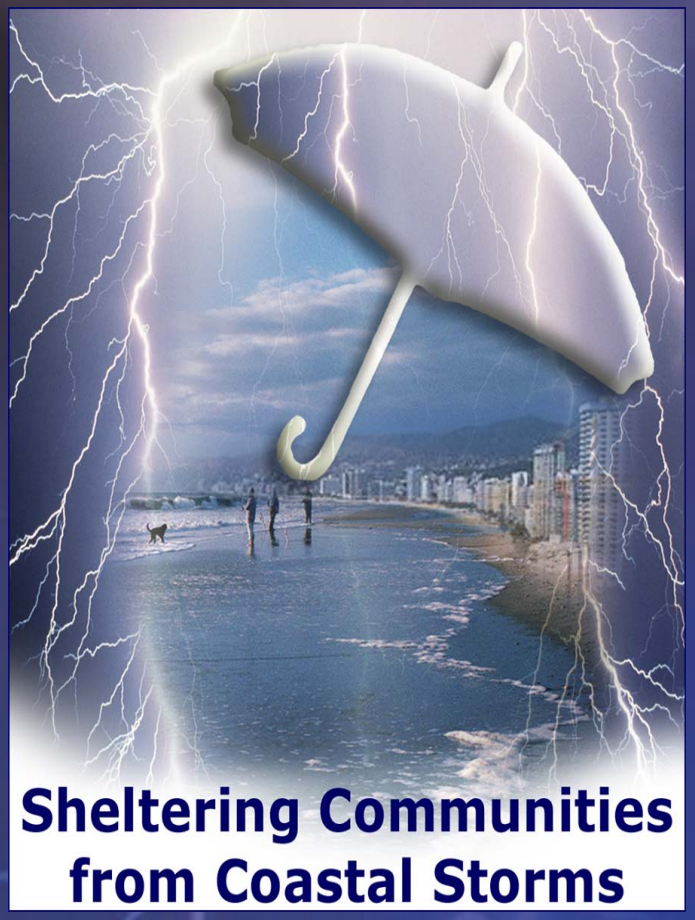
Ecological Assessment of Storm Impacts on Marine Resources



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Center for Coastal
Environmental Health and
Biomolecular Research

Acknowledgements

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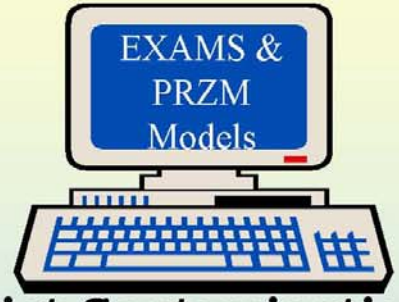
SJRWMD

Project Purposes

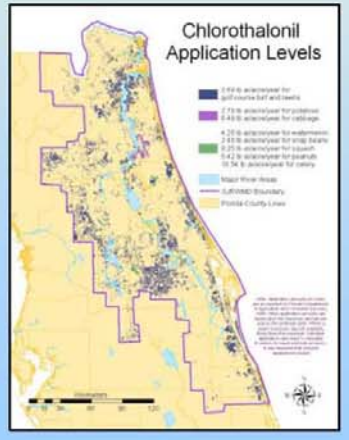
- Identify species at risk
- Identify geographic locations at risk
- Focus post-storm ecological assessments
- Assist mitigation planning
- Provide access to available risk information
- Promote responsible pesticide use

The Ecological Assessment of Storm Impacts on Marine Resources

Identify Species at Risk

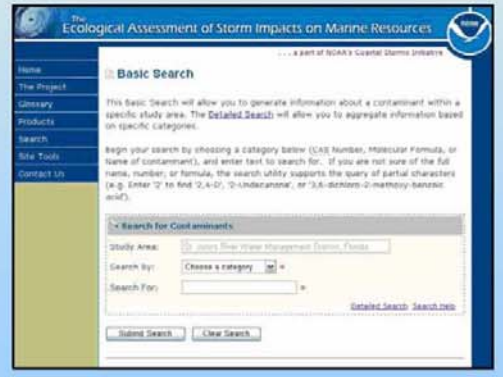


Predict Contamination of Habitats



Identify Areas at Risk

Compile a Risk Assessment Database



Provide Online Access to Data

Florida Pilot Area

Risk Assessment
- Land uses
- Toxicology
- Database

Modeling
- Transport and Fate
- Lake Bethel

Toxicology
- Indigenous Species
- Developmental Model (NWFC)

Source: www.sjrwmd.org

Risk Assessment

Crop Information

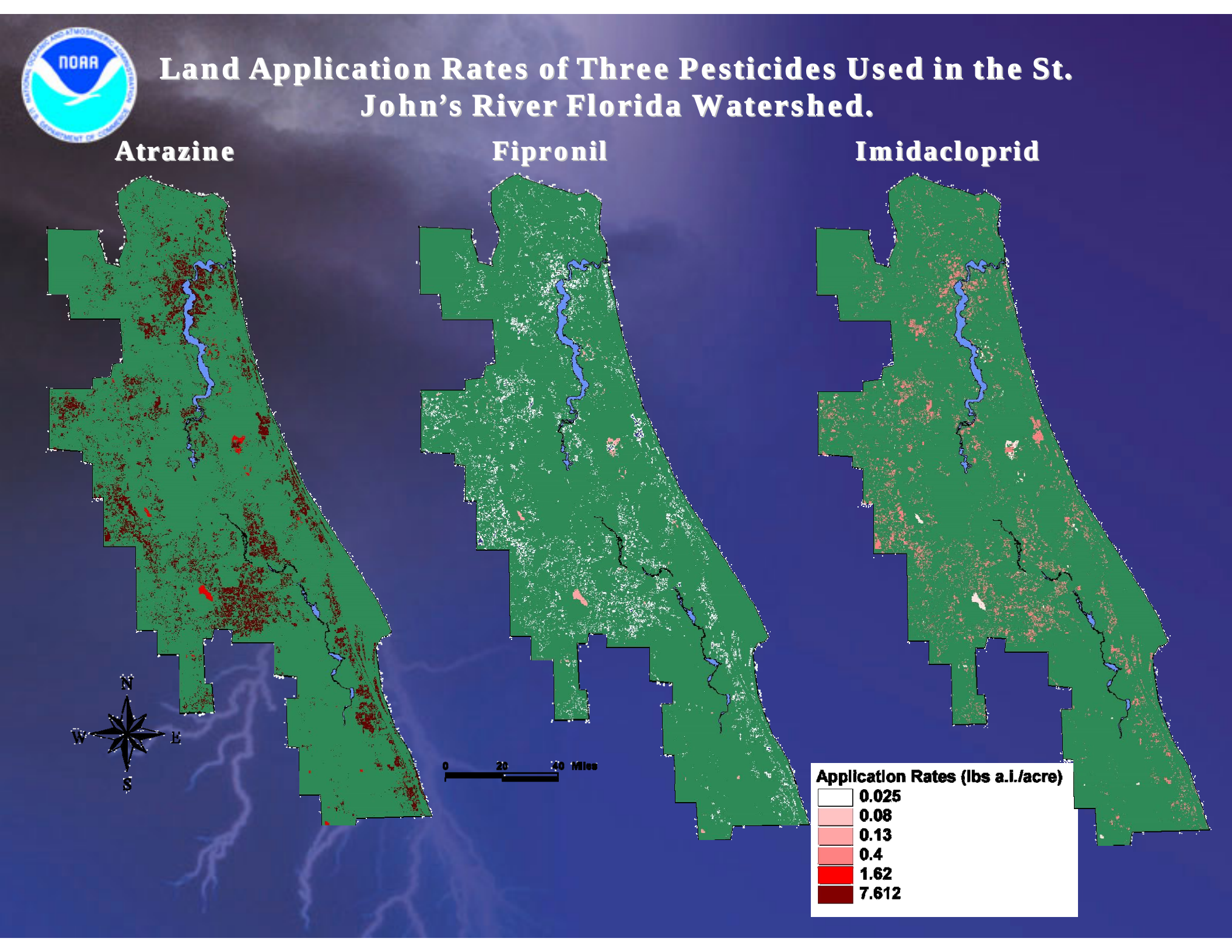
- Acreage of Each Crop per County
- Pounds of Active Ingredient per Crop Year Applied to Each Crop

Pesticide Information

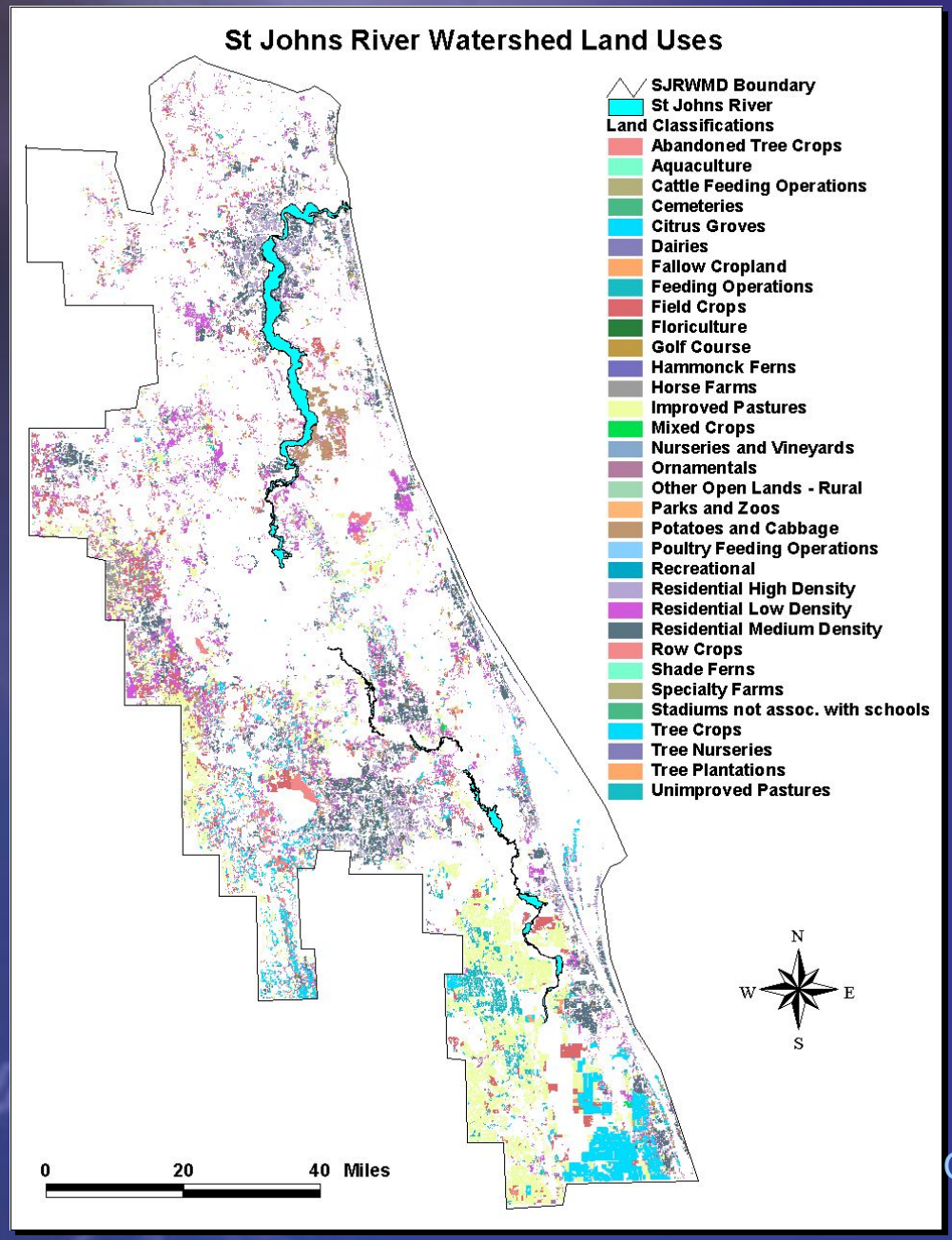
- Chemistry
- Toxicity
- Allowable Land Cover for Application

Web Accessibility

Land Application Rates of Three Pesticides Used in the St. John's River Florida Watershed.

