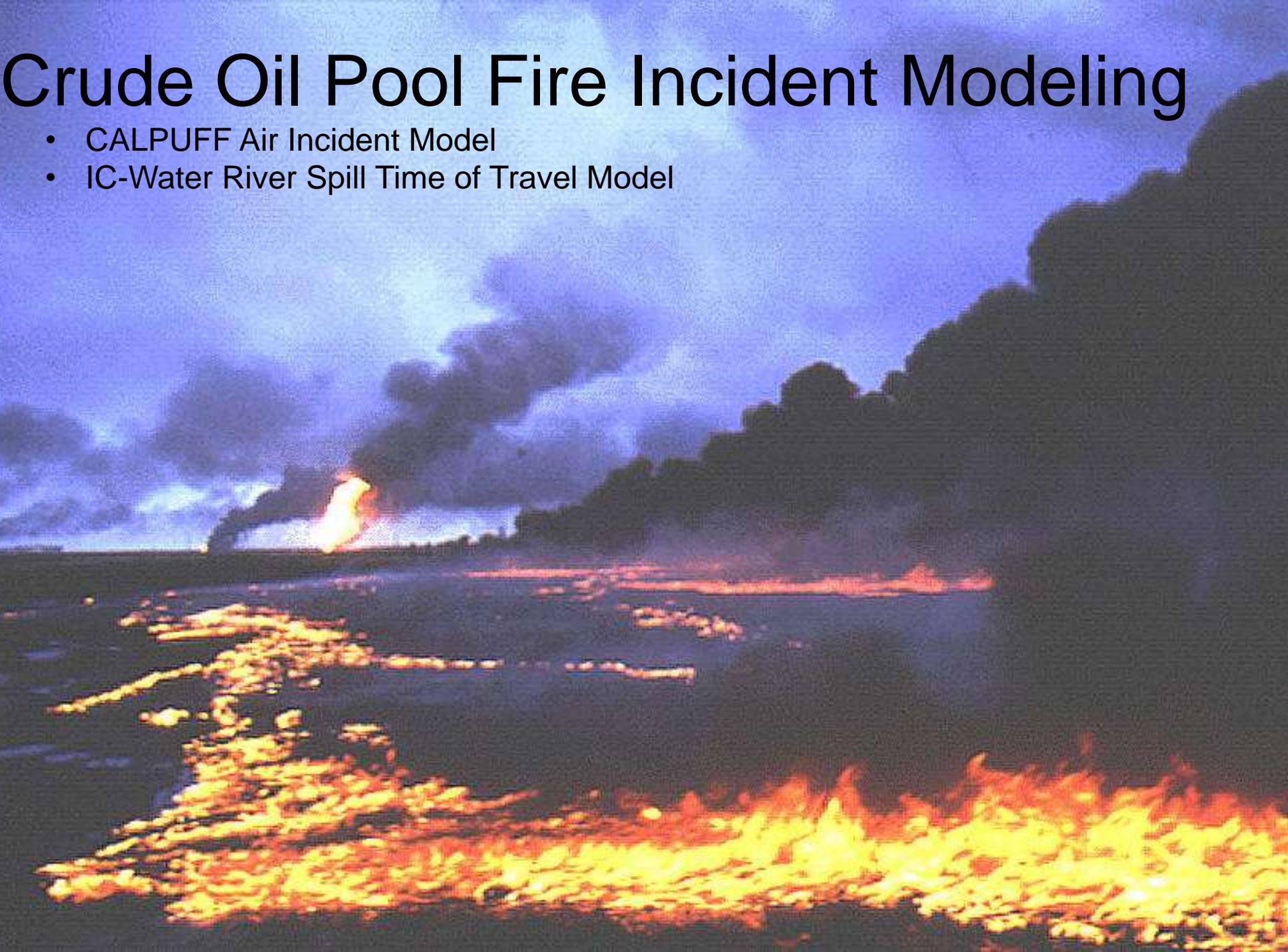


# Crude Oil Pool Fire Incident Modeling

- CALPUFF Air Incident Model
- IC-Water River Spill Time of Travel Model



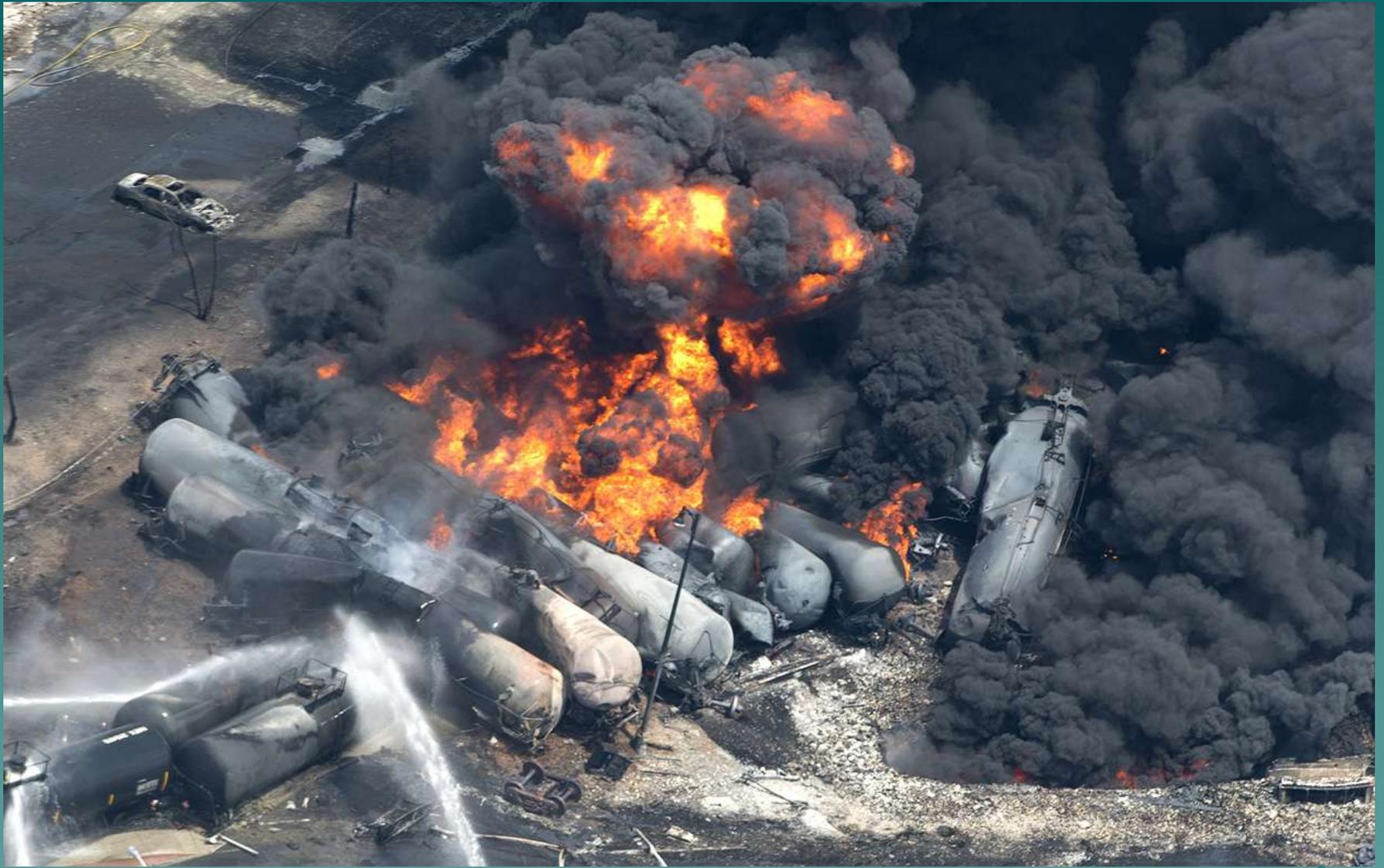
# Conclusions

- ◆ Crude Oil Pool fires produce smoke plumes and contaminated water bodies.
- ◆ Some crude recently being transported in our region is more volatile and susceptible to fires if spilled.
- ◆ Idaho DEQ has added Bakken Crude Pool fire scenarios to our Calpuff Incident Model and IC-Water time of travel river spill model.
- ◆ Our domain is the NW Region and we may be able to assist others if an accident occurs.















