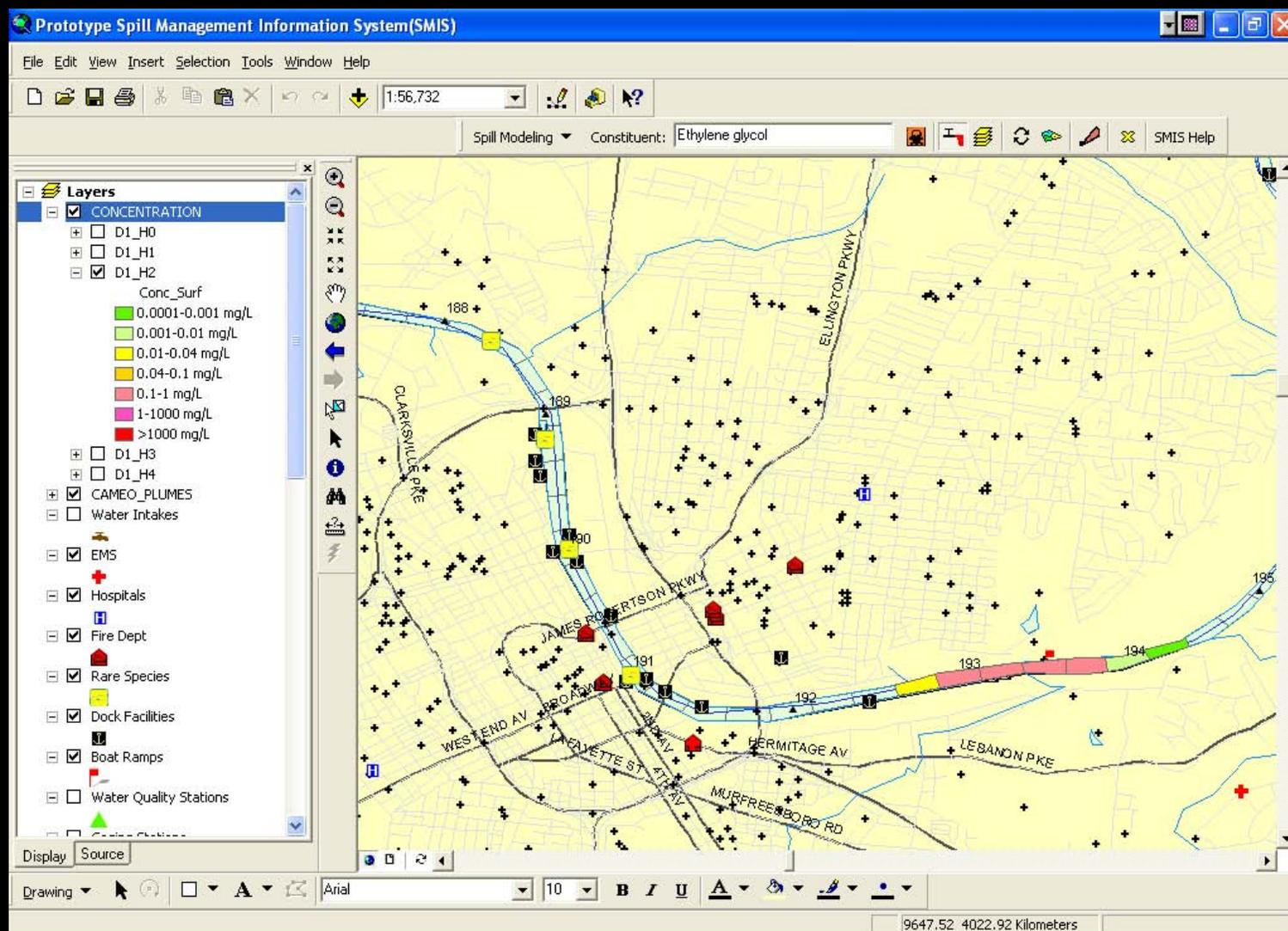
Temperature [T1]