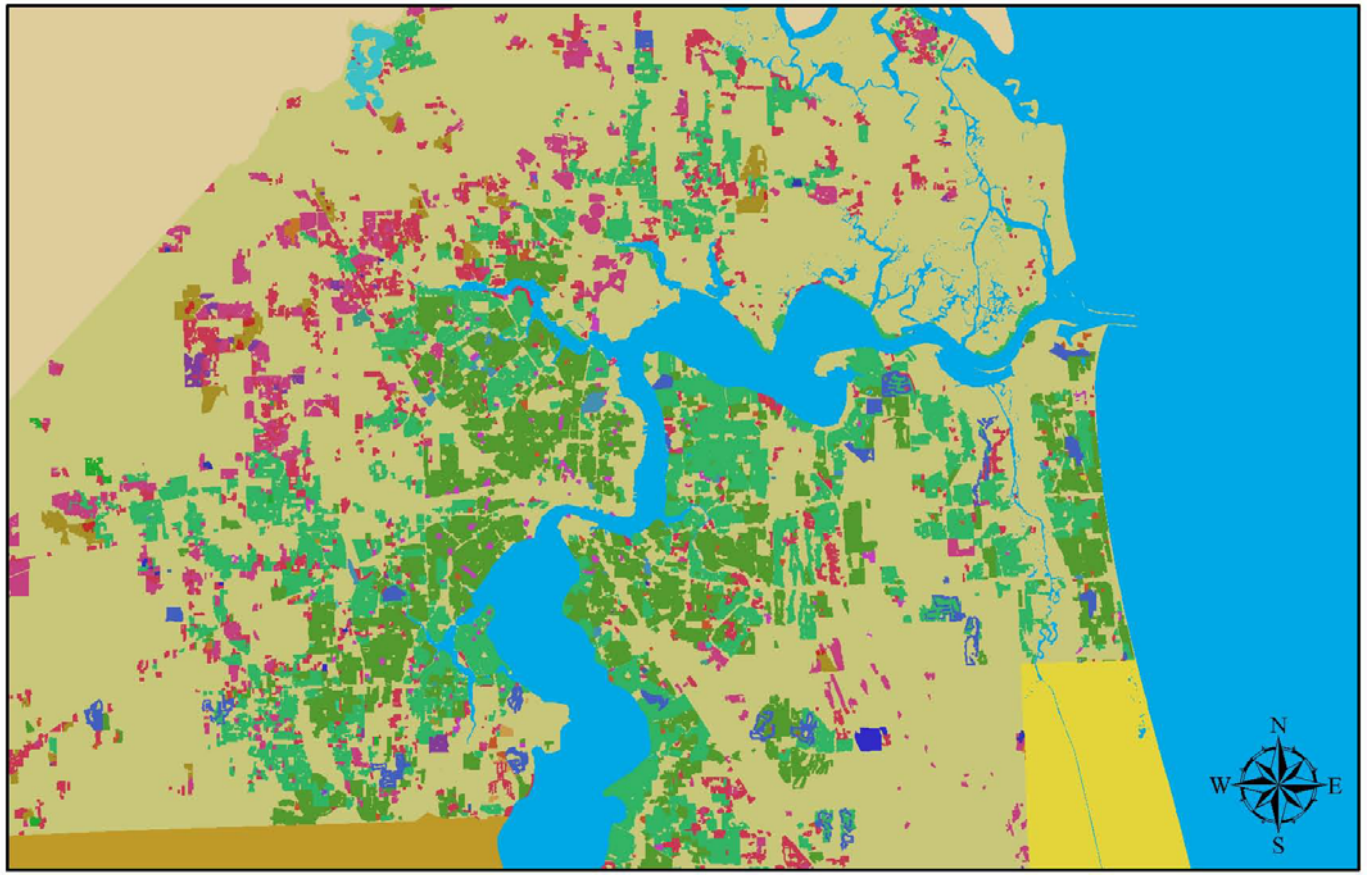


Land Cover Data



Duval County Land Use

- Abandoned Tree Crops
- Aquaculture
- Cattle Feeding Operations
- Cemeteries
- Dairies
- Fallow Cropland
- Field Crops
- Golf Course
- Horse Farms
- Improved Pastures
- Mixed Crops
- Nurseries and Vineyards
- Ornamentals
- Parks and Zoos
- Poultry Feeding Operations
- Recreational
- Residential High Density
- Residential Low Density
- Residential Med. Density
- Row Crops
- Specialty Farms
- Stadiums not associated with schools
- Tree Crops
- Tree Nurseries
- Tree Plantations
- Unimproved Pastures
- Clay County
- Duval County
- St Johns County
- Nassau County

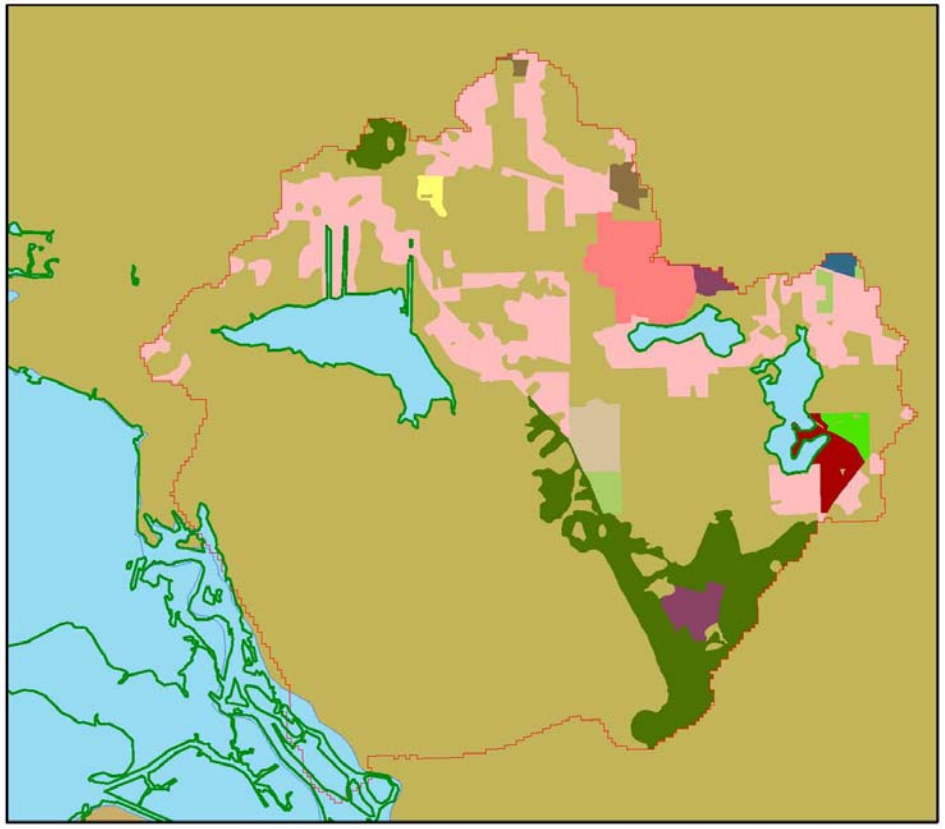


Lake Bethel Watershed

Lake Bethel Landuses

- Abandoned Tree Crops
- Field Crops
- Golf Course
- Horse Farms
- Improved Pastures
- Poultry Feeding Operations
- Residential High Density
- Residential Low Density - Less than two dwelling units per acre
- Residential Med. Density - Two to five dwelling units per acre
- Tree Nurseries
- Unimproved Pastures

- Lake Bethel Watershed
- Volusia County



EASIMR Web Site

http://www.chbr.noaa.gov/easi/

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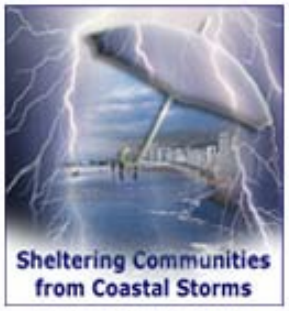
Ecological Assessment Project: Home Page

Welcome to the website of the Ecological Assessment of Storm Impacts on Marine Resources. This project is a part of the Coastal Storms Initiative (CSI) and is designed to assess potential effects on fish and shellfish from non-point source pollution.



For more about this project, please click here.

Resources available on this website

This site includes a database of chemical and toxicological information on pesticides permitted for use in the St. Johns River Watershed, Florida. It will include other classes of chemical contaminants and other study areas in the future. You can search the database by contaminant name, Chemical Abstract Service registry number or molecular formula. It will provide estimates of application rates and locations derived from actual reported agricultural applications and USEPA-permitted non-agricultural applications. Locations were cross-referenced to available GIS data layers.

Queries will also provide available information on chemical structure, molecular weight, octanol-water partition coefficients, organic carbon partition coefficients, water solubility, persistence in soil, general toxicity information and specific toxicity levels, to five groups of organisms (algae, mollusks, finfish, crustaceans, and select terrestrial animals).

Toxicity to terrestrial animals is provided as a general comparison to a large body of available toxicological literature. All of this information was obtained from available scientific literature and is provided to assist identifying locations where risks to aquatic organisms might occur following storm events.

To begin querying the project's database, click here. To learn more about this

As part of NOAA's Coastal Storms Initiative, the National Ocean Service (NOS), National Marine Fisheries Service (NMFS), and the Office of Response and Restoration (ORR) are conducting research on the transport of contaminants, estimation of the risks to aquatic organisms, and mitigation approaches to reduce those risks. The project provides users with ecological assessment tools to identify areas of risks, and to mitigate impacts from coastal storms.

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Geographic Locations

There are currently two geographic areas being studied.

St. Johns River Water Management District [Florida]

- The Florida Pilot
- The Pacific-Northwest Pilot

The Florida Pilot

The Florida pilot region is located along the northeast coast of Florida within the St. Johns River watershed.

If you are interested in learning more about the St. Johns River Water Management District (SJRWMD), please visit their official website at http://www.sjrwmd.org.

This region includes all or a portion of the following counties:

- Alachua
- Baker
- Brevard
- Clay
- Duval
- Flagler
- Indian River
- Lake
- Marion
- Nassau
- Orange
- Osceola
- Putnam
- Seminole
- St. Johns
- Volusia

The Pacific-Northwest Pilot

The second pilot program is planned for the Pacific Northwest. This pilot region will focus on part of the Lower Columbia River, the northwest Oregon coast, and the southwest Washington coast. NOAA is currently working with state and local partners to identify the issues CSI will address in this pilot region. Chemical contaminants, in additions to pesticides will be included in the database.

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Basic Search

This Basic Search will allow you to generate information about a contaminant within a specific study area. The Detailed Search will allow you to aggregate information based on specific categories.

Begin your search by choosing a category below (CAS Number, Molecular Formula, or Name of contaminant), and enter text to search for. If you are not sure of the full name, number, or formula, the search utility supports the query of partial characters (e.g. Enter '2' to find '2,4-D', '2-Undecanone', or '3,6-dichloro-2-methoxy-benzoic acid').

Search for Contaminants

Study Area: St. Johns River Water Management District, Florida

Search By: Choose a category *

- Choose a category
- CAS Number
- Molecular Formula
- Name of Contaminant

Search For: *

Detailed Search Search Help

Submit Search Clear Search

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Begin your search by choosing a category below (CAS Number, Molecular Formula, or Name of contaminant), and enter text to search for. If you are not sure of the full name, number, or formula, the search utility supports the query of partial characters (e.g. Enter '2' to find '2,4-D', '2-Undecanone', or '3,6-dichloro-2-methoxy-benzoic acid').

Search for Contaminants

Study Area:	St. Johns River Water Management District, Florida
Search By:	CAS Number *
Search For:	19 *

Detailed Search Search Help

Submit Search Clear Search

Search Results

Name: Atrazine
CAS No.: 1912-24-9
Formula: $C_8H_{14}ClN_5$
View more detail on this item

Name: 2,4-D 2-ethylhexyl ester
CAS No.: 1928-43-4
Formula: $C_{16}H_{22}Cl_2O_3$
View more detail on this item

Name: 2,4-D butoxyethyl ester
CAS No.: 1929-73-3
Formula: $C_{14}H_{18}Cl_2O_4$
View more detail on this item

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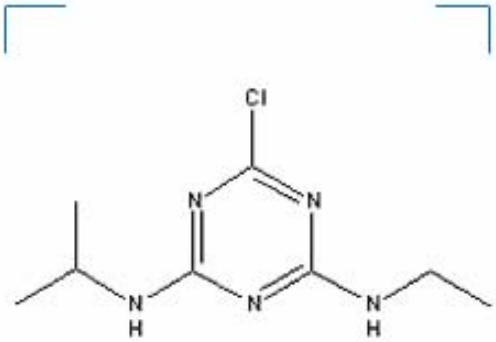
Contaminant Details

Atrazine

CAS Number: 1912-24-9



Synonym(s): Atrazine; Atrazine 4L; Atrazine 80W; Atrazine (Primatol); Atred; Atrex; Attrex; ATZ; Azinotox 500; Candex; Cekuzina-t; Chromozin; Crisamina; Crisatrina; Crisazine.

Formula: $C_8H_{14}ClN_5$

Molecular Weight: 215.6851

Boiling Point (°C): 200

Melting Point (°C): 175

Pronounciation: Ah-trah-zeen

Contaminant Type: Atrazine is an herbicide.

