



**Division of Nuclear Safety  
Bureau of Environmental Safety**



**2009 – Report on Environmental  
Monitoring for Nuclear Generating  
Stations**

November 2010



## **Executive Summary**

The Illinois Emergency Management Agency, Division of Nuclear Safety is charged with protecting the citizens of Illinois from the harmful effects of radioactive materials. To that end, the Division of Nuclear Safety monitors the environment around Illinois seven nuclear power stations for the presence of radionuclides. Samples of water, sediment, fish, milk and vegetables are collected from 132 locations analyzed for man-made and natural radionuclides. In addition, the Agency maintains a network 415 environmental dosimeters to measure and document the ambient gamma radiation levels within a ten-mile radius of each plant.

In 2009, 587 samples were collected and analyzed. The only radionuclide detected that can be attributed to nuclear power plant operations was tritium, which was detected in several water samples. Tritium is a normal part of the effluent stream of nuclear power stations and the concentrations detected met all regulatory standards. Of the drinking water supplies sampled, tritium was detected in only one, Wilmington, but at a concentration of 1% of the US Environmental Protection Agency's limit for drinking water. Historically, tritium has been detected at this location at concentrations of up to 20% of the limit.

In 2009, special attention was paid to the ground water in the immediate vicinity of the Braidwood nuclear power station as Exelon continued its efforts to remediate the tritium plume found there. Analysis of samples collected from the area of the plume suggests that mitigation efforts have generally been successful. No tritium has been detected in any of the private wells sampled.

Environmental dosimetry measurements at all stations were consistent with established background readings.

## **IEMA Environmental Monitoring Program**

Illinois is home to seven commercial nuclear power stations – more than any other state in the U.S. Although direct regulatory authority over all U.S. nuclear power stations rests with the US Nuclear Regulatory Commission (USNRC), the Illinois Emergency Management Agency (IEMA) has been charged with protecting the citizens of Illinois from unnecessary exposure to ionizing radiation in the environment. To this end, the IEMA Division of Nuclear Safety (DNS) maintains a monitoring program in order to confirm measurements made by the utilities, to evaluate any impact the stations may have on the environment and the public, and to establish a baseline in the event of a release of radioactive material.

Samples are collected on a quarterly basis through a contract with Midwest Laboratory and are analyzed by the IEMA radiochemistry lab. These samples are identical splits of samples collected for Exelon's Radiological Environmental Monitoring Program (REMP). Ambient gamma radiation is monitored using optically stimulated luminescence dosimeters. A network of 413 dosimeters is arrayed around the plants; the dosimeters are exchanged and analyzed quarterly.

### **Samples and Analyses**

Samples collected for the IEMA monitoring program reflect the critical pathways that radionuclides could be transported to and ingested by the general population: water, sediments, and fish from lakes and rivers downstream; ground water from nearby wells; milk from local dairies; vegetables from nearby farms. At six stations, split samples are collected on a quarterly basis through a contract with Midwest Laboratory. At the seventh station, Clinton, IEMA staff members collect all samples. All samples are analyzed by the IEMA radiochemistry laboratory.

#### *Water Samples*

Nuclear power stations use large volumes of water and may, from time to time, discharge this water to rivers and lakes. This discharge is regulated by the USNRC and the Illinois Environmental Protection Agency (IEPA). Impacted bodies of water include the Kankakee, Illinois, Rock and Mississippi Rivers, Lake Michigan and Clinton Lake. IEMA analyzes samples from these bodies and public drinking systems that draw their water from them. For surface water samples,



aliquots are collected weekly and composited for quarterly analysis.

Plant operations can also impact ground water so IEMA also analyzes samples collected from wells in and around the plants. Ground water samples are collected and analyzed quarterly. For all water samples, typically 3-4 liters are collected per quarter. Water samples are monitored for several radionuclides associated with nuclear power plant operations, including, but not limited to H-3 (tritium), Co-60, Cs-137, Fe-59, Zr-95, gross alpha and gross beta radiation.

### *Milk Samples*



In an emergency, the gas I-131 (iodine-131) can be released from nuclear power plants and ingested or inhaled by cows and exuded in their milk. Three of the stations, Braidwood, Byron and Quad Cities, have dairies operating within 10 miles of them, thus IEMA analyzes samples from these dairies. Samples consist of approximately four liters of milk, mailed directly to the IEMA laboratory. From May to October, samples are collected every two weeks; the rest of the year, samples are

collected once a month. Milk samples are submitted for gamma spectroscopy analysis, specifically for short-lived iodine isotopes.

### *Sediment Samples*

Radionuclides released into rivers would be expected to accumulate in sediments downstream. IEMA analyzes sediment samples are collected from the rivers and lakes downstream of the plant effluent points. Sediments are collected semi-annually in the spring and fall. All sediments are submitted for gamma spectroscopy analysis, specifically for Co-60, Cs-137, Fe-59, Zr-95, Mn-54 and other reactor-related radionuclides. One of these, Cs-137, is found in almost all soil and sediment samples – a remnant of nuclear weapons testing in the 1960's – at concentrations of 0.1 – 0.2 pCi/g.

### *Fish Samples*

Like sediments, fish are excellent accumulators of radionuclides. Fish samples collected from rivers, near plant discharge points. At each location, two different species of fish are collected annually, typically in October. Edible portions of the fish are harvested and analyzed. Like



sediments, fish samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

### *Vegetable Samples*



Vegetables provide a pathway for human ingestion of radionuclides. Annually, around each of the power plants except Zion, vegetables are collected from nearby farms. Generally, two varieties of vegetables are collected: one root vegetable and one leafy green. Ideally, vegetables are collected from four farms near each plant: one north of the plant, one east, one west and one south, although the farms may vary from year to year. Like other accumulators, vegetable samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

### *Ambient Gamma Monitoring*

IEEMA maintains a network of 477 environmental dosimeters around the seven nuclear power plants. Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. The dosimeters are arrayed within a 10 mile radius of each plant and are exchanged and analyzed quarterly. While the dosimeters are used to monitor for small changes in ambient background levels of gamma radiation that could result from plant activities, they also play another important role. In the event of a significant off-site release from a nuclear plant the environmental dosimeters would be collected, read and used to determine the extent and magnitude of the release, along with an estimate of the radiation dose that may have been received.

### **Limits of Detection**

All analytical methods have limitations: amounts that are just too small to be detected. The Minimum Detectable Concentration (MDC) is a measure of that limitation. It is defined as the smallest quantity that an analytical method has 95% likelihood of detecting. For example, the MDC for tritium in water is 200 pCi/l. Given a sample with a tritium concentration of 200 pCi/l, our laboratory would detect that tritium approximately 95 times out of 100. Samples with less than 200 pCi/l could be detected, but with less certainty. Samples with more than 200 pCi/l would be more likely to be detected, approaching 100% for samples with more than 500 pCi/l.

Analytical methods are chosen, in part, on their MDC. As a general rule, methods are chosen such that their MDC is less than 10% of any applicable regulatory limit. The table below lists MDC for selected radionuclides in the various types of samples analyzed.

**Table 1: Minimum Detectable Concentrations of Selected Radionuclides**

<b>Analyte</b>	<b>Water</b> (pCi/l)	<b>Fish</b> (pCi/kg)	<b>Milk</b> (pCi/l)	<b>Vegetables</b> (pCi/kg)	<b>Sediment</b> (pCi/g)
<b>H-3</b>	200	----	----	----	----
<b>I-131</b>	----	----	5	----	----
<b>Cs-137</b>	4	14	3	4	0.02
<b>Co-60</b>	4	15	----	4	0.02



## **Braidwood Nuclear Power Station**

Braidwood Station is located in Will County in northern Illinois, approximately fifteen miles south-southwest of Joliet, Illinois. This station utilizes two pressurized water reactors to generate electricity for Exelon. Unit 1 began operation in 1987 and unit 2 in 1988.

Liquid effluents from the Braidwood Station are released in controlled batches to the Kankakee River. Critical pathways for radiation exposure to the public include I-131 in milk, ingestion from drinking water and foodstuffs and external gamma radiation from noble gases. Samples collected include: downstream surface and public drinking waters, private wells, a control surface water, milk from a local dairy farm, fish, local vegetables, and river sediments from the Kankakee River.

In 2005 it was discovered that a leak in the line that transported effluents to the Kankakee River had allowed for the unlicensed release of effluents to groundwater. As a result, tritium (H-3) was found in ground water and a pond outside the boundaries of the plant. As part of its mitigation process to remove this tritium plume, Exelon has introduced a number of new monitoring wells in the area of the plume. IEMA analyzes samples from these wells to monitor the efficacy of the mitigation efforts and detect any further spread of the plume.





## **Water Samples**

Water samples are collected from two locations in the Kankakee River, four surface water locations on-site, nine private drinking water wells, one public well and public drinking water supply that draws its water from the Kankakee River approximately six miles downstream of the effluent point. Ground water samples are collected once each quarter. Surface water samples are collected weekly and composited for quarterly analysis, with one exception. The public drinking water sample collected at the Wilmington Water Treatment plant is collected by a device which draws an aliquot every 15 minutes. These aliquots are composited and collected for both weekly and quarterly analyses. For all samples, typically, 3-4 liters are collected per samples. All quarterly water samples are submitted for gross alpha, gross beta, tritium and gamma spectroscopy analyses. The weekly water samples from Wilmington are analyzed for tritium only.

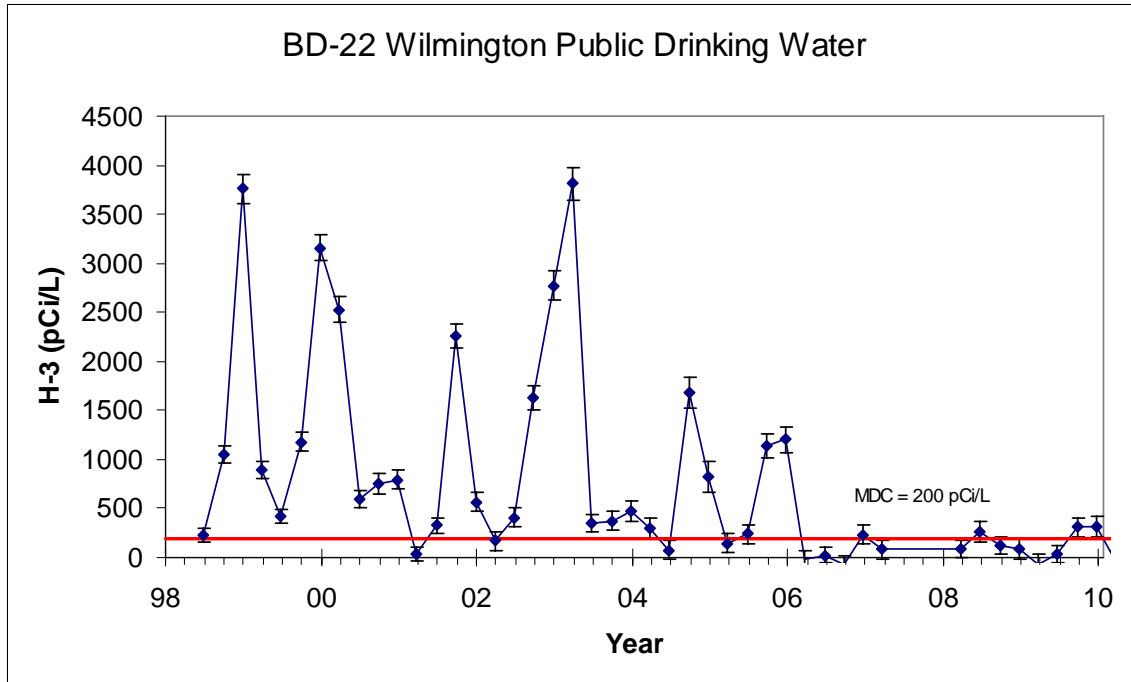
In 2007 IEMA began monitoring an additional thirty-four water sources in the area of the tritium plume. These include nine residential wells, a nearby pond and several monitoring wells in and around the plume. Samples from these locations are only monitored for tritium.

Water samples are monitored for several gamma-emitting radionuclides associated with nuclear power plant operations, including, but not limited to Co-60, Cs-137, Fe-59, and Zr-95. None of these were detected in 2009.

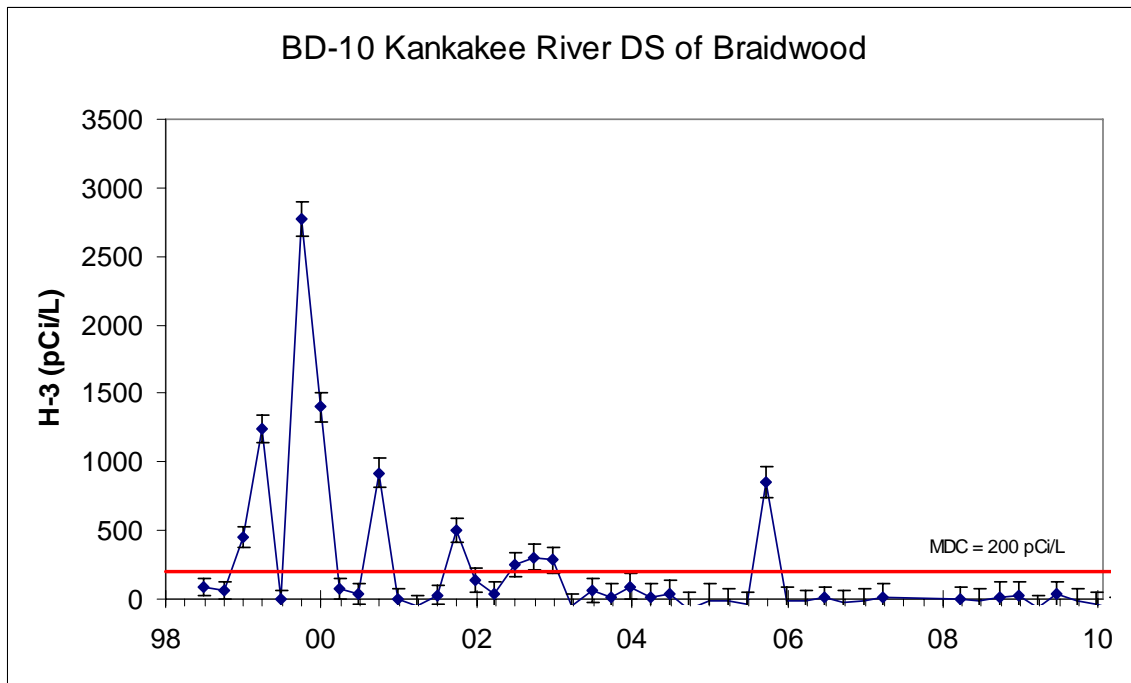
Tritium (H-3) is a normal component of the effluent stream of nuclear power plants. Liquid effluents from the LaSalle station are released to the Illinois River under permit from the Illinois Environmental Protection Agency (IEPA). However, in 2005 it was discovered that the pipe used to transport effluents to the river had leaked, resulting in a plume of tritium in nearby ground and surface water, in violation of the permit.

Historically, tritium has been detected in water from the Wilmington Public Water (BD-22), Kankakee River (BD-10) and a residential well along the Kankakee River (BD-36). The well at BD-36 is one of several residential wells near the Kankakee River that are monitored, but it is the only one in which tritium has been detected. It seems likely that the tritium is entering this well through infiltration of river water. Figures 1-3 show the history of tritium at each of these locations.