Segment number

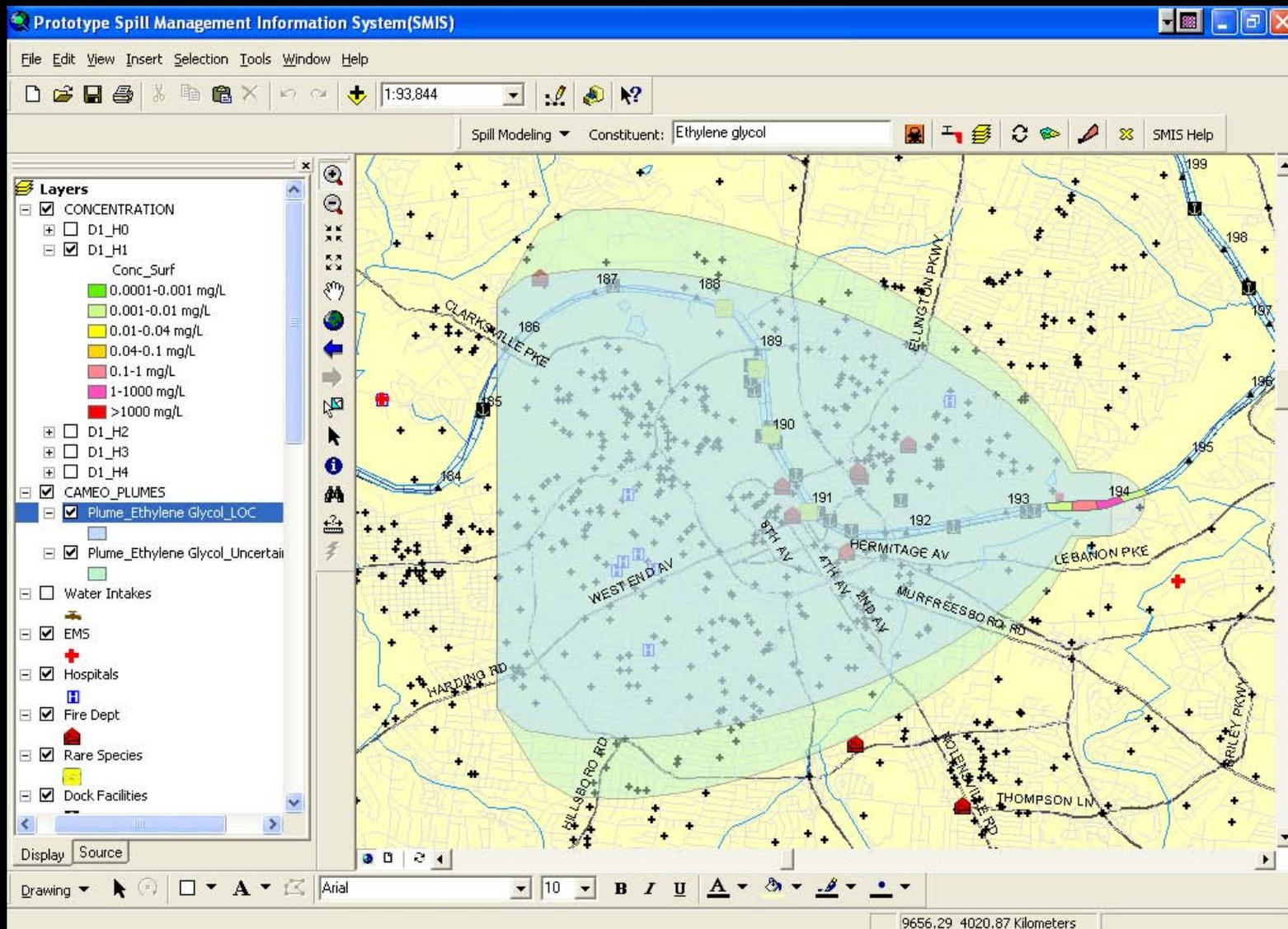
For Help, pr real*8 M(18, 264, M(1,1): -2

9646.92 4021.33 Kilometers

Spill Progression – 2 hours



Air Dispersion – 1 hour



Analysis and Abatement Routines

- **Animation Tool** – toggles on/off layers in succession to create dynamic viewing of spill incident progression
- **GIS Risk Analysis Routines** – search for sensitive receptors within generated GIS layers (water intakes, endangered species, population centers) and associated attributes (contact numbers, responders, HAZMAT teams)
- **Locating Access Points** – boat launches, bridges, dock facilities, etc.