Additional Information: Atrazine is moderately to highly mobile in soils, especially where soils have low clay or organic matter content. Because it does not absorb strongly to soil particles and it has a lengthy soil half-life, it is expected to have a high potential for groundwater contamination, even though it is only moderately soluble in water. [m]

Solubility (in water)

- **Solubility**: 33 mg/l [g]
  Temperature (°C): 25

- **Solubility**: 28 mg/l [k]

Solubility (in water)

- **Solubility**: 33 mg/l [g]
  Temperature (°C): 25

- **Solubility**: 28 mg/l [k]
  Temperature (°C): 20

- **Solubility**: 33 mg/l [k]
  Temperature (°C): 27

Half-Life

- **$t_{1/2}$**: 30 days [dd]
  Environment: Estuarine conditions

- **$t_{1/2}$**: 60 days [l]

- **$t_{1/2}$**: 60-100+ days [m]

Toxicity Effects

- **Type**: Algae [e]
  Scientific Name: *Microcystis aeruginosa*
  Toxicity: 0.003 mg/l
  Test: 8d EC0

- **Type**: Algae [e]
  Scientific Name: *Chlorococcum spp.*
  Toxicity: 100 µg/l
  Test: 10d EC50
  Formulation (°C): Technical acid

Environmental Partition Coefficients

- K_{oc}: 45 - 63 [b]
- K_{oc}: Log 1.95 - 2.71 [k]
- K_{oc}: 100 ml/g [m]
- K_{oc}: 100 ml/g [l]
- K_{oc}: 45 - 63 [e]
- **Log K_{ow}**: 2.33 - 2.8 [k]

Resource Map: Click below to open in a new window to view or print.
Potential applications of this contaminant in the St. Johns Water River Management District

Bibliography

a Beyond Pesticides Fact Sheets. Washington, DC: Beyond Pesticides. (n.d). Retrieved November 2003, from http://www.beyondpesticides.org

b AQUIRE (AQUatic toxicity Information REtrieval) Database (As part of the ECOTOX Database) [Internet]. Washington, DC:United States Environmental Protection Agency. [date unknown] - [updated February 2003, cited June 2002]. Available from http://www.epa.gov/ecotox/

c EPR Professional 2002 CD

d ChemFinder. Cambridge MA: CambridgeSoft Corporation. Retrieved November, 2003, from http://chemfinder.cambridgesoft.com

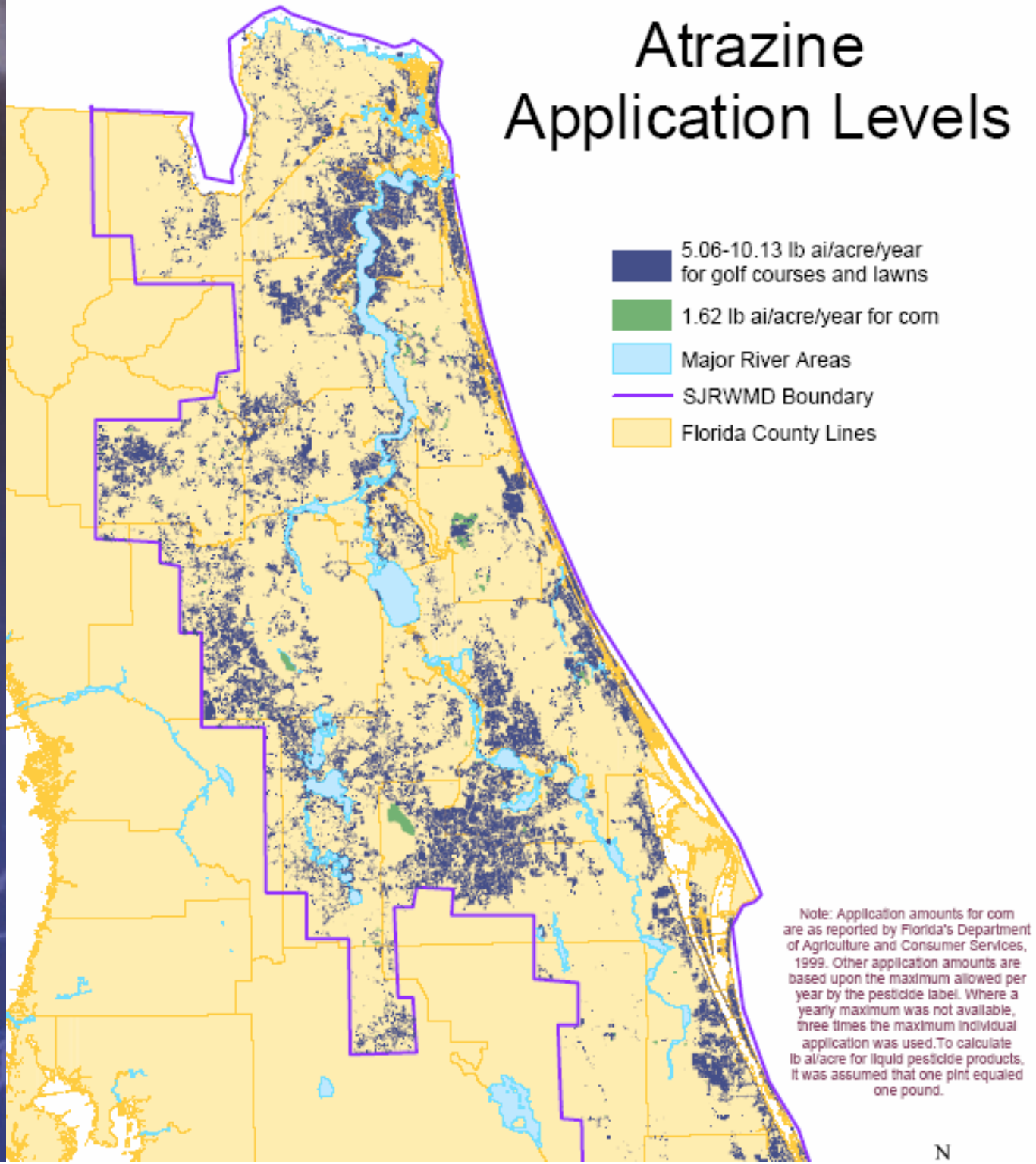
e Verschueren, K. (1996). Handbook of Environmental Data on Organic Chemicals (3rd ed.). New York: John Wiley & Sons, Inc.

f Howard, P.H., Boethling, R.S., Jarvis W.F., Meylan, W.M., & Michalenko, E.M. (1991). Handbook of Environmental Degradation Rates. Chelsea, MI: Lewis Publishers.

g Meister, R.T & Sine, C. (Eds.). (2003) Crop Protection Handbook (vol 86). Willoughby, OH: Meister Publishing Company

h Extension Toxicology Network. Corvallis, OR: Oregon State University. (n.d). Retrieved November, 2003, from http://ace.orst.edu/info/extoxnet/

Atrazine Application Levels



Note: Application amounts for corn are as reported by Florida's Department of Agriculture and Consumer Services, 1999. Other application amounts are based upon the maximum allowed per year by the pesticide label. Where a yearly maximum was not available, three times the maximum individual application was used.To calculate lb ai/acre for liquid pesticide products, it was assumed that one pint equaled one pound.

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Detailed Search

This utility will allow you to aggregate information based on three main categories. Choose one to begin your query:

- Agricultural Pesticide Use
- Toxicity Information
- Geographical Information

If you have a problem using this search utility, please look at our search help.

Search for Agricultural Pesticide Uses

Crops: Corn

Pesticide Type: All

Study Area: St. Johns River Water Management District, Florida

County: All

All
Alachua
Baker
Brevard
Clay
Duval
Flagler
Indian River
Lake
Marion
Nassau

Search Reset

Basic Search Search Help

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Detailed Search

Your search for the relation between a crop: '**Corn**', a pesticide type: '**All**' and County: '**Alachua**' returned 22 records on 3 pages. You are currently viewing page 1, which has 10 records.

County	Crop	Pesticide	Application *
Alachua	Corn	2,4-D	4672 lbs ai/y [cc]
Alachua	Corn	Alachlor	10585 lbs ai/y [cc]
Alachua	Corn	Atrazine	11826 lbs ai/y [cc]
Alachua	Corn	Dicamba	3650 lbs ai/y [cc]
Alachua	Corn	Metolachlor	10220 lbs ai/y [cc]
Alachua	Corn	Pendimethalin	5475 lbs ai/y [cc]
Alachua	Corn	Trifluralin	4599 lbs ai/y [cc]
Alachua	Corn	Carbaryl	29200 lbs ai/y [cc]
Alachua	Corn	Carbofuran	7300 lbs ai/y [cc]
Alachua	Corn	Chlorpyrifos	14600 lbs ai/y [cc]

1 2 3

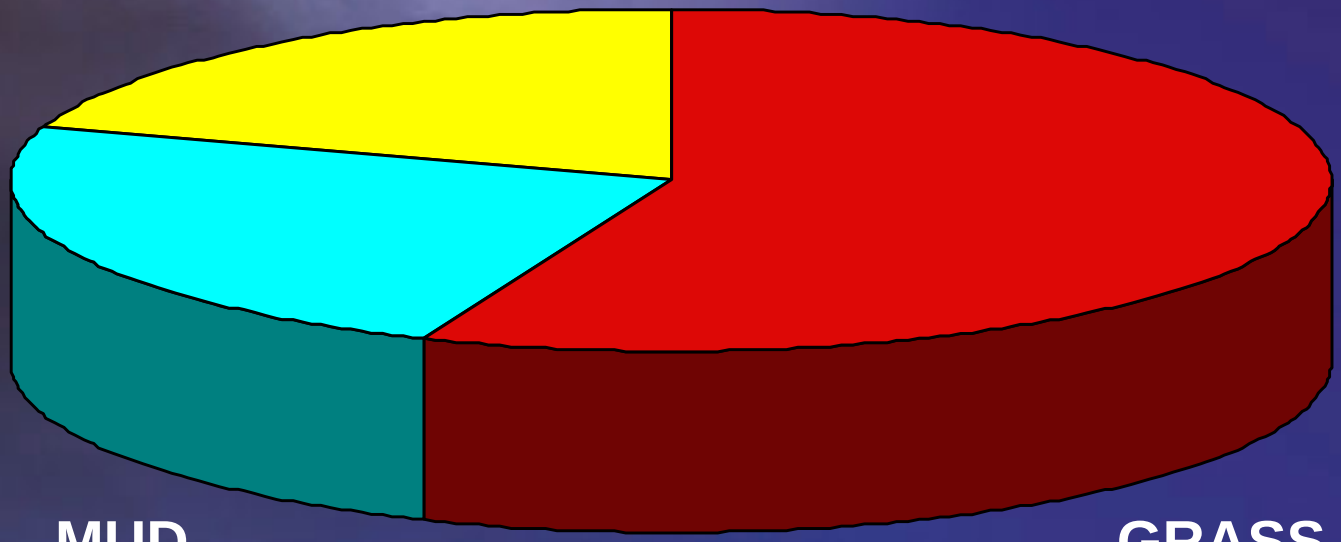
* Letters in red superscript indicate the source of the information for that record. View entire bibliography.

Larval Grass Shrimp Toxicity Testing

- Grass shrimp – common East Coast estuarine invertebrate.
- Larval stage most sensitive to pesticides.
- Pesticides tested singly and in mixture: Atrazine (ATZ), Fipronil (FIP), Imidacloprid (IMD)
- 96 hour LC50 tests with media changed every 24 hours.

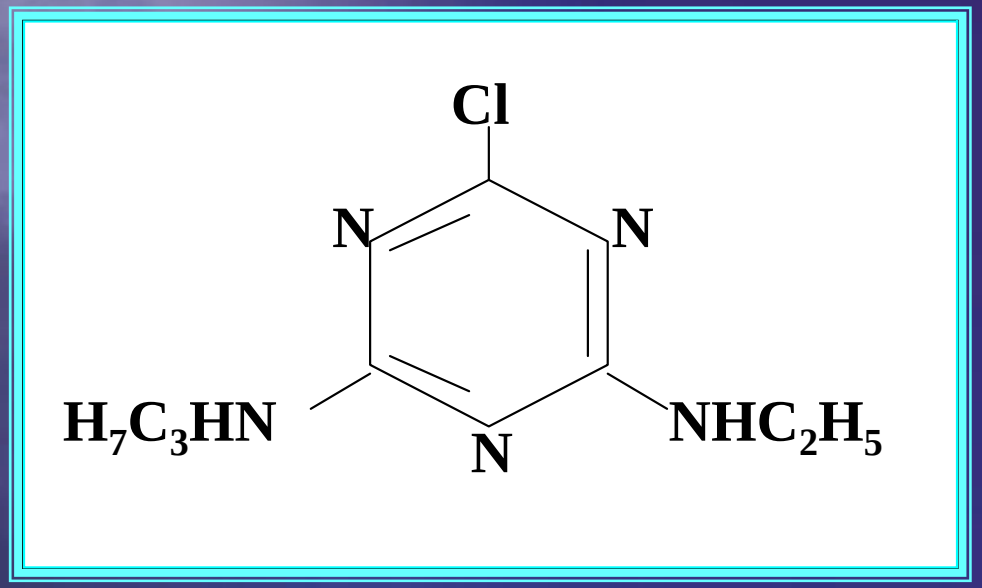
Grass Shrimp

- ***Palaemonetes pugio***
- **Common inhabitant of salt marshes along the Atlantic and Gulf Coasts.**
- **Important prey item for economically important fish and crustaceans.**
- **Used at CCEHBR as a model crustacean for toxicity assessments with contaminants in acute and chronic tests in aqueous and sediment exposures.**



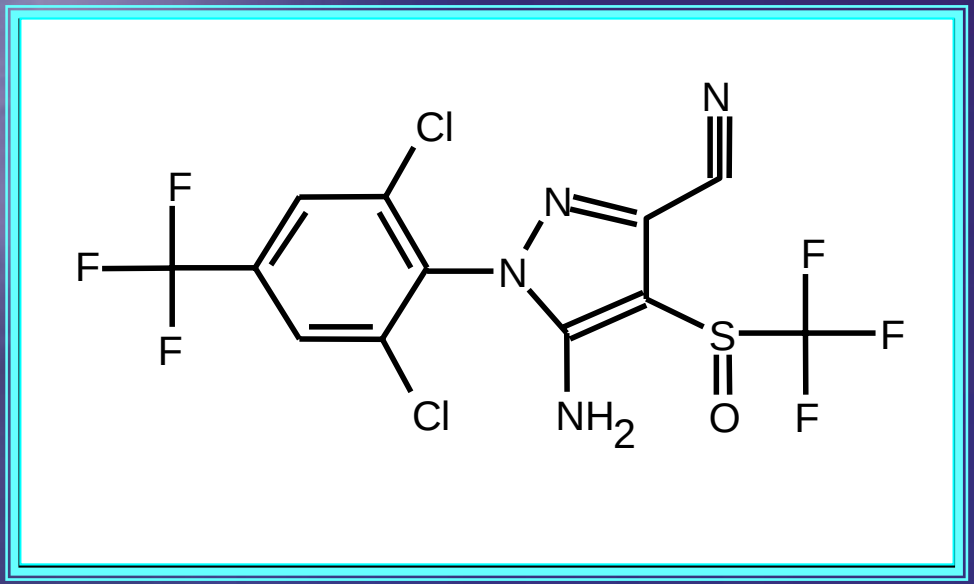
Dominant macrofauna in Southeastern estuarine creeks.

