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A

**A Spatial and Statistical Investigation of Dioxin-Furan Contamination**

**In the**

**Sediments of the Hudson Raritan Estuary**

**By**

**William John Hansen**

**A dissertation submitted to the Graduate Faculty in Earth and Environmental Sciences in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York**

**2002**

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This manuscript has been read and accepted for the Graduate Faculty in Earth and Environmental Science in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy

4/22/2002  
Date

Gerald M. Friedman  
Gerald M. Friedman, Ph. D.  
Chair of Examining Committee

April 22, 2002  
Date

Jeffrey Osleeb  
Jeffrey Osleeb, Ph. D.  
Executive Officer, Department of Earth and Environmental Science

David Locke, Ph. D., Queens College

Sean Ahearn, Ph. D., Hunter College

Richard Bopp, Ph. D., Rensselaer Polytechnic Institute

Supervisory Committee

The City University of New York

## **Abstract**

# **A Spatial and Statistical Investigation of Dioxin-Furan Contamination in the Sediments of the Hudson Raritan Estuary**

**By**

**William John Hansen**

**Advisor: Professor Gerald M. Friedman**

**Sediment sampling results from a number of studies were examined for the spatial, statistical and temporal patterns in dioxin concentration and dioxin congener patterns. Principal component analysis and cluster analysis were used to group the sediment samples into a smaller set of variables. The spatial and temporal distribution of these derived data were examined with respect to industrial activity, cultural trends and industrial accidents. A GIS was used to analyze sample points for spatial correlation with sources of dioxin contamination. Time horizons were established using Cesium 137 and Lead 210 activities and historical bathymetric.**

**The results of these analyses indicate that current deposition of dioxin contamination in the Harbor Estuary is dominated by higher chlorinated dioxin furans from combustion sources, such as automobiles, trucks and to a more limited extent, municipal and industrial incineration. Subsurface samples show a more complex array of dioxin-furan congener patterns with numerous dioxin sources including combustion sources, chemical discharges and sewage treatment plants. Some of the patterns are not found in the dioxin-furan source literature, they may result from historical industrial or combustion processes that have been banned or discontinued. The radioisotope and bathymetric dating procedures established time frames for the dioxin-furan congener patterns.**

**The most significant single source of dioxin contamination in the Harbor Estuary is the former Diamond Alkali Site, on the Lower Passaic River. Long-term production of 2,4,5**

trichlorophenoxy acetic acid (2,4,5-T) and an industrial accident in 1960 released massive amounts of dioxin contamination into the adjacent Passaic River, leaving a distinct pattern of dioxins, primarily 2,3,7,8-tetrachlorinated dibenzo dioxin. Two of the clusters identified result from contamination at this site; one represents long term production of 2,4,5-T, while the other is a unique signature from the 1960 explosion and fire. Although largely buried this hot spot of contamination is close to the surface in a number of locations. This represents a threat to biota due to the potential for reintroduction into biologically active zone as well as a barrier to human use of the Lower Passaic River for manufacturing and recreational boating.

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**To Josephine**

**and**

**Olivia**

**My heart and hope**

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## **Chapter 1 - Pollution in the Hudson Watershed**

### **Introduction**

The Hudson Estuary contains a population in excess of 17 million people. The development and industrialization of this urban complex over the past 350 years has had a severe impact on the water quality, sediments, topography and physical processes in the harbor. Environmental regulations enacted over the past quarter of a century have drastically reduced the input of contaminants, and as a result the water quality of the estuary has improved. However an ongoing and seemingly intractable problem concerns the high level of contamination in harbor sediments.

In its natural condition the harbor would have an average depth of less than 20 feet. To allow entry to large commercial vessels the harbor must be dredged. The creation of channels and berths below the harbor bottom's "profile of equilibrium," combined with the estuary's natural role as a sediment trap has resulted in the need to dredge millions of cubic yards of sediment per year (Friedman, 1996). Environmental regulations, which helped to reduce the loading of toxics and nutrients into the harbor, also affect the removal and disposal of contaminated sediments in the harbor.

The Port of New York-New Jersey is vital to the economy of the metropolitan area. It is currently the second leading port in the U.S. in terms of dollar amount of cargo. Fifty million tons of cargo per year is delivered here with an impact on the regional economy estimated to be around 20 billion dollars per year. The network of channels serving the Port totals 240 miles, they must be maintained at depths between 30 and 45 feet. About 75% of the dredging is done by the US Army Corps of Engineers (COE). They are responsible for the federal channels leading into the harbor. Additional dredging is carried out by private marinas, industrial facilities and the Port Authority of New York and New Jersey (Wakeman, 1996).

Until recently, virtually all dredged material was disposed at the Mud Dump site located 6 miles offshore of Sandy Hook New Jersey. In 1977 the EPA and the COE developed an Ocean Dumping Criteria for dredged material (O'Conner, 1982). Material that was toxic would not be permitted to be disposed at the Mud Dump Site. The criteria mandated that dredged material with the potential to result in the bioaccumulation of contaminants (metals, pesticides and PCB's) must be given special treatment. In 1992 the EPA revised its testing in addition, new analytical methods were developed for determining very low levels of dioxin contamination, down to parts per trillion. As a result of these two actions the percentage of sediments classified as too toxic for ocean disposal increased from 5% to 34%. This change has had a dramatic impact on dredging practices in the harbor as there were few procedures in place for handling large volumes of sediment (DeVicario 1996).

The presence of 2,3,7,8-TCDD in sediments in the estuary, particularly in Passaic River and Newark Bay sediments, has created a serious environmental management issue. A key issue is the extent and sources of dioxin contamination. The US Army Corps of Engineers and the US Environmental Protection Agency are considering dredging and decontaminating highly toxic sediments. This procedure is extremely expensive, between \$500 and \$1500 per cubic yard, and is only practical if there are highly contaminated localized "hot spots" which serve as a source of contamination to the harbor.

An area on the Passaic River upstream from the head of Newark Bay is considered by a number of investigators to be a hot spot of dioxin contamination. On the south bank of the river at this location is a former pesticide manufacturing plant, the Diamond Alkali Site. The plant produced 2,4,5 trichlorophenoxy acetic acid (2,4,5-T), a component of Agent Orange (Bopp, et al., 1991). Polychlorinated Dibenzo-p-dioxins (PCDD's) are a low level by-product in the production of 2,4,5-T. The PCDD mixture resulting from 2,4,5-T production contains significant

2,3,7,8-TCDD, the most toxic dioxin congener and one of the most toxic human synthesized chemicals.

### **Development in the Hudson Watershed**

The source of the Hudson River is Lake Tear of the Clouds, a small pond on the flank of Mount Marcy in the Adirondack Mountains. It flows 513 kilometers south before emptying into the Atlantic Ocean through the Hudson-Raritan Estuary. Between the Hudson, Passaic, Hackensack s and Raritan Rivers, the estuary receives the drainage from about 40,000 square kilometers. Land use in the drainage area varies from the forested Adirondack and Catskill Mountains, to the largest and most densely populated metropolitan area in the United States. The Estuary is surrounded by the New York metropolitan area containing a population in excess of 17 million people. The development and industrialization of this urban complex, as well as changes in the entire drainage area, over the past 350 years has had a severe impact on the water quality, sediments, topography and physical processes in the harbor.

Archeological evidence shows human habitation of the Hudson watershed since approximately 9000 years ago (Burrows and Wallace, 1999). The early Paleo-Indian cultures were hunter and gather societies using simple stone tools. Evidence of agriculture appears around AD 1000 with cultivation of maize, beans and squash. At the time of first contact with Europeans, in the 16<sup>th</sup> century, the total population in the watershed was estimated at between 62,000 and 68,000 (Salwen, 1976). The effect of this human population on the water quality was slight. Fires set to maintain open land for agriculture had begun to alter the woodland cover of the area and likely led to increased soil erosion. Mounds of oyster shells along the edge of the estuary demonstrate intensive shellfish harvesting. Native populations were decimated by the introduction of European diseases such as smallpox and cholera soon after the first contact. By



the time European settlement took place, almost a 100 years after the first contact, the environment had started to recover from these low intensity effects.

European settlement began in 1624 when a group of Dutch settlers established outposts at New Amsterdam (lower Manhattan) and Albany (Fort Orange). The colony grew very slowly due to the reluctance of Dutch citizens to leave their homes for the wilds of North America. After the takeover of the colony by the English in 1674 the population began to grow more rapidly. It reached 20,000 by 1703 and did not reach the level of highest estimated Native population until about 1750. The population reached 100,000 by the time of the War of Independence. Surges of immigration fueled by developments such as steam power, the opening of the Erie Canal and the development of the railroad led to a forty fold increase in population by 1880 (NYC DEP, 1996). The population in the watershed today is over 13 million based on the 1990 US Census of population.

The intensive use of the Hudson and it's watershed area as a human resource resulted from the numerous advantages it offers. The river is tidal for over 150 miles allowing easy two-way movement long before the development of steam power. The Hudson provides easy crossing of the Appalachian mountains, the main barrier to inland penetration of the North American continent from the east coast. This intensive use however is not without cost, it has resulted in a myriad of impacts on the physical, chemical and even temperature characteristics of the river. These anthropogenic alterations, commonly called pollution, have adversely affected the flora and fauna of the river as well as human uses such as fishing, swimming and water consumption.

The primary sources of historical pollution in the watershed are:

- Wastewater Discharge
- Dumping of Refuse
- Industrial Discharge

- **Accidental Spill of Toxic materials**
- **Non-Point Source Runoff**

These sources vary greatly in geographic and historic extent and regulatory control. For example, the direct dumping of refuse, at one time the most serious effect on water quality, has been largely eliminated while wastewater discharge remains the most important factor in the water quality of the watershed.

### **Wastewater Discharge**

Wastewater discharge has been a serious problem in the watershed since early European settlement. Today it ranks as the greatest and most intractable water quality issue in the Hudson basin. Even with improved treatment the sheer volume of wastewater discharge, 15% of average freshwater input up to 25% during low flow periods, means even low levels of contaminants in wastewater are a serious concern. Beside the obvious aesthetical drawback to sewage discharge into the waterway other problems include health concerns over pathogens either directly through bathing contact or by consumption of seafood. Additional problems are the Biological Oxygen Demand of sewage input resulting in diminished or totally eliminated Dissolved Oxygen. This condition known as anoxia results in fish and other aquatic organism deaths, disruption to the food chain, buildup of organic bottom sediments which may bind other toxic materials, and noxious odors. Sewage discharge includes high levels of nitrogen and phosphorus, which in addition to the organic carbon loading result in algal blooms. These blooms reduce DO and can result in fish kills and fish and shellfish toxicity.