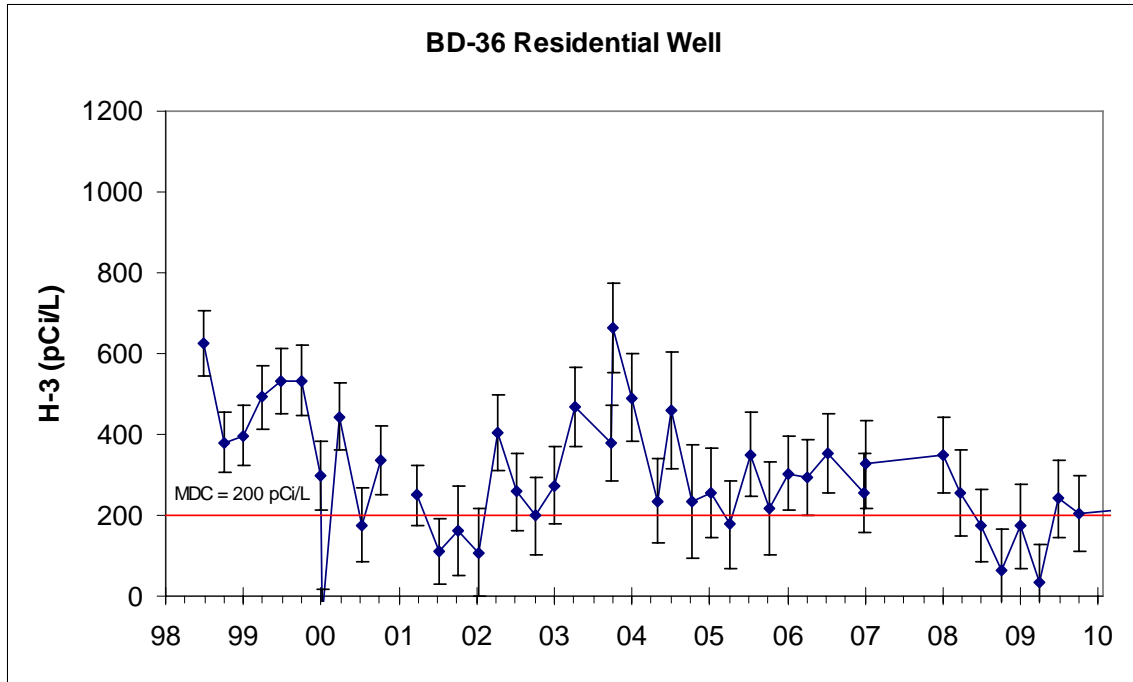
In 2009, tritium was detected in the Wilmington drinking water and in the residential well, BD-36, but at concentrations only slightly above the Minimum Detectable Concentration (MDC) of 200 pCi/L. The average concentration for the year at both locations was less than the MDC of 200 pCi/L. This is less than 1% of the USEPA's limit for tritium in drinking water, 20,000 pCi/L.



**Figure 1: Tritium in Wilmington Public Drinking Water**



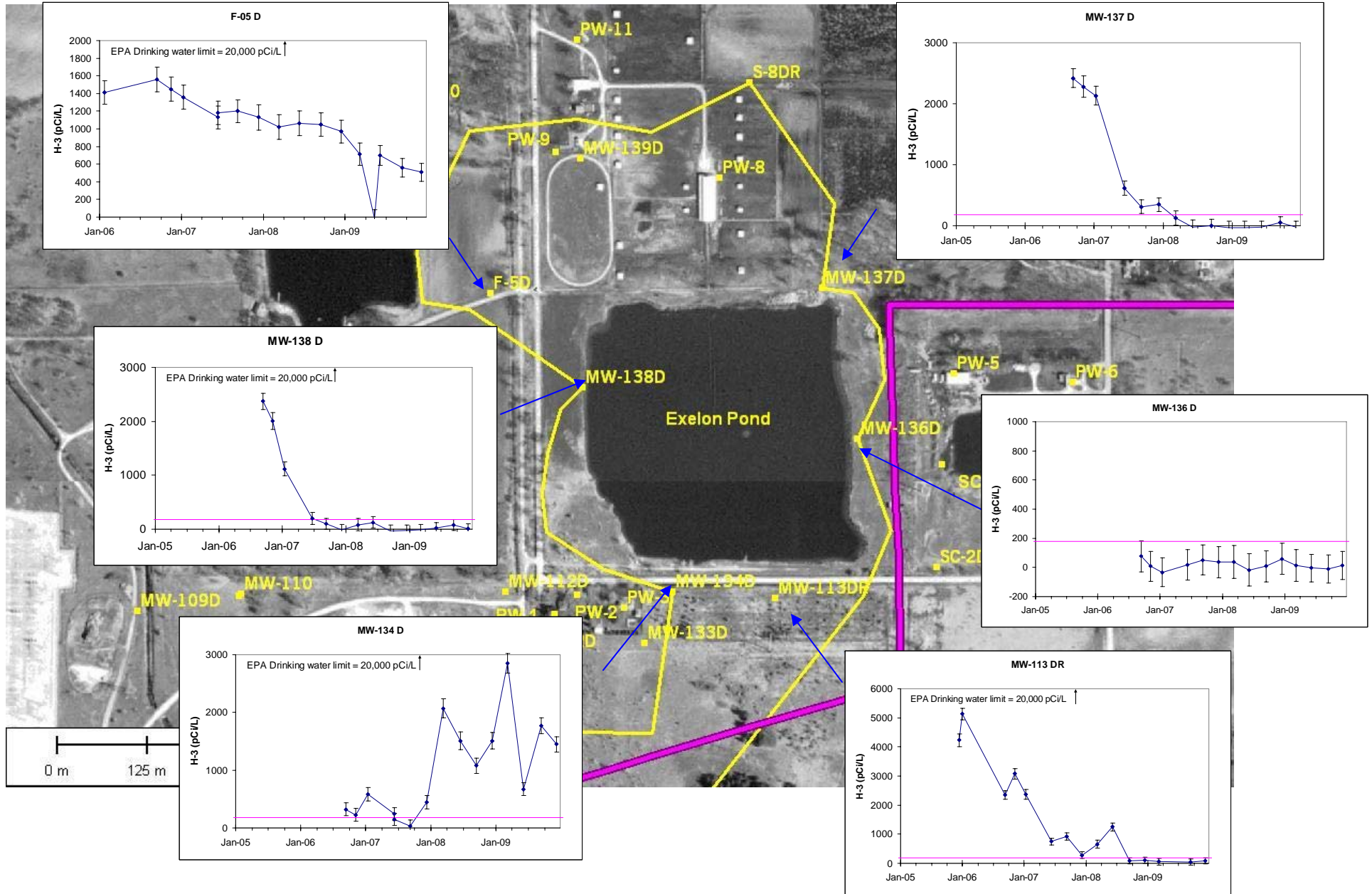
**Figure 2: Tritium Downstream of Braidwood Effluent**



**Figure 3: Tritium at Residential Well BD-36**

In samples collected around the plume, no tritium was detected in any of the residential wells and no tritium was detected in wells outside the established boundaries of the plume and in wells within the plume, concentrations have generally declined. These two facts suggest that the mitigation efforts are generally successful. Figure 4 shows the approximate extent of detectable tritium as of September 2007 and the historical trends at select wells. One notable exception to the trend is Well MW-134 D, which rose sharply in 2008. In 2009, the tritium concentration here reached at new high of  $(2850 \pm 170)$  pCi/L. By the end of 2009, tritium concentrations had decreased to  $(1450 \pm 130)$  pCi/L. This is of concern because it is on the boundary of the plume near several residential wells, although at this time, no tritium has been detected in the residential wells.

Figure 4: Braidwood Tritium Plume Monitoring



### **Milk Samples**

Milk samples are collected from two nearby dairies. Each month, approximately four liters of milk are collected and are mailed directly to the IEMA laboratory. Milk samples are mailed directly to the IEMA laboratory and analyzed within five days of sampling by gamma spectroscopy, specifically for short-lived iodine isotopes.

No radionuclides associated with nuclear power plant operations were detected in milk samples. Only naturally occurring K-40 was detected, within the range typical of established background (1200 to 1500 pCi/L).

### **Sediment Samples**

Sediment samples are collected from the rivers downstream of the plant effluent points. Sediments are collected annually in October. All sediments are submitted for gamma spectroscopy analysis.

Sediment samples are monitored for several radionuclides associated with nuclear power plant operations: Co-58, Co-60, Cs-134, Cs-137, and Mn-54. Cs-137, a remnant of atmospheric nuclear weapons testing, is present in most sediment and soil at concentrations of 0.1 – 0.2 pCi/g.

In 2009, Cs-137 was detected in sediment from BD-57 at concentrations too small to quantify (< 0.1 pCi/g). No radionuclides associated with nuclear power plant operations were detected in samples collected near Braidwood. Other radionuclides detected were naturally occurring.

### **Fish samples**

Like sediments, fish are collected from rivers, near the plant discharge point. At each location, two different species of fish are collected annually, typically in October. Edible portions of the fish are harvested by technicians at Midwest Incorporated Laboratory and prepared for analysis. Splits of the samples are provided to the IEMA laboratory. Fish samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in fish samples. Only naturally occurring K-40 was detected, at concentrations typical of background (3 – 5 pCi/g).

### **Vegetable samples**

Like fish, two varieties of vegetables are collected annually, generally one root vegetable and one leafy green. Ideally, vegetables are collected from four farms: one in each quadrant (north, east, south, and west) from the plant, although the availability of farms may vary from year to year. In 2009, only one farm was available, in quadrant 4, west of

the plant. Vegetable samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in vegetable samples. Only naturally occurring K-40 was detected. Concentrations vary too widely between varieties for meaningful comparisons.

### **Ambient Gamma**

IEMA maintains a network of 145 environmental dosimeters in a ten-mile radius around the Braidwood and Dresden stations. Because of the proximity of the two stations, the network includes dosimeters that fall within the ten-mile monitoring radius of both stations. Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. Dosimeters are exchanged and analyzed quarterly.

In 2009, measurements at all 145 locations were consistent with established background measurements.



**Table 2: Braidwood Monitoring Locations**

<b>IEMA ID</b>	<b>Exelon ID</b>	<b>Description</b>	<b>Medium</b>
140214	BD-10	Kankakee River D.S.	Surface Water
140215A	BD-22	Kankakee R. @ Wilmington Waterworks	Public Water
140218	BD-25	Kankakee River U.S.	Surface Water
140219	BD-36	Residential Well	Ground Water
140221	BD-13	Braidwood City Hall	Ground Water
140222	BD-34	Residential Well	Ground Water
140223	BD-35	Residential Well	Ground Water
140224	BD-37	Residential Well	Ground Water
140241	BD-38	Hotel Ditch	Surface Water
140242	BD-40	Cooling Lake	Surface Water
140243	BD-51	Residential Well	Ground Water
140244	BD-53	Residential Well	Ground Water
01SM071	BD-54	Residential Well	Ground Water
01SM048	BD-55	North Pond	Surface Water
01SM066	BD-56	South Pond	Surface Water
140503	BD-17	Dairy Farm	Milk
140504	BD-18	Dairy Farm	Milk
140916	BD-57	Circulating Water Blowdown	Sediment
140615	BD-28	Kankakee River, Discharge Point	Fish
140703	BD-QUAD#4	Farm in Quadrant #4	Vegetation
140708	BD-QUAD#2	Farm in Quadrant #2	Vegetation
140709	BD-QUAD#1	Farm in Quadrant #1	Vegetation
140710	BD-QUAD#3	Farm in Quadrant #3	Vegetation
140915	BD-41	Kankakee River, DS	Sediment

**Table 3: Braidwood Tritium Plume Monitoring Locations**

<b>IEMA ID</b>	<b>Location</b>	<b>Medium</b>
01SM131	F-05 D	Ground Water
01SM843	F-09	Ground Water
01SM195	MW-04	Ground Water
01SM816	MW-013	Ground Water
01SM845	MW-014	Ground Water
01SM766	MW-109 D	Ground Water
01SM103	MW-110	Ground Water
01SM844	MW-111 DR	Ground Water
01SM603	MW-112 D	Ground Water
01SM820	MW-113 DR	Ground Water
01SM769	MW-132 D	Ground Water
01SM770	MW-133 D	Ground Water
01SM771	MW-134 D	Ground Water
01SM773	MW-136 D	Ground Water
01SM774	MW-137 D	Ground Water
01SM775	MW-138 D	Ground Water
01SM776	MW-139 D	Ground Water
01SM781	MW-150 D	Ground Water
01SM783	MW-157 D	Ground Water
01SM846	MW-161 D	Ground Water
01SM044	PW-001	Ground Water
01SM045	PW-002	Ground Water
01SM048	PW-003 (BD-53)	Ground Water
01SM184	PW-006	Ground Water
01SM851	PW-006 A	Ground Water
01SM852	PW-006 B	Ground Water
01SM065	PW-006P	Surface Water
01SM043	PW-011	Ground Water
01SM069	PW-013	Ground Water
01SM291	PW-014	Ground Water
01SM071	PW-015 (BD-51)	Ground Water
01SM736	PW-016	Ground Water
01SM847	S-08 DR	Ground Water
01SM618	VB-04-05 D	Ground Water
01SM619	VB-04-06 D	Ground Water
01SM181	WCFP-01 D	Ground Water