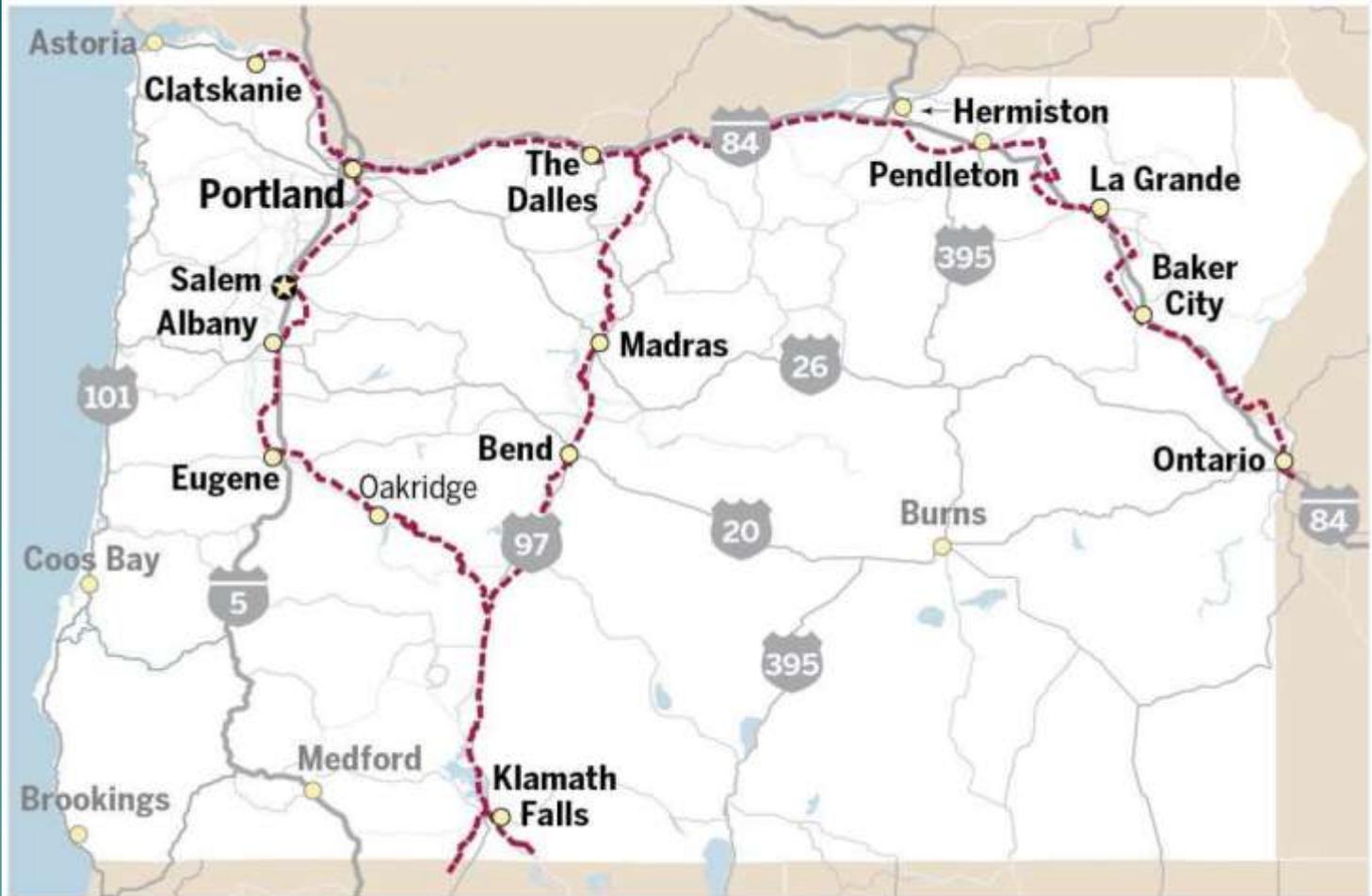




# Crude-by-Rail Facilities Map



## Oregon's oil train routes

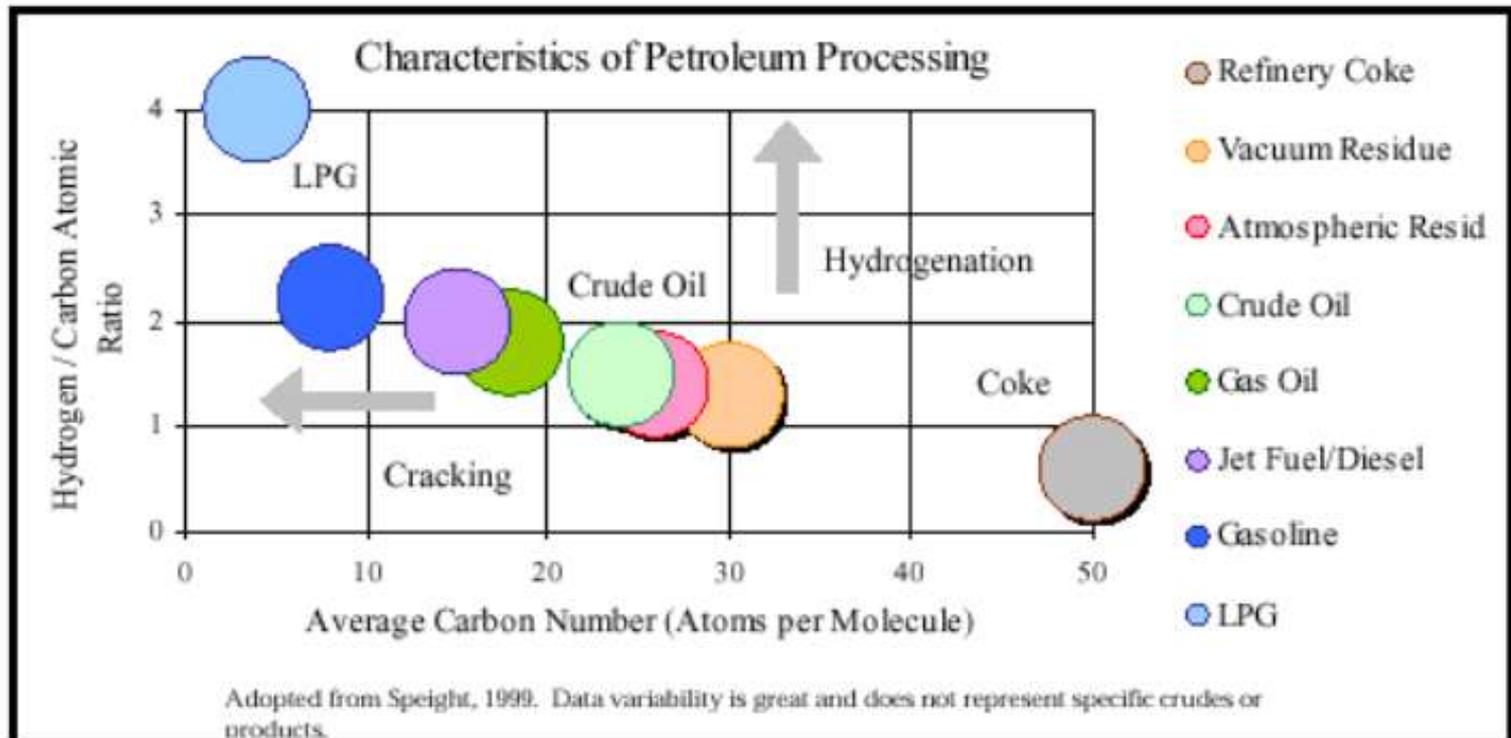


Source: ODOT

DAN AGUAYO/THE OREGONIAN



# Characteristics of Petroleum Products



*Refining Overview – Petroleum Processes & Products,*  
by Freeman Self, Ed Ekholm, & Keith Bowers, AIChE CD-ROM, 2000

## Under Pressure

Investigators are looking into how fast North Dakota crude emits gases and how that contributes to oil-train explosions.

Select types of crude oil that are commonly run in U.S. refineries, by average Reid Vapor Pressure\*





# Calpuff Incident Modeling System for Air Releases

R. Hardy, W. Zhang, S. Strachan



# Now



*Time saved: 14 hours*

Automated download WRF 48hr meteorological forecasts from UW

*Time saved: 1–2 d*

Pre-configured nested domains

CALMET  
Preprocessing

*Time saved: 1 hour*

*Time saved: 1–2 d*

Pre-configured source terms

GUI for rapid selection of met data, domain, source data

*Time saved: 0.5–1 days.*

*Time saved: 1–2 d*

Pre-configured GIS templates, automated scripts

CALPUFF

Final GIS processing and output

**45–90 minutes!**



# Preconfigured Source Terms: 264 starting scenarios in 13 Categories

Category	SubCategory
Aerial Dispersal	
Explosive Dispersal	
Industrial Spill	Catastrophic
Industrial Spill	Pipe Break
Industrial Spill	Stack Release
Pool Fire	
Rail Transport Spill	Catastrophic
Rail Transport Spill	Pipe Break
Volatiles in River	
Truck Transport Spill	Catastrophic
Truck Transport Spill	Pipe Break
Warehouse Fire	
Wastepile Fire	



# Source Term Example: Industrial Catastrophic

Table for Industrial-Catastrophic					
Hazardous Material	Species	Quantity (lbs)	Hole size (inches)	Release Rate (lb/min)	Duration (min)
Anhydrous Ammonia (liq)	NH3	1220000	20.4	160000	7.6
Anhydrous Ammonia (liq)	NH3	1080000	15	158000	6.8
Anhydrous Ammonia (liq)	NH3	600000	15	78900	7.6
Anhydrous Ammonia (liq)	NH3	300000	11	38800	7.7
Anhydrous Ammonia (liq)	NH3	160000	8	19000	8.4
Anhydrous Ammonia (liq)	NH3	70000	6	10100	6.9
Anhydrous Ammonia (liq)	NH3	12000	2.5	1430	8.4
Chlorine Gas (liq)	CL2	1080000	7.8	108000	10.0
Chlorine Gas (liq)	CL2	60000	2	3080	19.5
Chlorine Gas (liq)	CL2	24000	1.25	2630	9.1
Chlorine Gas (liq)	CL2	8000	0.7	821	10.0
Anhydrous SO2 (liq)	SO2	14000	1.15	1460	10.0
Aqueous Ammonia > 20%	NH3	160000	pool	2400	60.0
Aqueous Ammonia > 20%	NH3	74000	pool	1150	60.0
Aqueous Ammonia > 20%	NH3	24000	pool	1088	60.0
Hydrochloric acid > 38%	HCL	27743	pool	712	60.0
Chlorine Dioxide	CLO2	36350	3	5180	9.0
Carbon Disulfide	CS2	3500000	20	40500	60.0
Mono-Methyl Amine	MMA	350000	7	34400	11.0

# CHAPTER 3. ESTIMATING BURNING CHARACTERISTICS OF LIQUID POOL FIRE, HEAT RELEASE RATE, BURNING DURATION, AND FLAME HEIGHT

Version 1805.0

The following calculations estimate the heat release rate, burning duration, and flame height for liquid pool fire.