The first wastewater collection system was established in 1696 in response to complaints over the odor and vermin drawn by the buildup of human and animal wastes on the streets of lower Manhattan. These sewers were designed primarily for storm runoff, privies continued to be the primary means of human waste disposal well into the 19<sup>th</sup> century. As the population boomed after the opening of the Erie Canal in 1821 most of lower Manhattan was laid out with a network of sewer pipes. The collected effluent was discharged directly into the East River and Hudson (North) River

One of the earliest examples of water pollution in New York was the condition of the Freshwater Pond a 70 acre body of water in lower Manhattan which today is bisected by Centre street between Worth and Canal. By the late 1790's newspapers complained of the smell emanating from what was formerly the main source of drinking water for the dutch settlement. Human and animal waste as well as runoff from breweries, tanneries and slaughterhouses created such foul conditions that the city purchased the pond and the surrounding area in 1798 and filled it in.

As population and sewage discharge continued to increase at the end of the 19<sup>th</sup> century, concern grew over the effect of the degradation of water quality in New York harbor. Early advances in epidemiology and microbiology led to the discovery of the link between human waste and disease. Outbreaks of typhoid in Jamaica Bay and Raritan Bay in the early decades of nineteen hundreds led to the New York State Health Department's closure of the oyster beds in New York Harbor. A resource that helped support human habitation of the watershed for over two millennia ceased operation in 1925.

Health concerns led to the creation of the New York Metropolitan Sewerage Commission in 1906. The Commission was given the mandate to examine the magnitude and extent of water pollution and develop a plan for improving water quality. It issued a report in 1910, which

characterized the Harbor as more polluted than considerations of health and welfare should allow, " (Suszkowski, 1978). The Commission's study estimated that 26 cubic meters per second (m<sup>3</sup>/s ) (600 gallons per day) of raw sewage were being discharged into New York Harbor. A plan was drawn up calling for the upgrade of the New York City sewer system, a centralized discharge pipe in the middle of Upper New York Bay and improvement in sewage treatment (Suszkowski, 1990).

The first sewage treatment plant in the metropolitan area was constructed in 1886 in Coney Island. It consisted of screens to catch solids and keep floatables from washing up on the bathing beaches. Starting in the 1930's modern sewage treatment plants were constructed. Yonkers began construction on the North and South Yonkers plants in 1933, designed to treat 130 million gallons per day (mgd). The first New York City plant was the Coney Island water pollution control plant, started in 1935 (Brosnan and O'Shea, 1994). Three East river plants were started in 1938 and the Passaic Valley plant, constructed in 1924, was greatly expanded to handle 250 mgd in 1937 (Brosnan and O'Shea, 1994).

In the Passaic Valley rapid development and industrialization in the latter part of the 19<sup>th</sup> century resulted in greatly reduced water quality. Municipalities such as Passaic, Patterson and Newark needed to move their water intakes further upstream to avoid contamination. At the turn of the century Newark boasted the dubious distinction of having the highest typhoid rate in the nation at 27.4 cases per 1000 population (Brydon, 1974). After numerous fits and starts the Passaic Valley Sewerage Commission was established in 1902 to provide a solution to the waste disposal problem. The Commission was given authority over the entire Lower Passaic Valley from Great Falls to the head of Newark Bay. A massive sewage treatment plant was finally completed in 1924,. Wastewater was discharged through a long pipe from the plant along the west bank of Newark Bay out into the Upper Bay near Robbins Reef (Brydon, 1974)

Due to the growth in population and lack of new construction due to World War II, discharge of raw sewage into the harbor remained at just over 1 billion gallons per day (Suszkowski, 1990). New construction after the war resulted in a total of 11 water pollution control plants in operation by 1952 (Brosnan and O'Shea, 1994). In 1967 the 12<sup>th</sup> and largest plant in NYC, Newtown Creek, was opened. This lowered the rate of raw sewage discharge to about 450 million gallons per day (Suszkowski, 1990).

Sewage treatment used at that time period would be classified as primary treatment by today's standards, the method used settling and aeration and achieved a Biological Oxygen Demand (BOD) reduction of 60% (Brosnan and O'Shea, 1994). The Clean Water Act of 1972 established standards for wastewater discharges and provided Federal money for upgrades to existing plants and new construction. The Act mandated secondary treatment of all sewage discharges and defined secondary treatment as the elimination of 85% of the BOD and total suspended solids (TSS)(Brosnan and O'Shea, 1994). By 1980 9 of the 12 New York City plants had been upgraded to secondary treatment, however over 200 mgd of raw sewage were still being discharged into the harbor (Brosnan and O'Shea, 1994). The final two plants; North River in upper Manhattan and Red Hook in Brooklyn, were completed by June of 1987 (NYC DEP, 1996) and ended (dry weather) discharge of raw sewage into the harbor. The Owls Head plant and Coney Island plant were brought up to secondary treatment by May of 1995; the Newtown Creek plant is the remaining primary treatment plant with the upgrade currently in the planning stage.

Most of the sewage systems in the watershed are combined systems where storm runoff from street sewers is combined with sanitary discharge and processed at treatment plants. These combined systems have the drawback of limited capacity to handle the greatly increased effluent during storm events. As a result the system becomes overwhelmed and excess sewage is discharged directly into the harbor as Combined Sewage Overflow (CSO). Even with the continuing concern of CSOs, overall improvements in treatment have dramatically improved the

water quality of the harbor as measured by Dissolved Oxygen (DO). The New York City Department of Environmental Protection has monitored the harbor for BOD, DO and other physical and chemical parameters since 1909. The trend since the early 1970's has been an overall increase in dissolved oxygen. Bottom mean saturation levels of DO are approaching 70%, the highest since surveys were started (NYC DEP, 1996).

The upgrades and improvement in wastewater treatment address primarily the removal of organic carbon, nitrogen and to a lesser extent phosphorus. Additional contaminants of concern discharged by treatment plants include PAHs and heavy metals contributed by street runoff, improper disposal and illegal industrial hookups. These pollutants are not removed by current or planned treatment methods and can only be improved through enforcement and public awareness.

### **Dumping of Refuse**

The direct dumping of waste into the harbor was the standard procedure for solid waste disposal from the earliest settlement into the 19<sup>th</sup> century. Much of the landfill that was added onto Manhattan was composed of garbage, construction debris and excavation debris. Garbage dumps were established in tidal wetlands, which mobilized large amounts of floatable garbage during high tide. In 1888 the New York Harbor Act made it illegal to dump refuse into the tidal waters of NY harbor. This legislation was established at the national level in 1899. The task of enforcing the regulation was given to the US Army Corps of Engineers (USACOE). The Corps enforced the act only if navigation was threatened by the dumping.

While dumping into the harbor was ostensibly illegal ocean dumping of garbage was still used into the 20<sup>th</sup> century. Brought back into the harbor by the flood tides this practice created "seas of floating garbage... with bloated animal corpses washing ashore" as described by the

Metropolitan Sewage Commission in 1910 (NYC DEP, 1996). In 1936 the National Ocean Dumping Act made the dumping of refuse into the ocean illegal.

Increased primary treatment of sewage (removes the “big” stuff) and the ban on all refuse dumping reduced the focus on the garbage issue. However in the summers of 1988 and 1989 there was renewed attention due to a number of incidences of garbage washing up on beaches. The waste included bags of medical waste containing needles and other biohazards. As the public began avoiding beaches, the ones not closed due to high coliform counts, businesses dependent on ocean recreation and public officials put pressure on the regulatory agencies. The Corps of Engineers, the US EPA, NY DEP, NY DEC and the NJ DEP developed a Floatable Action Plan to address the problem. Using boats employing skimmers, shore crews (New Jersey employed convicts) and preemptive removal of rotting piers the program collected 3000 tons of debris by September of 1989 (Casper, 1990).

### **Industrial Discharge**

Prior to the Industrial Revolution commercial activity and discharge of non-human waste products was rarely concentrated enough to adversely affect the Hudson and its surrounding watershed. Pre 19<sup>th</sup> century industrial activities in the Hudson valley included livestock slaughterhouses, tanning operations, mining and lumber. Due to primitive and slow transportation systems and lack of preservation technology, slaughterhouses were located within cities and towns. Refuse and offal from slaughterhouses and other businesses such as tanneries fouled the waters of the Little Pond in lower Manhattan. As mentioned earlier the Pond had to be given up as a source of drinking water and eventually filled in.

The densely wooded Hudson Valley with its combination of softwood and hardwood quickly became a center for the harvesting of lumber. One of the first large mills was built in 1763

By 1850 New York led all states in cut lumber producing 1.6 billion board feet per year. Bark was stripped from the hemlocks and used to make tannic acid for processing of animal hides. The earliest effects on the Hudson were from siltation and the discharge of tannic acid wastes from the tanning industry.

New York became one of the earliest centers of oil refining in the United States soon after the discovery of oil in Titusville PA in 1859 (Burrows and Wallace, 1999). Williamsburg and Greenpoint Brooklyn were the center of this booming industry with refineries located on the East River and the Newtown Creek. By the early years of the Civil War nearly half a million barrels of petroleum products were exported through the harbor. The standard practice of the day was to discharge any waste product into the nearest body. Waldman, (1999) estimated a crude oil by-product discharge of three hundred thousand gallons per week based on production totals and standard practices.

The development of the Standard Oil Trust, headquartered in New York, expanded the industry. New refineries sprang up in Bayonne, which lay at the terminal of a pipeline running from the Pennsylvania oil fields (Burrows and Wallace, 1999). Today the Arthur Kill and its tributaries are the hub of the regional oil refinery and chemical industry.

The world's highest known levels of contamination by elemental cadmium and nickel have been found in sediments of Foundry Cove, a U.S. Environmental Protection Agency Superfund site on the lower Hudson River (USEPA, 1998). President James Madison established the namesake foundry during the War of 1812, one of four in the nation selected to manufacture pipes, cranks, gears, cotton presses, railroad engines and cannonballs (Burrows and Wallace,



1999). During the Civil War it expanded and became the nations primary supplier of heavy weapons. The foundry was finally closed in 1911 when local supplies of iron ore dried up.

The paint and dye industry has been a long running and easily noticed contributor to pollution in the watershed. The Gowanus Canal, in southwestern Brooklyn, was known as Lavender Lake due to the ongoing discharge from the dye works located along the canal. The General Motors (GM) Plant in Tarrytown New York was cited by author Robert Boyle for it's discharge of automobile paint into the Hudson. During the 80 years of US Army Corps of Engineer's enforcement of the Ocean Pollution Act the GM plant was one of only two cases the Corps ever referred to the US District Attorney's office for violations.