Key Project Accomplishments

- **Completed information system design for managing spills on waterways**
- **Deployed state-of-the-art information model, data, and technologies**
- **Established proof of concept that a comprehensive Spill Management Information System is feasible**

Current/Future Directions

- **Utilize existing system for spill management training, planning exercises, and operations**
 - SMIS exercise with federal/state/local agencies conducted in October 2003
- **Modular design allows for:**
 - Application to different waterways
 - Use of different prediction models
 - Validation of existing models
- **Development of additional interpretation tools:**
 - Automate identification of proximate responders and endangered receptors
 - Locate vulnerable areas along the waterway
 - Rapid queries that identify key facilities & access points
- **Provide remote Internet capability (with security)**

Potential Applications and Developmental Options

Model enhancements to existing Cheatham Reach may include:

- **Threat zone analysis queries to evaluate where a spill might occur that could threaten particular areas (e.g., endangered species areas, water intakes, schools, businesses, homes, etc.);**
- **Notification systems that can provide contact lists for facilities in affected areas, to include automated calling;**
- **Web-based SMIS to provide portability to first responders in the field (including employment of proper security measures to ensure access to SMIS is limited to authorized users);**
- **Resource analysis to help estimate the level of response needed to adequately address impacts of modeled spills, and the quantity of a particular resource that could be impacted by given spills (e.g., equipment required to isolate a specific endangered species area or water intake zone, such as length of boom, number of transport trucks, number of boats, number of personnel);**
- **Improved reactivity and transport capability within CE-QUAL-W2 to allow for inclusion of the effects of contaminant volatilization, reaction, and/or sorption; and**
- **Improved air dispersion model capabilities (nuclear, biological capability (HPAC))**

Potential Applications and Developmental Options

Transferability of Cheatham Reach SMIS to Similar Waterway Systems:

- **SMIS can be readily adapted to other waterways that can be effectively modeled with CE-QUAL-W2.**
- **Suggested prioritization of work includes other major population centers and/or large volume transportation sectors possessing similar water hydrodynamics to the Cheatham Reach of the Cumberland River.**
- **Required enhancements:**
 - **Incorporation of GIS layers representative of the geographic area of interest;**
 - **Development and calibration of CE-QUAL-W2 model to waterway of interest, to include:**
 - **Waterway bathymetry**
 - **Collection of appropriate flow and water quality data;**
 - **Establishment of ‘hot links’ to meteorological and water flow data; and**
 - **Installation and training.**