Parameters in **YELLOW CELLS** are Entered by the User.

Parameters in **GREEN CELLS** are Automatically Selected from the DROP DOWN MENU for the Fuel Selected.

All subsequent output values are calculated by the spreadsheet and based on values specified in the input parameters. This spreadsheet is protected and secure to avoid errors due to a wrong entry in a cell(s).

The chapter in the NUREG should be read before an analysis is made.



## INPUT PARAMETERS

Fuel Spill Volume (V)	2438.00	gallons	9.2288 m <sup>3</sup>
Fuel Spill Area or Dike Area (A <sub>dike</sub> )	3.910	ft <sup>2</sup>	363.251 m <sup>2</sup>
Mass Burning Rate of Fuel (m <sup>''</sup> )	0.06	kg/m <sup>2</sup> -sec	
Effective Heat of Combustion of Fuel (ΔH <sub>c,eff</sub> )	42700	kJ/kg	
Fuel Density (ρ)	816.6	kg/m <sup>3</sup>	
Empirical Constant (kβ)	2.8	m <sup>-1</sup>	
Ambient Air Temperature (T <sub>a</sub> )	77.00	°F	25.00 °C 298.00 K
Gravitational Acceleration (g)	9.81	m/sec <sup>2</sup>	
Ambient Air Density (ρ <sub>a</sub> )	1.18	kg/m <sup>3</sup>	
	<b>Calculate</b>		

Note: Air density will automatically correct with Ambient Air Temperature (T<sub>a</sub>) Input



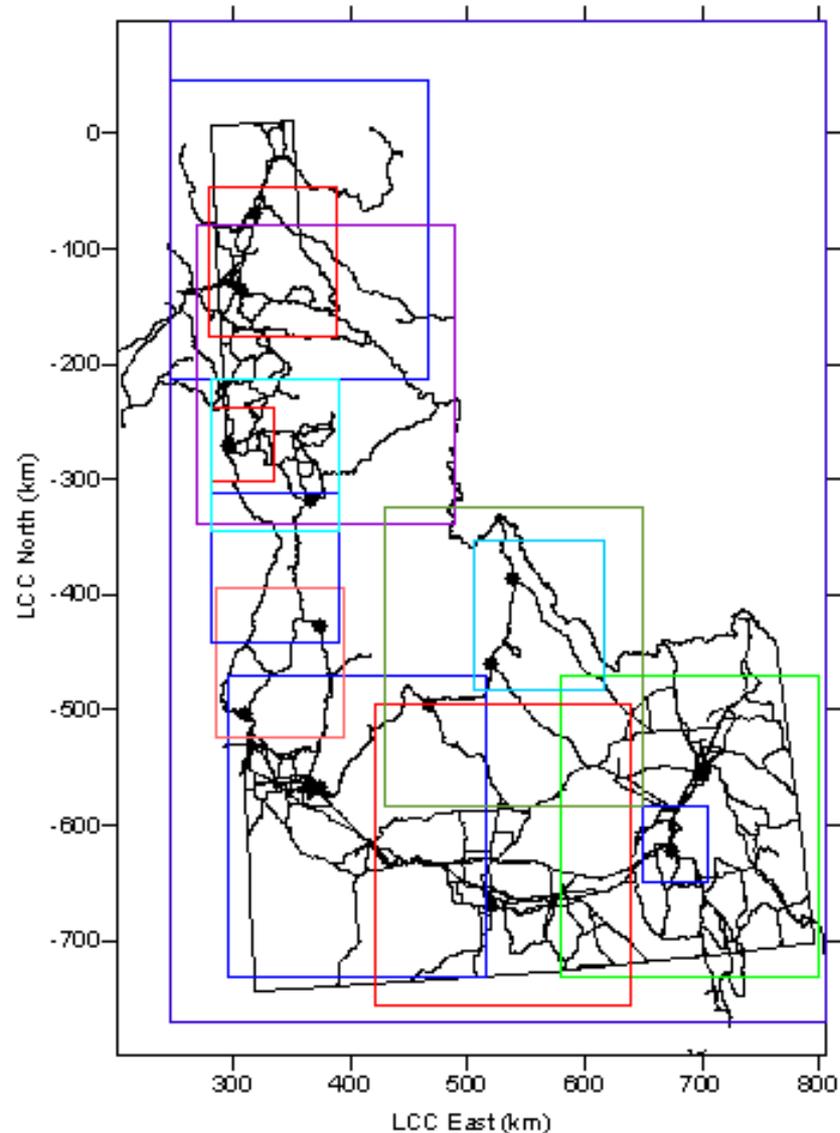
# Preliminary Bakken Crude Pool Fire Scenarios

Pool Fire Source Scenarios	Area, ft2	Vol (gal)	Mass Burn Rate	HRR, kW
10% of Avg Spill pooled 6 in deep	65	244	0.045 kg/m2-s	11,598
Average Rail Spill-pooled 6 in deep	652	2,438	0.045 kg/m2-s	116,391
1 DOT 111 car-pooled 6 in deep	8,021	30,000	0.045 kg/m2-s	1,431,854
3 DOT-111 cars - pooled 6 in deep	24,066	90,015	0.045 kg/m2-s	4,296,098
10 DOT-111 cars - pooled 6 in deep	80,208	300,000	0.045 kg/m2-s	14,318,186
33 DOT-111 cars - pooled 6 in deep	267,360	1,000,000	0.045 kg/m2-s	47,727,287
10% of Avg Spill pooled 2 ft deep	16	244	0.045 kg/m2-s	2,796
Average Rail Spill-pooled 2 ft deep	163	2,438	0.045 kg/m2-s	29,098
1 DOT 111 car-pooled 2 ft deep	2,005	30,000	0.045 kg/m2-s	357,919
3 DOT-111 cars - pooled 2 ft deep	6,017	90,015	0.045 kg/m2-s	1,074,114
10 DOT-111 cars - pooled 2 ft deep	20,052	300,000	0.045 kg/m2-s	3,579,547
33 DOT-111 cars - pooled 2 ft deep	66,840	1,000,000	0.045 kg/m2-s	11,931,822
10% of Avg Spill pooled 1 in on water	391	244	0.06 kg/m2-s	93,065
Average Rail Spill-pooled 1 in on water	3,910	2,440	0.06 kg/m2-s	930,649
1 DOT 111 car-pooled 1 in on water	48,125	30,000	0.06 kg/m2-s	11,454,596
3 DOT-111 cars - pooled 1 in on water	144,398	90,000	0.06 kg/m2-s	34,369,740
10 DOT-111 cars - pooled 1 in on water	481,248	300,000	0.06 kg/m2-s	114,545,488
33 DOT-111 cars - pooled 1 in on water	1,604,160	1,000,000	0.06 kg/m2-s	381,818,295