Robert Boyle's book, *The Hudson River: a natural and unnatural history*, is credited with reawakening interest in the environment of the Hudson. One of the main issues Boyle addressed was the intake and discharge from the power generating plants along the River. Massive fish kills resulted during the withdrawal of river water for cooling. Boyle argued that fishermen were fined for exceeding catch limits while power companies were allowed to kill millions of fish without penalty.

In a related case, in 1962 Con Edison applied to the Federal Power Commission (FPC) for a license to build a pump storage facility. The plant was to be built on the river at Storm King Mountain near Cornwall. In a landmark case, the Scenic Hudson Association took Con Edison to court over the proposed facility. The U. S. Court of Appeals set a major precedent when it sent the case back to the FPC to start the process over again. For the first time in U.S. history, a court had decided that consideration must be given to natural resources impacts of a project as well as economic gain. The case prompted Congress to enact a National Environmental Policy Act in 1969, which requires an environmental impact study on all major projects requiring federal oversight.

Since the passage of the Clean Water Act in 1972 the discharge of industrial refuse has required a National Pollution Discharge Elimination System (NPDES) Permit. Significant discharge of toxic material still took place under this system and around the system. General Electric discharged PCBs under a NPDES permit and Diamond Alkali discharged residue from 2,4,5-T production under a NPDES permit. As the toxicity and environmental effects of many chemicals and chemical by-products has come to light the list of banned substances has grown. Recent Right-To-Know legislation has resulted in the EPA and State Environmental Agencies compiling, and releasing to the public, an inventory of toxic releases to the environment. These agencies proudly point to the decreased volumes over the past few years as a sign of effectiveness of regulatory programs.

### **Spills of Toxic Materials**

As mentioned in the preceding section, New York became a center for the refining in the late 19<sup>th</sup> century. By World War I such quantities of oil were being spilled into the harbor that “..patches of floating oil ignited in various sections of New York Harbor” (Waldman, 1999). This led to passage of the Federal Oil Pollution Act of 1924. Although Newtown Creek no longer supports any refineries it is still an important oil storage center. An explosion at the Standard Oil Company of New York on October 5, 1950 resulted in a massive underground oil spill estimated to be over 17 million gallons (Thrush, 1995). This contamination has migrated away from the original site of the spill and is seeping into the Newtown Creek.

Currently, an average of seventeen hundred oil tankers enters the harbor transporting nearly half a billion barrels of oil each year (Waldman, 1999). Even a small percentage spilled means a great deal of oil in the harbor. One of the largest spills in recent years was the Exxon Bayway spill. On New Year's Eve in 1989 13,500 barrels of oil were spilled into the Arthur Kill

when oil discharged from an underwater refueling valve. The automatic alarm system was ignored as it had continuously malfunctioned producing numerous false alarms.

Although only a small percentage of the oil entering the harbor is transported up the Hudson River oil is the primary commodity moved on the river both in volume and number of trips. In February of 1977 the barge the Ethel H. struck a reef in the Hudson Highlands and discharged 10,000 barrels of oil into the river. Ten years later another large spill of 2500 barrels occurred at Diamond Reef. Coordination between shippers, the Coast Guard and other responsible agencies has greatly reduced the impact of spills, but the sheer volume of oil transported within the watershed mean spills will likely continue to be a source of pollution.

The most widely studied and publicized contaminants in the watershed are polychlorinated biphenyls (PCBs). PCBs are a group of 209 synthetic organic chemicals with the same basic chemical structure and similar physical properties. They are non-flammable, with a high chemical stability and boiling point and exhibit electrical insulating properties. PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; in paints, plastics, rubber product, dyes and carbonless copy paper and many other applications. Total production in the US exceeded 1.5 billion pounds of PCBs before they were banned in 1977 (Limburg, 1984).

In 1947 General Electric (GE) started using PCBs in the manufacture of electrical capacitors at its Fort Edward plant on the eastern shore of the Hudson River. In 1952 the nearby Hudson Falls GE plant began using PCBs in the manufacture of transformers. Waste from the Fort Edwards plant was contained behind a dam, in 1973 this dam was removed, causing large amounts of PCBs to flow into the lower Hudson (Sanders, 1989). Total releases of were estimated at over 150 metric tons (Brown et al. 1985). At the Hudson Falls plant transformers were filled with PCBs outside the factor, the overflow and solvent washed mixture was allowed

to runoff where it infiltrated into the soil, from there to the fractured bedrock aquifer below the plant grounds, and finally into the river (Sanders, 1989).

In 1974 an EPA sampling study done along the Hudson in 1974 showed high levels of PCBs in Hudson River fish. In 1976 the New York State Department of Environmental Conservation banned fishing in the Upper Hudson from Fort Edwards to the Federal Dam at Troy and began a program of fishing advisories to warn the public of the dangers of consuming fish caught in the Hudson (Sanders, 1989). In 1976 the US Congress passed the Toxic Substance Control Act, which among other mandates, banned the manufacture of PCBs. The following year the EPA outlawed the discharge of PCBs into navigable waters and prohibited all uses except in totally enclosed systems (Limburg, 1984).

An administrative hearing in 1976 found that the PCB problem was the fault of the General Electric Company (GE). Later that year GE reached an agreement with the EPA and the State of New York agreeing to halt all PCB discharges and to spend \$5 million for research and monitoring of PCBs in the Hudson (Sanders, 1989). In 1983 the Upper Reach of the Hudson was added to the EPA's Superfund National Priority List, a list of contaminated sites to be cleaned up under the Superfund program. Since that time the issue has involved a multitude of lawsuits, proposals, counter-proposals, monitoring studies, de-chlorination studies and risk assessments too numerous to detail. The primary issue remaining is what action to take on the "Hot Spots" stretches of the river where the sediments are contaminated with greater than 50 parts per million (ppm) of PCBs. GE advocates taking no action and allowing the Hot Spots to decontaminate themselves (Sanders, 1986). Some environmental groups are pushing for the Hot Spots to be dredged and the contaminated sediments be incinerated, de-chlorinated or transported to a hazardous waste site. The US EPA's proposed plan for the cleanup is to dredge 2.65 million cubic yards (1.85 million m<sup>3</sup>) of sediment, estimated to contain over 100,000 pounds (45,000 kg) of PCBs (USEPA, 1998).

**Runoff**

Runoff also known as non-point source pollution is the most difficult pollution source to quantify. The concentration of such large numbers of people in a small area creates a situation where minor activities add up to large volumes of pollution. The major categories of non-point source pollutants are:

- Atmospheric Deposition of airborne pollutants
- Runoff from farms and pavement
- Septic discharge

Atmospheric fallout from motor vehicles is a major concern, especially in the densely packed lower portion of the Estuary. Until the elimination of leaded gasoline airborne deposition of lead resulted in high levels of this toxic metal in soils and sediments. The New York City Metropolitan area has been classified as a non-attainment area for ozone and carbon monoxide. This status indicates a failure to achieve clean air standards, although the number of days per year of non-attainment has decreased from 45 days in 1987 to 5 days in 1997 (US EPA, 1998).

Although the area of land under cultivation in the Hudson Watershed has been decreasing, runoff from farms remains a concern. This is especially true in the New York City drinking water reservoir watershed. Problematic runoff includes fertilizers, pesticides, herbicides and animal waste. A U.S. Geological Survey sampling survey of in 1999 showed detectable levels of the herbicides atrazine, metolachlor, and cyanazine in the New York City watershed (Phillips, et al., 1999). High levels of pesticides have been found in the Walkill River, downstream from the “black dirt” region an area of intensive vegetable cultivation (NYSDEC, 1997).

In the majority of large cities in the Hudson watershed the municipal sewer system is a single combined system handling sanitary waste and storm water. Runoff from streets, sidewalks

and parking lots results in significant levels of grease and oil entering the waste treatment system. The New York City Department of Environmental Protection (NYCDEP) estimates 2 million gallons of oil per year are discharged into the New York Harbor through the NYCDEP treatment facilities.

Septic discharge poses a significant threat to drinking water supplies, both ground water and surface water. Water bodies such as lakes, ponds and reservoirs are recharged by subsurface flow. Areas in which septic is the primary waste disposal method are more likely to have private, shallow drinking water wells. Although zoning laws are designed to prevent construction of septic systems in unsuitable areas development pressures around the major metropolitan areas often override these concerns.

Another increasingly serious impact on groundwater is the gasoline additive Methyl Tertiary-Butyl Ether (MTBE). Ironically MTBE is added to gasoline formulations to help reduce air pollution. Since MTBE is much less volatile than gasoline it remains behind when gasoline leaks from underground tanks and evaporates. A survey of wells in the Albany area conducted by the US Geological Survey in 1994 showed detectable MTBE levels in 18% of the wells tested (USGS, 1995).

## **Summary**

Sources of pollution in the Hudson Watershed are as varied as the watershed itself. Since European settlement humans have had an increasing impact on the water quality in the streams, rivers, lakes, estuaries and the adjacent ocean. Recently though the tide has begun to change. Increasing awareness of the importance of the Hudson River in terms of commercial and recreational usage as well as the ecological health of the River has spurred efforts to control pollution. The combined efforts of non-profit groups such as the Riverkeeper, Clearwater and the Hudson River Foundation as well as governmental agencies on Federal, State and Local levels

have resulted in a noticeably cleaner River over the past 30 years. Yet some vexing issues remain.

This study focuses on the problem of dioxin contamination in the sediments of the Hudson-Raritan Estuary. While the water column has become cleaner, sediments below still contain high levels of toxic material including dioxins. These materials are absorbed by organisms living in the estuary and pose a risk to human health when if they are consumed. The abundance of seafood in the estuary was one of the factors that drew in settlement, yet today the bounty of the estuary is largely off limits due to health advisories.

## **Chapter 2 -Physical Description of the Hudson Watershed; Geology, Hydrology, Sedimentation and Landuse**

This investigation is focused on the sediments of the Hudson Raritan Estuary.

Ascertaining the source of contamination to these sediments, particularly dioxins and furans requires an examination all areas that contribute water and sediment to the Estuary. Figure 2-1 shows the major water bodies, inlets and straits of the Hudson Estuary and the rivers emptying directly into the Hudson Estuary.

The combined watershed of the area drained by these rivers total 42,467 square kilometers. Figure 2-2 shows the major tributaries of the watershed and indicates the average flow volume for these rivers. The Hudson-Raritan watershed can be divided into the sub-basins for closer analysis: the Upper Hudson, the Mohawk, the Lower Hudson and the Hackensack-Passaic-Raritan Basins (Figure 2-3). The following sections describe the sub-basins of the watershed in terms of hydrology, geology and landuse. The Physiological Sections of the Watershed are shown in Figure 2-4.

Land use varies from the heavily forested and lightly developed Adirondack and Catskill Mountains, to the largest and most densely populated metropolitan area in the United States. The total population of entire watershed was 13,779,000 as of 1990 census. (US Census Bureau, 1993) This population is unevenly distributed with the bulk of it residing around the Hudson Estuary.