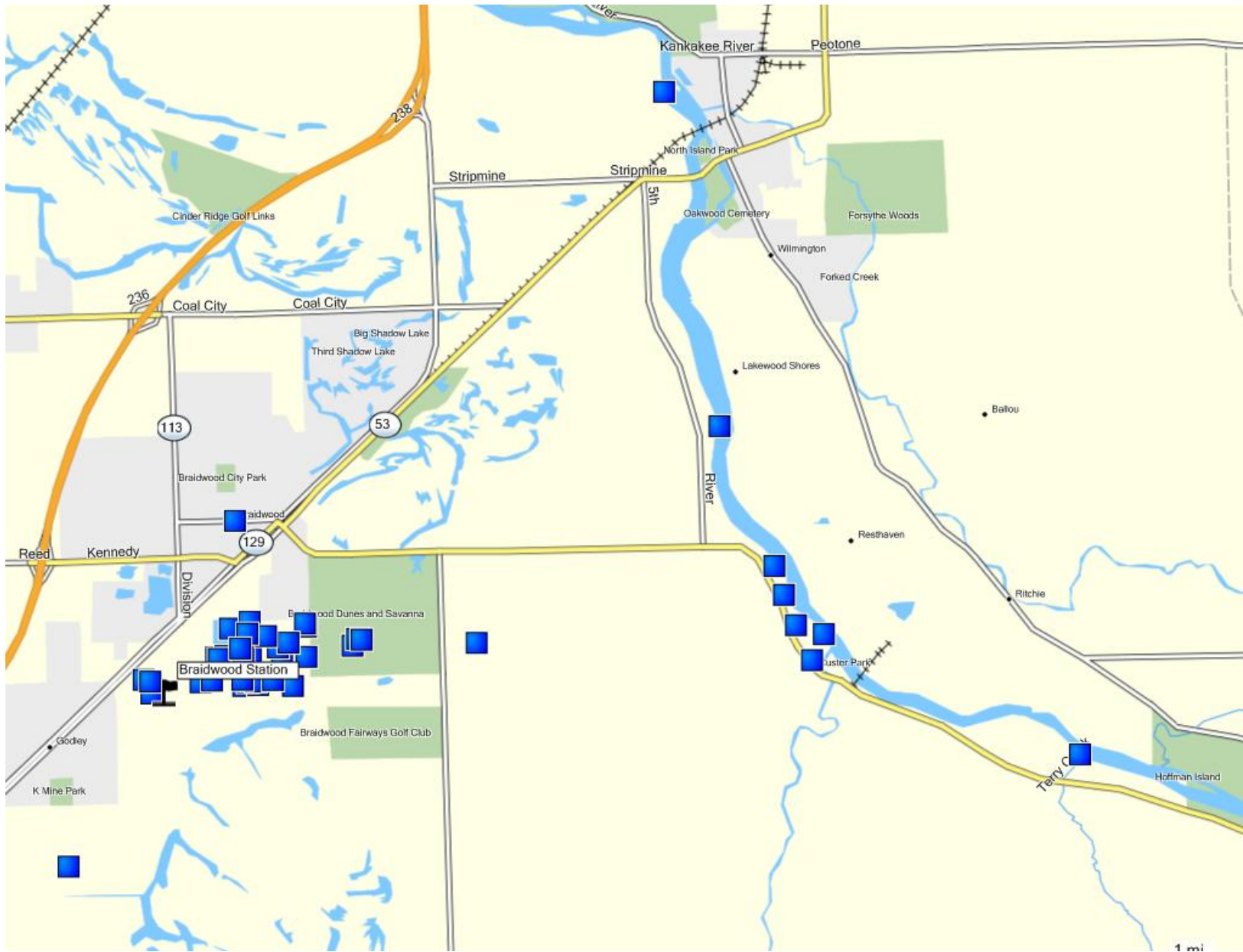
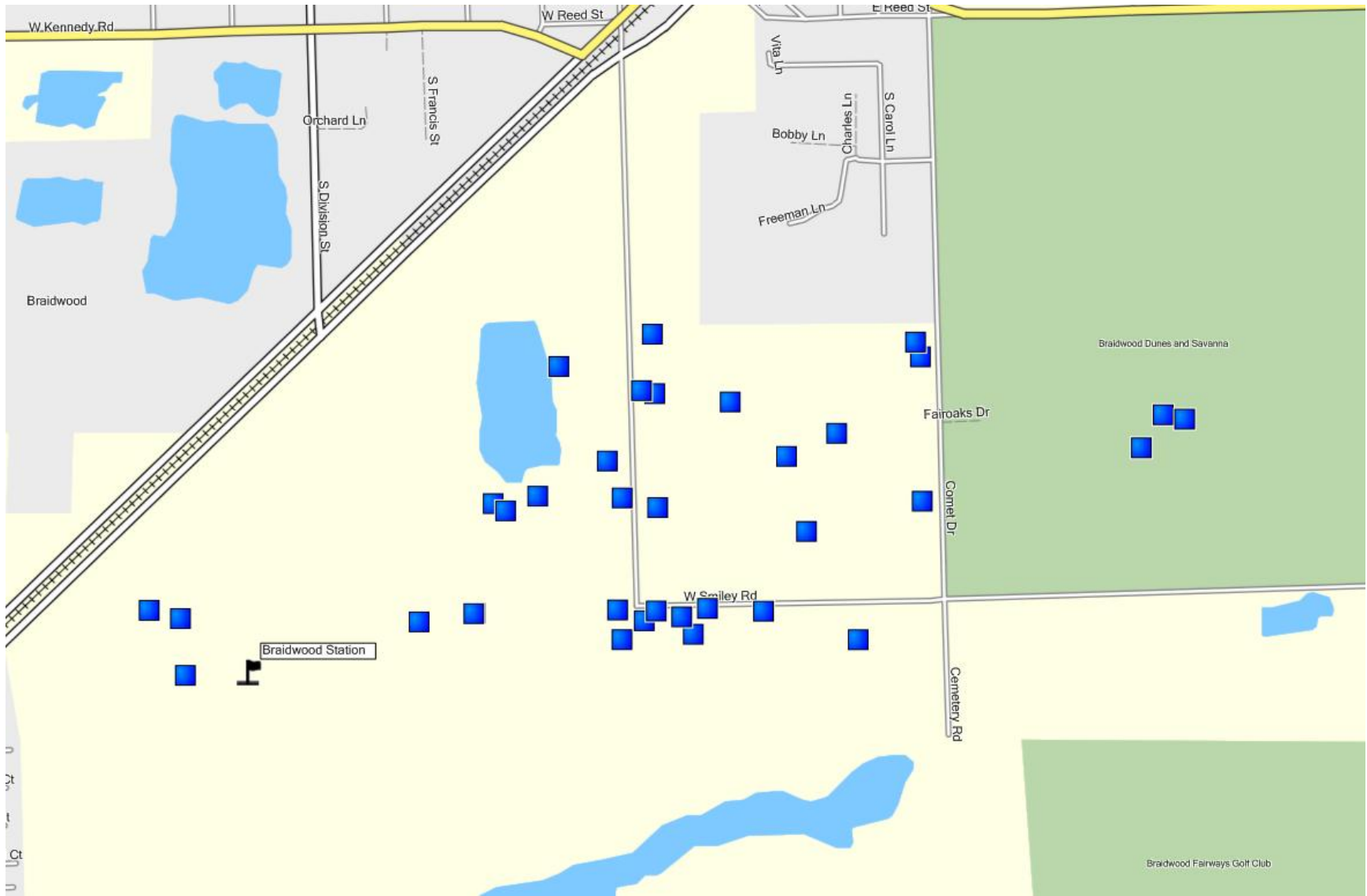
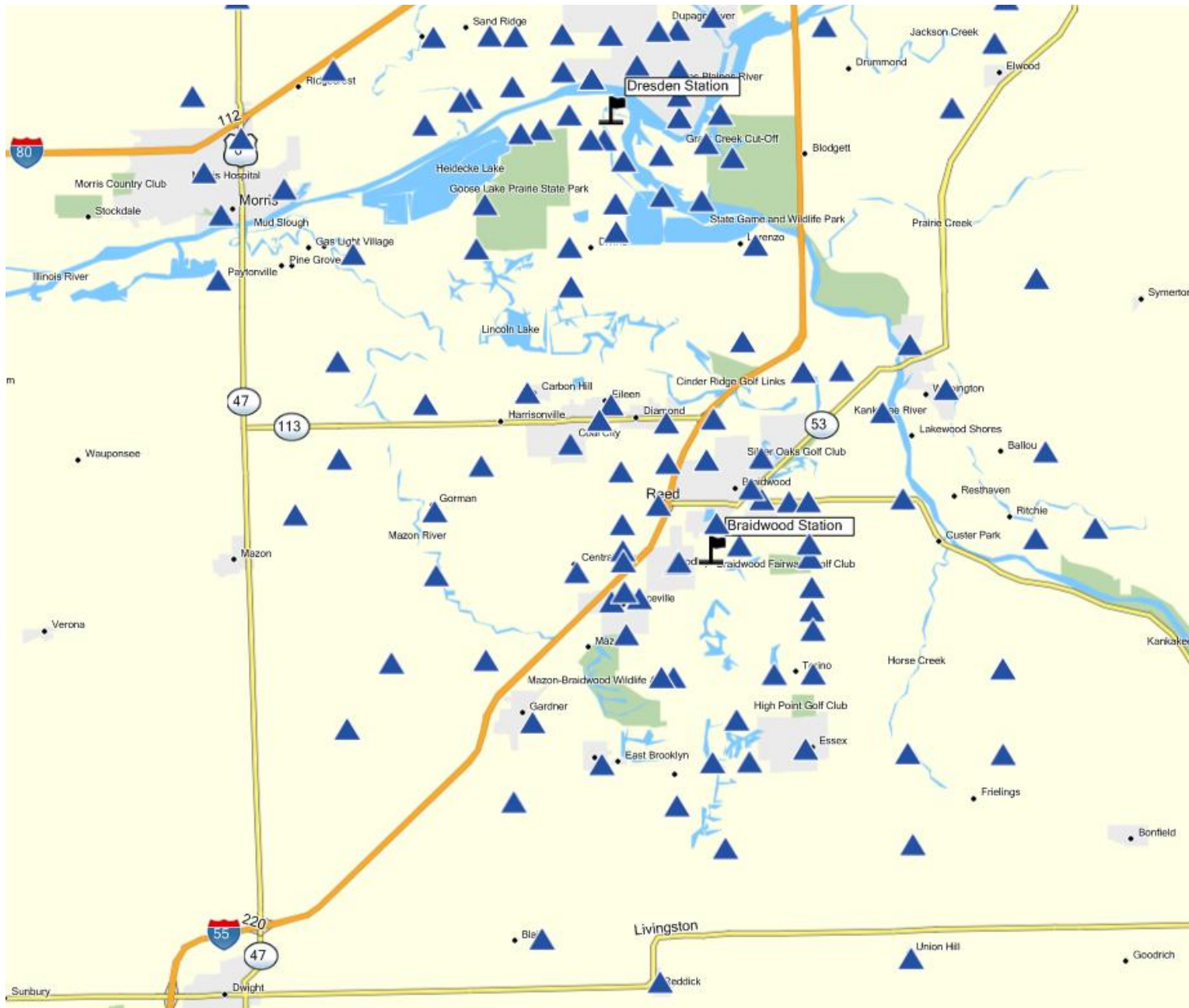


Figure 5: Braidwood Monitoring Locations Overview



**Figure 6: Braidwood Monitoring Locations, Plume Detail**



**Figure 7: Braidwood Environmental Dosimeter Locations**



## **Dresden Nuclear Power Station**

Dresden Station is located in Grundy County in northern Illinois, approximately twelve miles southwest of Joliet, Illinois at the confluence of the Des Plaines and Kankakee rivers where they form the Illinois River. This station utilizes two boiling water reactors to generate electricity for Exelon.

Liquid effluents from the Dresden Station are released to the Illinois River. Critical pathways for radiation exposure to the public include: ingestion from drinking water and foodstuffs and external gamma radiation from noble gases. Environmental samples collected include: upstream and downstream surface water, a private well, milk, fish, and river sediment from the Illinois River.



### **Water Samples**

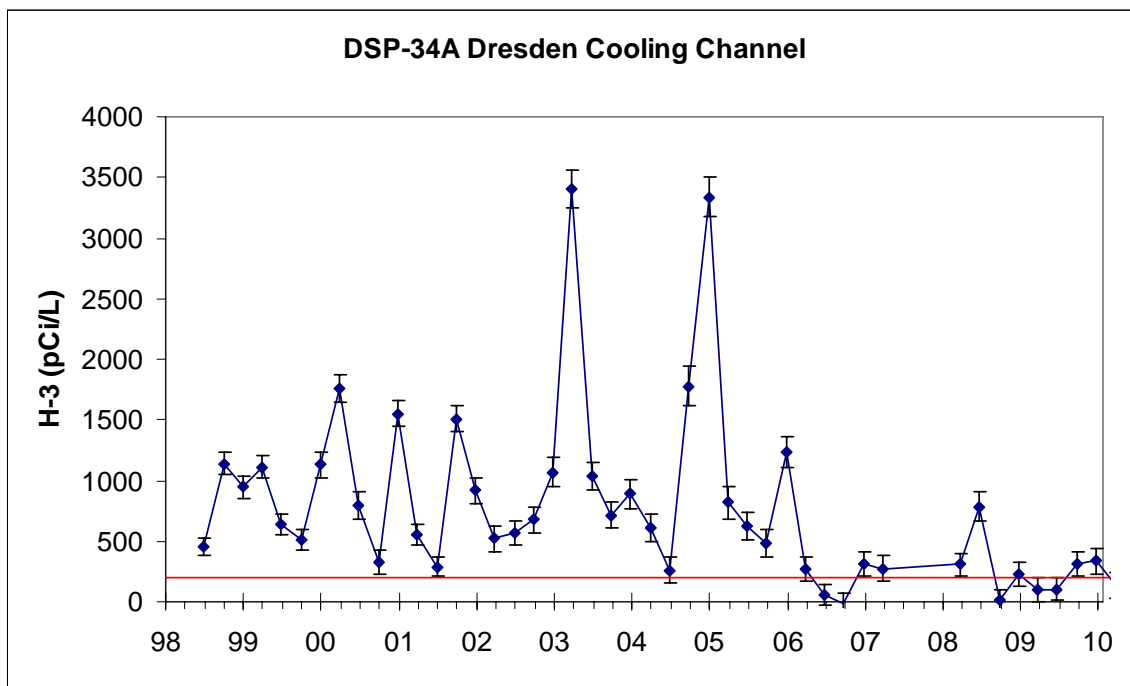
Water samples are collected from five locations in the Kankakee, Des Plaines and Illinois Rivers and two ground water wells. Ground water samples are collected once each quarter. Surface water samples are collected weekly and composited for quarterly analysis. Typically, 3-4 liters are collected per quarter. Water samples are submitted for gross alpha, gross beta, tritium and gamma spectroscopy analyses.

Water samples are monitored for several radionuclides associated with nuclear power plant operations, including, but not limited to H-3 (tritium), Co-60, Cs-137, Fe-59, and Zr-95. None of these were detected in 2009. Gross alpha and beta analyses were consistent with background.

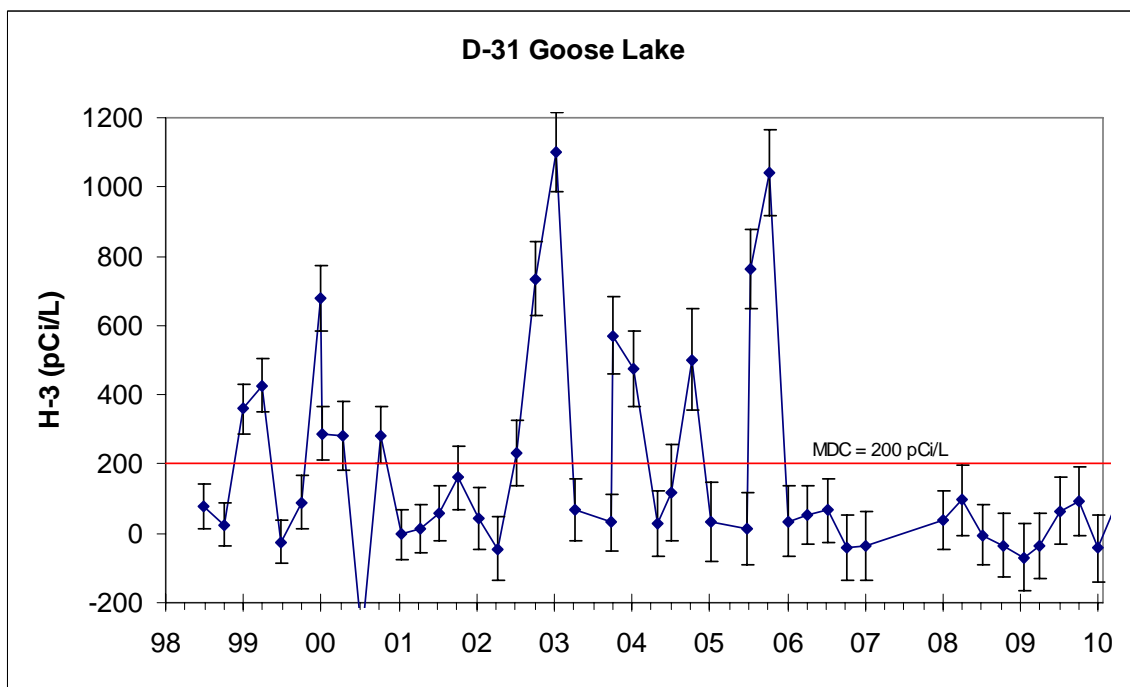


Tritium is a normal component of the effluent stream of nuclear power plants and its release to the environment is regulated by USNRC and Illinois Environmental Protection Agency (IEPA) permitting. Historically, detectable concentrations of tritium have been found at three Monitoring Locations near the Dresden station: Dresden Cooling Channel (DSP-34A); Goose Lake in the Kankakee River (D-31), in the Residential Well (D-23) and; in the Illinois River, Downstream (D-21). Figures 1-4 respectively, show the historical records of tritium concentrations at these locations. Figure 5 shows the historical record of tritium at the Wilmington Water Treatment plant, upstream of the Dresden station.

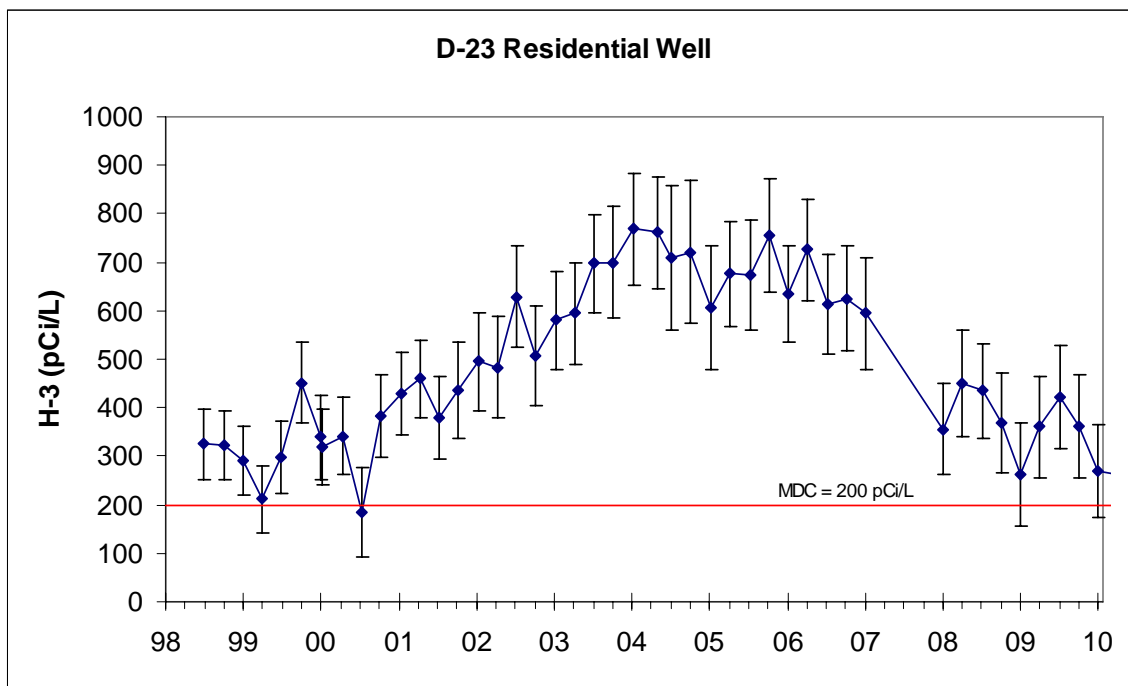
Tritium in the cooling channel is not surprising; the channel transports cooling water from the cooling pond back to the plant prior to being released to the Illinois River. Weekly sampling provides a snapshot of concentrations throughout the year. Tritium in Goose Lake is also not surprising as it is immediately adjacent to the cool pond. It is instructive to compare these concentrations to the USEPA drinking water standard of 20,000 pCi/L. The highest concentration seen at either of these two sites was 3400 pCi/L in 2003.