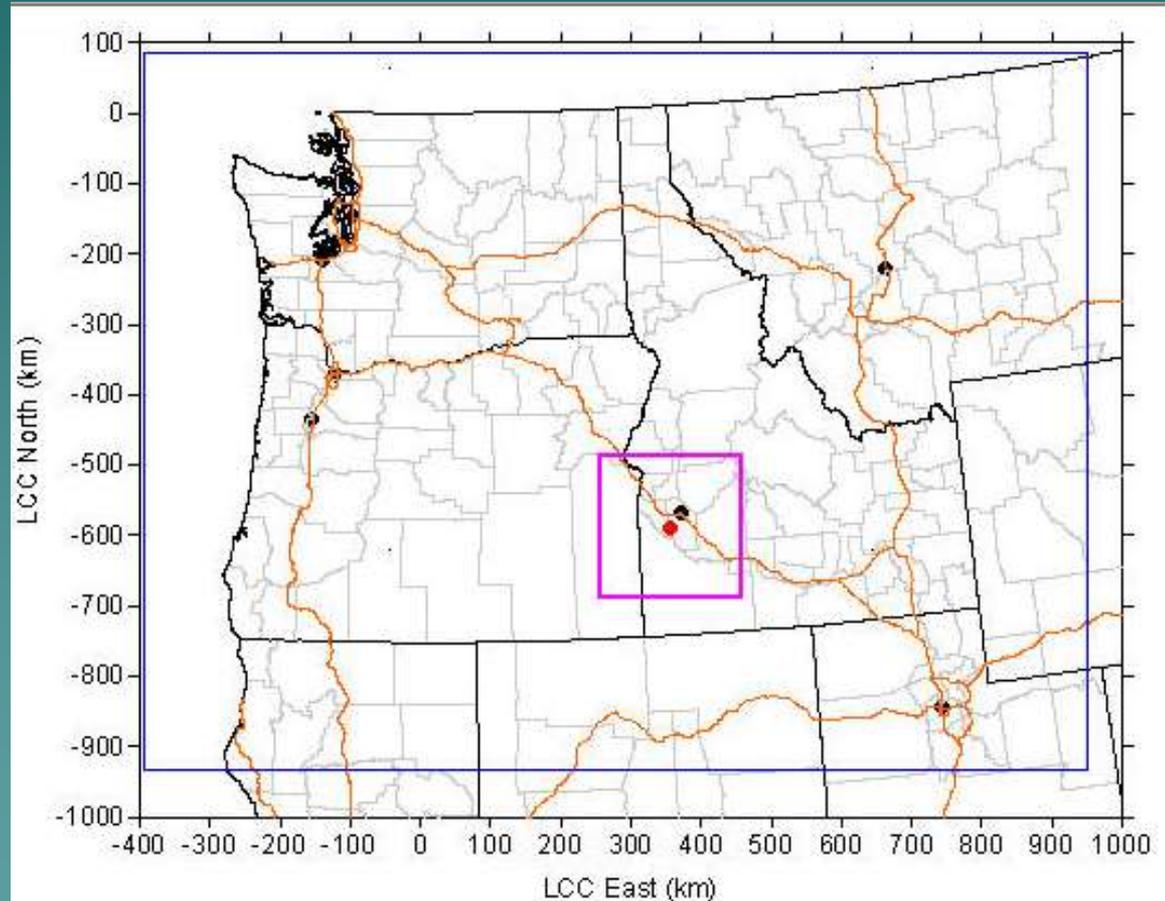
# Idaho Modeling Domains and Resolution

- ◆ id\_4km
- ◆ CDA\_1km
- ◆ CDA\_500m
- ◆ Lewiston\_1km
- ◆ Lewiston\_500m
- ◆ Lewiston\_250m
- ◆ Riggins\_500m
- ◆ McCall\_500m
- ◆ Boise\_1km
- ◆ TwinFalls\_1km
- ◆ Salmon\_1km
- ◆ Salmon\_500m
- ◆ Pocatello\_1km
- ◆ Pocatello\_250m



# Expanded Geographic Coverage

- ◆ Added 4 km Pacific Northwest domain
- ◆ Pacific coast to western MT and WY
- ◆ Lower Fraser River valley, BC, to Salt Lake City, UT
- ◆ Allows Idaho to model releases outside of Idaho that might affect us (e.g., large fires, FMD)



# Graphical User Interface

Incident Calpuff

help

**CALPUFF Incident Modeling Domains**

The map displays several modeling domains across the Pacific Northwest, including Washington, Oregon, and Idaho. Each domain is outlined with a colored border and contains a grid of red dots representing modeling cells. The domains are color-coded as follows:

- MCAL: Pink
- INGRA: Cyan
- TOX-FAB: Yellow
- WAC: Brown
- WASCO: Grey
- WASCO-2: Blue
- WASCO-3: Red
- WASCO-4: Black

Grid Cell Size options are shown as:

- 200 m
- 500 m
- 1 km
- 2 km

A scale bar indicates distances from 0 to 200 kilometers. A north arrow is also present.

Buttons on the right side of the interface:

- Setup
- New Scenario
- Unfinished Scenario
- Review Finished Scenario
- Exit

Version 1.0.0



# Enter Scenario Name and Description

Scenario Description

Run Type

Network  Desktop

Review All Scenarios

Scenario Name

Select Finished Scenario as template

Scenario Name starts with your Initials, can not contain space, underscore, and must be less than or equal to 8 characters

Event

Scenario Description

A tanker truck containing liquified chlorine crashed on Highway 12 just south of Orofino at 3 am, July 24. The contents of the tanker were released in less than a half hour. Several casualties were reported near the accident site and numerous calls were recieved reporting irritation and respiratory difficulties in Orofino.

Next Save and Stop Cancel



# Enter Source Coordinates

## Source Location - Incident Calpuff

### Attention:

If you are modelling river volatiles, You need to enter coordinates of center of 1km river section (centered on a point 5 miles downstream from spill)--NOT coordinates of the spill location

If you are modelling source other than river volatiles, you need to enter coordinates of source center

Projection  Datum

### Latitude Longitude (decimal degrees)

Latitude

dd  mm  ss.ss

Longitude

dd  mm  ss.ss

Next

Save and Stop

Back



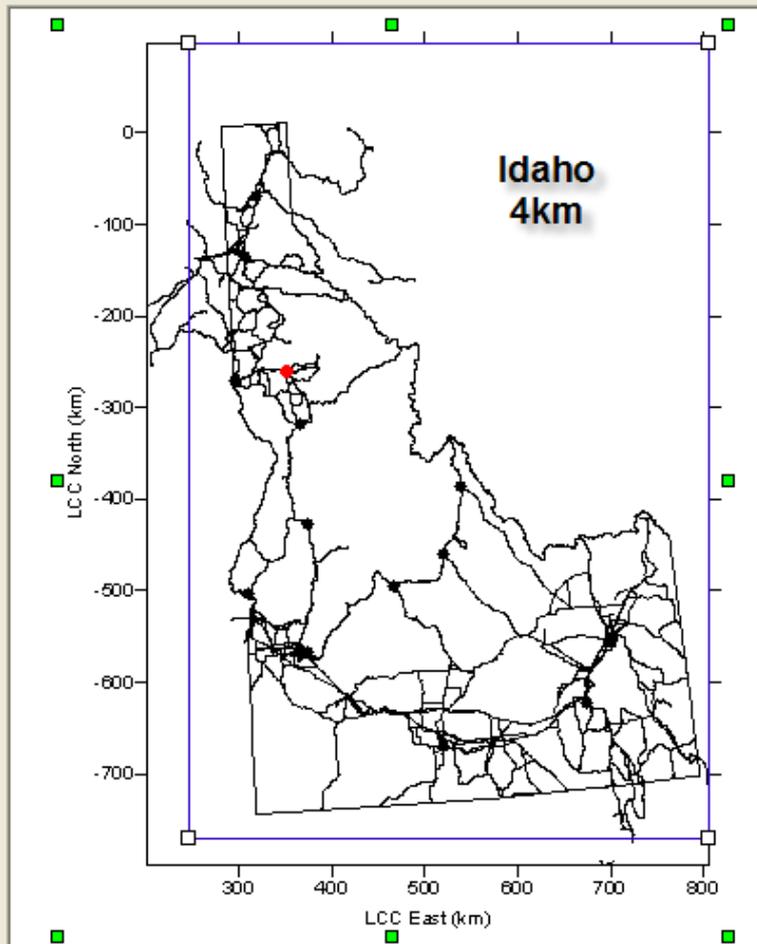
# Select Domain and Resolution

## Select Domain

Select Domain from the table below:

Selected Domain

	Domain_No	Domain_Name	Short_Name	Grid_Origin_X	Grid_Origin_Y	Grid_Spacing	NX	NY
▶	0	idaho_4km	id_4km	246	-770	4	140	217
	2	lewiston_1km	lew_1km	268	-339	1	220	260
	12	lewiston_500m	lew_500m	280	-344	0.5	220	260



### Legend

 Source Location

### Datum and LCC (km)

Datum

X Easting: Y Northing:

Source Location:

Offset:

### Origin of Projection (decimal degrees):

Latitude:  Longitude:

### Matching Latitudes (decimal degrees):

Latitude 1:  Latitude 2:

### Distance from Domain Edge (km)

West  East

South  North

Next

Save and Stop

Back



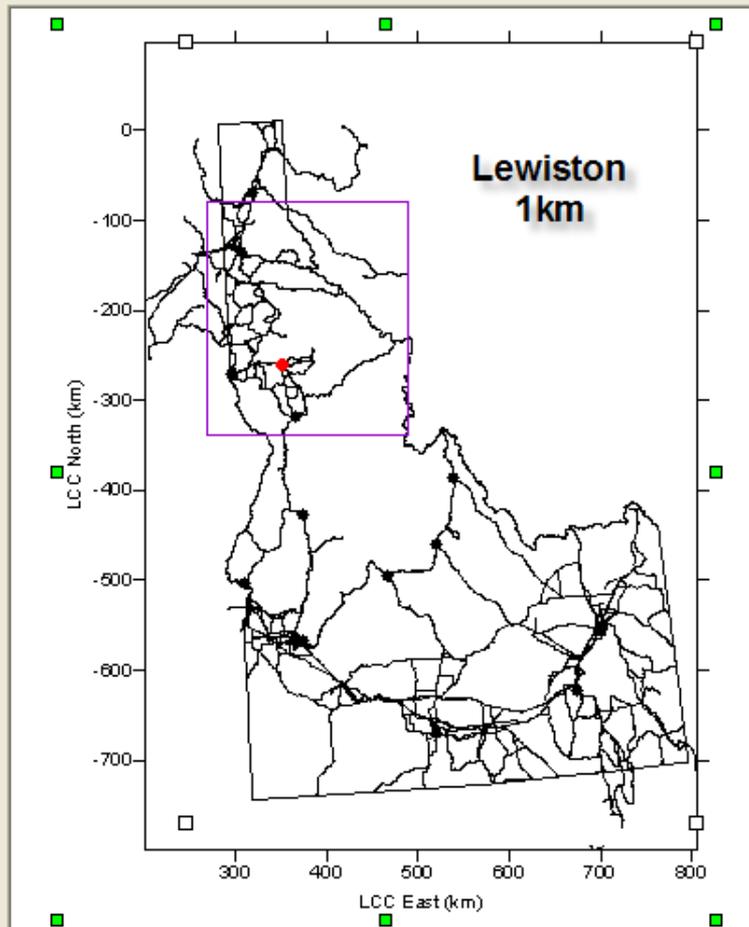
# Lewiston: 1km Resolution

## Select Domain

Select Domain from the table below:

Selected Domain

Domain_No	Domain_Name	Short_Name	Grid_Origin_X	Grid_Origin_Y	Grid_Spacing	NX	NY
0	idaho_4km	id_4km	246	-770	4	140	217
2	lewiston_1km	lew_1km	268	-339	1	220	260
12	lewiston_500m	lew_500m	280	-344	0.5	220	260



### Legend

● Source Location

### Datum and LCC (km)

Datum

X Easting: Y Northing:

Source Location:

Offset:

### Origin of Projection (decimal degrees):

Latitude:  Longitude:

### Matching Latitudes (decimal degrees):

Latitude 1:  Latitude 2:

### Distance from Domain Edge (km)

West  East

South  North

Next

Save and Stop

Back



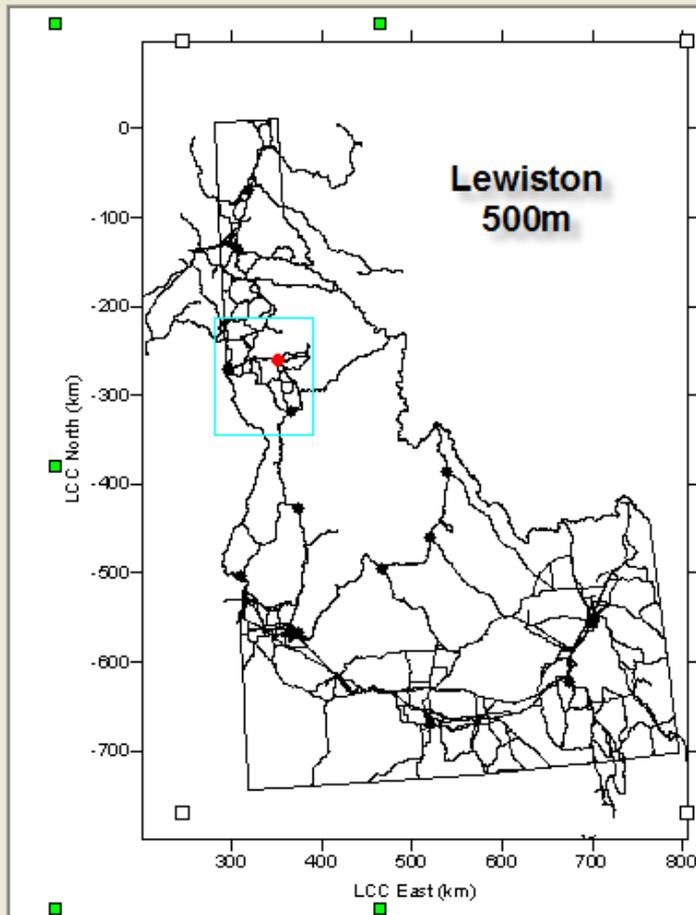
# Lewiston: 500m Resolution

## Select Domain

Select Domain from the table below:

Selected Domain

Domain_No	Domain_Name	Short_Name	Grid_Origin_X	Grid_Origin_Y	Grid_Spacing	NX	NY
0	idaho_4km	id_4km	246	-770	4	140	217
2	lewiston_1km	lew_1km	268	-339	1	220	260
▶ 12	lewiston_500m	lew_500m	280	-344	0.5	220	260



### Legend

● Source Location

### Datum and LCC (km)

Datum

X Easting:  Y Northing:

Source Location:

Offset:

### Origin of Projection (decimal degrees):

Latitude:  Longitude:

### Matching Latitudes (decimal degrees):

Latitude 1:  Latitude 2:

### Distance from Domain Edge (km)

West  East

South  North

Next

Save and Stop

Back



# Select Meteorology File

Select or Generate Calmet Output

**Datum and LCC (km)**

Datum:

**Origin of Projection (decimal degrees):**

Latitude:  Longitude:

**Matching Latitudes(decimal degrees):**

Latitude 1:  Latitude 2:

**Offset (km):**

X Easting:  Y Northing:

**Source Location**

X Easting (km):  Y Northing (km):

Column:  Row:

Terrian Elevation (m):

Calmet Domain								
Domain_No	Domain_Name	Short_Name	Grid_Origin_X	Grid_Origin_Y	Grid_Spacing	NX	NY	
▶ 12	lewiston_500m	lew_500m	280	-344	0.5	220	260	

Base Time Zone:  UW MM5 Domain:  Calmet Type:

Basic						
Available	Met_Name	Beginning_Date	Beginning_Hour	Ending_Date	Ending_Hour	
▶ Yes	mm5_4km_06072012_lew_500m	7/21/2006	0	7/22/2006	5	
No	mm5_4km_06072000_lew_500m	7/20/2006	0	7/21/2006	17	
No	mm5_4km_06072100_lew_500m	7/21/2006	0	7/22/2006	17	
No	mm5_4km_06072112_lew_500m	7/22/2006	0	7/23/2006	5	
No	mm5_4km_06072200_lew_500m	7/22/2006	0	7/23/2006	17	
No	mm5_4km_06072212_lew_500m	7/23/2006	0	7/24/2006	5	
No	mm5_4km_06072300_lew_500m	7/23/2006	0	7/24/2006	17	
No	mm5_4km_06072312_lew_500m	7/24/2006	0	7/25/2006	5	
No	mm5_4km_06072400_lew_500m	7/24/2006	0	7/25/2006	17	
No	mm5_4km_06072412_lew_500m	7/25/2006	0	7/26/2006	5	
No	mm5_4km_06072500_lew_500m	7/25/2006	0	7/26/2006	17	

Note: If the Desired MM5 Met Data file is not available, click on Next anyway. It will generate it automatically (It may take about from 10 to 40 minutes) and take you to Source Term Template. If an available file is selected, click on Next will take you to Source Term Template directly.



# Select Source Category and Template

## Select Source Term Template

Map Projection and Source Location **Met Information**

Base Time Zone  UW MM5 Domain  Calmet Type

**Calmet Domain (km)**

Domain No	Domain Name	Short Name	Grid Origin X	Grid Origin Y	Grid Spacing	NX	NY
<input type="text" value="12"/>	<input type="text" value="lewiston_500m"/>	<input type="text" value="lew_500m"/>	<input type="text" value="280km"/>	<input type="text" value="-344km"/>	<input type="text" value="0.5km"/>	<input type="text" value="220"/>	<input type="text" value="260"/>

**Calmet Covering Time Period**

Met Name  Calmet Beginning Time   Calmet Ending Time

### Select Source Category First

Category	SubCategory	Calpuff_Catego	Description
Industrial Spill	Pipe Break	Area	Release of RMP chemicals via 2-inch pipe break to air or to evaporating pool
Industrial Spill	tack/Vent Release	Point	Release of RMP chemicals via 8-inch emergency vent at 80% of choked flow.
Pool Fire		Area	Combustion toxics from burning pool of gasoline, fuel oil or methanol
Rail Transport Spill	Catastrophic	Area	Total release of railcar load in 10 minutes for common hazardous commodities
Rail Transport Spill	Pipe Break	Area	Release of railcar load via 2-inch pipe break to air or to an evaporating pool
Truck Transport Spill	Catastrophic	Area	Total release of truck load in 10 minutes for common hazardous commodities
Truck Transport Spill	Pipe Break	Area	Release of truck load via 2-inch pipe break to air or to evaporating pool

### Select the Template Second

ID	Commodity	Species	Form/ Boiling Pt	Truck Capacity (gal)	Material Weight (lbs)	Hole size (inches)	Poo
1	Anhydrous Ammonia	NH3	Liq Gas/239K	11500	48000	2	
2	Chlorine	CL2	Liq Gas/240K	3000	32000	1.4	
3	Hydrogen Fluoride	HF	Liq Gas/292K	3000	20000	3	
4	Anhydrous SO2	SO2	Liq Gas/263K	3150	32000	1.75	
5	Mono-Methyl Amine	MMA	Liq Gas/266K	10000	48000	2.7	
6	Oleum/Sulfuric Acid	H2SO4	Aqueous Soln	3000	40000	N/A	
7	hydrochloric Acid > 37	HCL	Aqueous Soln	5000	32000	N/A	
8	Fuming Nitric Acid	HNO3	Aqueous Soln	3000	32000	N/A	
9	Aqueous NH3 > 20%	NH3	Aqueous Soln	6000	32000	N/A	