**Figure 2-1 New York New Jersey Hudson Estuary showing major waterbodies, tidal straits, and inlets and adjoining land areas.**

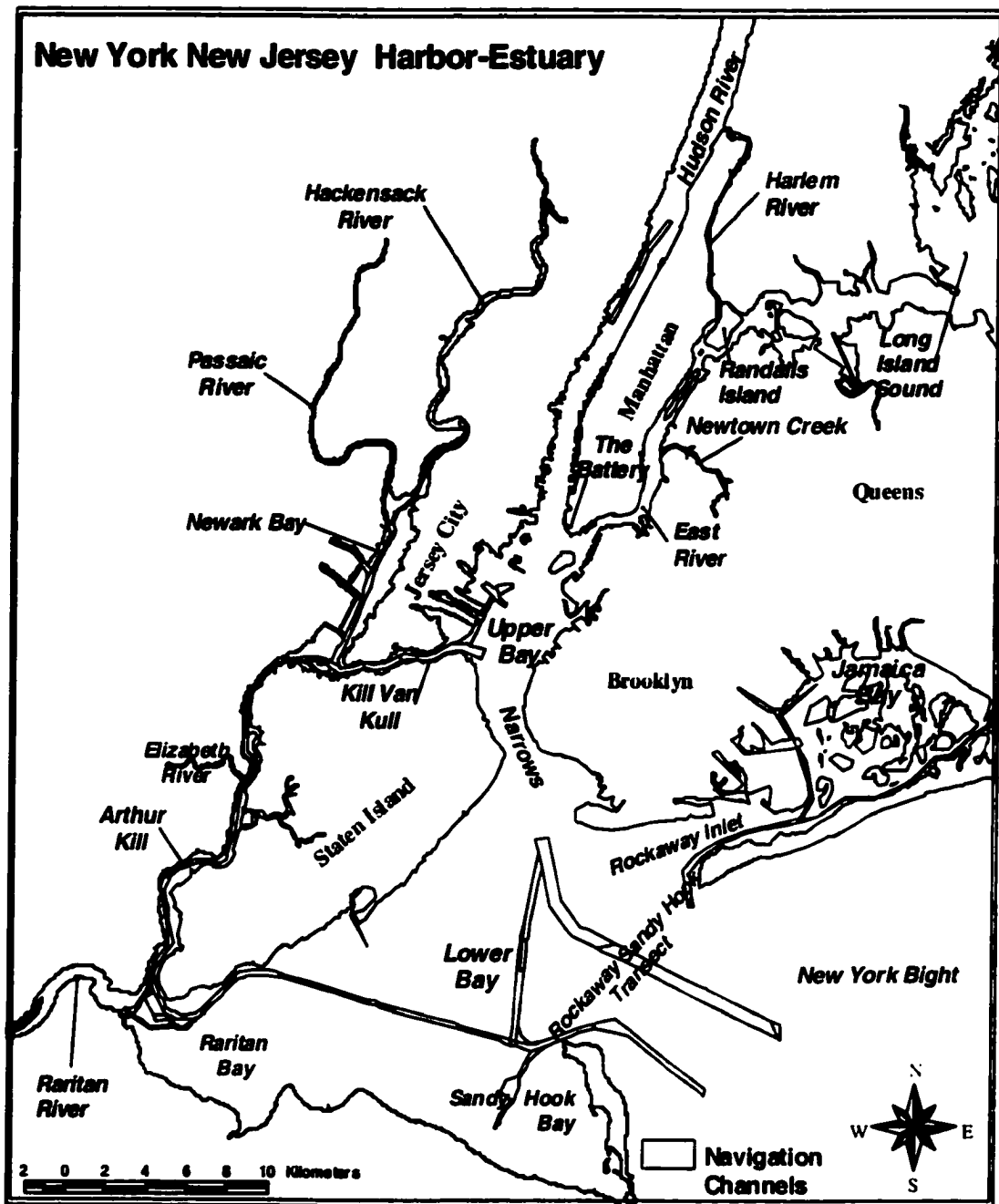
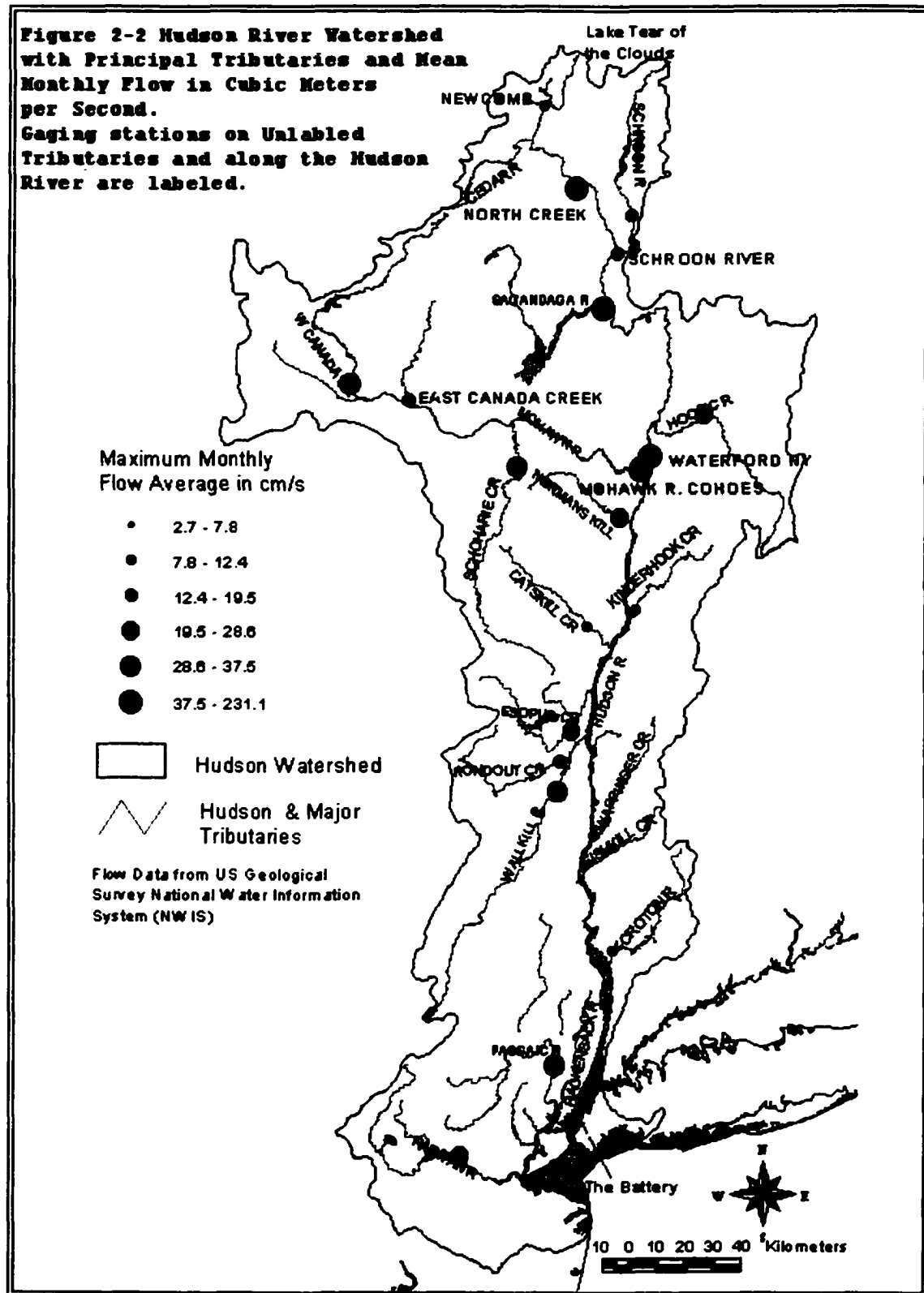