Atrazine



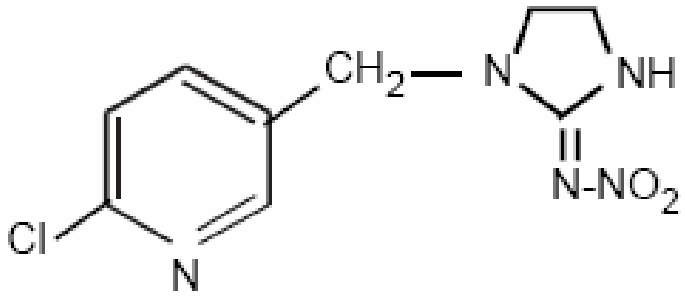
- Herbicide
- Second most widely used herbicide in U.S.
  - 34,000 to 36,000 metric tons AI/yr (2001)
  - Agriculture, turf grass and residential

Fipronil



- Insecticide
- Eight hundred metric tons produced for worldwide use in 2000.
- Active ingredient for control of termites, fire ants, fleas, ticks, agricultural pests.
- EPA lists it as a chemical alternative to chlorpyrifos.
- Widely marketed in Southeastern US for fire ant control (e.g., Over ‘n Out)
- Reports of non-target aquatic animal kills

Imidacloprid



- Insecticide
- Used on soil, seed and foliage to control turf and agricultural pests. Also controls termites and fleas.
- EPA lists it as a chemical alternative to chlorpyrifos.
- Like Fipronil, growing use.

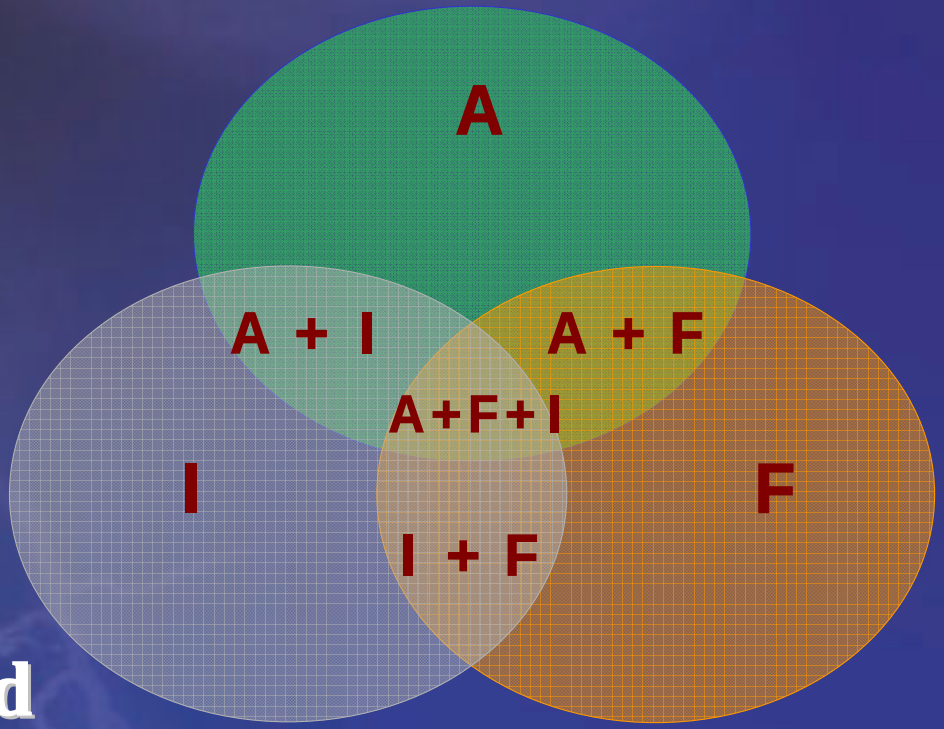
Methods

Test Organism

- Grass shrimp collected from Leadenwah Creek, SC.
- Acclimated in 75-L tanks at 25°C, 20 ppt salinity and 16-h light:8-h dark cycle.
- Fed Tetramin Fish Flakes and Artemia.
- Larvae pooled from at least 10 females.
- Newly hatched larvae exposed.

Experimental Design

Atrazine



Imidacloprid

Fipronil

Results

Individual Tests

PESTICIDE	LARVAE 96-h LC50 (95% CI) µg/L	ADULT 96-h LC50 (95% CI) µg/L
Atrazine	**>10,000**	**ND**
Fipronil	**0.68 (0.57 – 0.80)**	**0.32 (0.24 – 0.41)**
Imidacloprid	**308.8 (273.6 – 348.6)**	**563.5 (478.1 – 664.2)**

Results

Mixture Tests

Contaminants	96-h LC50 (95% CI) µg/L	
	Mixture	Individual
Imidacloprid + Atrazine	**287.6 (241.8 – 341.9)**	**308.8 (273.6 – 348.6)**
Fipronil + Atrazine	**0.59 (0.43 – 0.81)**	**0.68 (0.57 – 0.80)**

Results

Mixture Tests

Contaminants	Index Range	Mixture Toxicity	Magnification Factor
Fipronil + Imidacloprid	**-0.205…-0.081…0.08**	**Additive**	**ND**
Fipronil + Imidacloprid + Atrazine	**0.326…0.208…0.082**	**Greater than Additive (Synergism)**	**1.21X**

Conclusions

- **Individual Tests**
  - **Fipronil most toxic to grass shrimp larvae with LC50 of 0.68 ug/L**
  - **Imidacloprid LC50 of 309 ug/L**
  - **Atrazine non-toxic at environmentally relevant concentrations.**
  - **Fipronil and Imidacloprid are additive**
  - **Fipronil, Imidacloprid and Atrazine are synergistic**

Transport and Fate Modeling

- Identify Locations of Concern
  - Florida - Atrazine, Fipronil and Imidacloprid
- PRZM-3 (Pesticide Root Zone Model)
  - Groundwater Hydrology and Chemical Transport
  - Effects of Rain, Application, Transpiration, etc.
- EXAMS-II (Exposure Analysis Modeling System)
  - Surface Water Effects of Sorption, Biodegradation, Photolysis, etc.
  - Uses Output of PRZM
  - Predicted Concentrations Compared to Aquatic Animal and Human Health Levels of Concern.

Pesticide Root Zone Model (PRZM)

- Used by EPA and others to estimate groundwater contamination
- Shallow groundwater is major source of surface water contamination after rainfall
- Provides input to surface water model (EXAMS) to better estimate risks to aquatic organisms
- Available free to anyone

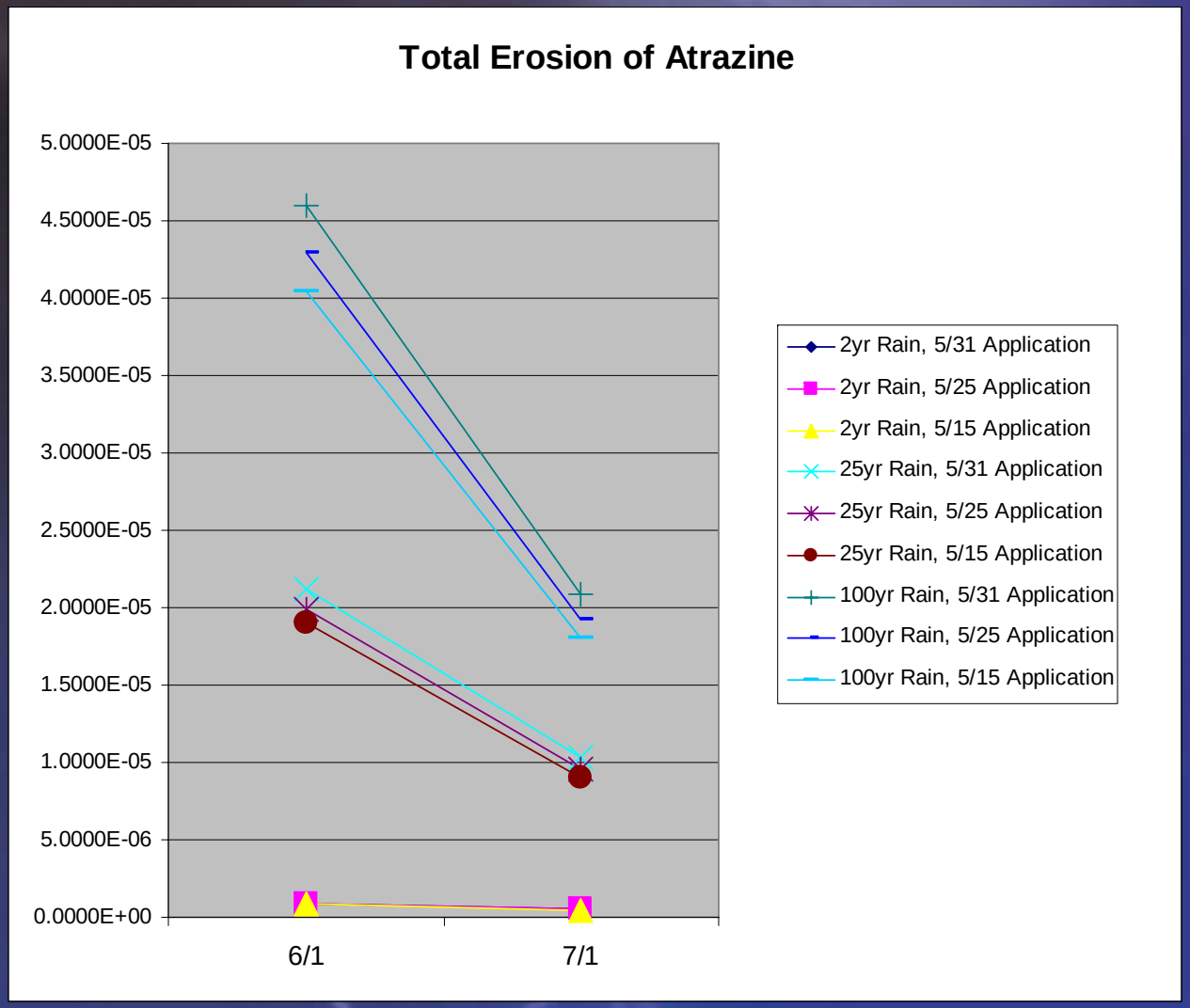
PRZM Methods

- 3 pesticides identified by preliminary risk assessment (EASIMR)
- Published chemical parameters
- Florida meteorological data
  - Rainfall on June 1, July 1
  - 2-Yr, 25-Yr and 100-Yr storms

PRZM Methods

- Pesticides applied at maximum allowed rate
  - Atrazine 142 times Fipronil
  - Atrazine 4 times Imidacloprid
  - Imidacloprid 32 times Fipronil
- Pesticides applied 1, 6 or 16 days before storms
- Lake Bethel, Florida environment
  - Estuarine headwaters are most susceptible
  - Typical of Southeastern US changing adjacent land uses