**Figure 8: Tritium in Dresden Cooling Channel**



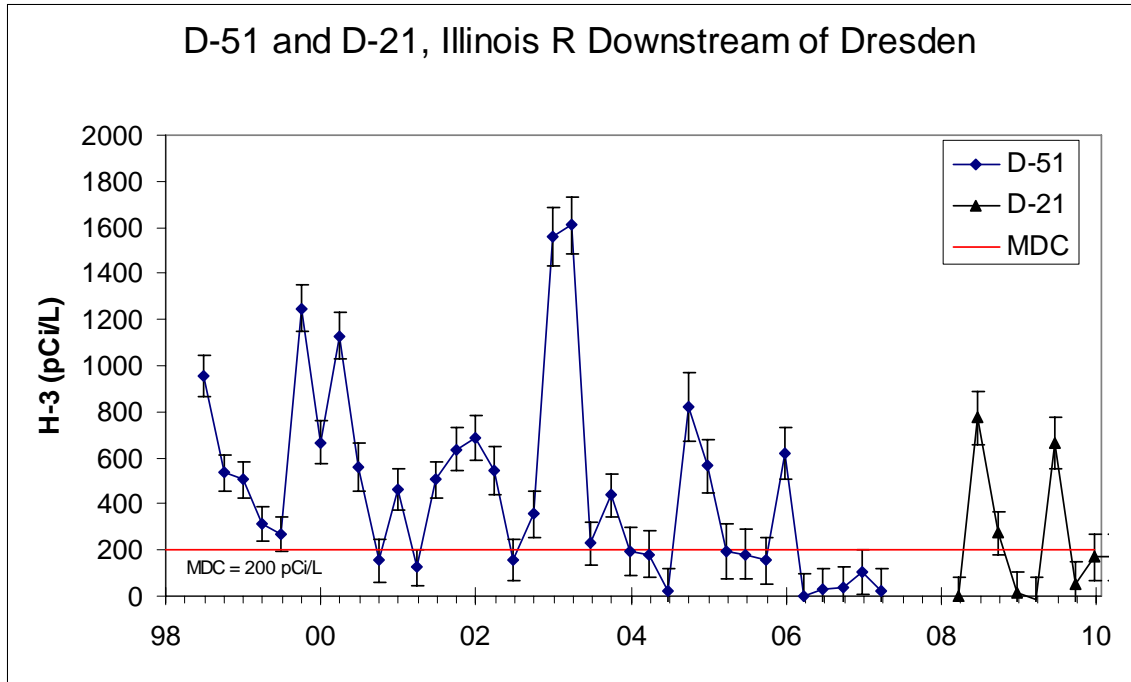
**Figure 9: Tritium at Goose Lake in Kankakee River**



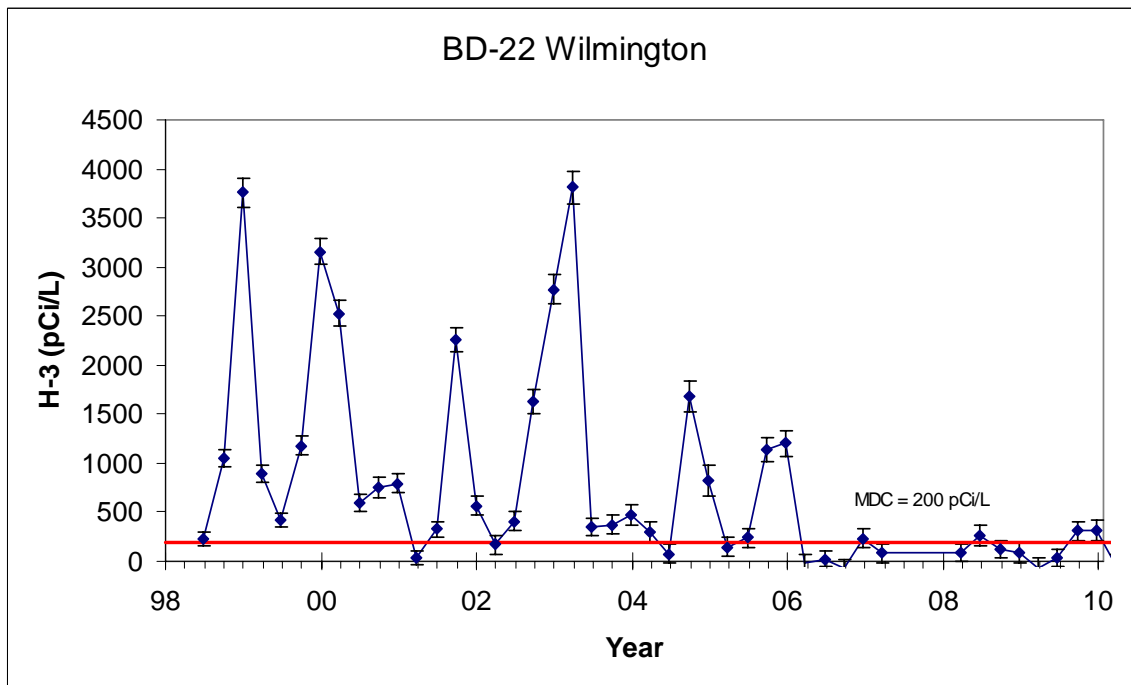
**Figure 10: Tritium in Residential Well**

Tritium in this residential well has been detectable above the Minimum Detectable Concentration limit of 200 pCi/L for some time. The highest concentration observed was 770 pCi/L in 2004. Concentrations have been declining since then. In 2009 the average concentration observed was 350 pCi/L. Again, concentrations here are only a fraction of the USEPA drinking water limit.

Comparing figures 4 and 5, we notice that the tritium concentration downstream of Dresden seems to rise and fall with the concentration upstream at Wilmington. In fact, there is a slight positive correlation between the two plots ( $r^2 = 0.47$ ). This suggests that at least a portion of the tritium in the river downstream of Dresden is in fact due to an upstream source.



**Figure 11: Tritium Downstream of Dresden**



**Figure 12: Tritium Upstream of Dresden at Wilmington**

### **Milk Samples**

No dairy falls inside the ten-mile EPZ. In the event that milk samples were collected, the sample collected at BD-18 would provide a control sample.

### **Sediment Samples**

Sediment samples are collected from Illinois downstream of the plant effluent point. Sediments are collected semi-annually in May and October. All sediments are submitted for gamma spectroscopy analysis.

Sediment samples are monitored for several radionuclides associated with nuclear power plant operations: Co-58, Co-60, Cs-134, Cs-137, and Mn-54. Cs-137, a remnant of atmospheric nuclear weapons testing, is present in most sediment and soil at concentrations of 0.1 – 0.2 pCi/g.

In 2009, Cs-137 was detected in sediment from D-27, Illinois River at Dresden Lock & Dam, at 0.1 pCi/g. As stated above, this is typical of background. No radionuclides attributable to nuclear power plant operations were detected in samples collected near Dresden. Other radionuclides detected were naturally occurring.

### **Fish samples**

Like sediments, fish are collected from the Illinois River, near the plant discharge point. Two different species of fish are collected annually. Edible portions of the fish are harvested by technicians at Midwest Incorporated Laboratory and prepared for analysis. Splits of the samples are provided to the IEMA laboratory. Fish samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in fish samples. Only naturally occurring K-40 was detected, at concentrations typical of background (3 – 5 pCi/g).

### **Vegetable samples**

Two varieties of vegetables are collected annually, generally one root vegetable and one leafy green. Ideally, vegetables are collected from four farms: one in each quadrant (north, east, south, and west) from the plant, although the availability of farms may vary from year to year. In 2009, samples were collected from two quadrants, south and west of the plant. Vegetable samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in vegetable samples. Only naturally occurring K-40 was detected. Concentrations vary too widely between varieties for meaningful comparisons.

### **Ambient Gamma**

IEMA maintains a network of 145 environmental dosimeters in a ten-mile radius around the Braidwood and Dresden stations. Because of the proximity of the two stations, the network includes dosimeters that fall within the ten-mile monitoring radius of both stations. Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. Dosimeters are exchanged and analyzed quarterly.

In 2008, measurements at all 145 locations were consistent with established background measurements.

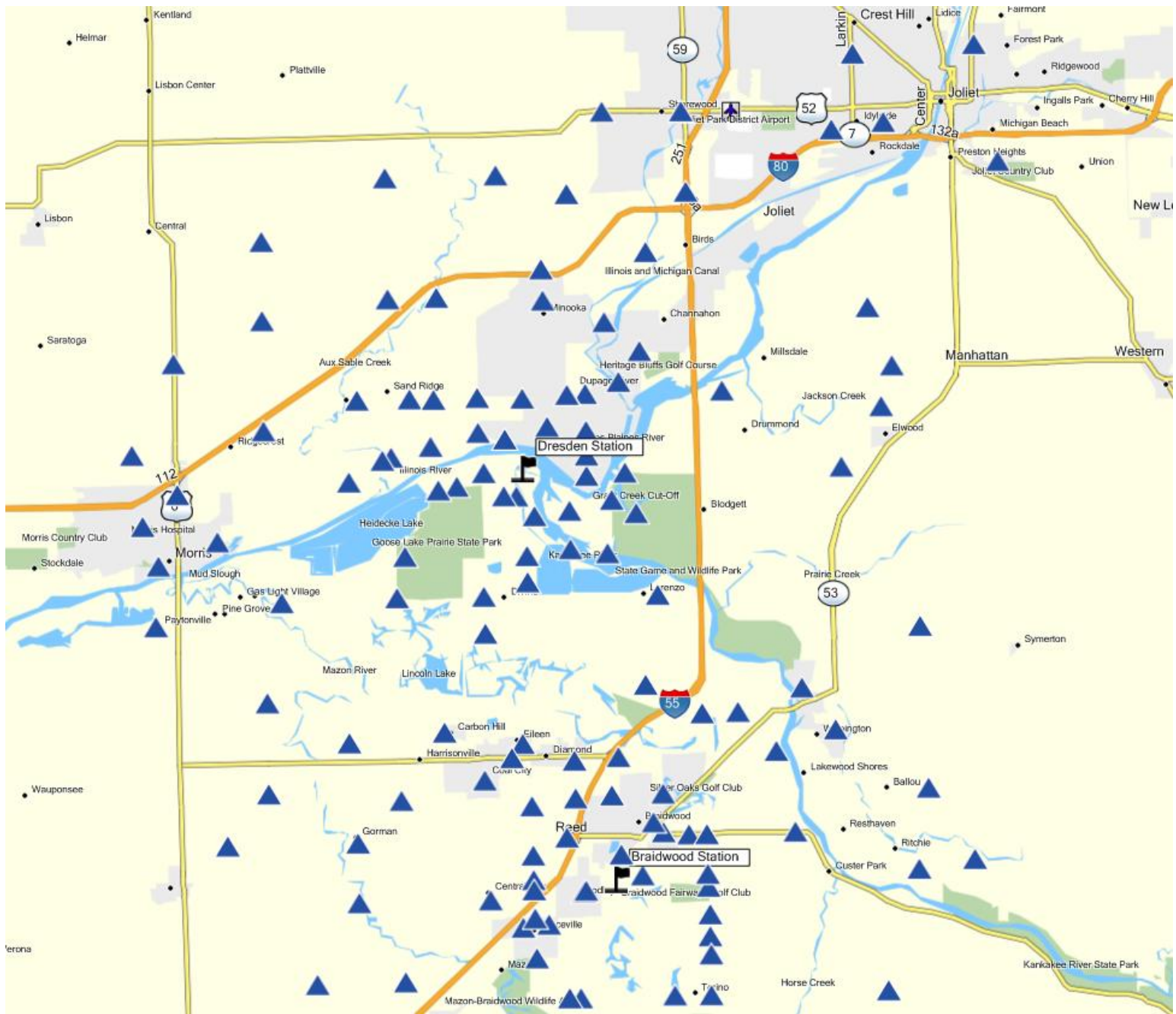
**Table 4: Dresden Monitoring Locations**

<b>IEMA ID</b>	<b>Exelon ID</b>	<b>Description</b>	<b>Medium</b>
010216	DSP-34A	Dresden Road Crossing A	Surface Water
010219	D-51	Illinois River at Dresden Lock & Dam	Surface Water
010220	D-52	Des Plaines River, US	Surface Water
010221	D-35	Well at Dresden Lock & Dam	Ground Water
010602	D-28	Illinois River, Dresden Pool	Fish
010703	D-QUAD#3	Farm in Quadrant #3	Vegetation
010704	D-QUAD#4	Farm in Quadrant #4	Vegetation
010705	D-QUAD#1	Farm in Quadrant #1	Vegetation
010706	D-QUAD#2	Farm in Quadrant #2	Vegetation
010901	D-27	Dresden Lock & Dam	Sediment
180201	D-23	Residential Well	Ground Water
180203	D-31	Goose Lake	Surface Water





Figure 13: Dresden Monitoring Locations



**Figure 14: Dresden Environmental Dosimeter Locations**

## **Byron Nuclear Power Station**

Byron Station is located in Ogle County in northern Illinois, approximately seventeen miles southwest of Rockford, Illinois. This station utilizes two pressurized water reactors to generate electricity for Exelon. Unit 1 began operation in February 1985 and unit 2 in January 1987.

Liquid effluents from the Byron Station are released to the Rock River. Critical pathways for radiation exposure to the public include I-131 in milk, ingestion of water and foodstuffs and external gamma radiation from noble gases. Samples collected include: surface and well waters, milk from local dairy farms, fish, local vegetables and river sediments from the Rock River.



### **Water Samples**

Water samples are collected from two locations in the Rock River and six ground water wells. Ground water samples are collected once each quarter. Surface water samples are collected weekly and composited for quarterly analysis. Typically, 3-4 liters are collected per quarter. Water samples are submitted for gross alpha, gross beta, tritium and gamma spectroscopy analyses.

Water samples are monitored for several radionuclides associated with nuclear power plant operations, including, but not limited to H-3 (tritium), Co-60, Cs-137, Fe-59, and Zr-95. None of these were detected in 2009. Gross alpha and beta analyses were consistent with background.

Tritium is a normal component of the effluent stream of nuclear power plants. Liquid effluents from the Byron station are released to the Rock River under permit from the

Illinois Environmental Protection Agency (IEPA). Historically, tritium has been detected in water from the Oregon Pool of the Rock River (BY-12).

Figure 1 shows the historical record of tritium concentrations at BY-12 from 1994 to 2008. Effluent releases to the river are not continuous or constant and tritium concentrations vary accordingly. Weekly sampling provides a snapshot of what tritium concentrations are throughout the year. Although no municipalities draw their drinking water from the Rock River, it is instructive to compare the tritium concentrations found in the river to the USEPA drinking water standard of 20,000 pCi/L, averaged over one year. This highest concentration seen at BY-12 in any one quarter is 7300 pCi/L, in 1998; the highest average for any four quarters was 2300 pCi/L from January to December, 2001. In the third quarter of 2009, tritium was detected at an average concentration of  $(700 \pm 100)$  pCi/L. The average for the year was less than the MDC of 200 pCi/L.