**Figure 2-2 shows the Hudson Raritan Watershed and the major tributaries.**



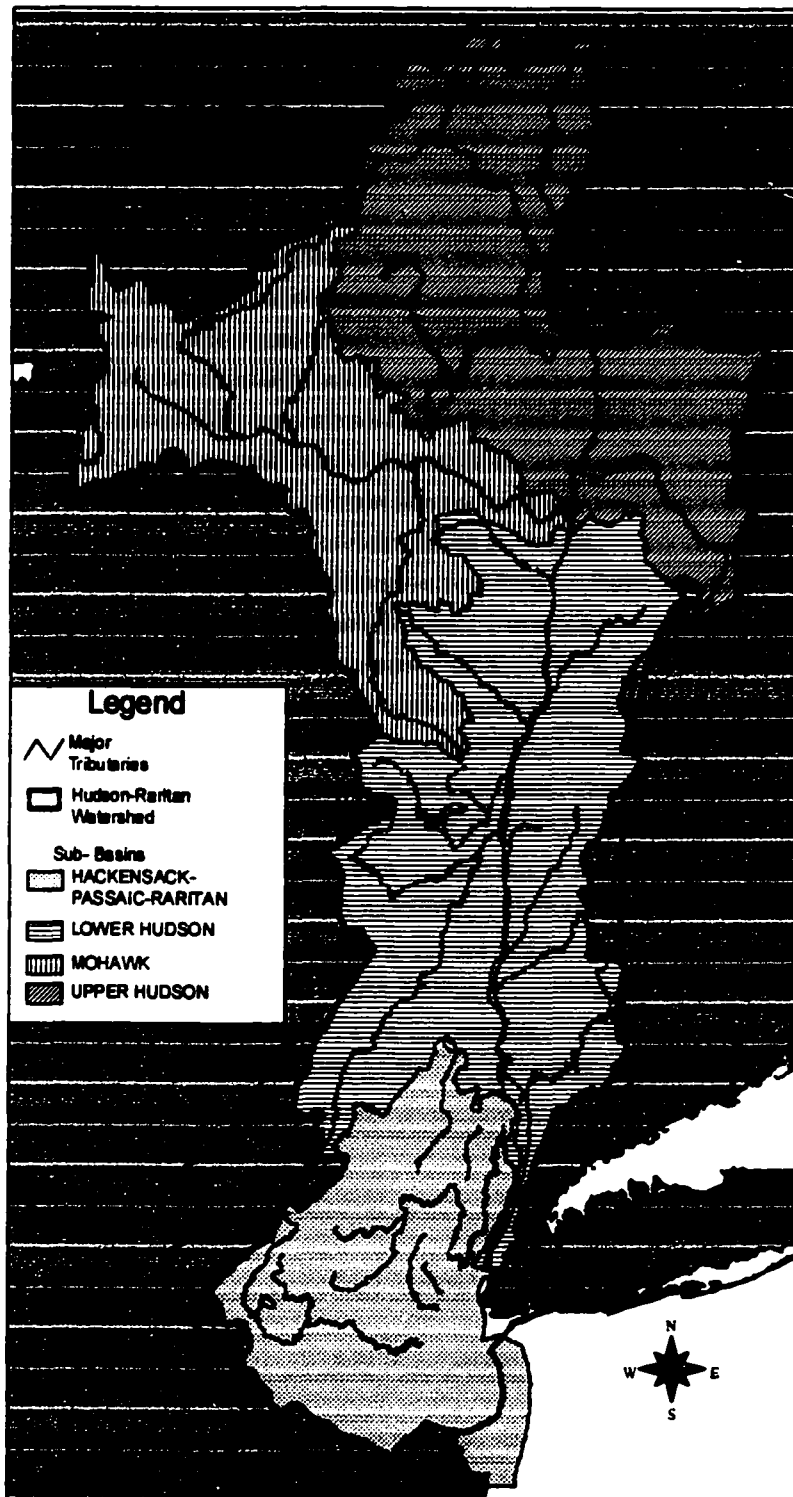
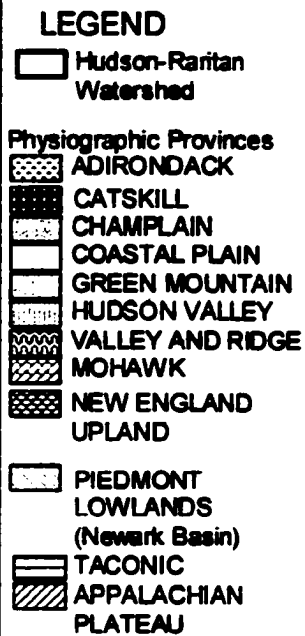
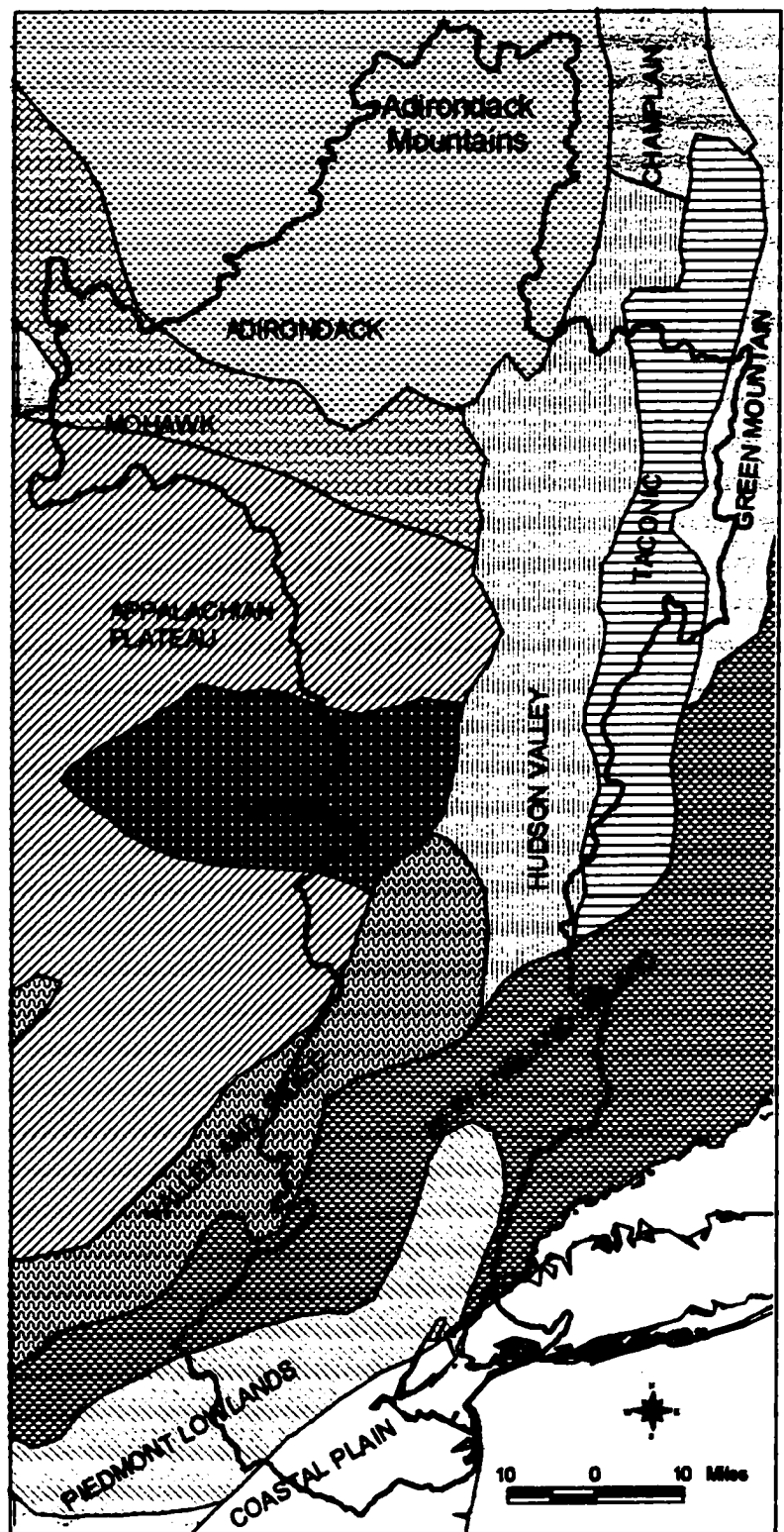


**Figure 2-4  
Physiographic  
Regions  
of the  
Hudson-Raritan  
Watershed.**



**Data Sources:**  
 Physiographic Regions  
 from US Geological Survey  
 Physiographic Atlas, 1982  
 Watershed from  
 NOAA Coastal Assessment  
 Program, 1992



## **The Hudson River**

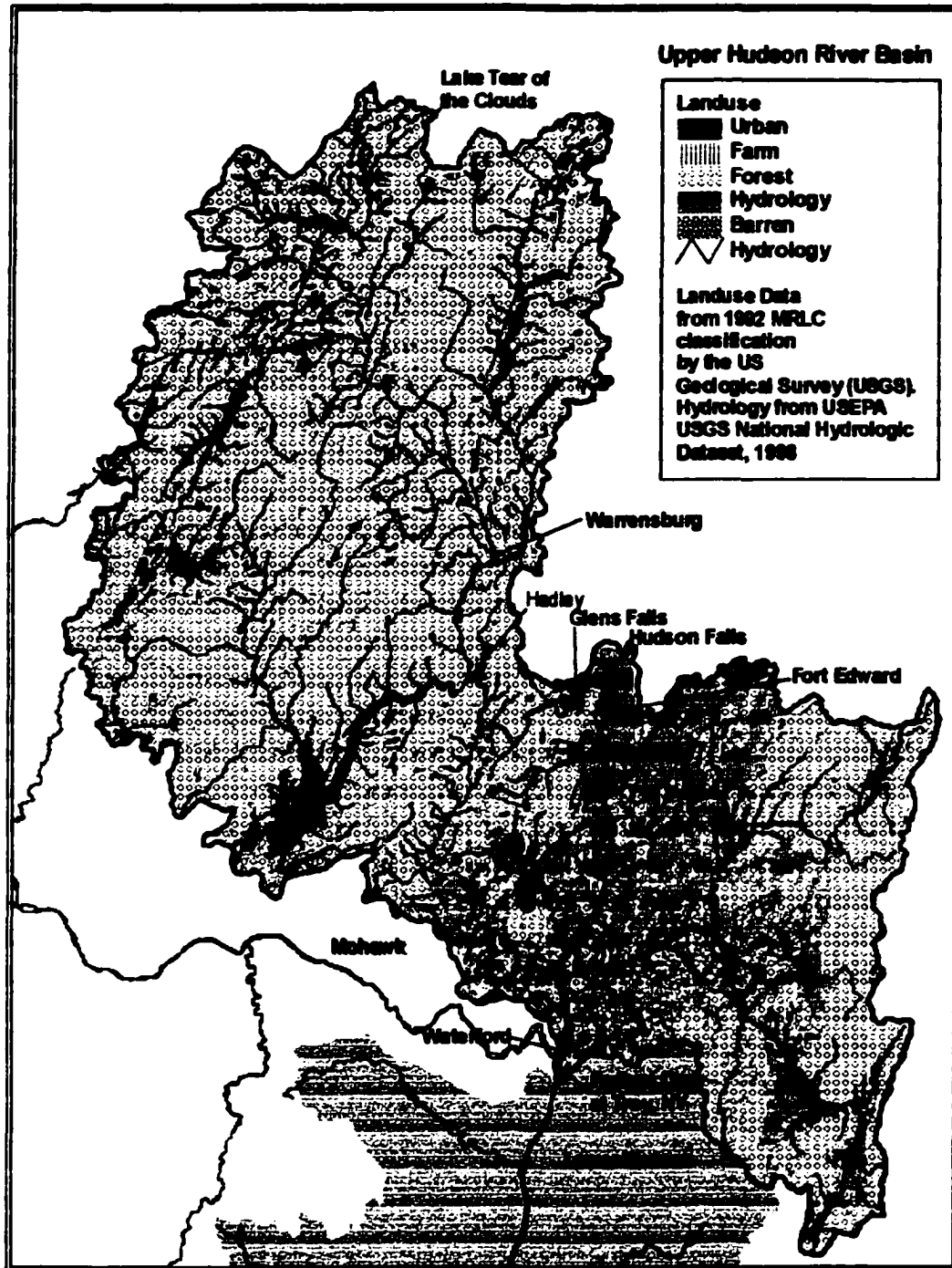
All flow data given in the following sections are from the US Geological Service's National Water Information System (NWIS) located online at <http://waterdata.usgs.gov/nwis-w/NY/>. Historical flow data for individual stations was downloaded and converted into dBase files. The data were summed by month, totaled and then joined to a point location Geographic Information System dataset of the gaging stations.

The Hudson River contributes the bulk of the freshwater input and upland sediment to the Harbor-Estuary. The source of the Hudson is Lake Tear of the Clouds, a small pond on the flank of Mount Marcy in the Adirondack Mountains of northern New York State. It flows 513 kilometers south before emptying into the Atlantic Ocean through the Harbor-Estuary. At the furthest upriver gauging station, Newcomb, mean annual flow is 10.9 cubic meters per second (CM/s). At the southern tip of Manhattan, where the Hudson empties into the Harbor-Estuary, flow averages 635 CM/s.