Skip

Next

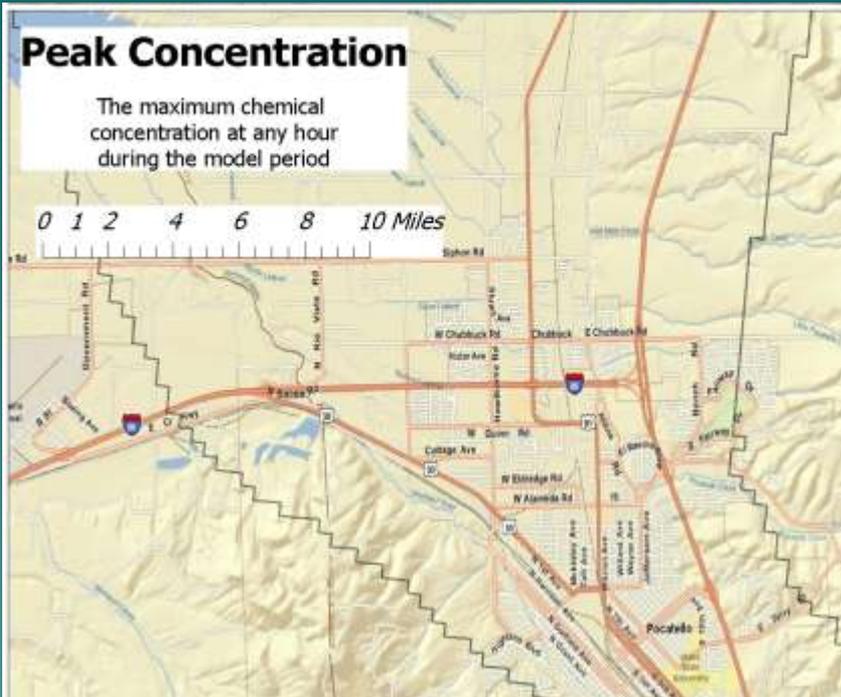
Save and Stop

Back

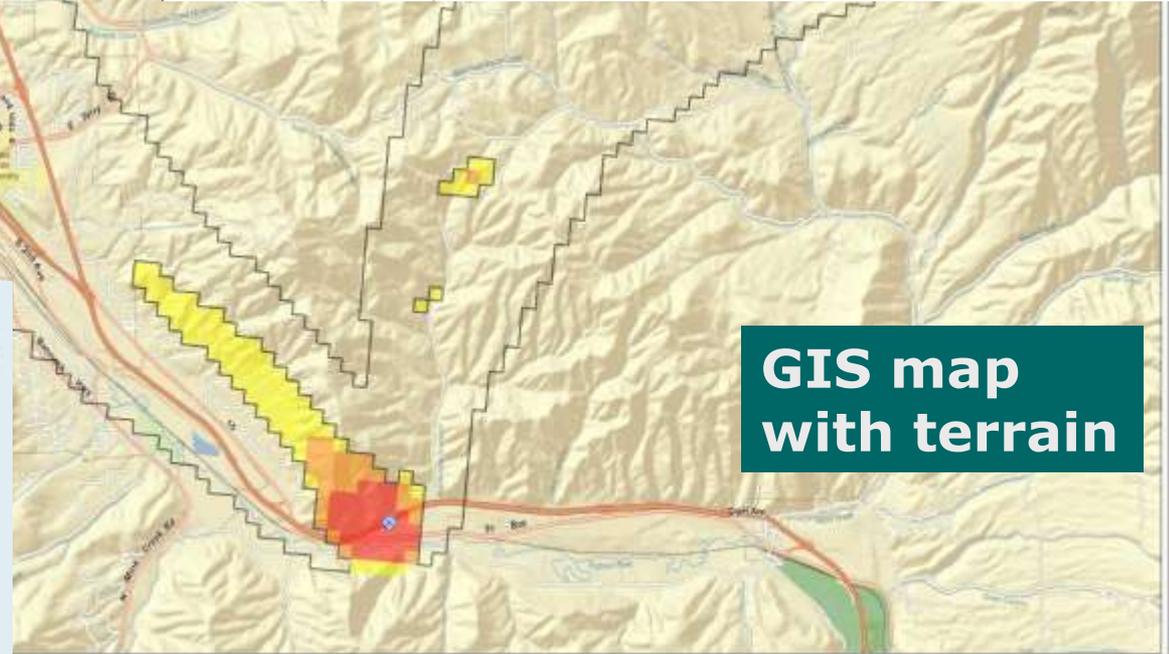


# GIS Outputs

## Address ranges for zones



ERPG zone	Zipcode	Full Address Range
1	83406	9999 to 9897 and 0 to 0 S Huff Rd , 83406
1	83440	9999 to 9861 and 9998 to 9860 S Snake River Rd , 83440
1	83440	9999 to 9777 and 9998 to 9776 S 400 W, 83440
1	83440	9999 to 9001 and 9998 to 9000 S 600 E, 83440
1	83274	999 to 997 and 998 to 996 E 700 N, 83274
2	83274	999 to 997 and 998 to 996 Goshen Rd , 83274
2	83236	999 to 995 and 998 to 994 N 500 E, 83236
2	83455	999 to 995 and 998 to 994 Aspen Grove , 83455
2	83274	999 to 993 and 998 to 992 E 900 N, 83274
2	83333	999 to 989 and 0 to 0 Buckhorn , 83333
3	83274	999 to 987 and 998 to 986 N 1000 E, 83274
3	83221	999 to 985 and 0 to 0 W 150 N, 83221
3	83424	999 to 979 and 998 to 978 32 , 83424



**GIS map with terrain**

## Population estimates

Species Name: CL2  
 Concentration unit of Calpuff output: ug/m3  
 Unit of ERPG: ug/m3  
 ERPG-1: 2.9517E+03 (1 ppm)  
 ERPG-2: 8.8550E+03 (3 ppm)  
 ERPG-3: 5.9033E+04 (20 ppm)

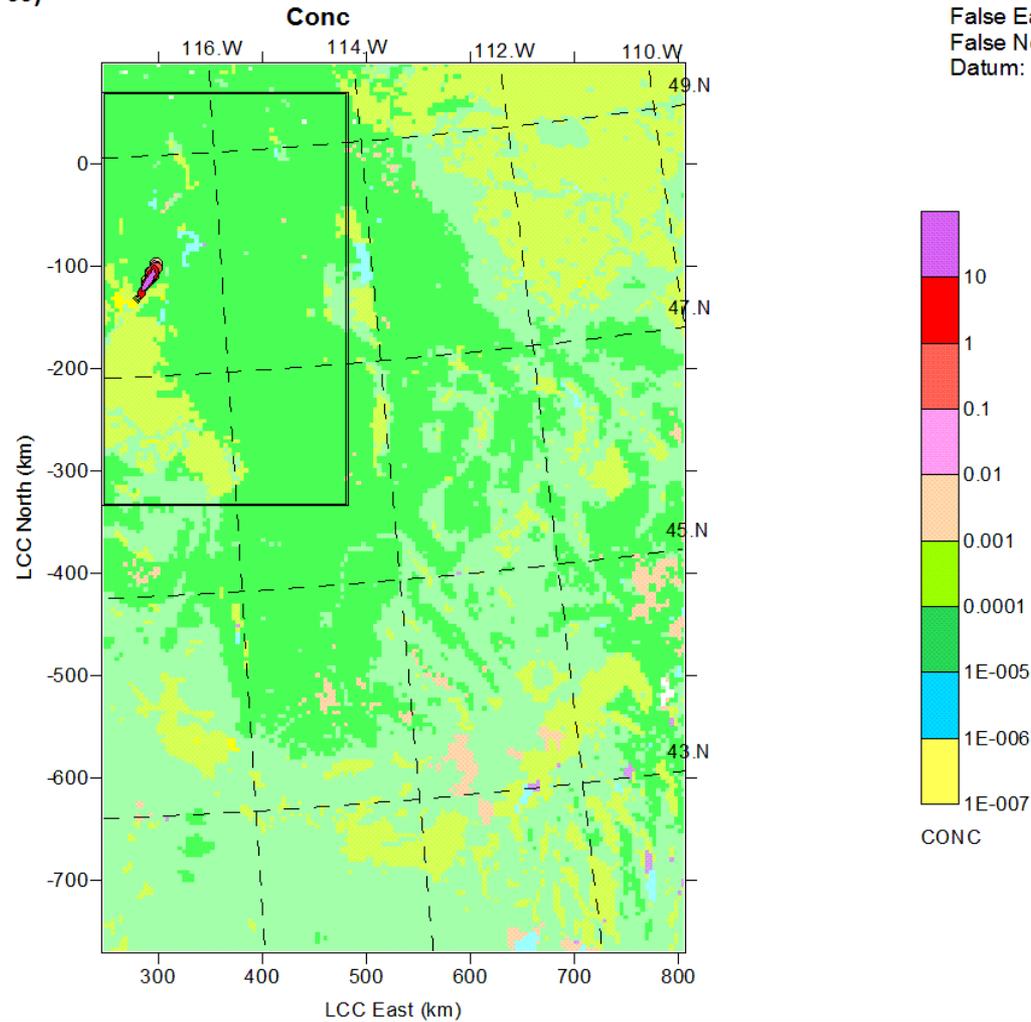
Total Persons in ERPG Zone:  
 ERPG-1 = 165 (peak), 13 (mean)  
 ERPG-2 = 50 (peak), 9 (mean)  
 ERPG-3 = 34 (peak), 13 (mean)