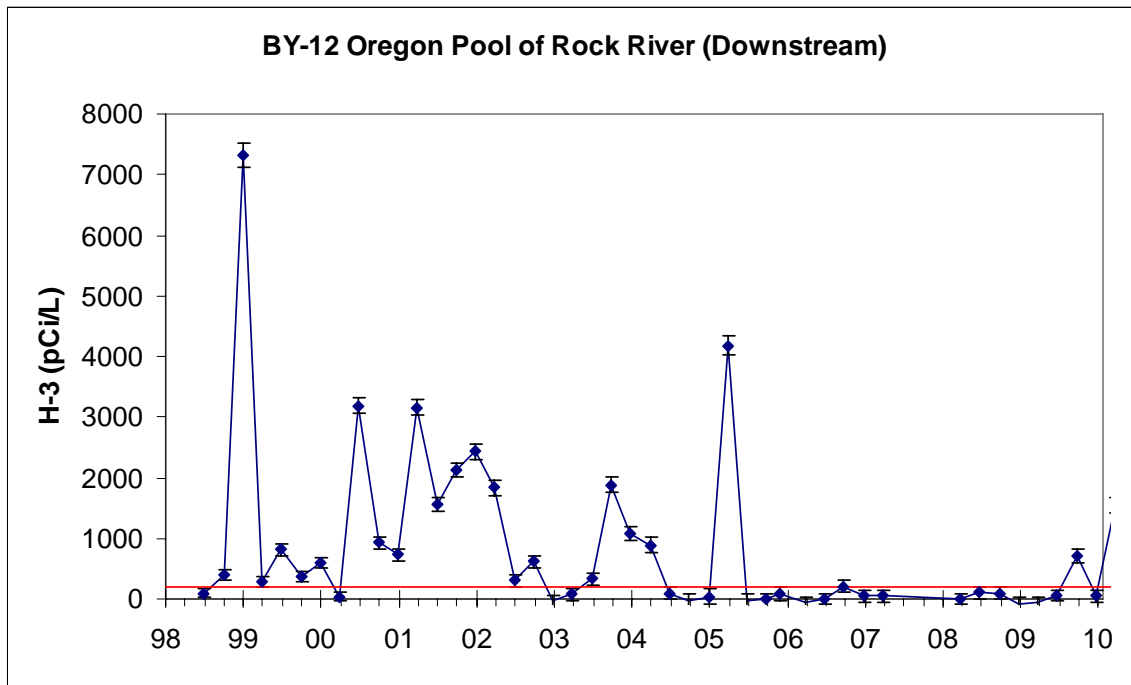


Figure 15: Tritium Downstream of Byron Station

### Milk Samples

Milk samples are collected from three local dairies, one of which is outside the 10-mile monitoring radius and serves as a control. Milk samples are collected monthly from November through April or bi-weekly May through October. Milk samples are mailed directly to the IEMA laboratory and analyzed within five days of sampling by gamma spectroscopy, specifically for short-lived iodine isotopes.

No radionuclides associated with nuclear power plant operations were detected in milk samples. Only naturally occurring K-40 was detected, within the range typical of established background (1200 to 1500 pCi/L).

### **Sediment Samples**

Sediment samples are collected from the Rock River at a point downstream of the plant effluent stream. Sediment samples are monitored for several radionuclides associated with nuclear power plant operations: Co-58, Co-60, Cs-134, Cs-137, and Mn-54. Cs-137, a remnant of atmospheric nuclear weapons testing, is present in most sediment and soil at concentrations of 0.1 – 0.2 pCi/g.

In 2009, Cs-137 was detected in sediment from BY-34, Oregon Pool of the Rock River, at concentrations too small to quantify (< 0.1 pCi/g). No radionuclides associated with nuclear power plant operations were detected in samples collected near Byron. Other radionuclides detected were naturally occurring.

### **Fish samples**

Fish are collected from the Rock River at a point near the plant discharge point. Two different species of fish are collected each spring and fall. Edible portions of the fish are harvested by technicians at Midwest Incorporated Laboratory and prepared for analysis. Splits of the samples are provided to the IEMA laboratory. Fish samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in fish samples. Only naturally occurring K-40 was detected, at concentrations typical of background (3 – 5 pCi/g).

### **Vegetable samples**

Two varieties of vegetables are collected annually, generally one root vegetable and one leafy green. Ideally, vegetables are collected from four farms: one in each quadrant (north, east, south, and west) from the plant, although the availability of farms may vary from year to year. In 2009, samples were collected from all four quadrants. Vegetable samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in vegetable samples. Only naturally occurring K-40 was detected.

### **Ambient Gamma**

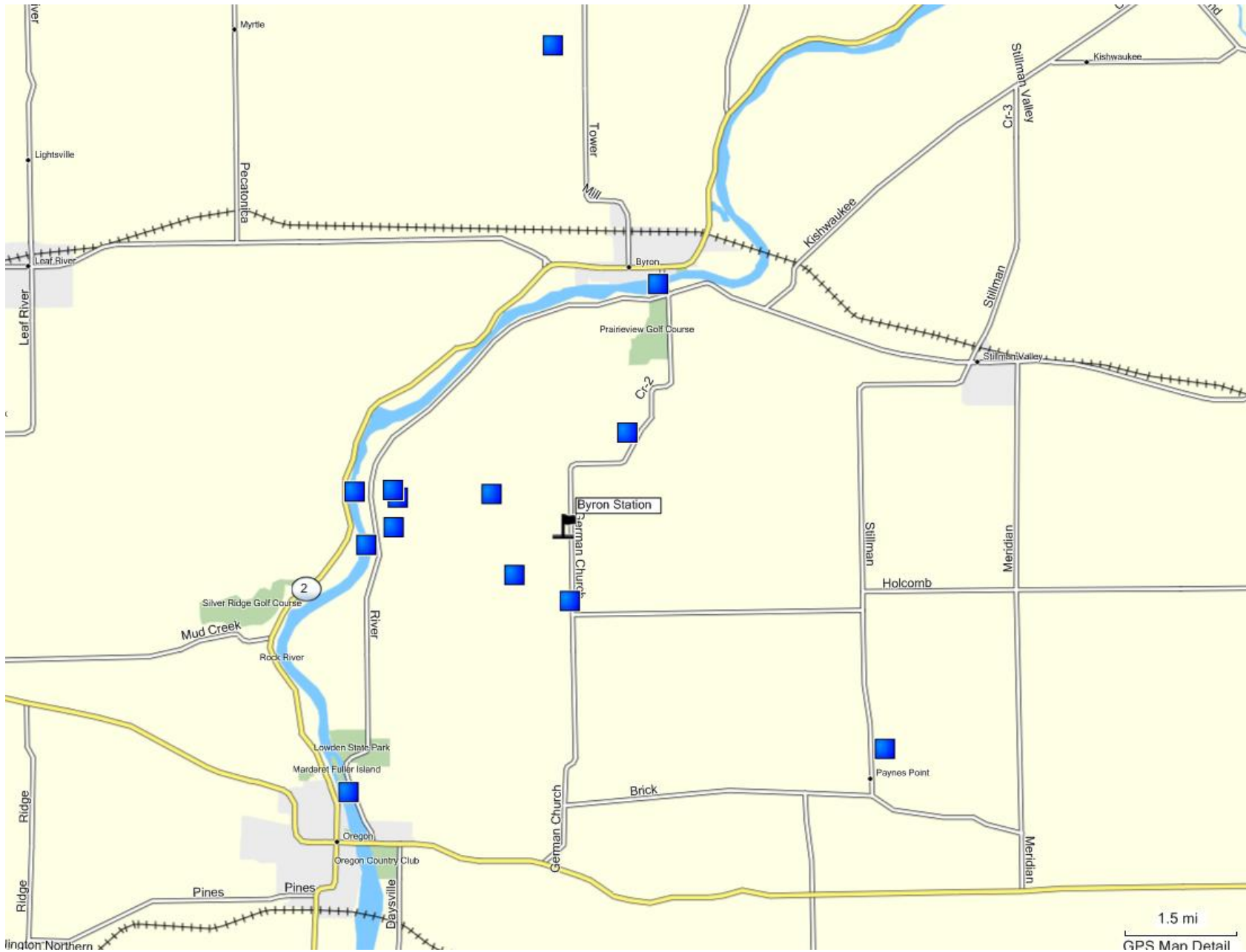
IEMA maintains a network of 74 environmental dosimeters in a ten-mile radius around the Byron station. Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. Dosimeters are exchanged and analyzed quarterly.

In 2009, measurements at all 74 locations were consistent with established background measurements.

**Table 5: Byron Monitoring Locations**

<b>IEMA ID</b>	<b>Exelon ID</b>	<b>Description</b>	<b>Medium</b>
130204	BY-12	Rock River, Downstream	Surface Water
130220	BY-29	Rock River, Upstream	Surface Water
130221	BY-18	Residential Well	Ground Water
130223	BY-32	Residential Well	Ground Water
130224	BY-14-1	Residential Well	Ground Water
130225	BY-35	Residential Well	Ground Water
130226	BY-36	Residential Well	Ground Water
130227	BY-37	Residential Well	Ground Water
130501	BY-20	Dairy Farm	Milk
130507	BY-30	Dairy Farm	Milk
130510	BY-26-1	Dairy Farm (Control)	Milk
130603	BY-31	Rock River @ Discharge	Fish
130701	BY-QUAD#1	Farm in Quadrant #1 (North)	Vegetation
130702	BY-QUAD#2	Farm in Quadrant #2 (East)	Vegetation
130703	BY-QUAD#3	Farm in Quadrant #3 (South)	Vegetation
130704	BY-QUAD#4	Farm in Quadrant #4 (West)	Vegetation
130911	BY-34	Rock River, Downstream	Sediment





**Figure 16: Byron Monitoring Locations**

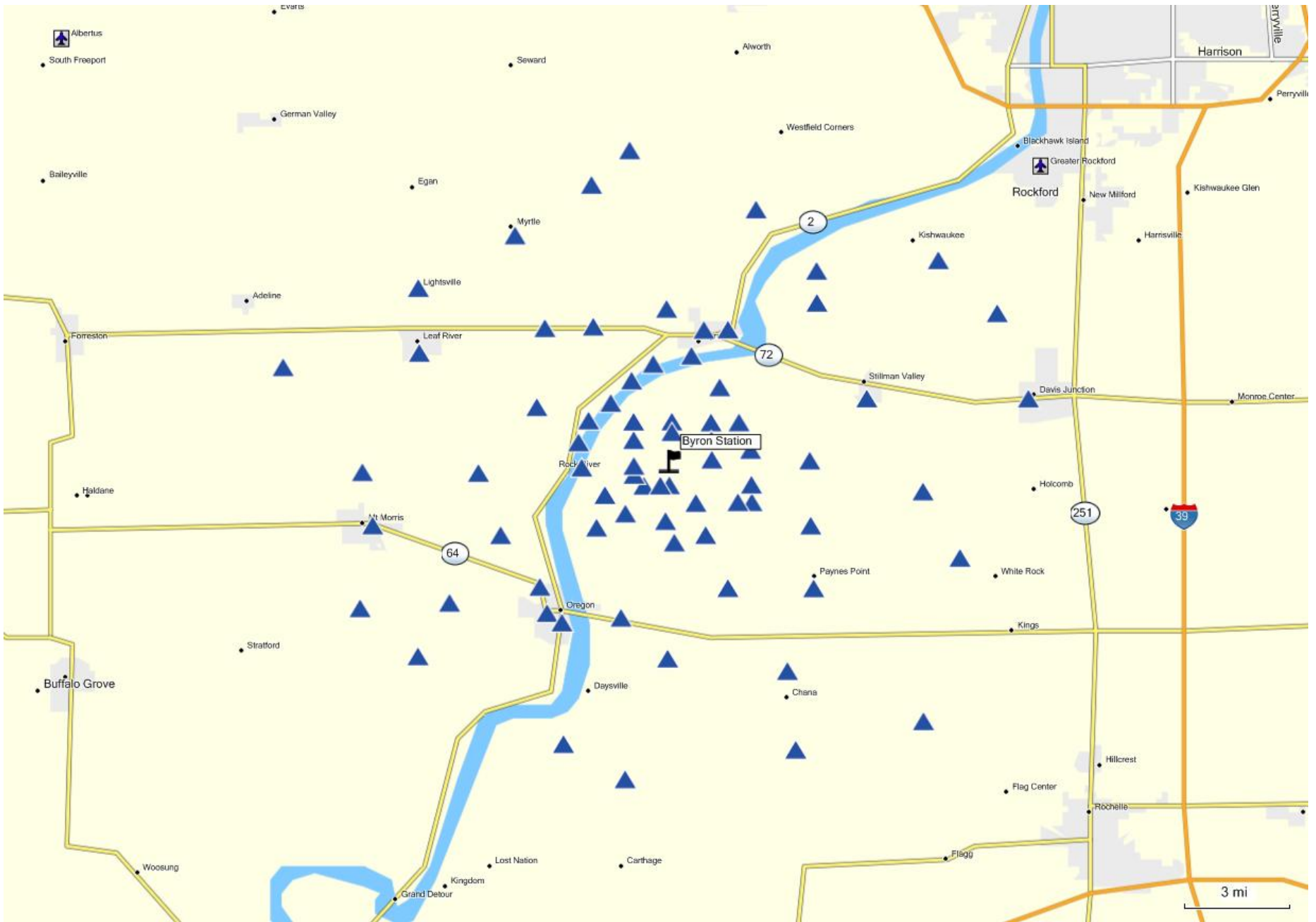


Figure 17: Byron Environmental Dosimeter Locations



## **Clinton Nuclear Power Station**

Clinton Station is located in DeWitt County, approximately six miles east of the city of Clinton in central Illinois. The station has one boiling water reactor used to generate electricity for Exelon.

Liquid effluents from the Clinton Station are released into the eastern arm of Clinton Lake, a 4900-acre man-made cooling lake. Outflow from Lake Clinton falls into Salt Creek, a tributary of the Sangamon River. The critical pathway for radiation exposure to the public is external gamma radiation from noble gases. Environmental samples collected include: lake sediment, surface and well waters.



### **Water Samples**

Water samples are collected from two wells in public recreation areas, seven locations around Lake Clinton. All water samples are collected once each quarter and typically 1 liter of water is collected per quarter. Water samples are submitted for gross alpha, gross beta, tritium and gamma spectroscopy analyses.

Water samples are monitored for several radionuclides associated with nuclear power plant operations, including, but not limited to H-3 (tritium), Co-60, Cs-137, Fe-59, and Zr-95. None of these were detected in 2009. Gross alpha and beta analyses were consistent with background.

### **Sediment Samples**

Sediment samples are collected from six locations in Clinton Lake. Sediment samples are monitored for several radionuclides associated with nuclear power plant operations: Co-58, Co-60, Cs-134, Cs-137, and Mn-54. None of these were detected in 2009.

### **Ambient Gamma**

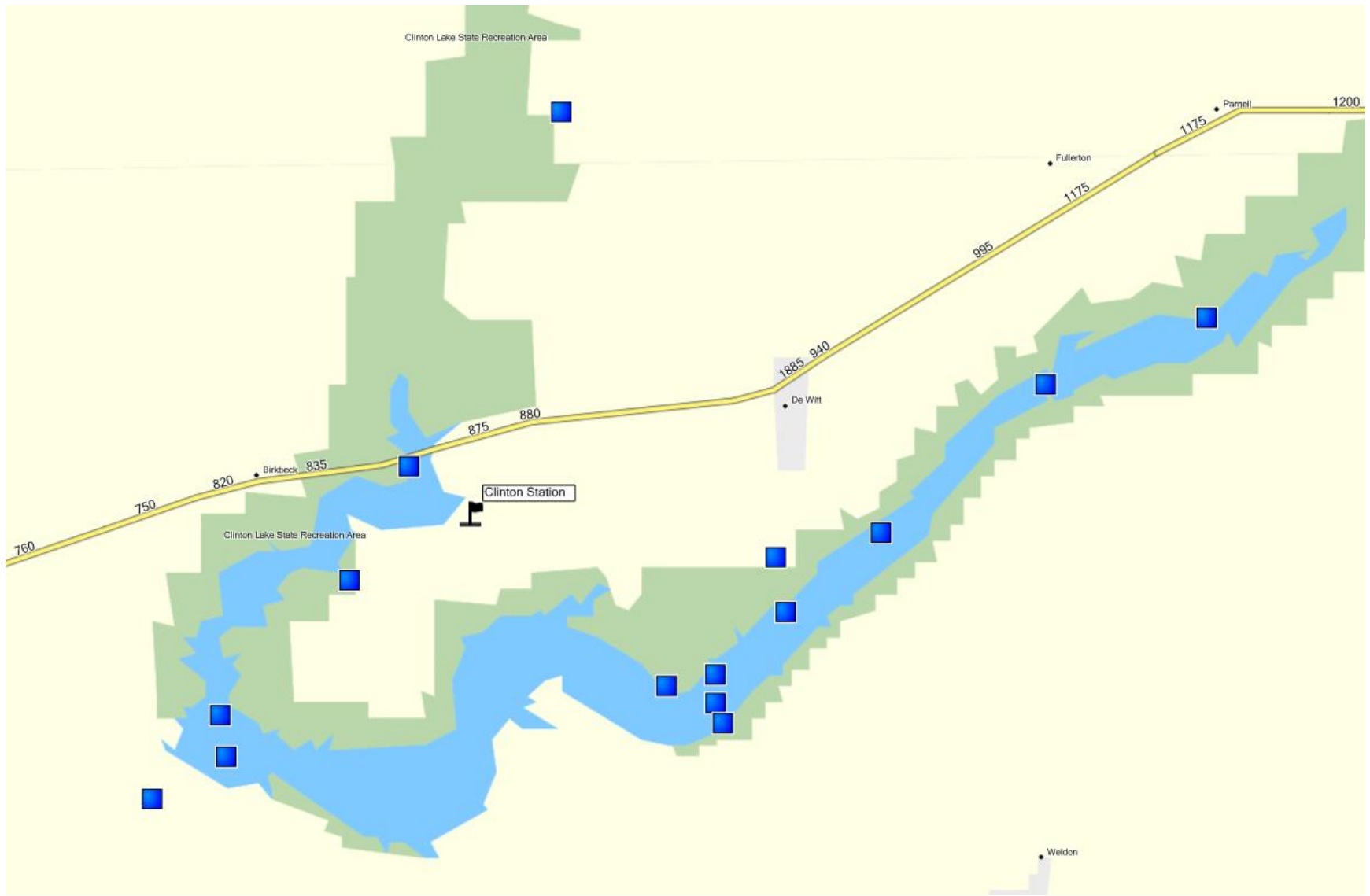
IEMA maintains a network of 50 environmental dosimeters in a ten-mile radius around the Byron station. Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays.