### **Upper Hudson Basin: Hydrology**

The Upper Hudson includes the drainage basin from the federal dam at Troy up to its source. It drains a total of 11,945 square kilometers. The basin includes the rugged and heavily forested Adirondack Mountains as well as glacial outwash plains around the Saratoga Lake area. Large parts of this region have been included in the Adirondack Park Preserve, a collection of state and privately owned lands, which are strictly controlled in terms of development. Figure 2-5 shows the Upper Hudson Basin with land use and hydrology.

Figure 2-5 Upper Hudson Basin Land Use and Hydrology. Land Use determined by classification of 1992 LandSat imagery. Hydrology developed by the USEPA and USGS for the National Hydrologic Dataset, 1998.



Lake Tear of the Clouds is the highest elevation source for the Hudson at 950 meters above sea level. As mentioned previously the farthest upstream continuously maintained gauging station is at Newcomb at an elevation of 478 meters. This station recorded a long-term monthly average of 11 CM/s. Around 43 kilometers south at North Creek the river has dropped to an elevation of 300 meters and has an average flow of 43.6 CM/s. In this section is known the river has cut deeply into the soft underlying marble creating what is known as the Hudson Gorge. Two major tributaries join the Hudson before it leaves the Adirondack region. The Schroon River joins the Hudson near Warrensburg and the Sacandaga River, which empties into the Hudson near Hadley NY. Below the Scandaga confluence the Hudson turns northeast and drops down out of the southern Adirondack foothills. It turns south again at Glens Falls enters a more developed region of the watershed flowing through the old industrial towns built to exploit the hydro power potential of Hudson Falls, Glens Falls and other cascades. Below Fort Edwards is the stretch of the Hudson that has been heavily impacted by discharge of PCBs from two General Electric manufacturing plants. An entire 20 kilometer section of the river has been designated an EPA Superfund site and is currently undergoing litigation over the various cleanup proposals put forth by the NY State Department of Environmental Conservation, Federal EPA, local environmental groups and the plaintiff, General Electric.

Downstream from Fort Edwards, the Hudson is connected to Lake Champlain by the Hudson-Champlain ship canal. Below the canal the Hoosic River joins the Hudson near Stillwater NY. The last gauging station of the Upper Hudson is located at Waterford NY. Average monthly flow at this station is 225.5 CM/s. Below this station are a series of locks culminating in the Federal Dam at Troy NY. These bring the Hudson River down to an elevation only 3 meters above sea level. Near the outlet end of the basin the Mohawk River empties into the Hudson, which is

now a tidal estuary. Average tidal range is 1.46 meters (4.8 feet), high tide at Troy Federal Dam occurs 9 hours after high tide at the Battery.

### **Upper Hudson Basin: Geology**

Most of the Upper Hudson Watershed is part of the Adirondack Province. The Adirondacks are part of a larger belt of bedrock known as the Grenville Province, a region that extends from Labrador to Texas but is exposed in few places south of Canada. Rocks of the Grenville Province were formed between 1.0 and 1.4 billion years ago. The Adirondacks consist of intensely metamorphosed sedimentary rock (metasedimentary) volcanic (metavolcanic) and intrusive igneous (metaplutonic) (Isachen, et al. 1991). At some point during the Tertiary Period the Adirondacks began to dome up or rise, probably due to upwelling of magma from the mantle. The sedimentary material overlying the metamorphic basement rock was largely eroded away. It is present today only on the margins of the uplifted dome or in the grabens, many of which developed into river or stream valleys.

The Adirondacks were again altered during the Pleistocene by glacial activity. The immense ice sheet moving south from Canada altered many of the existing river and stream valleys into chains of lakes by carving rock basins during ice advance and by depositing earth dams during ice retreat. The prominent northeast-trending rivers, streams, and lakes occur where faults and fracture zones greatly weakened the bedrock to make it easily eroded.

The lower reaches of the basin are part of the Hudson-Walkill Valley province. The geology of this area will be described in a subsequent section.

### **Upper Hudson Basin: Land Use**

Land use in the Upper Hudson is primarily forest. Table 2-1 shows the land use/land cover areas in square kilometers and the percent of total area for that category. The land use categories



are the Anderson Level 1 classifications (Anderson, 1981). The data is from the Multi resolution Land Characterization (MRLC) Land Use/Land Cover dataset. This dataset was developed in a cooperative effort between the US Geological Survey, the US Environmental Protection Agency along with the cooperation of state and local agencies. The data were derived from Landsat Thematic Mapper (TM) imagery. The original data is in a modified Anderson classification, these categories were summed to determine level 1 areas using the Arcview <sup>TM</sup> GIS software from Environmental Systems Research Institute (ESRI). The total population of the Upper Hudson watershed was 305,839 as of the 1990 census. This population is spread thin with an average population density (number of people per unit area) of 25.6 people per square kilometer. The highest densities and in fact the bulk of the population, is along the Hudson River from Glens Falls to Troy.

**Table 2-1 Land Use / Land Cover in the Upper Hudson Basin by Area and fraction of total basin area. Data is from MRLC land use/Land Cover Dataset developed from 1992 Landsat Imagery.**

| <b>Area in km2</b> | <b>Fraction of Total Area</b> | <b>Description</b>            |
|--------------------|-------------------------------|-------------------------------|
| 402.0              | 0.0341                        | Open Water                    |
| 316.0              | 0.0268                        | Urban                         |
| 17.0               | 0.0015                        | Bare                          |
| 9521.0             | 0.8075                        | Forest                        |
| 21.0               | 0.0081                        | Shrub and Grassland           |
| 1213.0             | 0.1029                        | Agriculture including Pasture |
| 300.0              | 0.0255                        | Woody Wetlands                |

The majority of the land area of the Upper Hudson Basin (8515 km2) falls within the Adirondack Park, a patchwork of public and private lands protected under New York State law. Second growth forest dominates most of the state owned land. The forested area is largely coniferous especially at higher altitudes. This results in slightly acidic soils with little buffering

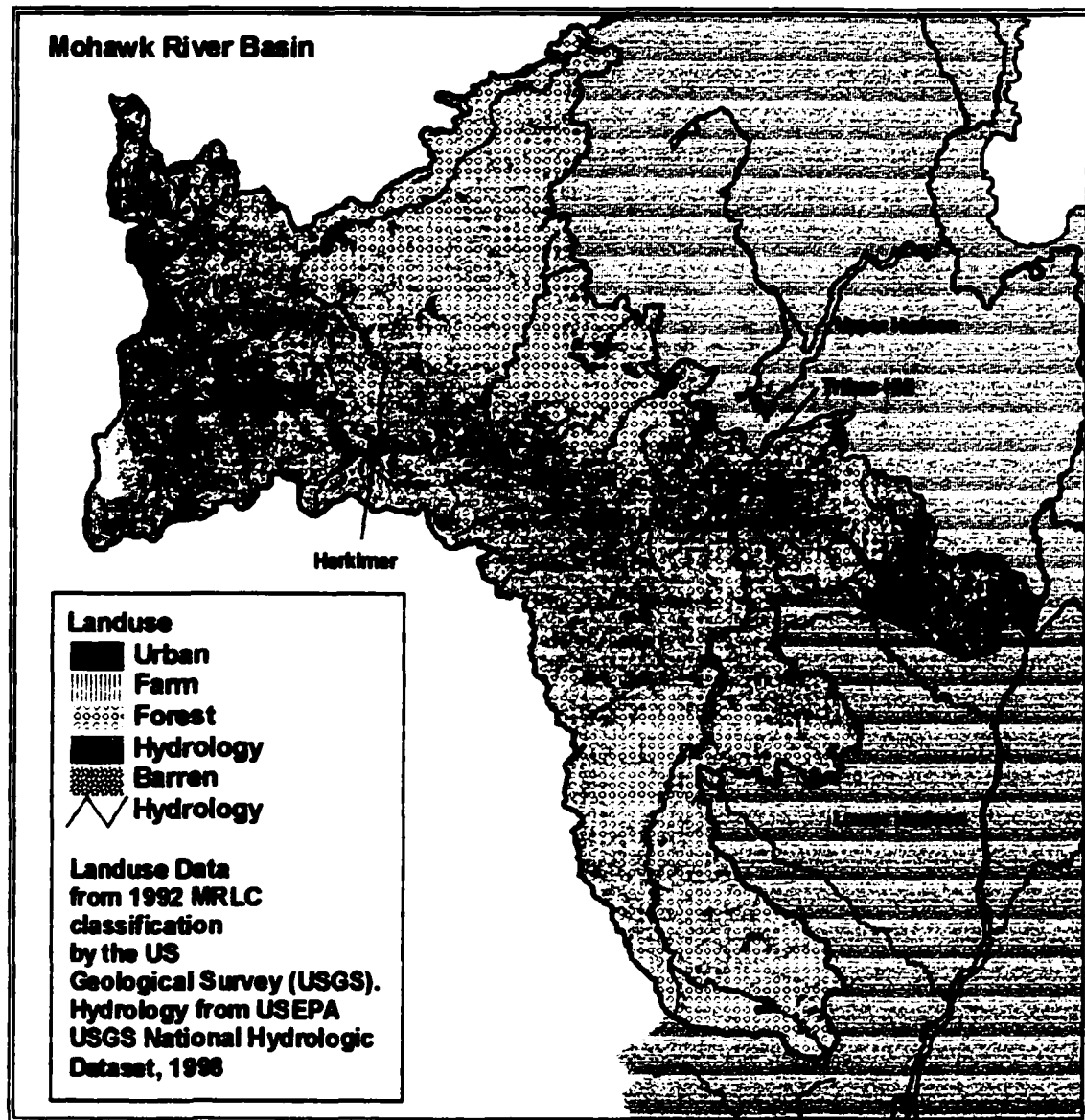
capacity. A significant percentage of lakes in the Adirondacks no longer support aquatic life, a result of the increased acidity of precipitation.

Agricultural areas make up the next largest land use. Area under agriculture has decreased in New York State since the turn of the century. Farms have reverted to forest, been converted to subdevelopments and occasionally reverted to the wetlands they were before being filled in for agriculture. Urban areas, including residential, commercial and industrial, make up less than 3% of the land area in the Upper Hudson basin. These areas are concentrated below the foothills of the southern Adirondacks in the glacial outwash area between Glens Falls and Albany. Concentrated along the Hudson River are a number of old industrial towns built adjacent to the cascades, which provided the power for their early development. Since World War II there has been a decline in industrial production in this area with a number of the former facilities being shut down. Evidence of their existence remains however both in the crumbling structures that line the river and the contamination in its sediments.