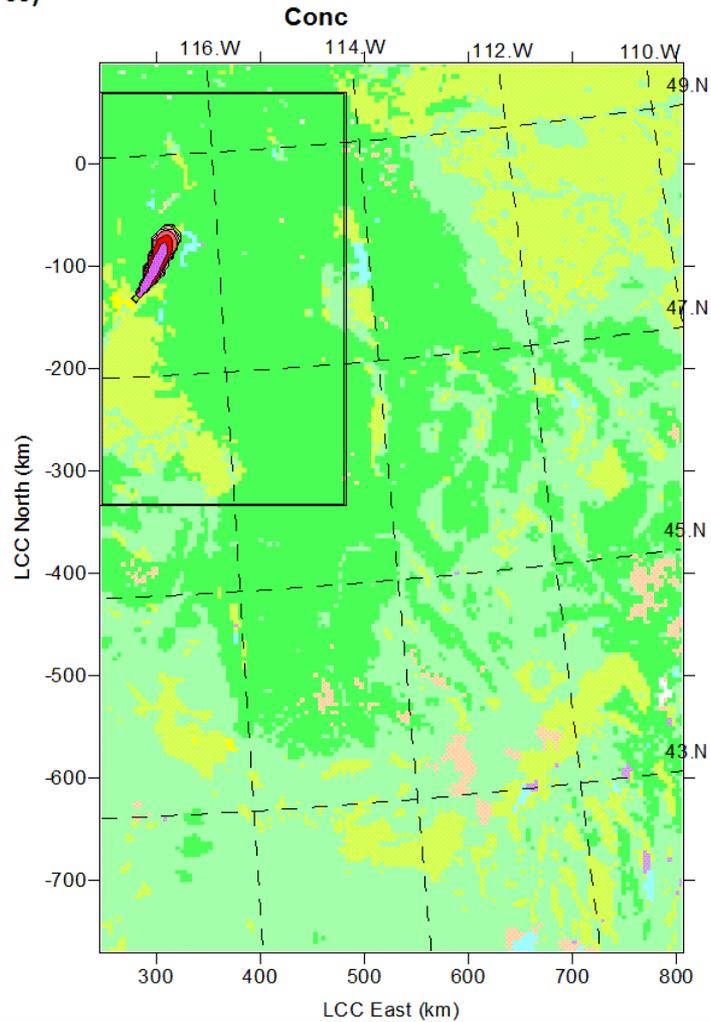
# Preliminary Testing

Jun 16, 2014  
05:00 LST(UTC-0700)

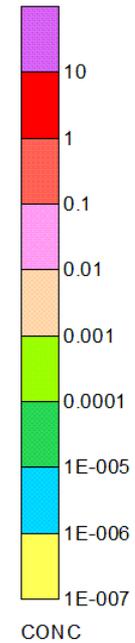
LCC Origin: 49N, 121W  
Matching Parallels: 30N, 60N  
False Easting: 0  
False Northing: 0  
Datum: NAR-C



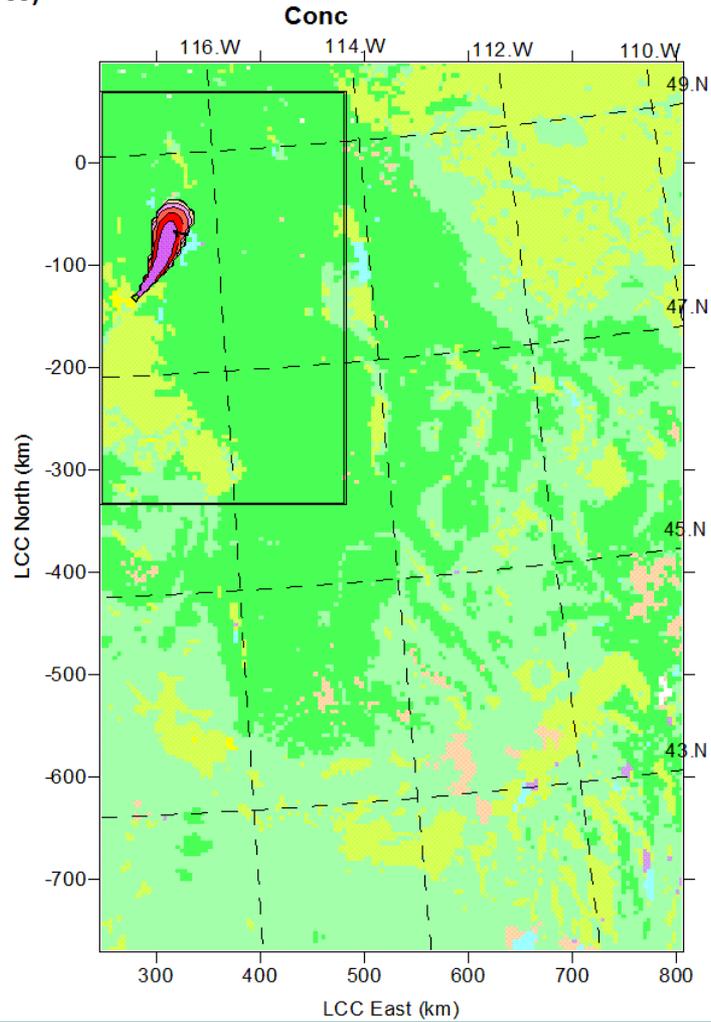
Jun 16, 2014  
06:00 LST(UTC-0700)



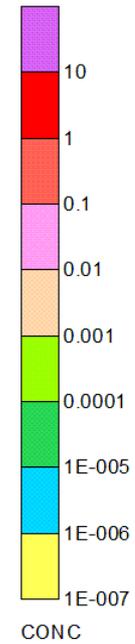
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Datum: NAR-C



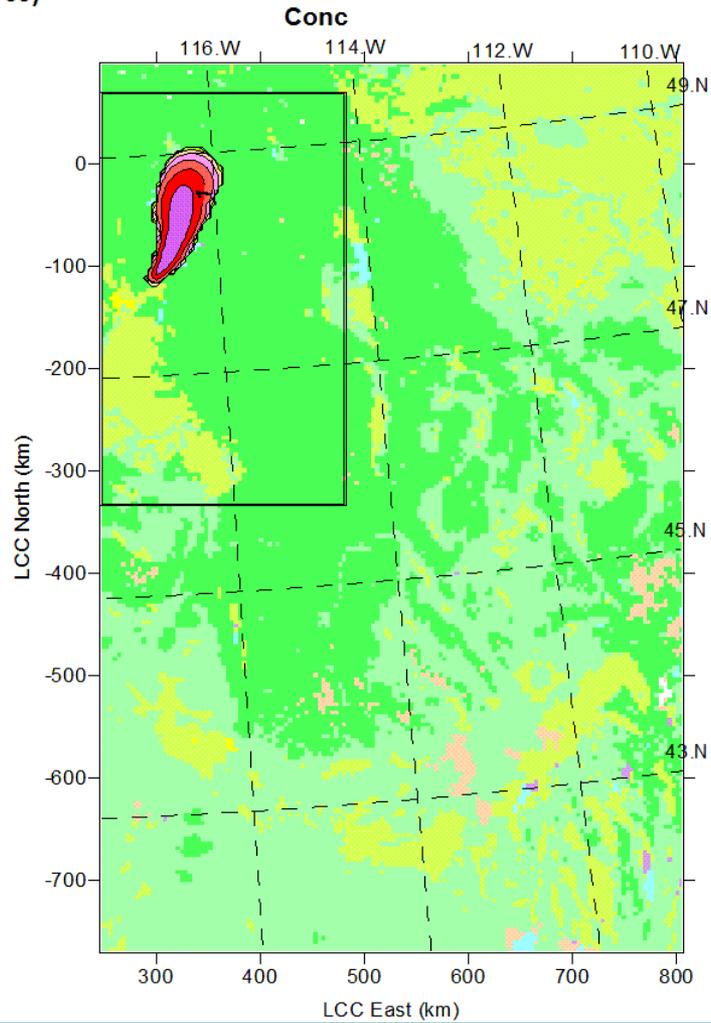
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07:00 LST(UTC-0700)



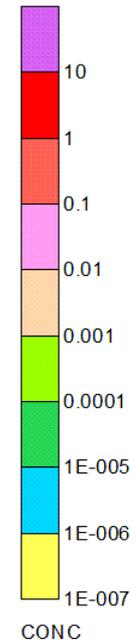
LCC Origin: 49N, 121W  
Matching Parallels: 30N, 60N  
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False Northing: 0  
Datum: NAR-C