Dosimeters are exchanged and analyzed quarterly.

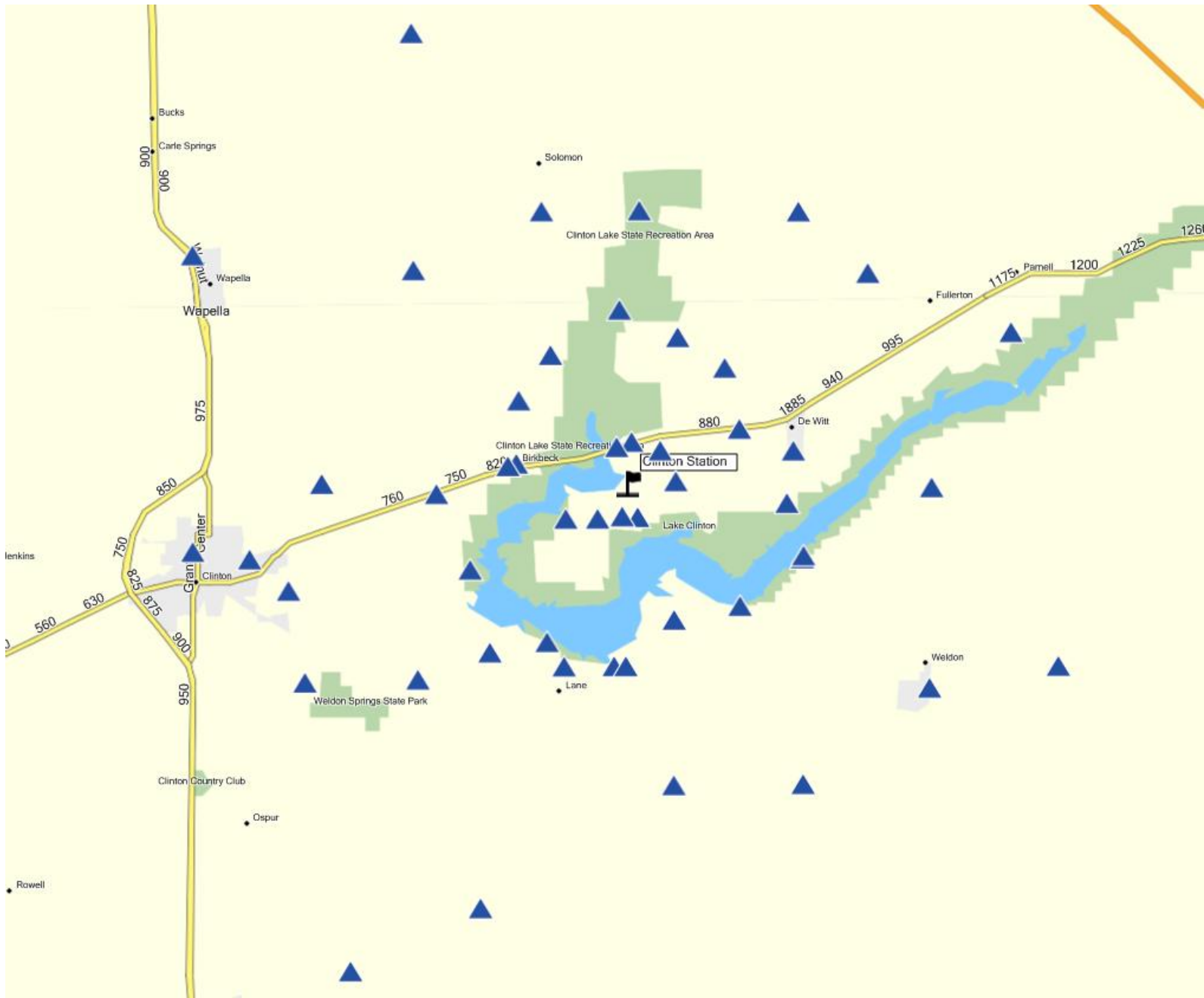
In 2008, measurements at all 50 locations were consistent with established background measurements.

**Table 6: Clinton Monitoring Locations**

<b>IEMA ID</b>	<b>Description</b>	<b>Medium</b>
150202	Well#7 At Weldon Springs Park	Ground Water
150209	Effluent Flume (@ bridge or buoys)	Surface Water
150211	North Fork Creek	Surface Water
150214	Bridge Over Lake At Rte 1489	Surface Water
150216	Salt Creek D.S. From Spillway	Surface Water
150217	Bridge Over Lake At Rte 48	Surface Water
150218	Parnell Boat Ramp	Surface Water
150219	Clinton Lake North Branch @ Rte 54 Bridge	Surface Water
150220	Mascutin Recreation Area Well	Ground Water
150221	Effluent from Alternate Cooling Pond	Surface Water
150903	Mascutin Recreation Area	Sediment
150904	Bottom Between 03 And 05	Sediment
150905	Shoreline Across Lake SE Of 03	Sediment
150907	Clinton Lake @ Flume Discharge	Sediment
150910	Channel from N. Fork	Sediment
150911	Channel Junction	Sediment



**Figure 18: Clinton Monitoring Locations**



**Figure 19: Clinton Environmental Dosimeter Locations**

## **LaSalle Nuclear Power Station**

LaSalle Station is located in LaSalle County, near Marseilles in northern, Illinois. This station has two boiling water reactors used to generate electricity for Exelon. Unit 1 began operation in March 1982 and Unit 2 in late December of 1983.

Liquid effluents from the LaSalle Station are released to the LaSalle cooling lake and from there to the Illinois River at a point 3.5 miles north of the station. However, the discharge point is approximately 20 miles downriver of the Dresden nuclear power station. Effectively, samples taken downstream of Dresden station are upstream controls for the LaSalle station. Critical pathways for radiation exposure to the public include ingestion from water and foodstuffs and external gamma radiation from noble gases. Environmental media sampled include: upstream and downstream surface water, milk, fish, and river sediment.



### **Water Samples**

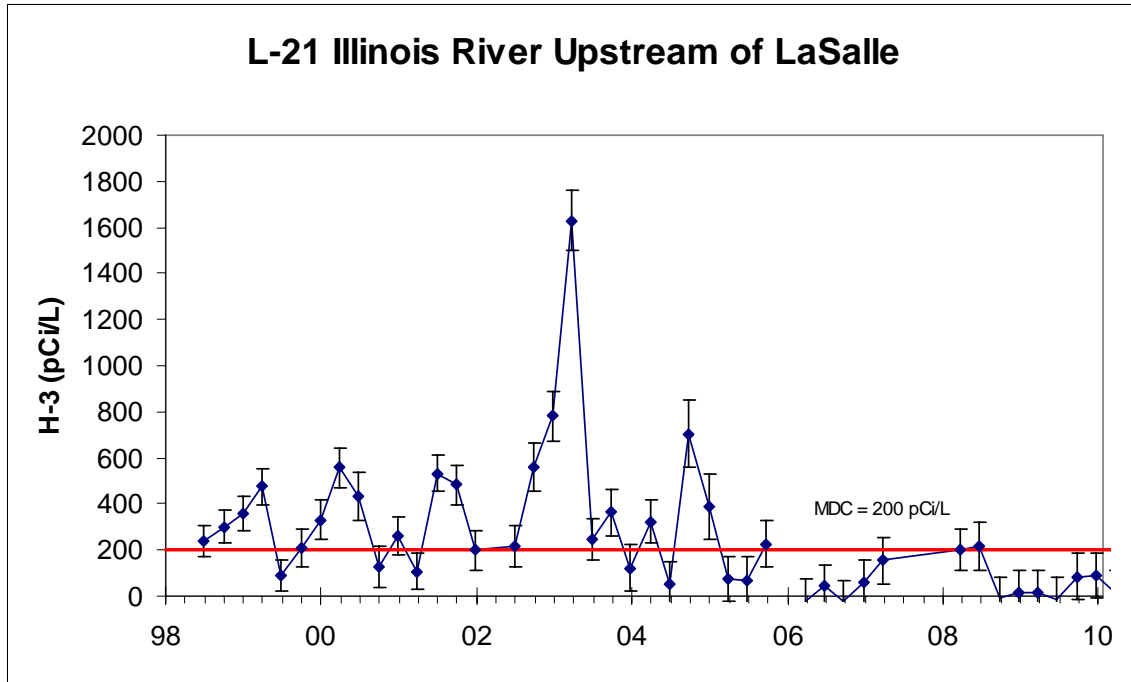
Water samples are collected from two locations in the Illinois River and two ground water wells. Ground water samples are collected once each quarter. For surface water samples, aliquots are collected weekly and composited for quarterly analysis. Typically, 3-4 liters are collected per quarter. Water samples are submitted for gross alpha, gross beta, tritium and gamma spectroscopy analyses.

Water samples are monitored for several radionuclides associated with nuclear power plant operations, including, but not limited to Co-60, Cs-137, Fe-59, and Zr-95. None of these were detected in 2009. Gross alpha and beta analyses were consistent with background.

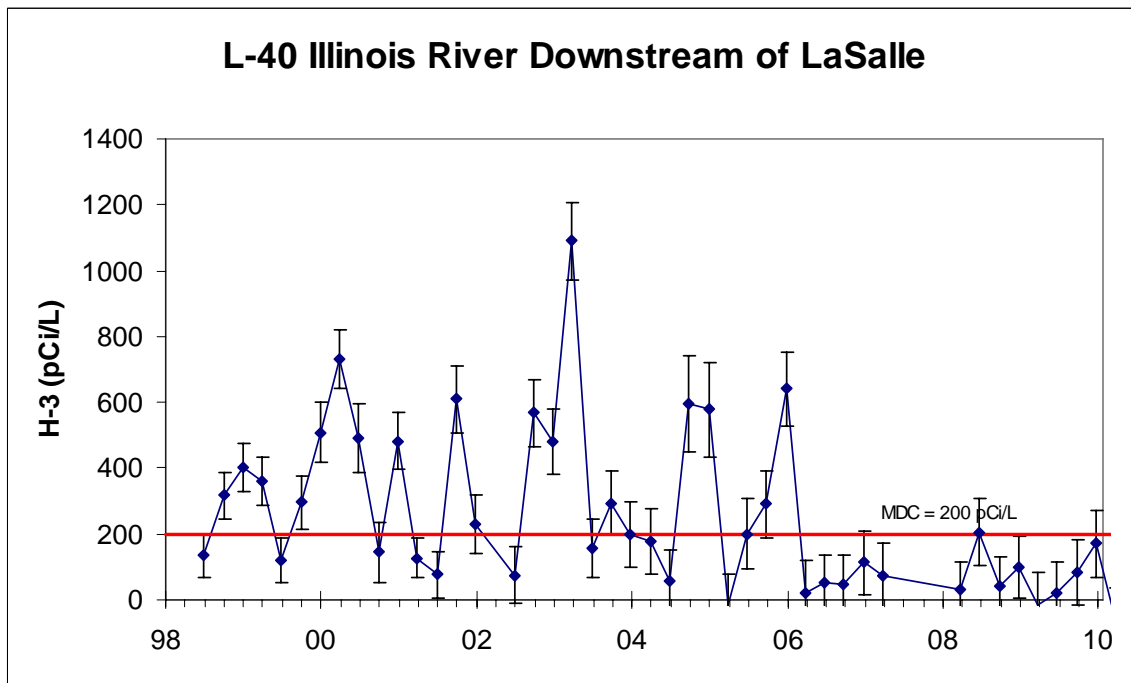
Tritium (H-3) is a normal component of the effluent stream of nuclear power plants. Liquid effluents from the LaSalle station are released to the Illinois River under permit from the Illinois Environmental Protection Agency (IEPA). Tritium was detected in Illinois River during the second quarter of 2008, both upstream and downstream of the plant, at a concentration barely above the Minimum Detectable Concentration of 200 pCi/L. By comparison, the USEPA limit for tritium in drinking water is 20,000 pCi/L. Historically, detectable concentrations of tritium have been found in the Illinois River both upstream and downstream of the LaSalle effluent point: locations L-21 and L-40, respectively, as shown in figures 1 and 2 below.

Effluent releases to the river are not continuous or constant and tritium concentrations vary accordingly. Weekly sampling provides a snapshot of what tritium concentrations are throughout the year. Although no municipalities draw their drinking water from the Illinois River, it is instructive to compare the tritium concentrations found in the river to the USEPA drinking water standard of 20,000 pCi/L, averaged over one year. This highest concentration seen at BY-12 in any one quarter is 7300 pCi/L, in 1998; the highest average for any four quarters was 2300 pCi/L from January to December, 2001.

The most striking feature of Figures 1 and 2 is that, for most of its history, tritium concentrations upstream and downstream appear to rise and fall together. There is, in fact, a positive correlation ( $R^2 = 0.72$ ) between the concentrations at points L-21 and L-40, suggesting that the concentrations are in fact related (figure 3). LaSalle monitoring points on the Illinois River are downstream from both Dresden and Braidwood nuclear power plants. Figure 4 shows the historical tritium concentrations at locations immediately downstream of Dresden station, near the Dresden Lock & Dam. There is also a positive correlation ( $R^2=0.56$ ) between concentrations at the Lock and Dam and L-21, both upstream of the LaSalle Station. This suggests that a significant portion of the tritium seen downstream of LaSalle Station is in fact not from LaSalle station.