Soil Erosion of Atrazine

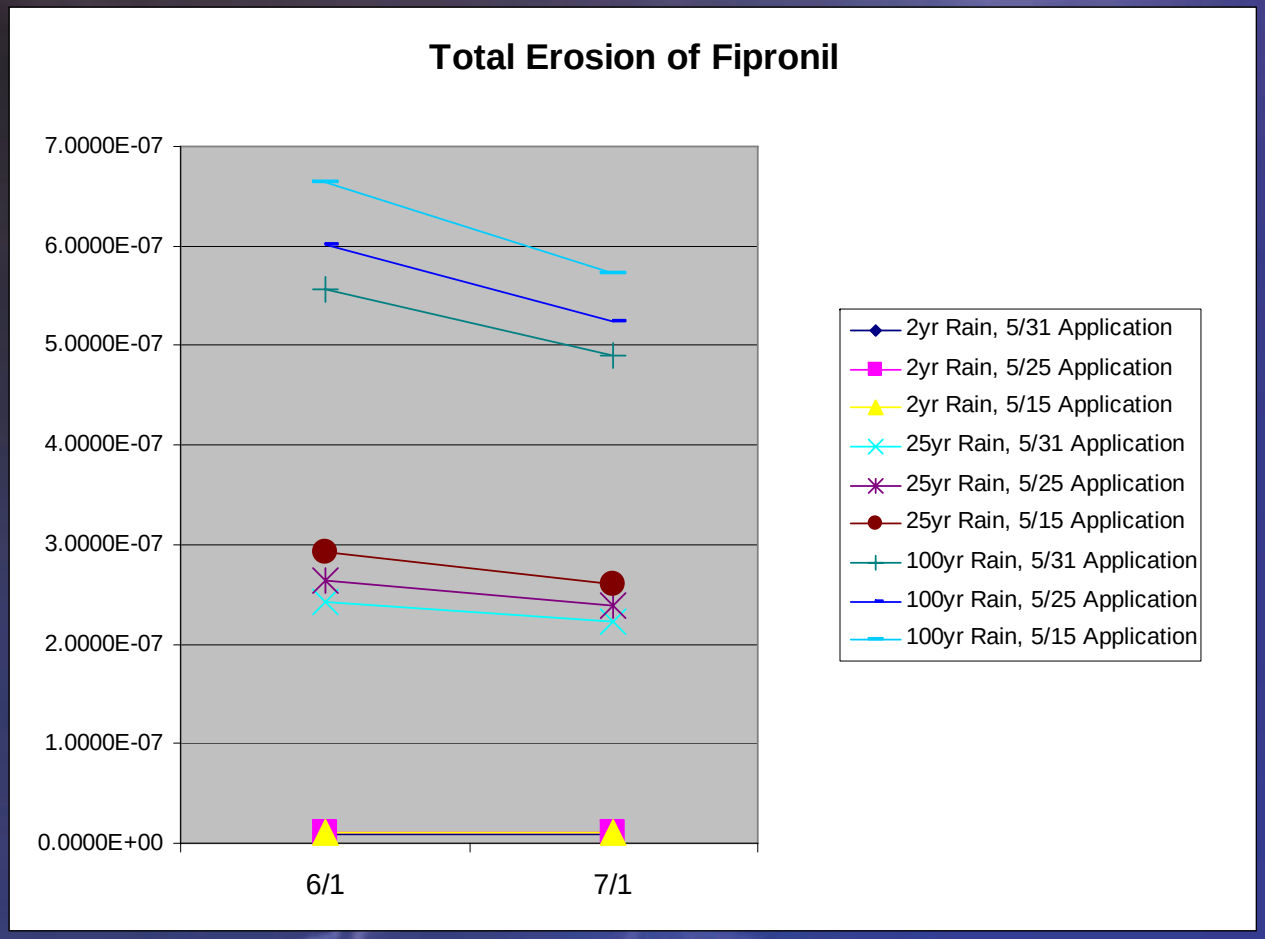


- **Highest of the 3 pesticides**
- **Storms:**

  100-Yr > 25-Yr > 2-Yr
- **Application:**

  1-D > 6-D > 16-D
- **First storm > second for 25-Yr and 100-Yr**

Soil Erosion of Fipronil



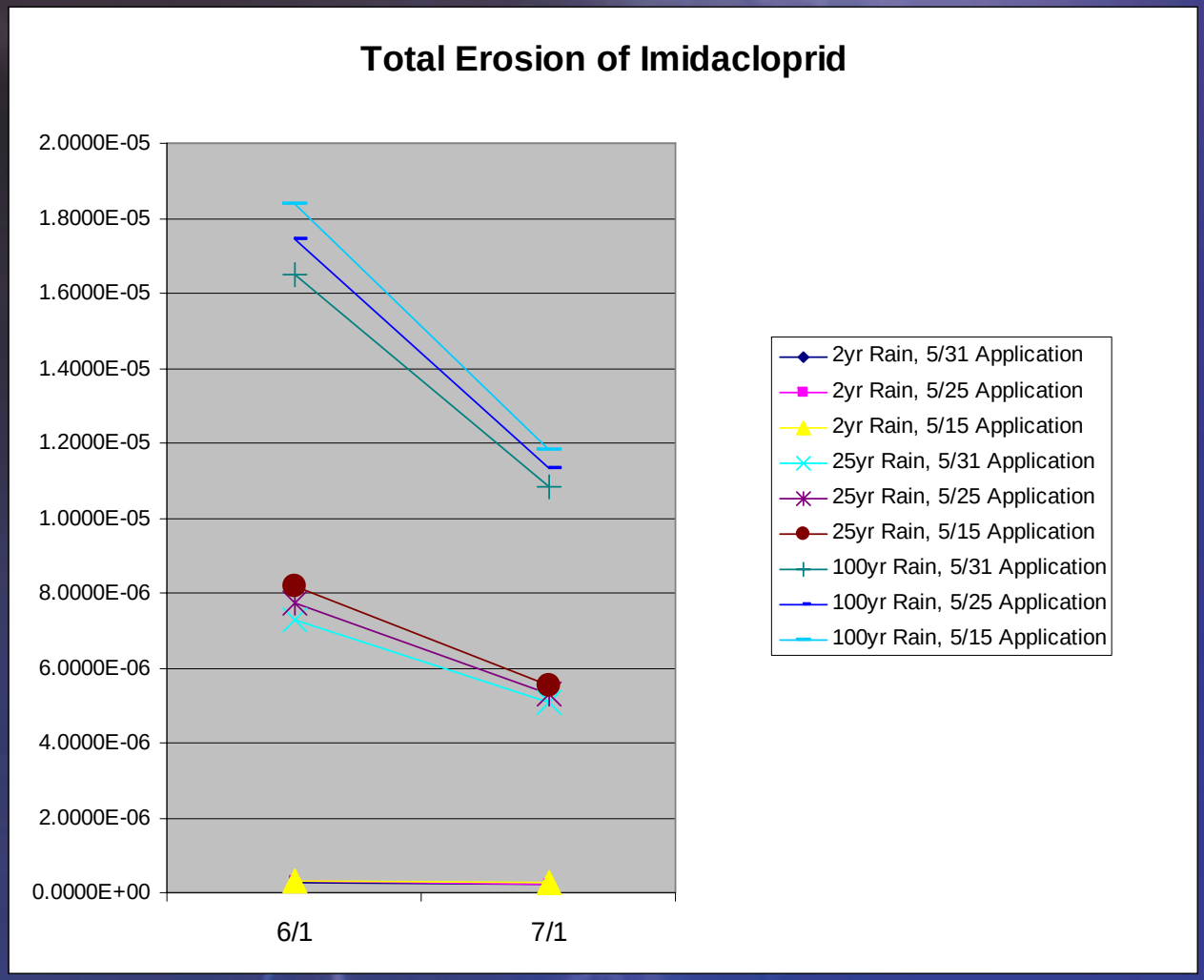
- Much lower than Atrazine or Imidacloprid
- Storms:

  100-Yr > 25-Yr > 2-Yr
- Application:

  16-D > 6-D > 1-D

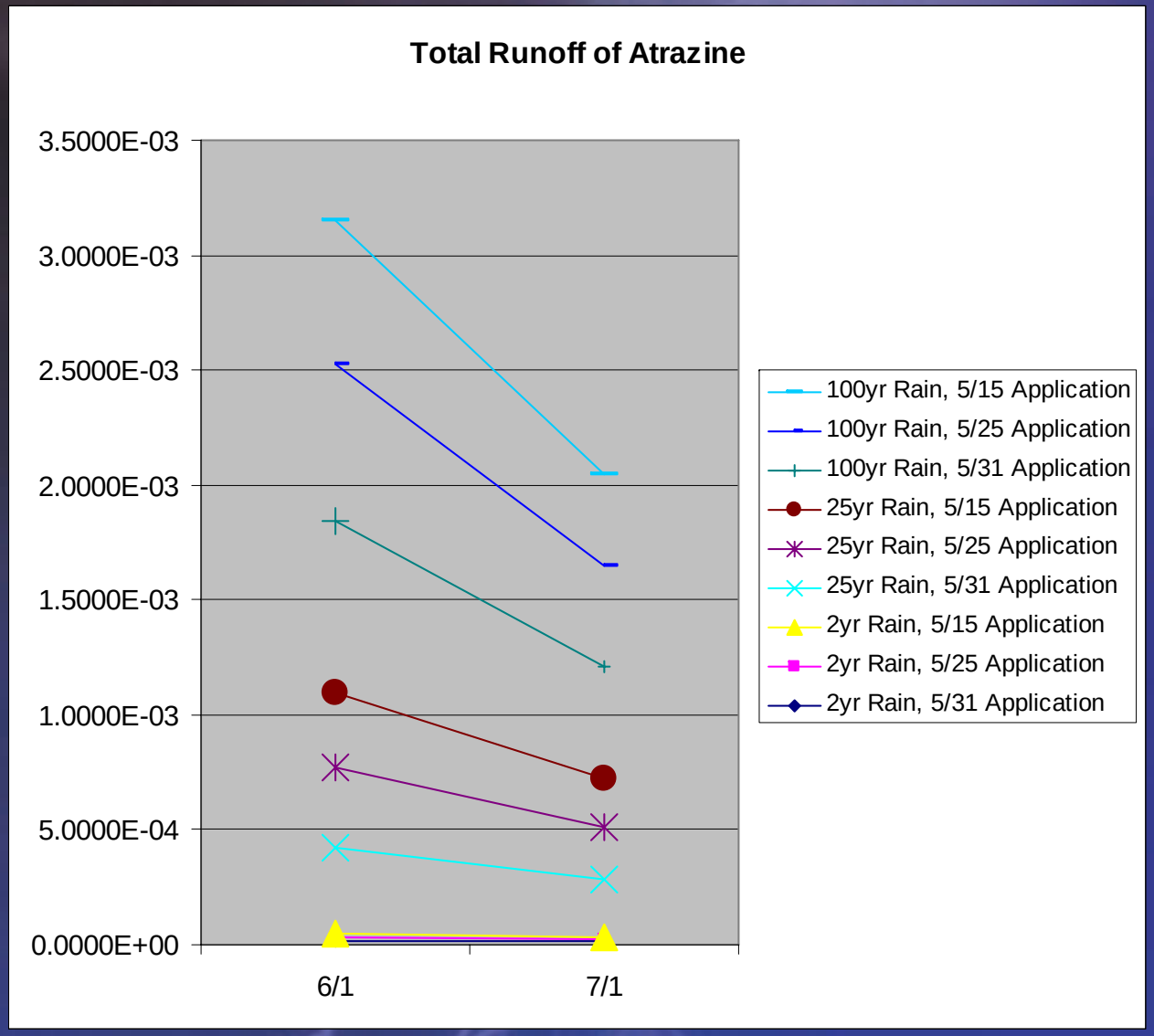
  Different than Atrazine
- First storm > second for 100-Yr

Soil Erosion of Imidacloprid



- **Storms:**
  100-Yr > 25-Yr > 2-Yr
- **Application:**
  16-D > 6-D > 1-D
  Like Fipronil
- **First storm > second for 100-Yr and 25-Yr**