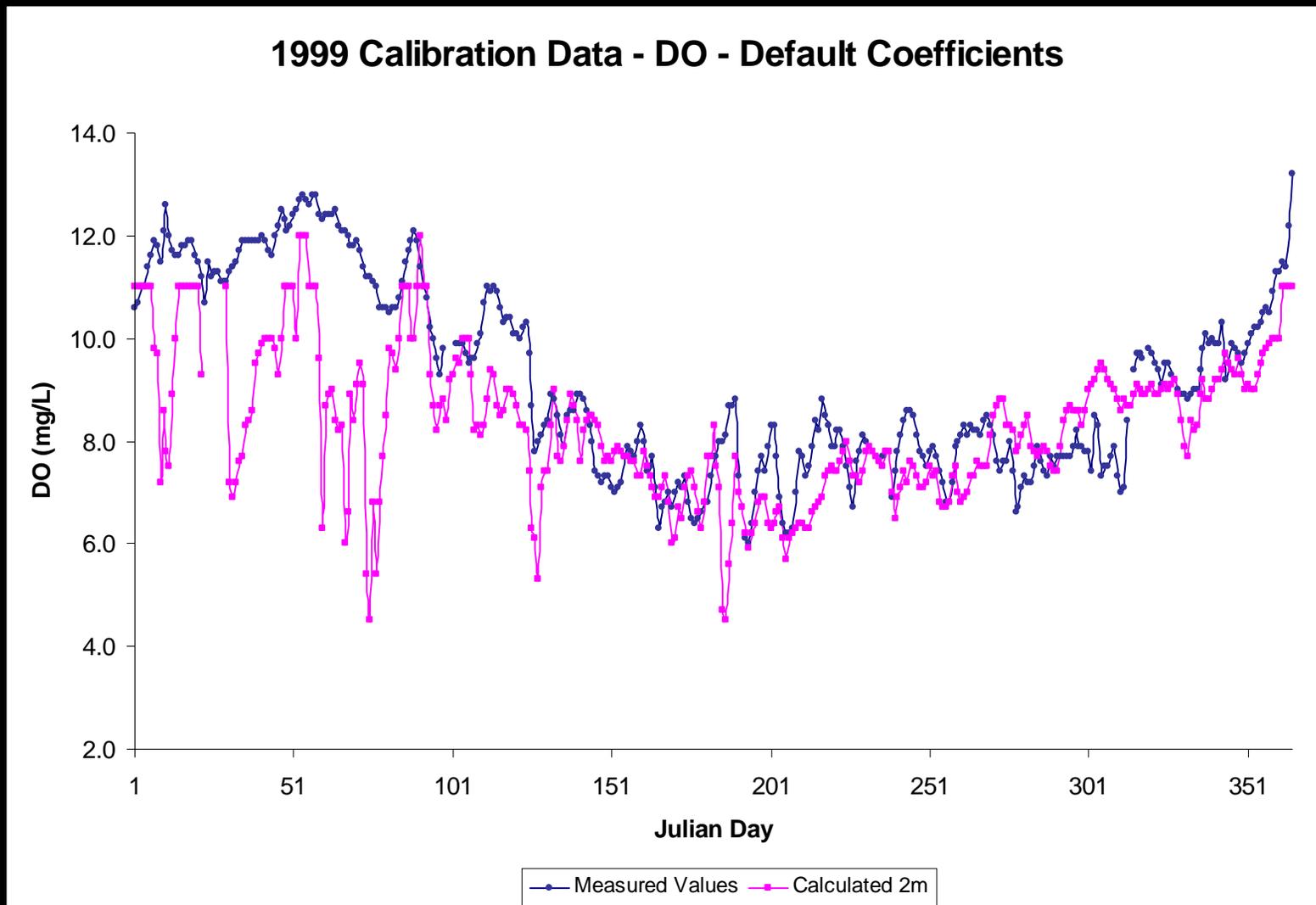
Potential Applications and Developmental Options

Model enhancements for dissimilar waterway systems:

- **Modular framework of SMIS allows employment of additional water quality models to more appropriately model water bodies possessing hydrodynamics that are dissimilar to those modeled by CE-QUAL-W2.**
- **Such systems may include Resource Management Associates 2 (RMA-2) and Resource Management Associates 4 (RMA-4), and others.**
- **Required enhancements:**
 - **Evaluation of the waterway and needs of the client to determine the most appropriate hydrodynamic and contaminant transport models;**
 - **Incorporation of GIS layers representative of the geographic area of interest;**
 - **Development and calibration of the hydrodynamic and contaminant transport models of interest, to include:**
 - **Waterway bathymetry**
 - **Collection of appropriate flow and water quality data;**
 - **Design and implementation of applications module to activate and integrate model functionality within SMIS;**
 - **Establishment of ‘hot links’ to meteorological and water flow data; and**
 - **Installation and training.**

Questions?

CE-QUAL-W2 Calibration



CE-QUAL-W2 Calibration