**Figure 20: Tritium Upstream of LaSalle**



**Figure 21: Tritium Downstream of LaSalle**



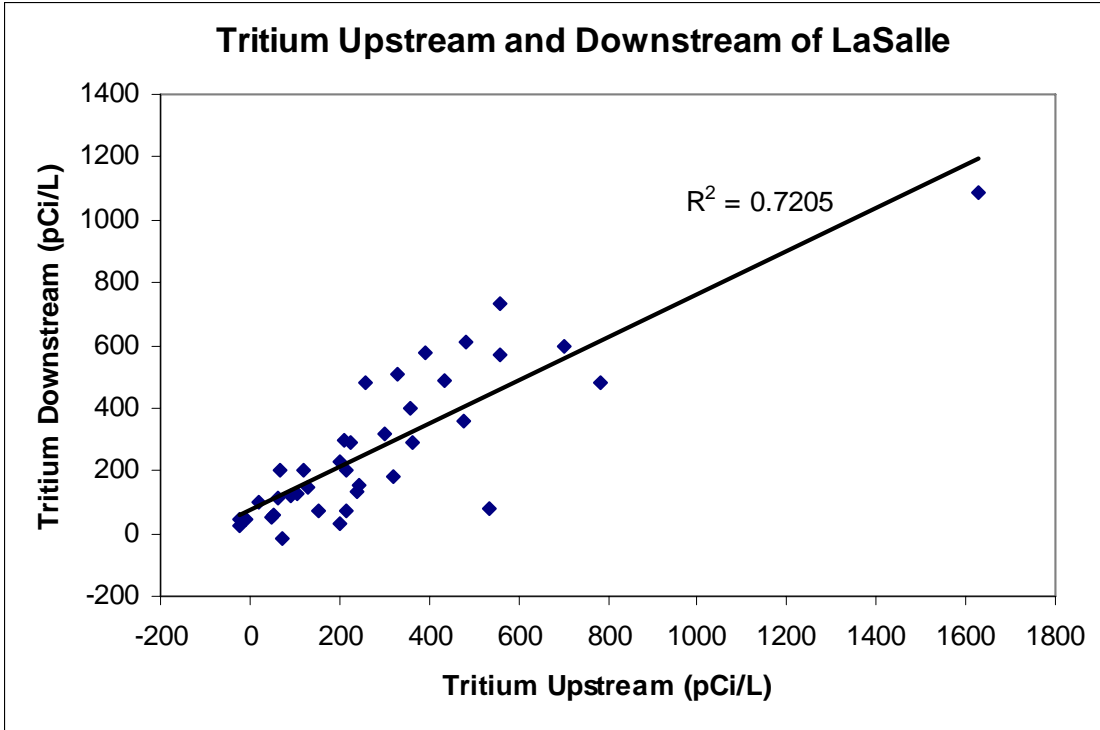


Figure 22: Correlation of Tritium Upstream and Downstream of LaSalle

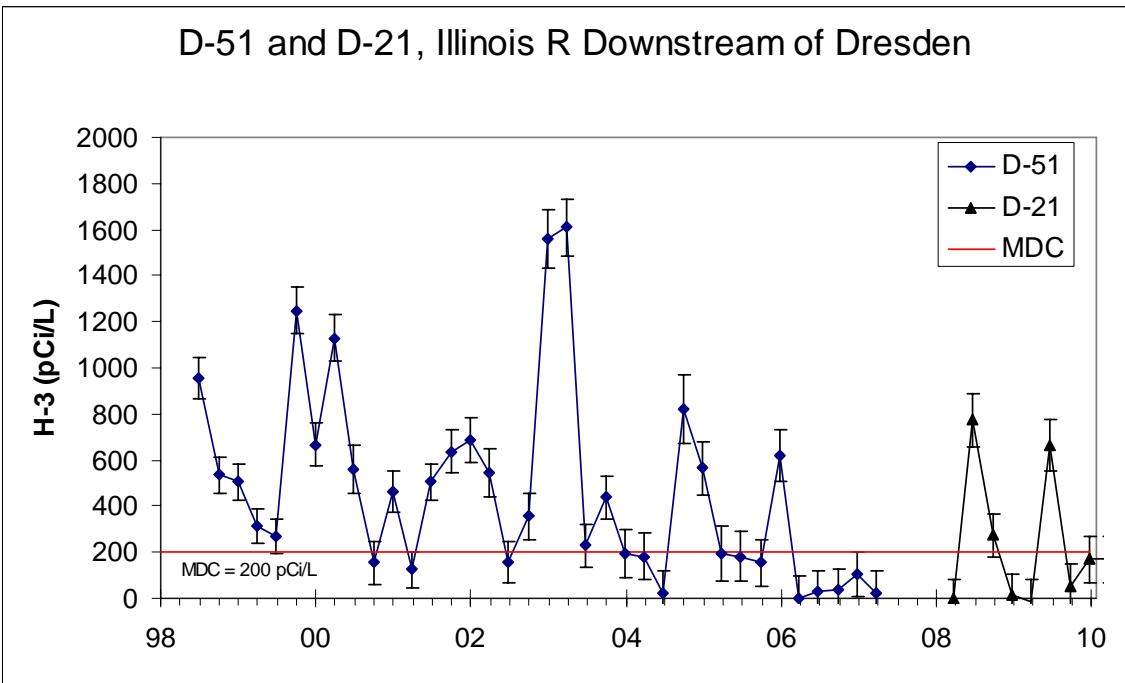


Figure 23: Tritium Downstream of Dresden (Upstream of LaSalle)

### **Milk Samples**

No dairy falls inside the ten-mile EPZ. In the event that milk samples were collected, the sample collected at BD-18 would provide a control sample.

### **Sediment Samples**

Sediment samples are collected from the rivers downstream of the plant effluent points. Sediments are collected semi-annually in spring and fall. All sediments are submitted for gamma spectroscopy analysis.

Sediment samples are monitored for several radionuclides associated with nuclear power plant operations: Co-58, Co-60, Cs-134, Cs-137, and Mn-54. Cs-137, a remnant of atmospheric nuclear weapons testing, is present in most sediment and soil at concentrations of 0.1 – 0.2 pCi/g.

In 2009, Cs-137 was detected in sediment from L-41, Illinois River, downstream, at concentrations too small to quantify (< 0.1 pCi/g). No other radionuclides associated with nuclear power plant operations were detected in samples collected near LaSalle. Other radionuclides detected were naturally occurring.

### **Fish samples**

Fish are collected from the Illinois River at a point near the plant discharge point. Two different species of fish are collected each spring and fall. Edible portions of the fish are harvested by technicians at Midwest Incorporated Laboratory and prepared for analysis. Splits of the samples are provided to the IEMA laboratory. Fish samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in fish samples. Only naturally occurring K-40 was detected, at concentrations typical of background (3 – 5 pCi/g).

### **Vegetable samples**

Two varieties of vegetables are collected annually, generally one root vegetable and one leafy green. Ideally, vegetables are collected from four farms: one in each quadrant (north, east, south, and west) from the plant, although the availability of farms may vary from year to year. In 2009, samples were collected from all four quadrants. Vegetable samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in vegetable samples. Only naturally occurring K-40 was detected.

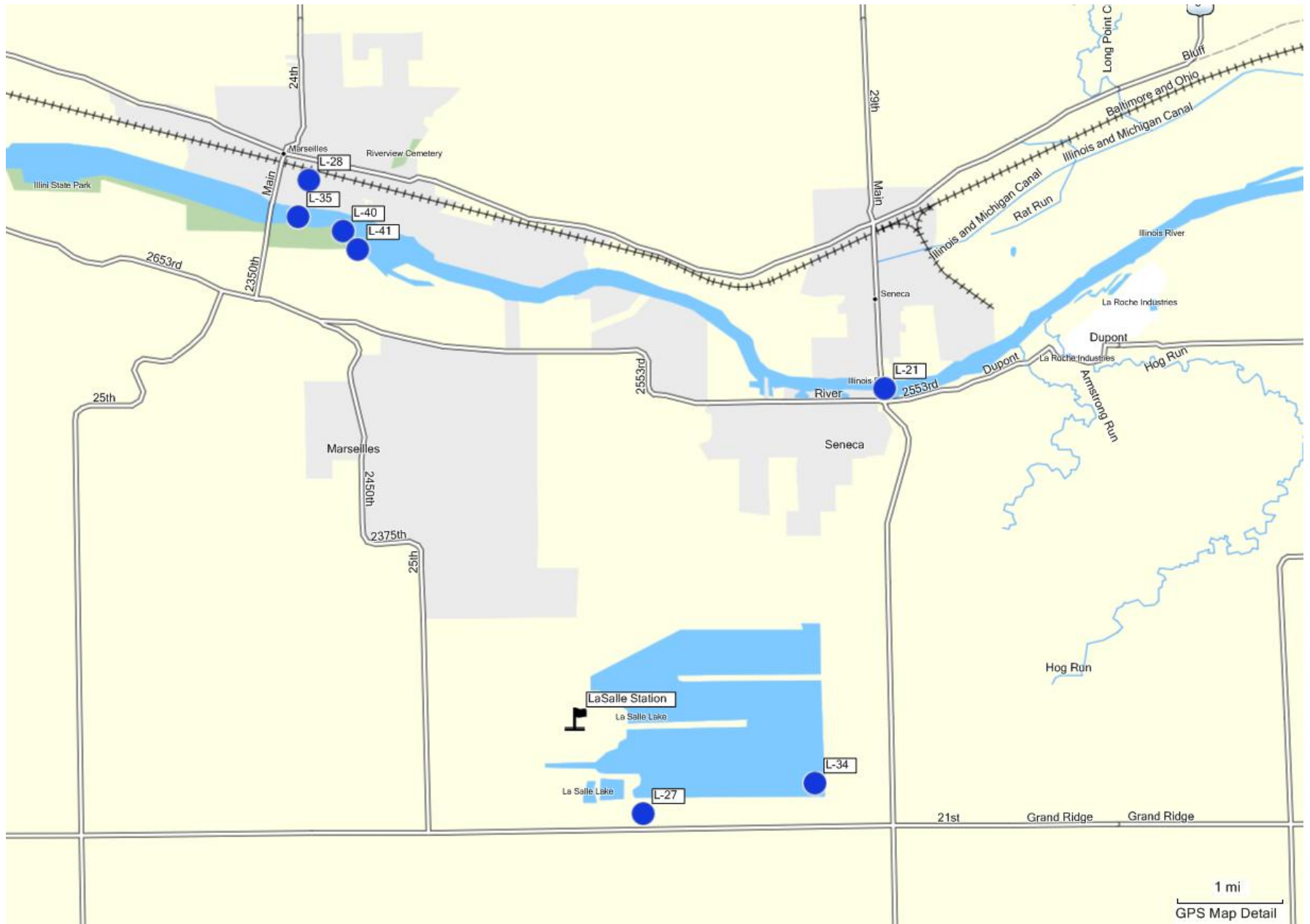
**Ambient Gamma**

IEMA maintains a network of 54 environmental dosimeters in a ten-mile radius around the Byron station. Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. Dosimeters are exchanged and analyzed quarterly.

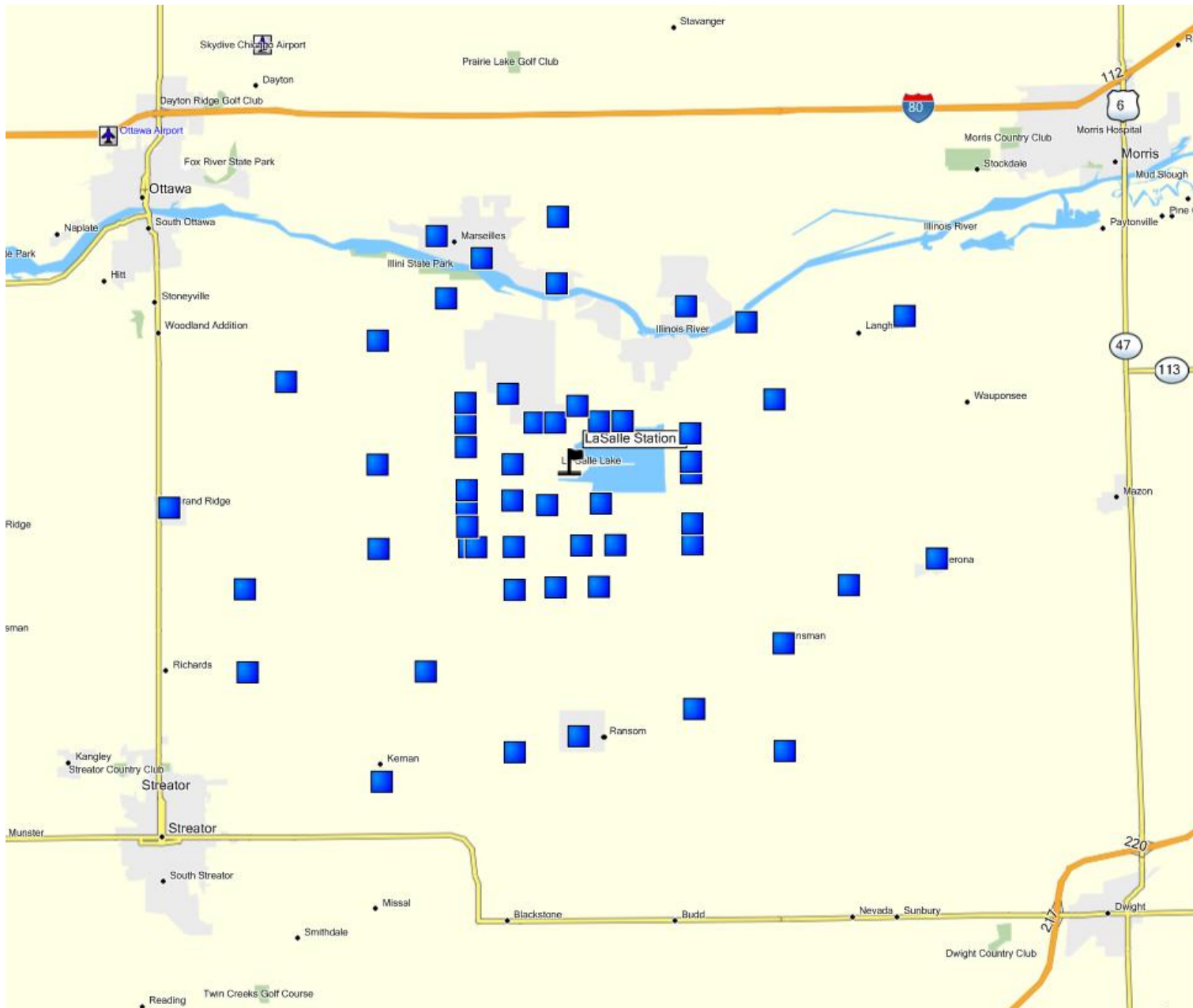
In 2009, measurements at all 54 locations were consistent with established background measurements.

**Table 7: LaSalle Monitoring Locations**

<b>IEMA ID</b>	<b>Exelon ID</b>	<b>Location</b>	<b>Medium</b>
050214	L-21	Illinois River Upstream	Surface Water
050216	L-40	Illinois River Downstream	Surface Water
050217	L-28	Public Well	Ground Water
050218	L-27	Onsite Well	Ground Water
050616	L-35	Illinois River, Marseilles Pool	Fish
050619	L-34	LaSalle Cooling Lake	Fish
050701	L-QUAD#1	Farm in Quadrant #1	Vegetables
050702	L-QUAD#2	Farm in Quadrant #2	Vegetables
050703	L-QUAD#3	Farm in Quadrant #3	Vegetables
050704	L-QUAD#4	Farm in Quadrant #4	Vegetables
050905	L-41	Illinois River Downstream	Sediment



**Figure 24: LaSalle Monitoring Locations**



**Figure 25: LaSalle Environmental Dosimeter Locations**

## **Quad Cities Nuclear Power Station**

Quad Cities Station is located in Rock Island County in northwestern Illinois, approximately twenty miles northeast of Moline, Illinois. This station utilizes two boiling water reactors to generate electricity for Exelon.

Liquid effluents from the Quad Cities Station are released to the adjacent Mississippi River. Critical pathways for radiation exposure to the public include I-131 in milk, ingestion from drinking water and foodstuffs and external gamma radiation from noble gases. Samples collected include: downstream surface and public drinking waters, milk from a local dairy farm, fish, local vegetables and river sediments from the Mississippi River.



### **Water Samples**

Water samples are collected from two points in the Mississippi River and two ground water wells. Ground water samples are collected once each quarter. For surface water samples, aliquots are collected weekly and composited for quarterly analysis. Typically, 3-4 liters are collected per quarter. Water samples are submitted for gross alpha, gross beta, tritium and gamma spectroscopy analyses.

Water samples are monitored for several radionuclides associated with nuclear power plant operations, including, but not limited to H-3 (tritium), Co-60, Cs-137, Fe-59, and Zr-95. None of these were detected in 2009. Gross alpha and beta analyses were

consistent with background. Although Quad Cities station does release tritium to the Mississippi River, no tritium has ever been detected in the river.

### **Milk Samples**

Milk samples are collected from a local dairy. Milk samples are collected monthly from November through April or bi-weekly May through October. Milk samples are mailed directly to the IEMA laboratory and analyzed within five days of sampling by gamma spectroscopy, specifically for short-lived iodine isotopes.

No radionuclides associated with nuclear power plant operations were detected in milk samples. Only naturally occurring K-40 was detected, within the range typical of established background (1200 to 1500 pCi/L).

### **Sediment Samples**

Sediment samples are collected from the Mississippi River at a point downstream of the plant effluent stream. Sediments are collected semi-annually in spring and fall. All sediments are submitted for gamma spectroscopy analysis.

Sediment samples are monitored for several radionuclides associated with nuclear power plant operations: Co-58, Co-60, Cs-134, Cs-137, and Mn-54. Cs-137, a remnant of atmospheric nuclear weapons testing, is present in most sediment and soil at concentrations of 0.1 – 0.2 pCi/g.

In 2009, Cs-137 was detected in sediment from Q-39, Mississippi River at Cordova, at concentrations too small to quantify (< 0.1 pCi/g). This is typical of background. No radionuclides associated with nuclear power plant operations were detected in samples. Other radionuclides detected were naturally occurring.