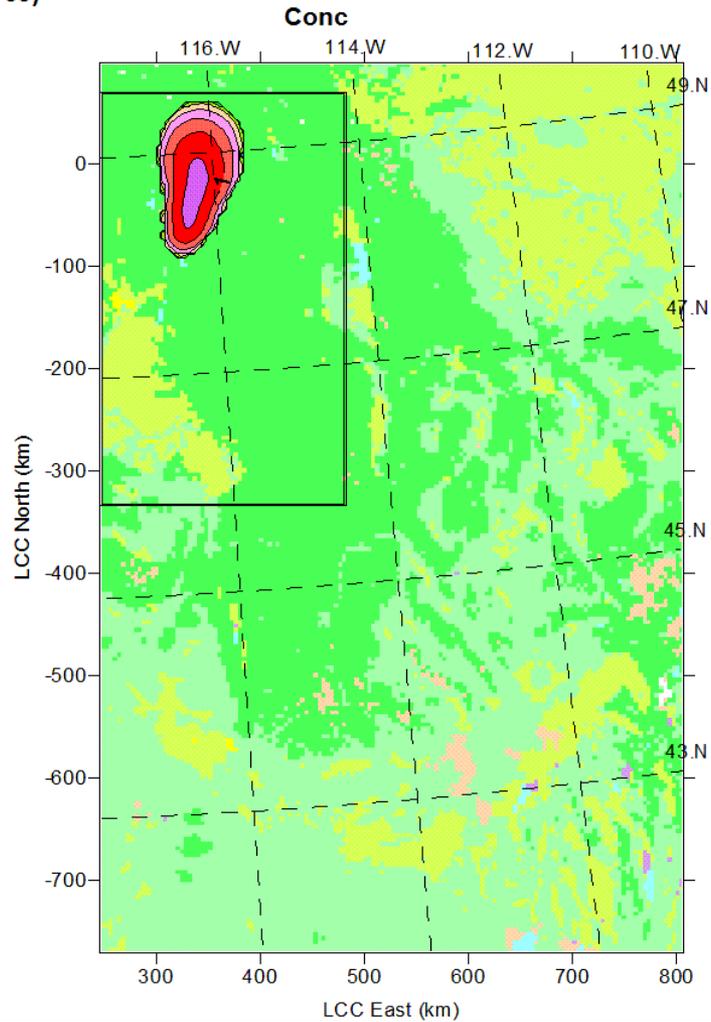
Jun 16, 2014  
09:00 LST(UTC-0700)



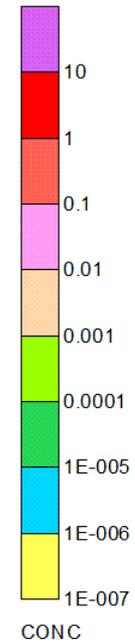
LCC Origin: 49N, 121W  
Matching Parallels: 30N, 60N  
False Easting: 0  
False Northing: 0  
Datum: NAR-C



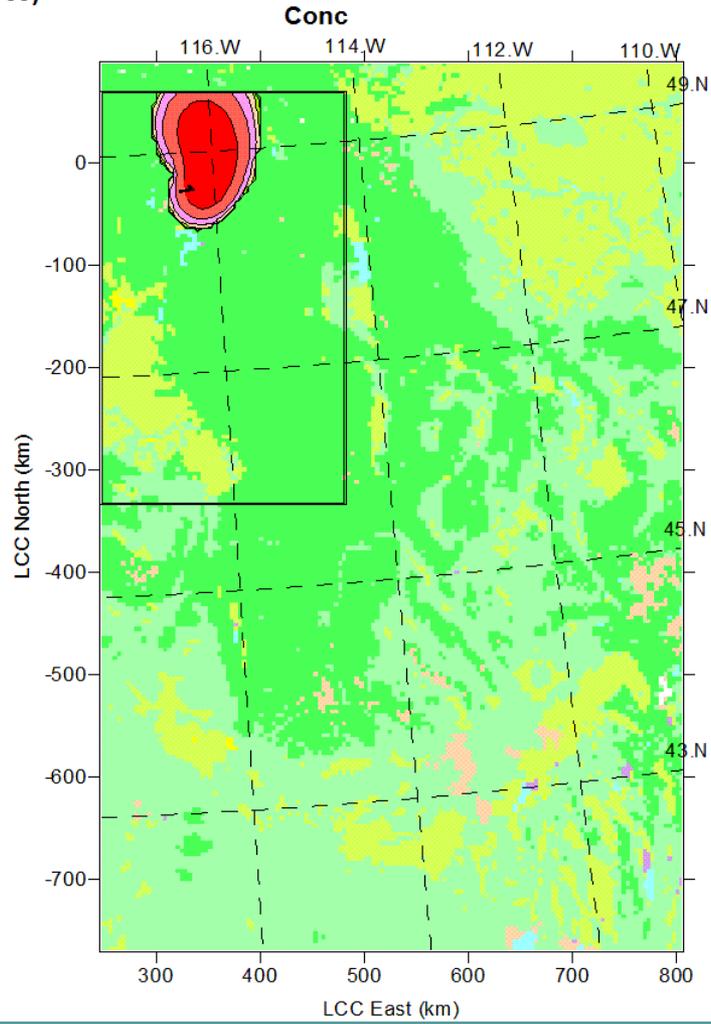
Jun 16, 2014  
11:00 LST(UTC-0700)



LCC Origin: 49N, 121W  
Matching Parallels: 30N, 60N  
False Easting: 0  
False Northing: 0  
Datum: NAR-C



Jun 16, 2014  
13:00 LST(UTC-0700)



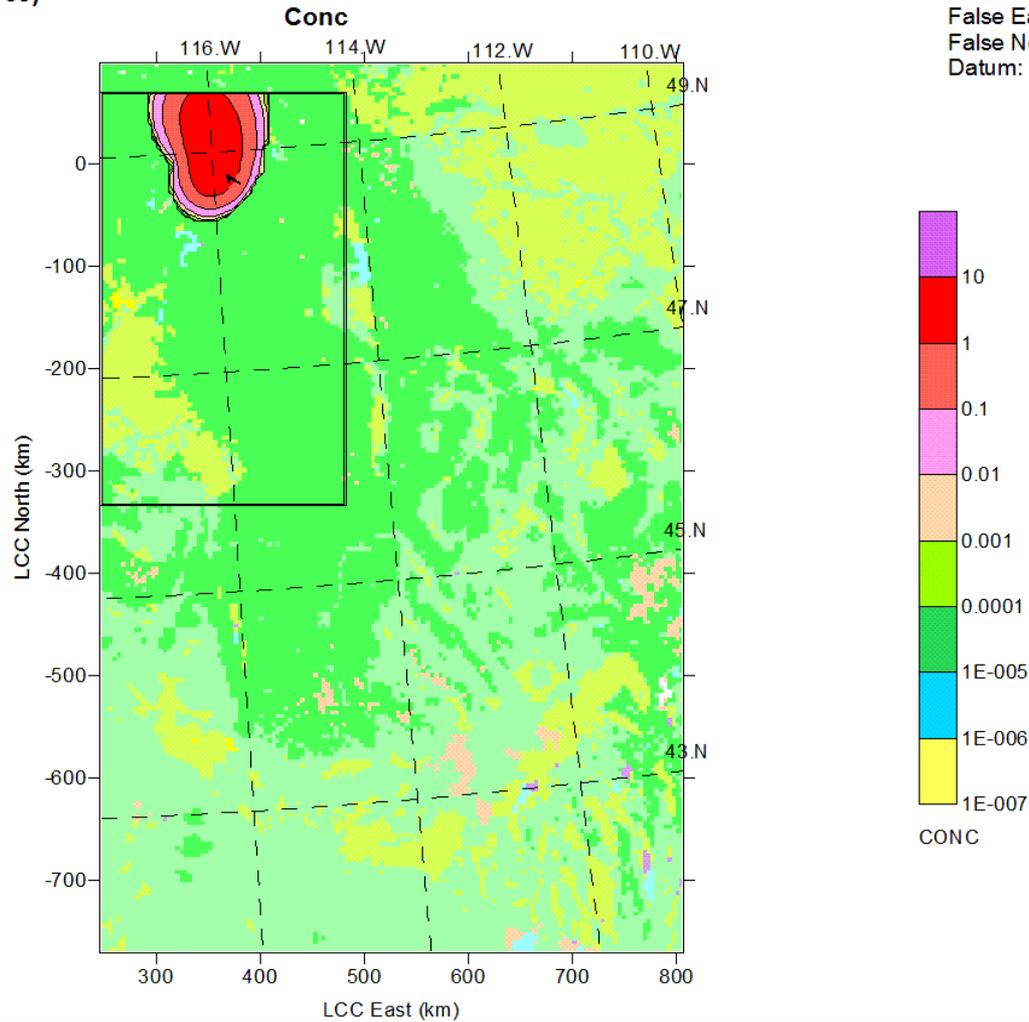
LCC Origin: 49N, 121W  
Matching Parallels: 30N, 60N  
False Easting: 0  
False Northing: 0  
Datum: NAR-C



# Preliminary Testing

Jun 16, 2014  
14:00 LST(UTC-0700)

LCC Origin: 49N, 121W  
Matching Parallels: 30N, 60N  
False Easting: 0  
False Northing: 0  
Datum: NAR-C



# Future Work

- ◆ Let modelers in Washington and Oregon know that we have the capability to model spills (pool fire plumes and river spill time of travel) throughout the NW (the purpose of this presentation).
- ◆ IF we are in the office, time to complete a model run can be 1 – 2 hours.
- ◆ But we caution that we are not funded to be on call or available 24/7.
- ◆ Continue to test the Crude oil pool fire scenarios.
- ◆ Upgrade the system, when time permits to utilize WRF met outputs directly through MMIF rather than or in addition to CALPUFF/CALMET.



Questions? Discussion?

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