Runoff of Atrazine

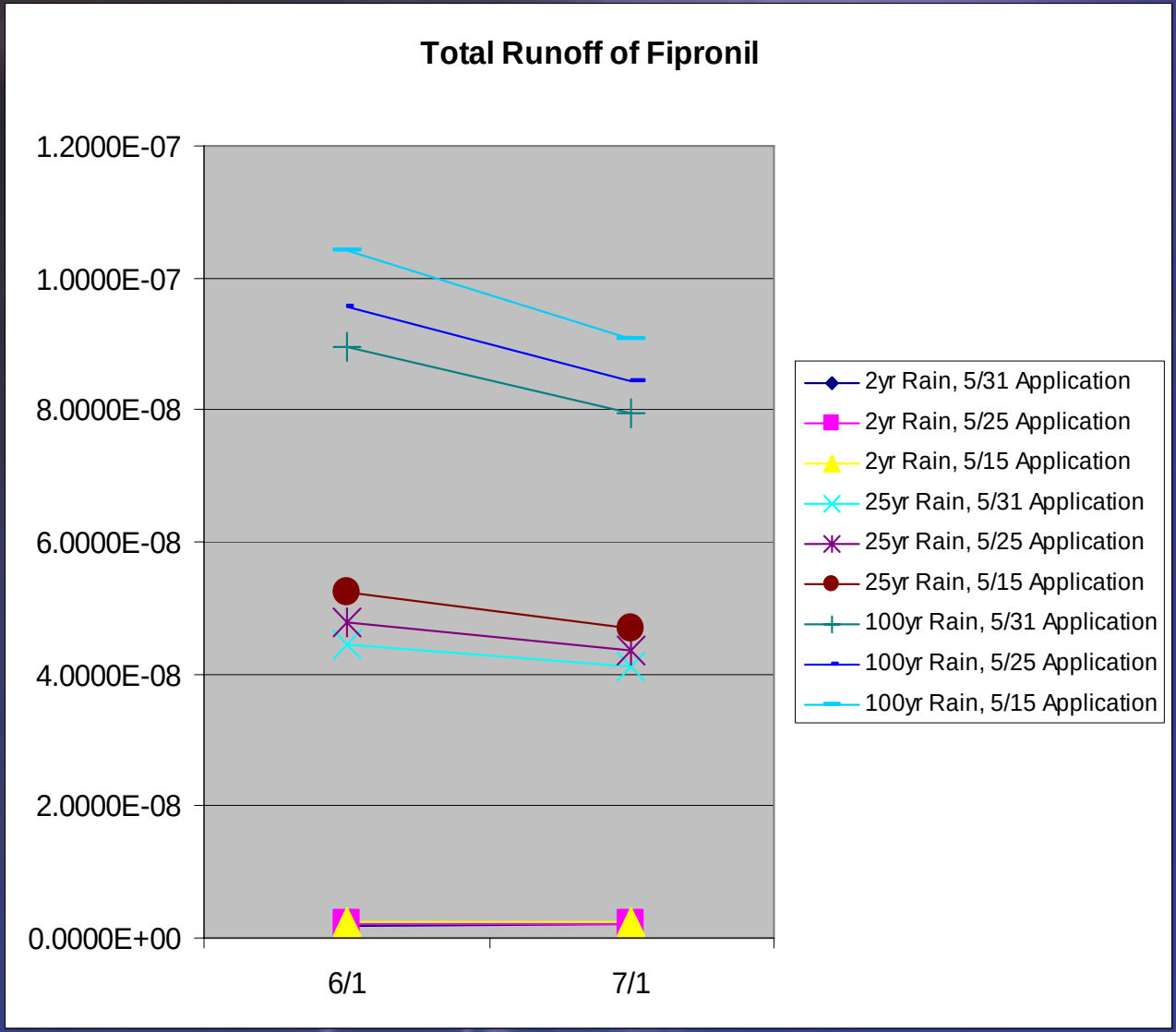


- **Highest of the 3 pesticides**
- **Storms:**

  100-Yr > 25-Yr > 2-Yr
- **Application:**

  16-D > 6-D > 1-D
- **First storm > second for 25-Yr and 100-Yr**

Runoff of Fipronil

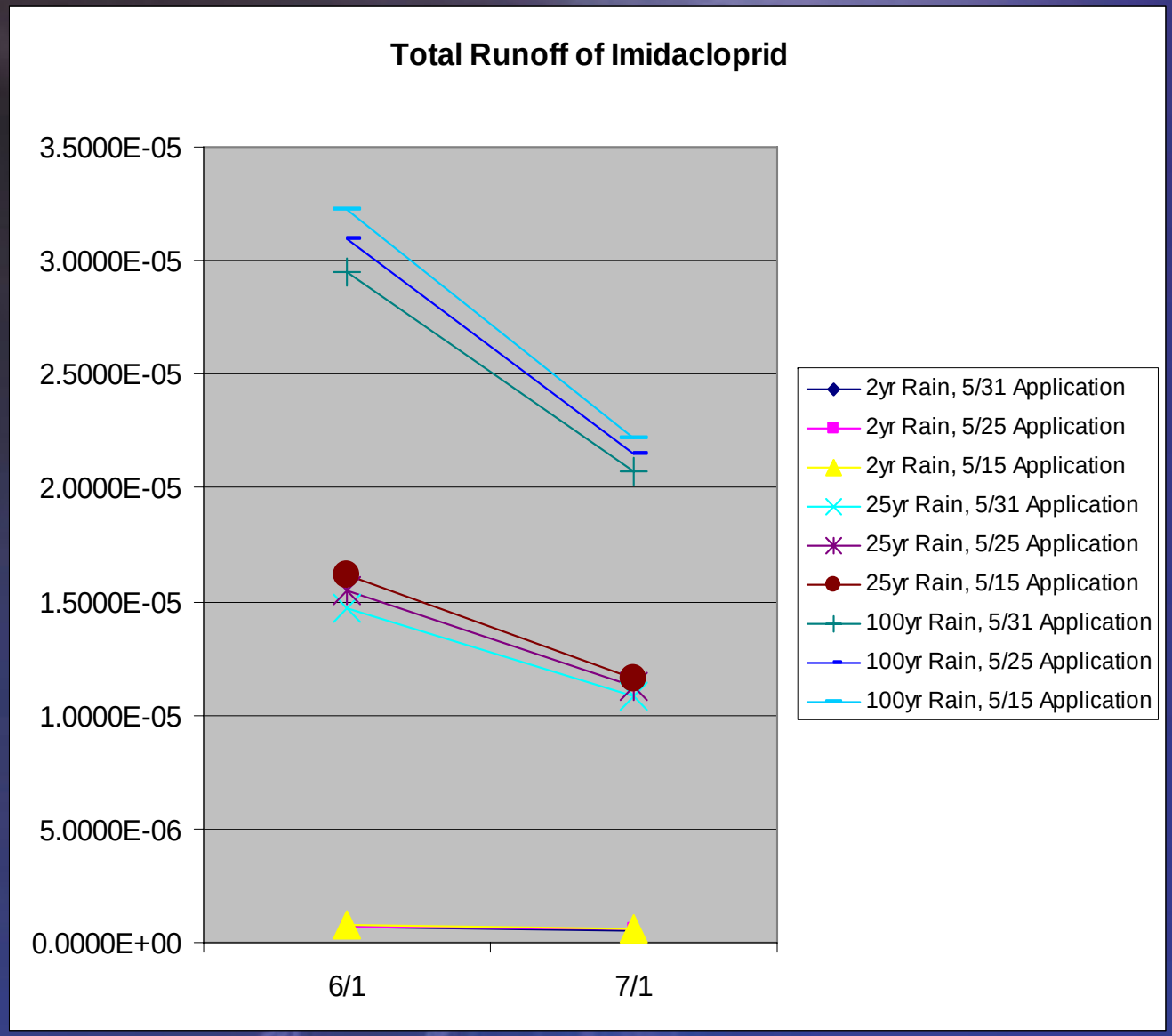


- Lowest of the 3 pesticides
- Storms:

  100-Yr > 25-Yr > 2-Yr
- Application:

  16-D > 6-D > 1-D
- First storm > second for 25-Yr and 100-Yr

Runoff of Imidacloprid



- **Storms:**

  100-Yr > 25-Yr > 2-Yr

- **Application:**

  16-D > 6-D > 1-D

- **First storm > second for 25-Yr and 100-Yr**

PRZM Summary

- Many other results
- Provides input to transport, fate and exposure model (EXAMS)
- Shallow groundwater loading:
  - Atrazine >> Imidacloprid > Fipronil
- Storm and application date dependent

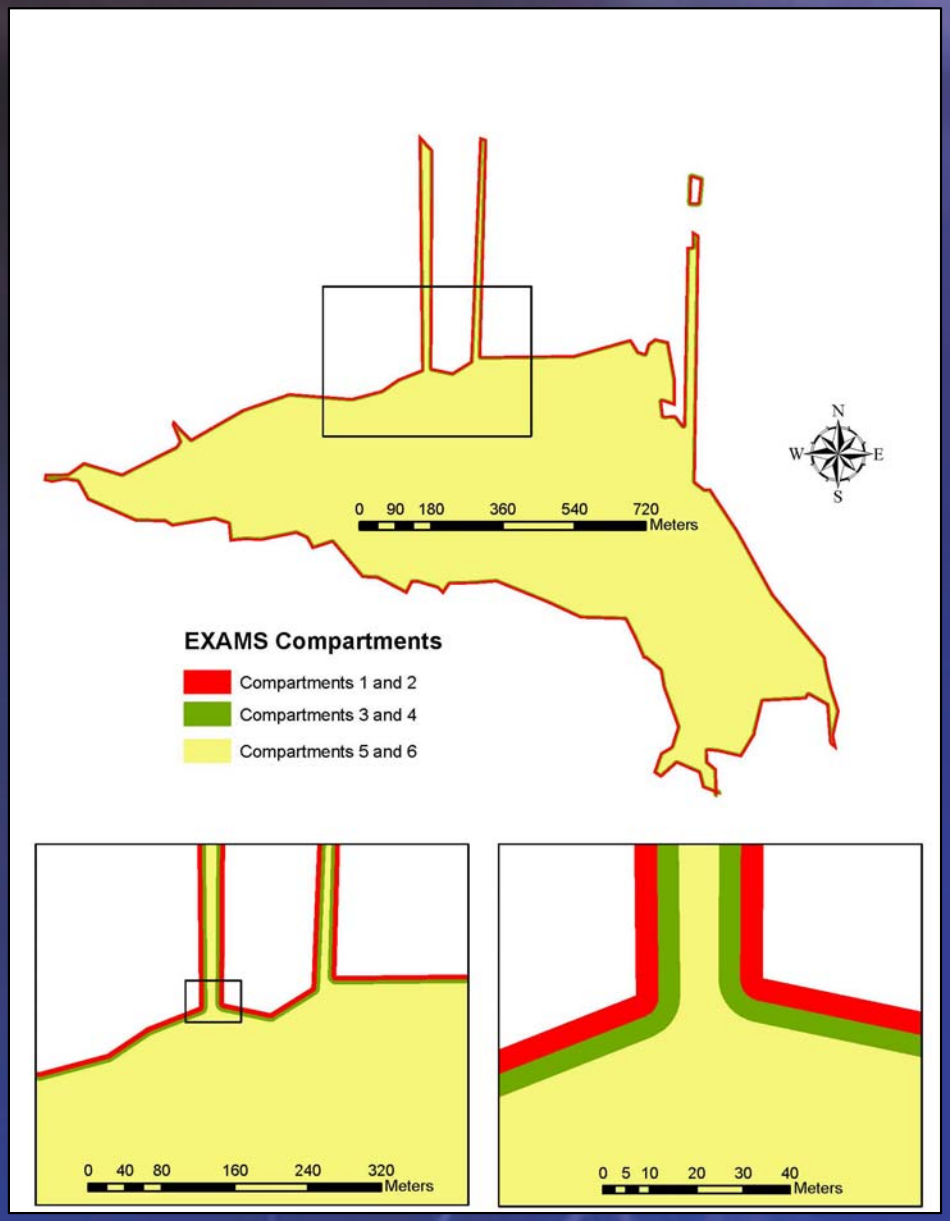
Exposure Analysis Modeling System (EXAMS)

- Used by EPA and others to estimate surface water contamination, transport and fate
- Estimates exposure and risk to aquatic fauna
- Available free to anyone

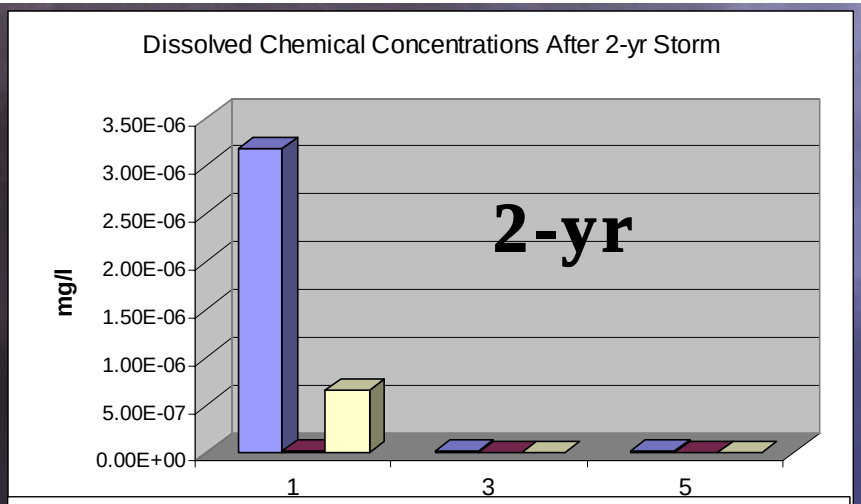
EXAMS Methods

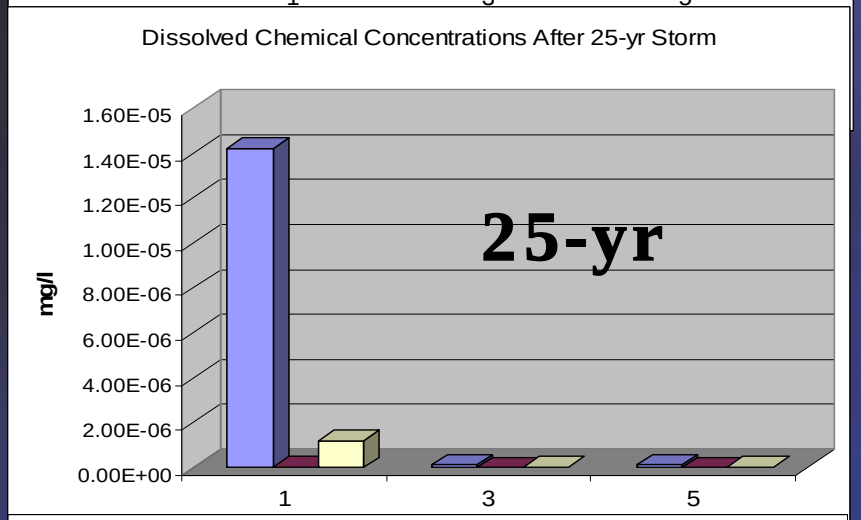
- Same three pesticides used in PRZM
- Three pesticides identified by preliminary risk assessment (EASIMR)
- Used PRZM loadings and other inputs
- Published chemical parameters
- Jacksonville, Florida meteorological data
- Lake Bethel, Florida environment