### **Mohawk Basin: Hydrology**

The major tributary to the Hudson is the Mohawk River, which begins in the southwest Adirondack Uplands, initially flows southwest and then turns east before joining the Hudson at Troy NY. The drainage basin of the Mohawk is approximately 9100 square kilometers. Below the Cohoes Falls, just before reaching the Hudson, the Mohawk's monthly average flow is 157 CM/s. Three major tributaries join the Mohawk, West Canada Creek, East Canada Creek and the Schoharie River. Figure 4-6 shows the Mohawk River basin hydrology and land use.

Figure 4-6 Mohawk River Basin Land Use and Hydrology. Land Use determined by classification of 1992 Landsat imagery. Hydrology developed by the USEPA and USGS for the National Hydrologic Dataset, 1998.



The major tributary to the Mohawk River by volume is West Canada Creek, which drains out of the Western Adirondacks before joining the Mohawk near Herkimer NY. Average flow from West Canada Creek is 36.5 CM/s. Another fifteen kilometers to the east the Mohawk is joined by East Canada Creek, contributing an average monthly flow of 19 CM/s. Approximately 75 kilometers downstream from the East Canada Creek confluence the Mohawk is joined by the Schoharie Creek.

Schoharie Creek. The Schoharie begins in the western Catskill Mountains and flows north through a series of reservoirs before joining the Mohawk near Tribes Hill NY. The average flow of the Schoharie is 29 CM/s.

### **Mohawk Basin: Geology**

The underlying rocks of the Mohawk Valley are sandstones and carbonates, which were formed for the most part during the Middle and Late Ordovician (Isachen, et al. 1991). The area lies to the west of the Taconics and escaped the effects the Taconic Orogeny, both the metamorphic alterations and the overturning of crustal material. The unaltered sediments were more easily eroded than the surrounding material resulting in the formation of the broad, gently rolling valley.

The Mohawk basin shares the Appalachian Upland Province with the Lower Hudson Basin. The Appalachian Plateau is a rugged area of high elevations south of the Mohawk Lowlands and west of the Hudson Lowlands. In age almost all the rocks of the Appalachian Plateau are Devonian, spanning almost 50 million years of geological history. They are exclusively sedimentary and contain a diverse array of fossils including some of the earliest evidence of land plants.

The Helderberg group, exposed along the Helderberg Escarpment, is composed of carbonate formations, Above the Helderberg group is a series of clastic formations the Oriskany, Esopus and Schoharie. These in turn are topped by the Onondaga Limestone, a facies similar to the Heldeberg group (Friedman et al. 1992).

Sediments shed from the mountains formed during the Acadian Orogeny formed the Catskill Delta. This thick apron of sediments grade upward from off shore shales to nearshore deltaic sediments into riverine and alluvial fan facies. Overall the Catskill sequence shows a

coarsening upward trend which is thickest in the east and gradually thins out to the west. By the Late Devonian the facies in the Castkills changed to non-marine. Thick deltaic sequences are topped by riverine and floodplain facies (Friedman et al. 1992).

### **Mohawk Basin: Land Use**

The Mohawk basin is a region of great diversity in land use and history. It includes the sparsely developed southwest Adirondacks, the heavily industrialized Mohawk River valley and part of the rich farming area of the northern tier. Table 2-2 lists the land use / land cover areas in the Mohawk basin by area and percent of total area. The basin contains a total population of 716,355. This works out to an average density of 78 people per square kilometer. As with the Upper Hudson basin this population is concentrated along the lower, navigable stretch of the Mohawk River.

North of the Mohawk River much of the land is forest, primarily second growth forest. Heavy exploitation of the area's forests took place in the 19<sup>th</sup> century for lumber, paper and bark for the tanning industry. The entire northern third of the basin is within the Adirondack Park Boundary (the "Blue Line") and large tracts are preserved as parts of the Adirondack Forest Preserve or Adirondack Wilderness Preserve.

**Table 2-2 Land Use/Land Cover in the Mohawk Basin by Area and fraction of total basin area. Data is from MRLC Land Use Land Cover data developed from 1992 Landsat Imagery.**

| <b>Area in km<sup>2</sup></b> | <b>Fraction of Total Area</b> | <b>Description</b> |
|-------------------------------|-------------------------------|--------------------|
| 138.0                         | 0.0154                        | Open Water         |
| 427.0                         | 0.0476                        | Urban              |
| 5.0                           | 0.0006                        | Bare               |
| 5670.0                        | 0.6330                        | Forest             |
| 51.0                          | 0.0057                        | Grasslands         |
| 2433.0                        | 0.2717                        | Agriculture        |
| 233.0                         | 0.0260                        | Woody Wetlands     |

The second largest land use / land cover category is agriculture. The agricultural areas of the Mohawk basin are concentrated along rolling hills surrounding the Mohawk River itself. Corn, dairy and livestock are the dominant farming types. Some of these areas have been under agricultural production since the 18<sup>th</sup> century when a New England population and immigration boom resulted in an influx of displaced farmers. Urban areas are concentrated along the river in a number of moderate sized metropolitan areas. These are the old industrial and river port towns that started as trading posts in the 17<sup>th</sup> century.

### **Lower Hudson Basin: Hydrology**

The Lower Hudson is the drainage area south of the Federal Dam at Troy and the junction of the Mohawk and the Hudson. The entire lower Hudson River is tidal, from the Battery, where the river empties into Upper New York Bay, to the Federal Dam at Troy NY. This sub basin includes a total of 246 river kilometers and a drainage area of 13,741 square kilometers. Along this route the river receives the flow of a number of tributaries, some are tidal in their lower reaches. Below Albany the Hudson is joined on the west bank by the Normans Kill, which begins near Delanson NY and flows eastward skirting the northern flanks of the Helderberg Formation. Normans Kill contributes an average flow of 21.5 cubic meters per second (CM/s). Below the Normans Kill confluence two small tributaries join the Hudson, the Kinderhook Creek and the Catskill Creek, contributing an average monthly flow of 12 and 11 CM/s respectively. Figure 4.7 shows the land use and hydrology of the Lower Hudson Basin.

The Esopus Creek discharges into the Hudson near Saugerties NY. This creek flows into and out of the Ashokan Reservoir, which diverts much of the Esopus' stream flow into the New York City Water Supply system. Prior to construction of the Ashokan dam monthly flow averaged 25.5 CM/s, current average flow is 13 CM/s. The next major tributary downstream is the Wallkill River which joins the Hudson near Kingston NY. The Wallkill originates in the highlands of Northern New Jersey and flows north through a valley carved between the Hudson Highlands and the Schwangunk Mountains. The Wallkill includes an extensive drainage area and contributes an annual average flow of 29.5 CM/s. The Wallkill is the last tributary with an average annual flow of over 15 CM/s.

As mentioned previously the Lower Hudson River is tidal. Tidal range is 1.3 meters (4.4 feet) at the Battery and 1.46 meters (4.8 feet) at Troy Federal Dam, high tide at Troy occurs 9 hours after the Battery. The upriver extent of the chemical estuary varies depending upon the measurement used and the time of year. Fresh river water contains on average 0.02 parts per thousand (ppt) salt, ocean water is commonly at 35 ppt. The Salt Front is the boundary between the two and depends on the criteria used for "fresh". For drinking water usage the requirement is no more than 0.1 parts per thousand. Most ecological studies use a cutoff of 0.05 ppt. Under this latter definition the chemical estuary extends up to 100 to 135 kilometers above the Battery during extreme low flow during the summer months while only extending 34 to 17 kilometers during spring runoff (Coch and Bokuniewicz, 1986).

### **Lower Hudson Basin: Geology**

The Lower Hudson Basin contains a number of Geologic Provinces. The Taconic Mountains lie to

the east of the Hudson River Valley along the border of New York and the states of Connecticut and Massachusetts. It is a region of rugged north to south trending mountains composed largely of metamorphic rock. Thick sheets of shales and slates are interspersed with greywackes, volcanic ash and broken off boulders of the carbonate shelf sediments. The area is known as the Taconic Klippe, a term used for large overthrust sheets of rock separated by fault zones often filled with material pulverized during emplacement (Isachen, et al. 1991).

The Hudson and Wallkill Valleys are an extension of the Valley and Ridge province of the middle Appalachian Mountains. Here in its northernmost extent the province is primarily a long wide river valley bounded by ridges. The ridges are formed from resistant sandstones and conglomerates while easily eroded shales and siltstones underlie the valley.

The New England Upland Province is a rugged area composed largely of metamorphic rock. There are two areas, distinct from each other in age, mechanism of formation and composition. The Hudson Highlands run southwest to northeast from central New Jersey into Connecticut. The Hudson River cuts through the Highlands between Peekskill and Newburg, forming a deep fjord where river depths reach over 200 meters. During the Grenville Orogeny shallow marine sedimentary materials were metamorphosed into gneisses, mixed with some quartzite and marble. These formations contain abundant magnetite, a source of iron ore. The presence of these economically important deposits brought development to this area, which had been considered too rugged for settlement. Until the discovery of iron ore around Lake Superior the Highlands were the primary source of iron in the United States. In the mid 19<sup>th</sup> century, especially during the Civil War, the iron industry flourished and became one of the earliest sources of pollution in the region.

The Manhattan Prong runs mainly north to south from the edge of the Hudson Highlands,



around the Putnam - Westchester border down into New York City. It was formed from sediments and nearshore carbonates, folded and altered primarily during the Taconic Orogeny.

### **Lower Hudson Basin: Landuse**

The Lower Hudson River Basin consists of a wide valley flanked on either side by mountains. The basin is only 100 kilometers wide at its maximum extent. On the east the Taconic Mountains divide the Hudson drainage from that of the Housatanic River. On the west side of the river the Catskill Mountains divide the drainage of the Hudson and the Delaware Rivers. In the southeast section of the basin the Wallkill River Valley is a south-southeast trending extension of the Hudson River Valley. The total population of the basin is 3,916,253 with an average density of 299 people per square kilometer. In the upper two-thirds of the basin the population is concentrated along the river in a series of old industrial and trading towns, which line both sides of the river. In the lower section the population density increases with decreasing distance to New York City. Table 2-3 shows the major Land Use / Land Cover classes for the Lower Hudson Basin. Forest is the major land class; over 66 percent of the area is forest. These areas are concentrated in the upland areas on either side of the river valley.

In the west central section of the basin are the Catskill Mountains. This rugged area has escaped large-scale development for more than 300 years. As with the Adirondack Mountains large areas were clear cut both for lumber and for tannic acid which was used in the tanning and leather industry. Large tracts are now controlled by the state and are combined with the privately owned lands into the Catskill Mountain Preserve, a state designation designed to limit development in the area. The Catskill Mountains also serve as a source of drinking water for the roughly 7 million residents of New York City. The Ashokan and Rondout Reservoirs are within the Lower Hudson Basin.