### **Fish samples**

Fish are collected from the Mississippi River at a point near the plant discharge point. Two different species of fish are collected each spring and fall. Edible portions of the fish are harvested by technicians at Midwest Incorporated Laboratory and prepared for analysis. Splits of the samples are provided to the IEMA laboratory. Fish samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in fish samples. Only naturally occurring K-40 was detected, at concentrations typical of background (3 – 5 pCi/g).



### **Vegetable samples**

Two varieties of vegetables are collected annually, generally one root vegetable and one leafy green. Ideally, vegetables are collected from four farms: one in each quadrant (north, east, south, and west) from the plant, although the availability of farms may vary from year to year. In 2009, samples were collected from all four quadrants. Vegetable samples are analyzed for reactor-produced radionuclides using gamma spectroscopy.

No radionuclides associated with nuclear power plant operations were detected in vegetable samples. Only naturally occurring K-40 was detected. Concentrations vary too widely between varieties for meaningful comparisons.

### **Ambient Gamma**

IEMA maintains a network of 66 environmental dosimeters in a ten-mile radius around the Quad Cities station. Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. Dosimeters are exchanged and analyzed quarterly.

In 2008, measurements at all 66 locations were consistent with established background measurements.

**Table 8: Quad Cities Monitoring Locations**

<b>IEMA ID</b>	<b>Exelon ID</b>	<b>Description</b>	<b>Medium</b>
020214	Q-36	Cordova Well	Ground Water
020215	Q-33	Miss. River, downstream at Cordova	Surface Water
020216	Q-34	Miss. River, upstream at Comanche	Surface Water
020217	Q-35	Residential Well	Ground Water
020505	Q-26	Dairy Farm	Milk
020601	Q-24	Miss. River, Pool #14	Fish
020701	Q-QUAD#1	Farm in Quadrant #1 (north)	Vegetation
020702	Q-QUAD#2	Farm in Quadrant #2 (east)	Vegetation
020703	Q-QUAD#3	Farm in Quadrant #3 (south)	Vegetation
020704	Q-QUAD#4	Farm in Quadrant #4 (west)	Vegetation
020905	Q-39	Miss. River, downstream at Cordova	Sediment

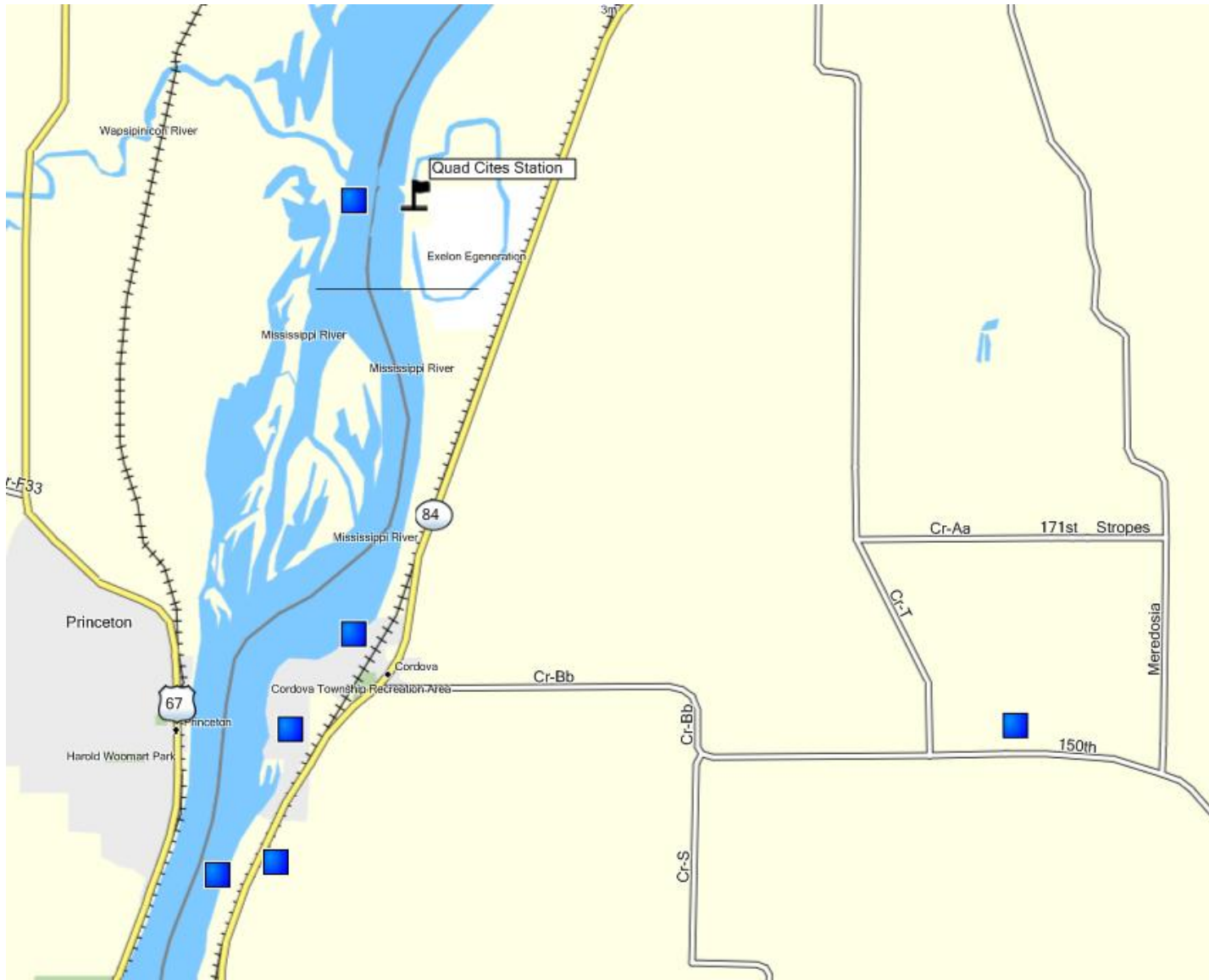
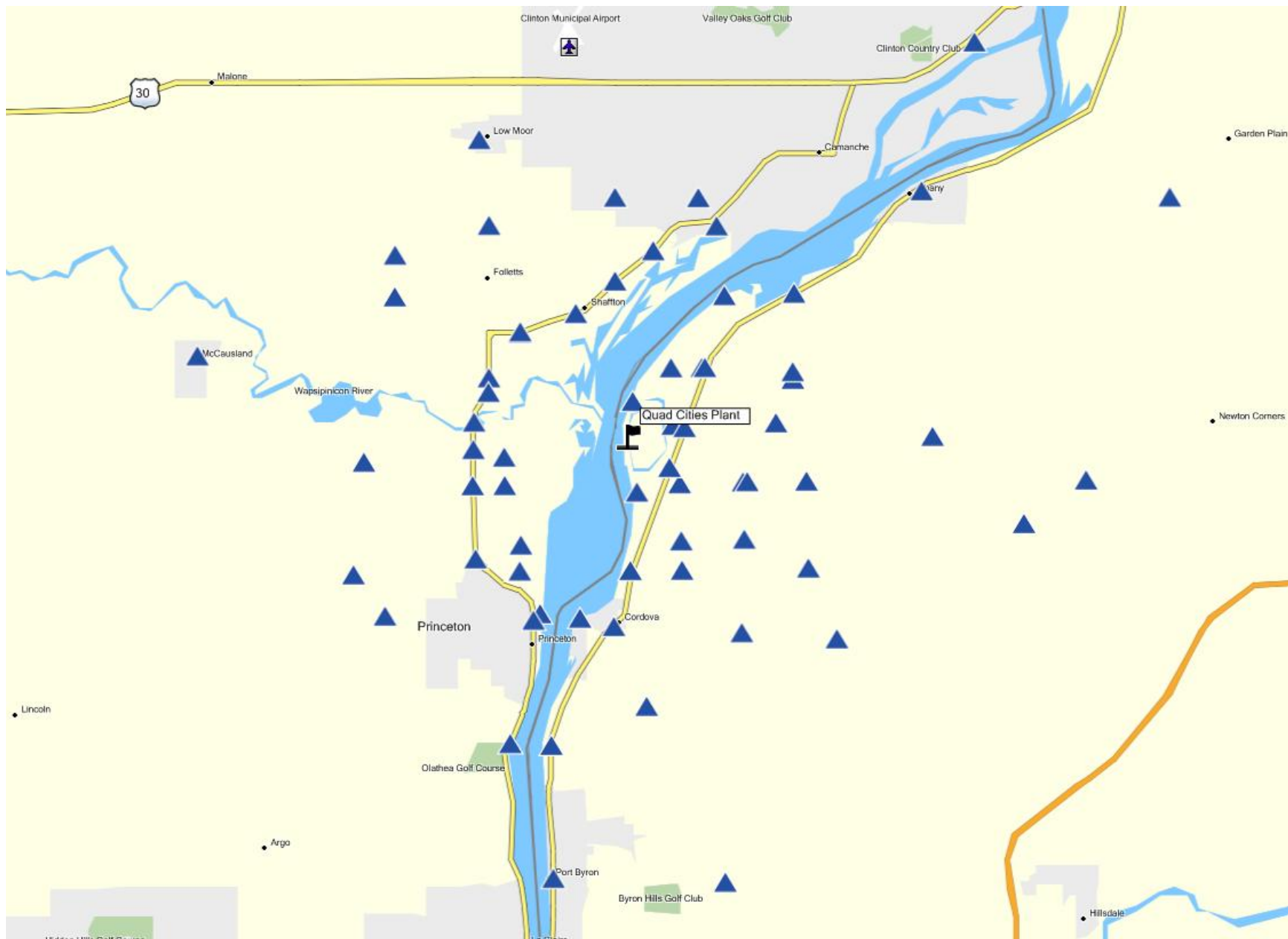


Figure 26: Quad Cities Monitoring Locations



**Figure 27: Quad Cities Environmental Dosimeter Locations**

## **Zion Nuclear Power Station**

Zion Station is located next to Lake Michigan in Zion, Illinois, approximately forty miles north of Chicago. The plant ceased operation permanently in February 1998 and was defueled soon thereafter. Spent fuel assemblies remain stored in the fuel pool of the fuel building. Prior to 1998, the station utilized two pressurized water reactors to generate electricity.

Liquid effluents from the Zion Station are released to Lake Michigan at a point near Zion Beach. Critical pathways for radiation exposure to the public include ingestion from drinking water and foodstuffs. Because of decay, iodine is no longer present. Samples collected include: public drinking waters in Illinois and Wisconsin, as well as sediment from Lake Michigan.



### **Water Samples**

Water samples are collected from four public water systems which draw their water from Lake Michigan near Zion station: Lake County, Waukegan, Kenosha and Lake Forest. At each water supply, aliquots are collected weekly and combined to make a single quarterly composite sample for each community. Typically, 3-4 liters are collected per quarter. Water samples are submitted for gross alpha, gross beta, tritium and gamma spectroscopy analyses.

Water samples are monitored for several radionuclides associated with nuclear power plant operations, including, but not limited to H-3 (tritium), Co-60, Cs-137, Fe-59, and Zr-95. None of these were detected in the community water samples in 2008.

Although tritium (H-3) is a normal component of the effluent stream of nuclear power plants, because the fuel has been removed from the reactor, it is unlikely that significant amounts of tritium would be released.

### **Sediment Samples**

Sediment samples are collected from Lake Michigan near Illinois Beach State Park. Sediments are collected semi-annually in May and October. All sediments are submitted for gamma spectroscopy analysis.

Sediment samples are monitored for several radionuclides associated with nuclear power plant operations: Co-58, Co-60, Cs-134, Cs-137, and Mn-54. Cs-137, a remnant of atmospheric nuclear weapons testing, is present in most sediment and soil at concentrations of 0.1 – 0.2 pCi/g.

In 2009, no radionuclides associated with nuclear power plant operations were detected in samples collected near Zion. Other radionuclides detected were naturally occurring.

### **Ambient Gamma**

IEMA maintains a network of 24 environmental dosimeters in a ten-mile radius around the Quad Cities station. Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. Dosimeters are exchanged and analyzed quarterly.

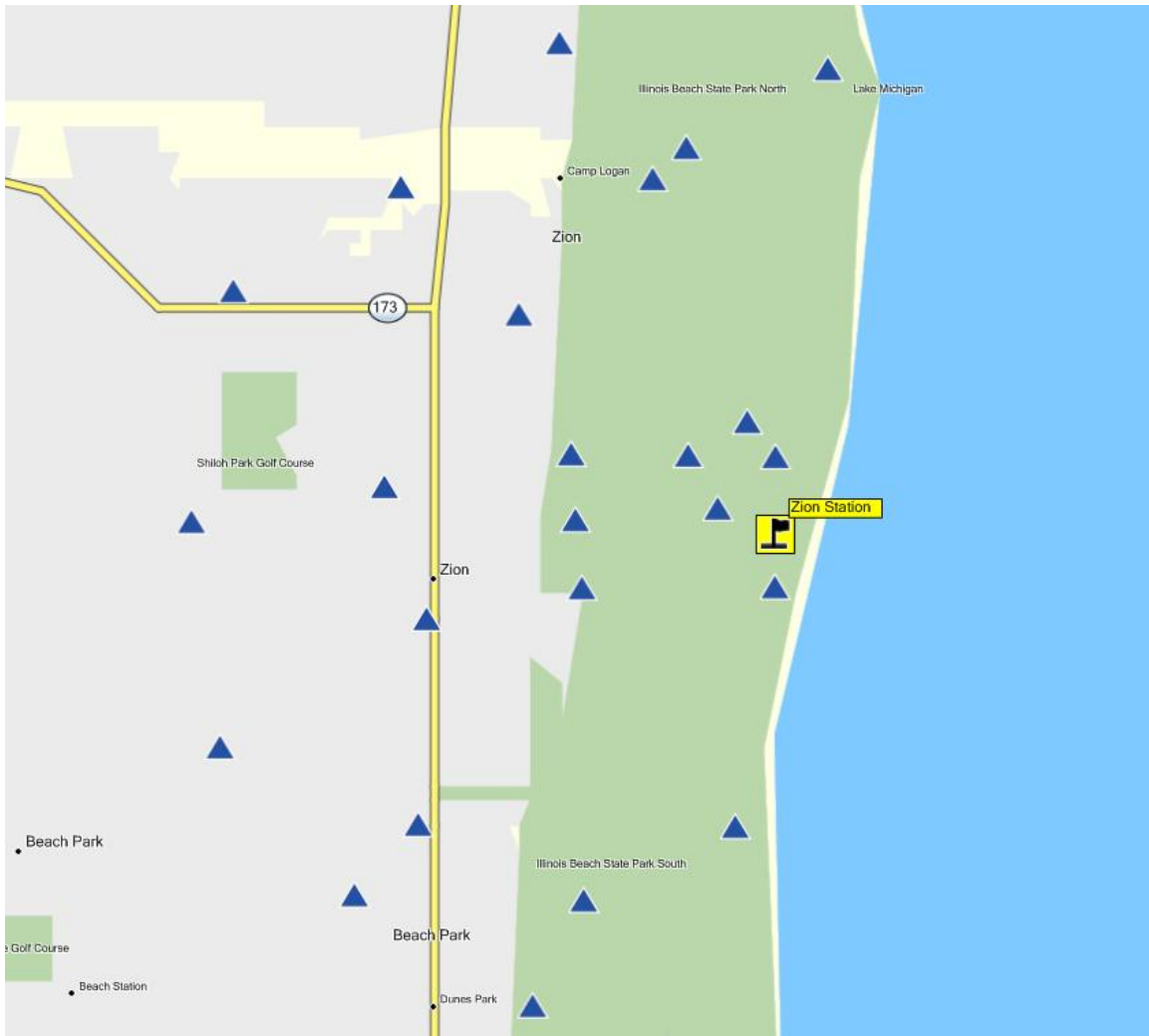
In 2008, measurements at all 24 locations were consistent with established background measurements.

**Table 9: Zion Monitoring Locations**

<b>IEMA ID</b>	<b>Exelon ID</b>	<b>Description</b>	<b>Medium</b>
030205	Z-15	Lake County PWS	Public Water
030206	Z-16	Waukegan PWS	Public Water
030208	Z-14	Kenosha PWS	Public Water
030210	Z-18	Lake Forest PWS	Public Water
030902	Z-25	Lake Michigan @ State Park	Sediment



**Figure 28: Zion Monitoring Locations**



**Figure 29: Zion Environmental Dosimeter Locations**