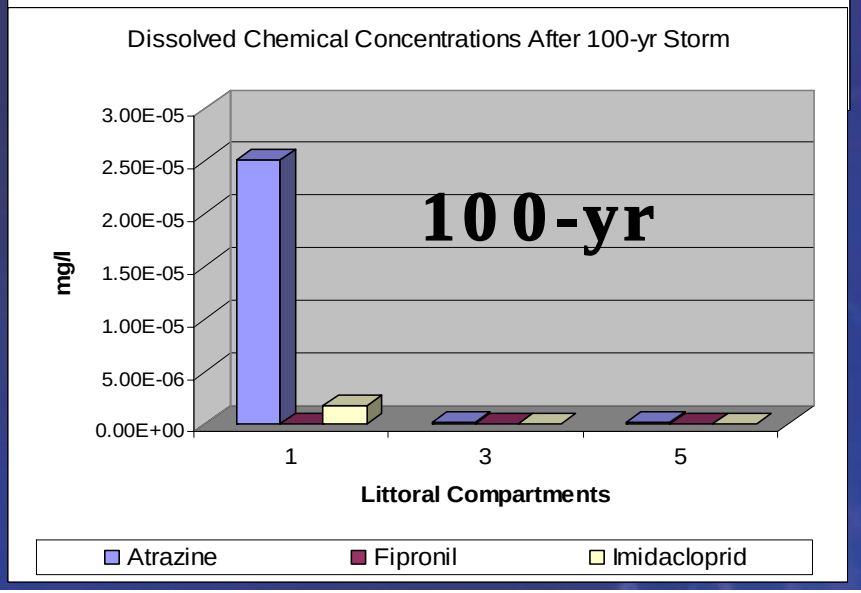
Lake Bethel EXAMS Compartments *(Conceptual)*



- Odd numbers are littoral
- Even numbers are benthic
- 1 and 2 are closest to shoreline
- 3 and 4 are next
- 5 and 6 are main lake body







Dissolved Chemical Concentrations in Littoral Compartments

Storms:

100-Yr > 25-Yr > 2-Yr

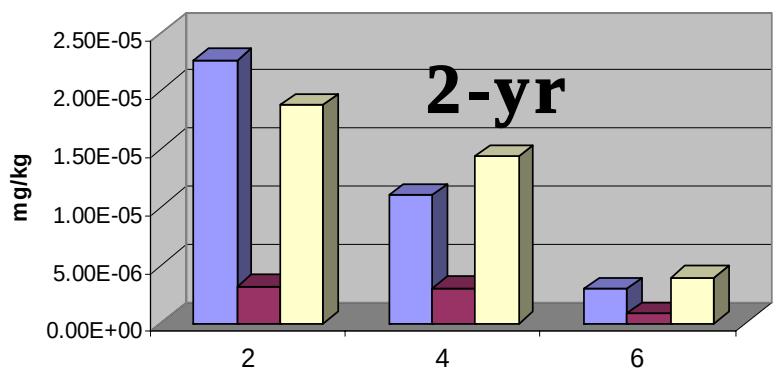
Compartments:

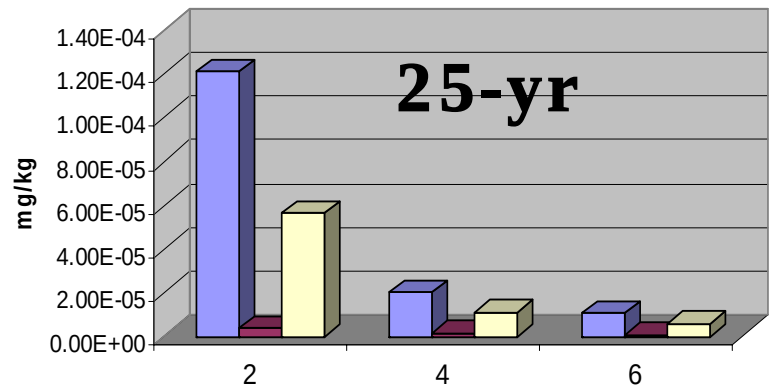
1 >> 3 > 5

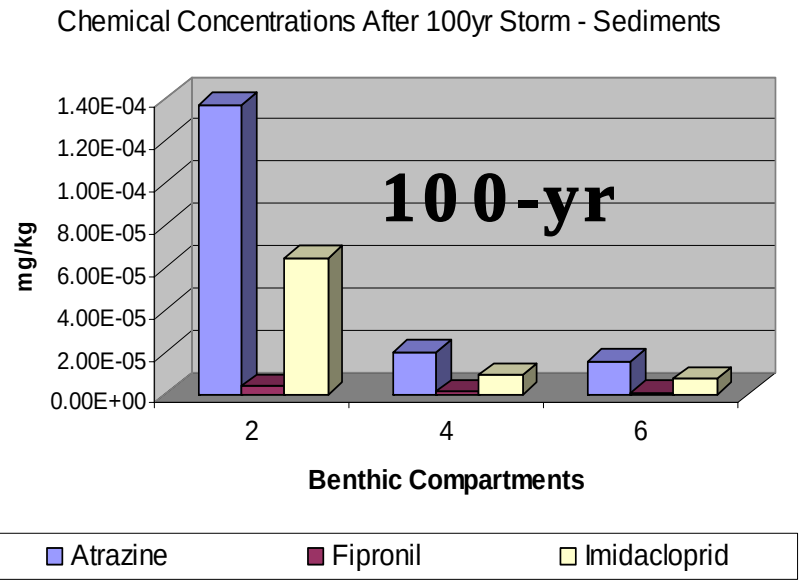
Pesticides (concentration not toxicity):

Atrazine >> Imidacloprid > Fipronil

- Note different Scales







Pesticide Concentrations in Benthic Sediment

Storms:

100-Yr > 25-Yr > 2-Yr

Compartments:

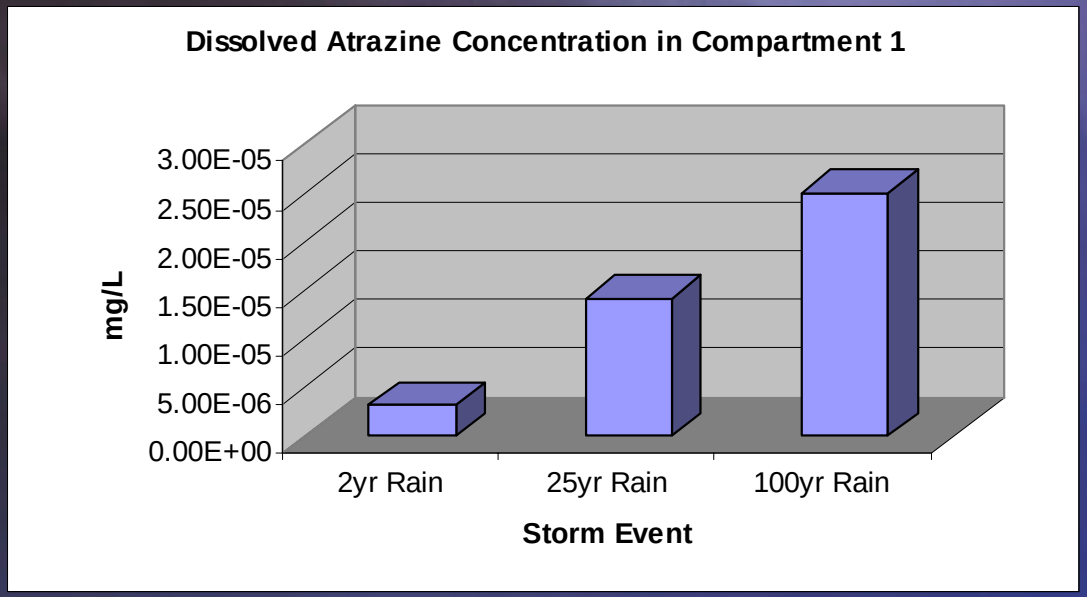
2 > 4 > 6

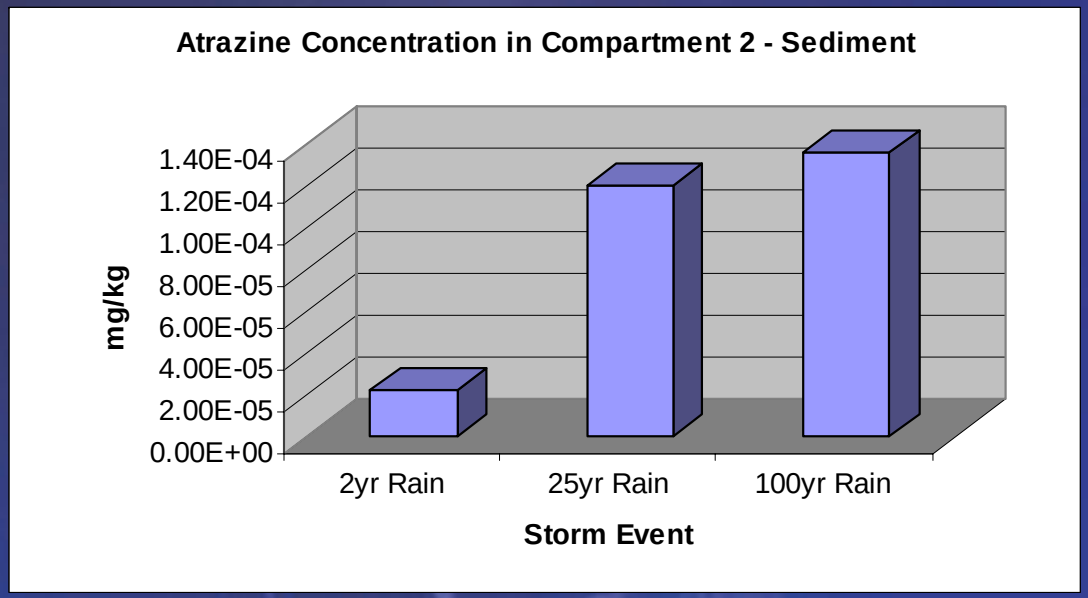
Pesticides (concentration not toxicity):

Atrazine > Imidacloprid > Fipronil

- **Note different Scales**

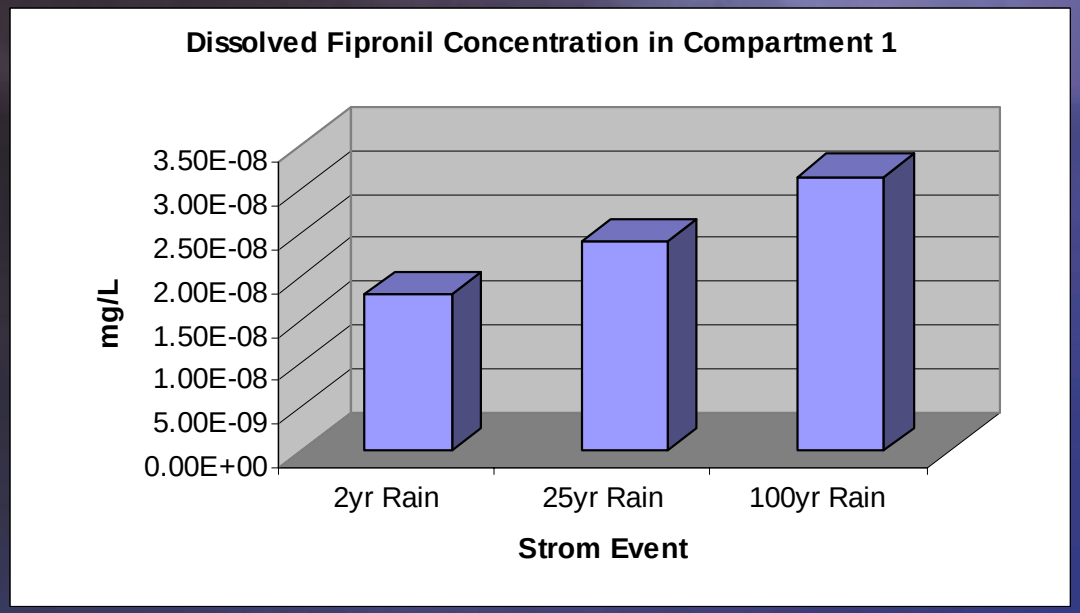
Atrazine Near Shoreline

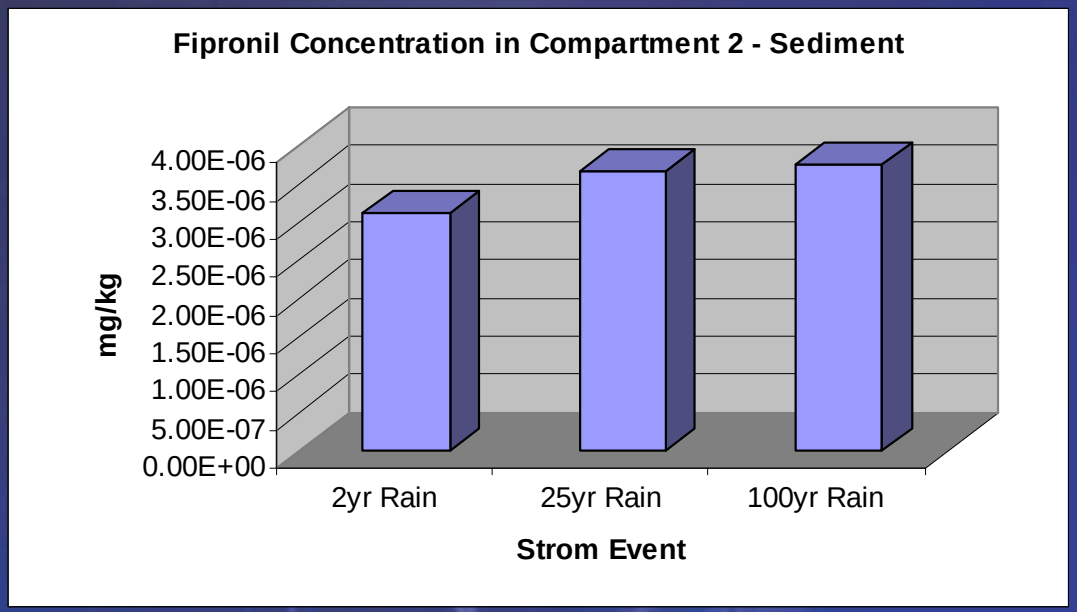




- Different Storm types
- Much higher than main lake
- Did not model feeder creeks, etc
- Increased exposure to both pelagic and benthic fauna

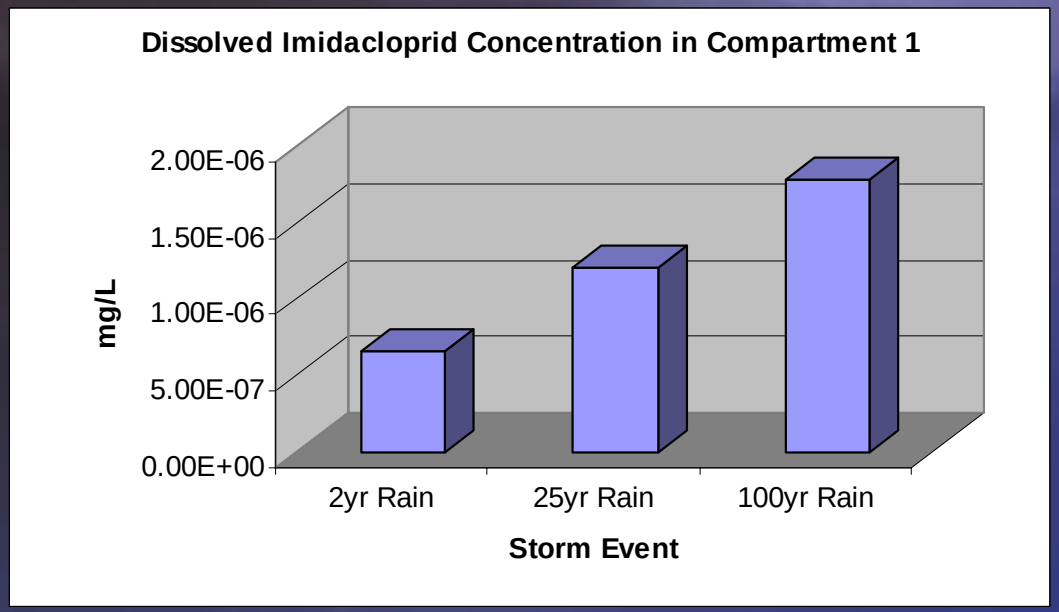
Fipronil Near Shoreline

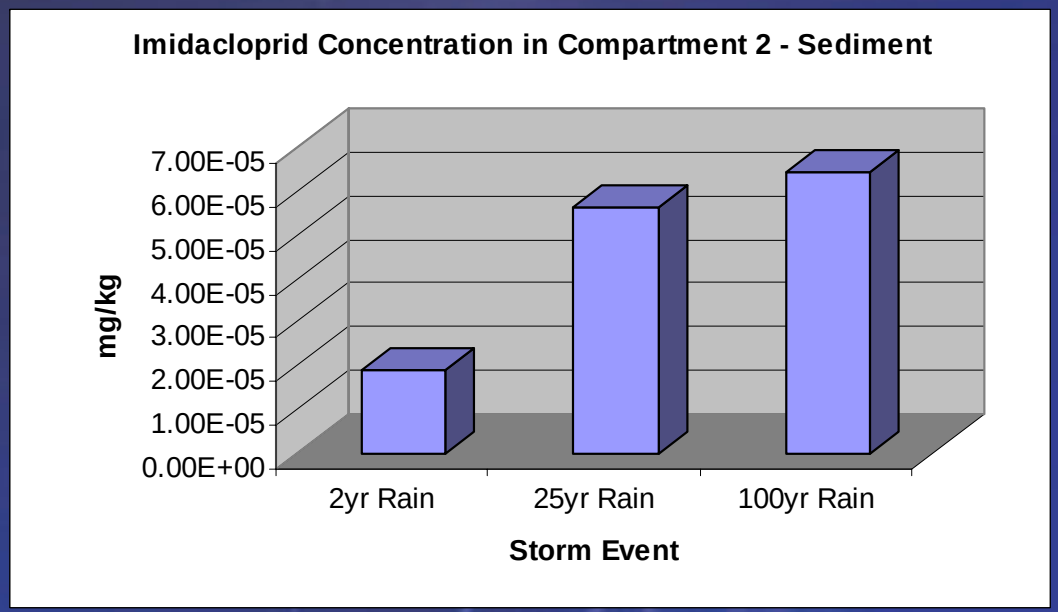




- Different Storm types
  - Not as much effect
- Much higher than main lake
- Did not model feeder creeks, etc
- Increased exposure to both pelagic and benthic fauna

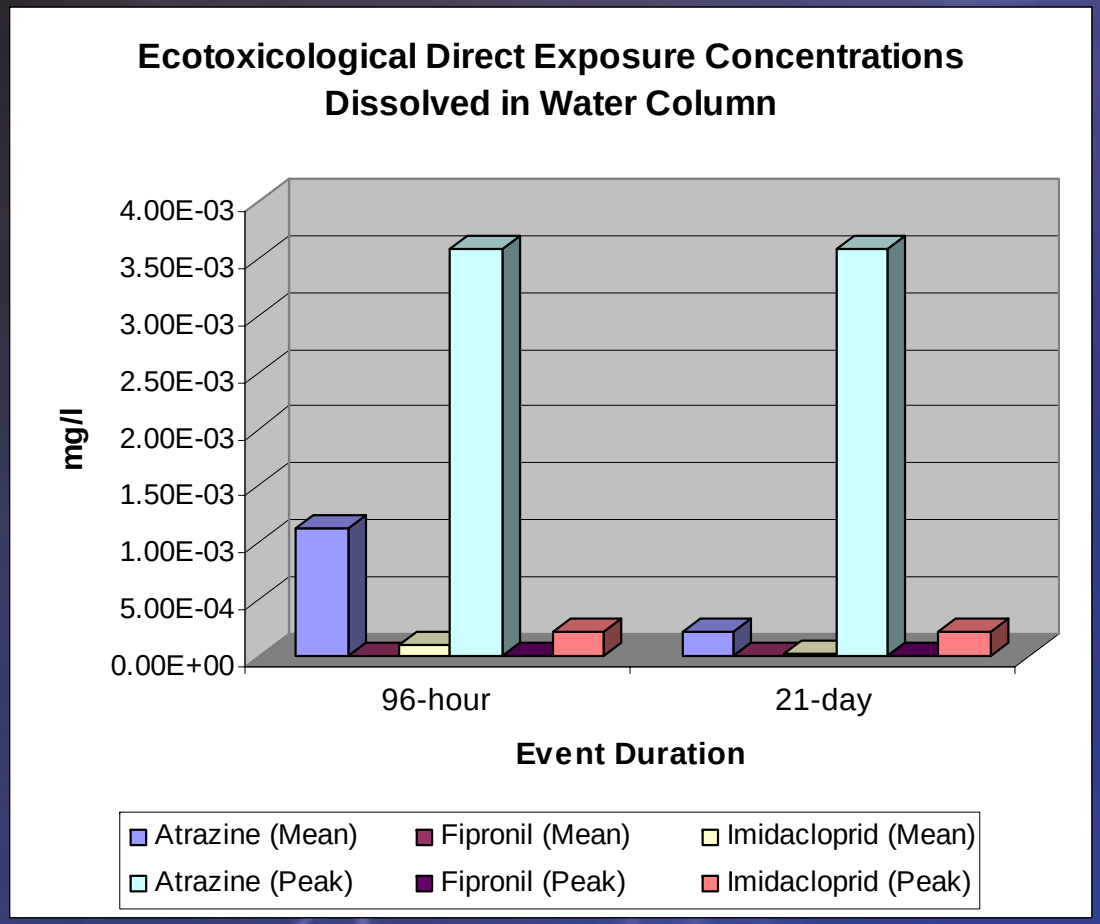
Imidacloprid Near Shoreline





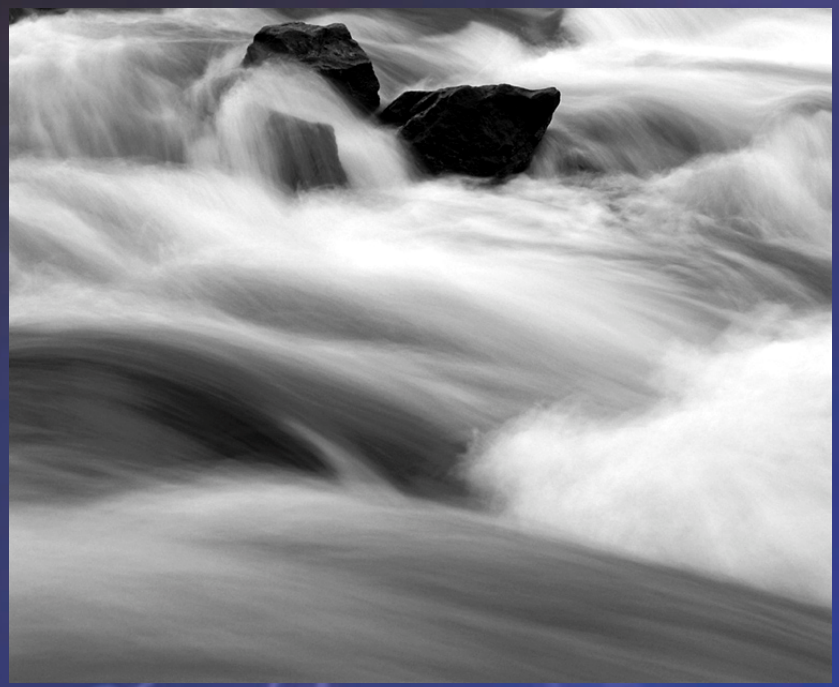
- Different Storm types
- Much higher than main lake
- Did not model feeder creeks, etc
- Increased exposure to both pelagic and benthic fauna

Pesticide Concentrations: Mean vs. Peak



- 100-Yr Storm
- Short term peaks much higher than average
- High transient exposure

EXAMS Summary



- Shows vulnerability of areas nearest runoff
- Can be used to identify other areas of concern
- Compares effects of storm types
- Compares chemical contaminants
- Can be used to estimate risk without being there

Assessing Risk

It's Not Simple!

Application	*A > I > F*
Exposure	*A > I > F*
Toxicity	*F > I >> A*

Overall Summary

- EASIMR
  - Web-accessible risk assessment database
  - Risk based upon landuses
  - Useful for preliminary risk estimation

- Toxicity testing
  - Estimates of toxicity of three pesticides
  - Heavily used pesticides in Southeastern US
  - Fipronil > Imidacloprid > Atrazine
  - Mixtures even more toxic
    - Mixtures rarely studied

Overall Summary

- PRZM Model
  - Estimates shallow groundwater and runoff contamination
  - Identifies effects of storm types, application date
  - Compares pesticides
  - Provides NPS inputs to exposure model

- EXAMS Model
  - Estimates surface water and sediment concentrations
  - Used to identify sensitive areas/habitats
  - Effects of storms types, application date
  - Compares pesticides, other contaminants
    - Exposure: Atrazine > Imidacloprid > Fipronil

Uses

- Easy preliminary risk assessments based upon land use data
- Identify species at risk
- Identify geographic locations at risk
- Focus post-storm ecological assessments
- Assist mitigation planning
- Provide access to available risk information
- Promote responsible pesticide use