**Table 2-3 Land Use/Land Cover in the Lower Hudson Basin by Area and fraction of total basin area. Data is from MRLC Land Use Land Cover data derived from 1992 Landsat Imagery.**

| <b>Area km2</b> | <b>% Total Area</b> | <b>Description</b> |
|-----------------|---------------------|--------------------|
| 565.0           | 0.0416              | Open Water         |
| 1300.0          | 0.0957              | Urban              |
| 21.0            | 0.0016              | Transitional       |
| 9038.0          | 0.6651              | Forest             |
| 159.0           | 0.0117              | Orchard            |
| 2186.0          | 0.1609              | Agriculture        |
| 320.0           | 0.0236              | Wetlands           |

Agricultural areas, making up 16% of the total land use, are concentrated along the Wallkill River Valley and the east bank of the Hudson River in the northern area of the basin. The Wallkill Valley is a particularly rich farming area containing extensive areas of "black dirt" fine silty soils deposited by glacial runoff. This is one of the few areas agricultural areas in the entire Hudson Raritan watershed where vegetable production is the dominant agricultural practice. Orange County, which contains the bulk of the Wallkill Valley in New York State, is the second leading county in the state in vegetable production (NYS Department of Agriculture, 1999). The intensive use of this area for this commodity has resulted in high levels of pesticides in the sediments of the Wallkill River. (NYSDEC, 1997). Other important agricultural products include dairy, sweet corn, apples and grapes. In the lower Hudson Valley extensive areas which were formerly agricultural have been converted to residential sub-developments. This trend is most apparent in Westchester, Putnam and Rockland counties, which have lost close to 80% of their post World War II farms (NY State Agriculture, 1995).

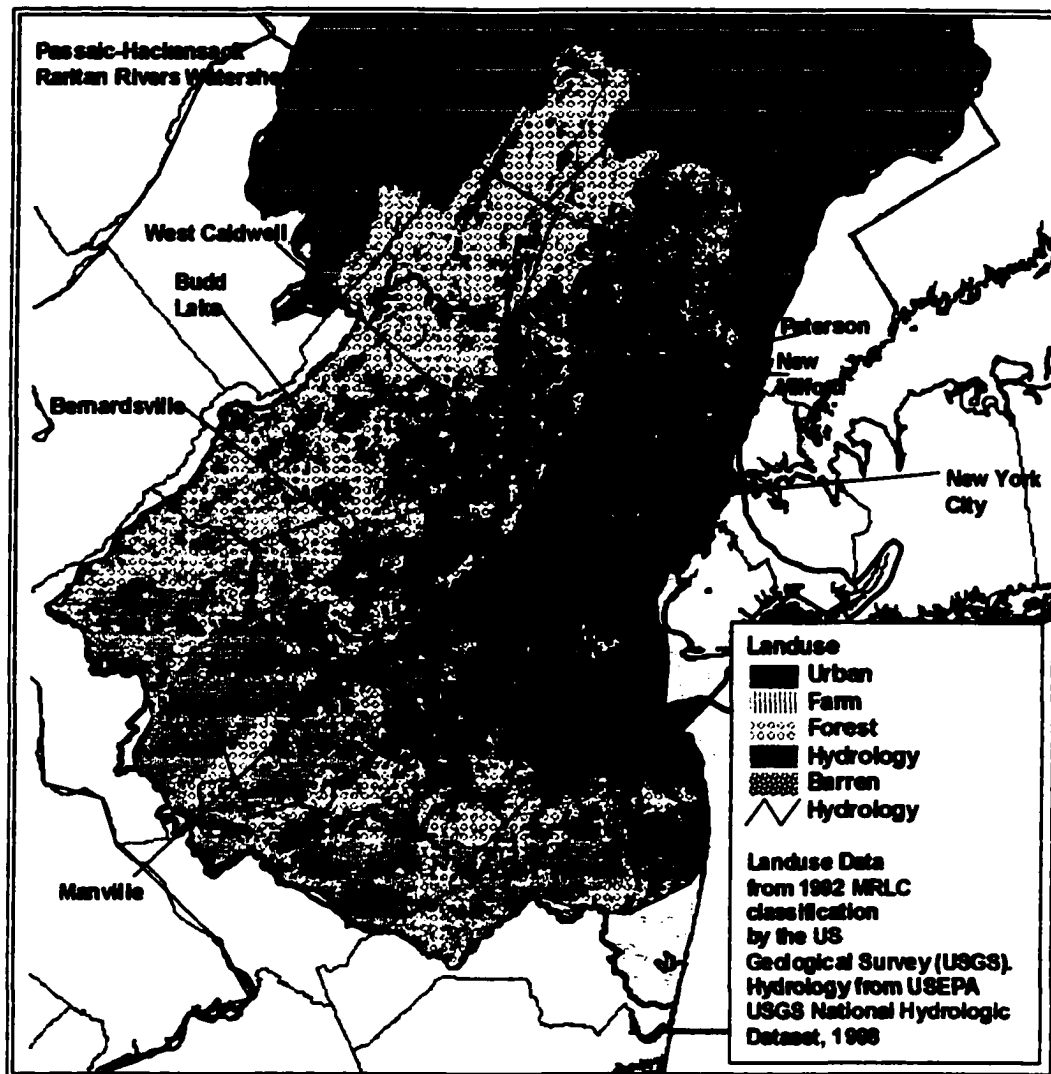
Urban areas are concentrated along the river in a number of cities and their suburbs, which line the Hudson River on the east and west banks. The Hudson Highlands became an early center for the iron industry reaching peak production during and just after the Civil War. The world's highest known levels of contamination by elemental cadmium and nickel have been found in

sediments of Foundry Cove, a U.S. Environmental Protection Agency Superfund site on the lower Hudson River (USEPA, 1998). The quarrying, cement and brick making industries have been important parts of the economy of the Hudson Valley since the late 18<sup>th</sup> century. Many of the operations were, and some still are, located immediately adjacent to the river to ease the transport of these bulky commodities. Numerous electrical generating plants line the river using massive amounts of river water to cool their equipment.

### **Passaic, Hackensack and Raritan Basin: Hydrology**

This area includes the areas draining into the three rivers as well as areas that drain directly into the Hudson Estuary. The latter includes the Elizabeth and Rahway Rivers, which drain directly into the Arthur Kill, and the Navasink River, which drains into the Lower Bay. It also includes drainage from Staten Island and the borough of Brooklyn. These latter two have little “natural” drainage, the bulk of their contribution to the waters of the Hudson Estuary are in the form of sewage discharge and combined sewage overflow. Combined sewage overflow (CSO) takes place when the sewage system, which combines sanitary and storm sewers into one system, is overloaded by heavy rainfall. Raw sewage is then directly discharged into the harbor through a series of overflow outlets that line the edge of the harbor. The total area in this aggregate basin is 7058 square kilometers. The land use and hydrology of this area is shown in Figure 2-8.

**Figure 4-6 Lower Hudson River Basin Land Use and Hydrology. Land Use determined by classification of 1992 Landsat imagery. Hydrology developed by the USEPA and USGS for the National Hydrologic Dataset, 1998.**



The Raritan River's source is Budd Lake in the Highlands of New Jersey. It makes a sweeping curve southeast, east and then to the northeast before emptying into Raritan Bay, a part of the Lower Bay. Below New Brunswick NJ the Raritan is estuarine, with numerous coves and inlets surrounded by a mixture of salt marshes, industrial plants and recreational boat basins. The lowermost gaging station is at Manville NJ. Annual average flow volume there is 21.5 cubic meters

meters per second (CM/s). Major tributaries to the Raritan River include the Millstone River, Middle Brook and the South River, which is estuarine when it joins with the Raritan.

The Passaic River also rises in the Highlands of New Jersey near Bernardsville. In it's headland area the river is dammed into a series of reservoirs providing drinking water for northern New Jersey. It flows north between the second and third Watchung Ridges, a series of basalt flows within the largely sedimentary Newark Supergroup. The Whippany River empties into the Passaic near West Caldwell NJ. At Little Falls the USGS gaging station records an annual average monthly flow of 28 CM/s. The river makes a graceful turn east and then south at Paterson passing through a gap in the Watchungs. Here it drops over the 23-meter (77 feet) tall Great Falls. Before the falls some of the flow is diverted through a series of raceways, which provided hydropower to the early industrial facilities first built here in the late 18<sup>th</sup> century. The Ramapo River, draining south out of Rockland County, empties into the Passaic below Paterson. In Garfield NJ the Dundee Dam, a hydroelectric and water supply dam holds the river in Dundee Lake at a level 9 meters (27 feet) above the base of the dam and 10 meters (33 feet) above mean tidal level. The Passaic River is tidal below Passaic NJ, which sits 5 kilometers downstream from the Dundee Dam. The Lower Passaic is entirely bulkheaded lined with numerous chemical plants, power stations and petroleum storage facilities. Refuse from 19<sup>th</sup> century industrial activity, especially slag from coal gas plants, was used to fill in wetlands around the Passaic. The IT Corporation (1986) estimated 21 tons of fill was employed in creating new upland areas, largely in the city of Newark, used largely for industrial activities.

The Hackensack River begins in Rockland County NY near Hook Mountain, the northernmost exposed extension of the Palisades Ridge. This ridge is also part of the Newark Formation, it was intrusively emplaced from a magmatic source similar to that which formed the Watchungs. The Hackensack flows south through a series of reservoirs, which divert much of its

flow to provide drinking water for both northern New Jersey and Rockland County NY. Below these reservoirs at the gaging station near New Milford average annual flow is only 3 CM/s. Below this point the Hackensack is largely tidal. It is joined by Overpeck Creek to form the Hackensack Meadowlands an extensive area of tidal wetlands. The Meadowlands have been extensively filled, channelized and used as a garbage and hazardous waste dumping ground. It includes 21 former landfills as well as Berry's Creek the site of extensive Mercury contamination from a number of facilities including Ventron, a former Mercury processing plant. Current efforts aimed at restoration include the designation of a Riverkeeper and the creation of a Hackensack Meadowlands Development Commission. The Commission is endowed with oversight over development with the goal of creating a balance between commercial interests and the natural role of the meadowlands as a bird nesting site, flyway and nursery for the Hudson Estuary.

#### **Passaic, Hackensack and Raritan Basin: Geology**

Bounding New York Harbor to the south and southwest is the Coastal Plains province. It is a gently sloping region, which extends from the fall line out under the Atlantic Ocean to the edge of the continental shelf. The underlying rock of the Coastal Plain is composed of Cretaceous and Tertiary sediments deposited in a wedge of sediments that thickens toward the continental edge (Isachen, et al. 1991). During the last glacial period the maximum extent of the ice sheet reached the New York City – Long Island area. As the glacier stalled and finally retreated it left behind a number of features that dominate the Coastal Plain landscape. The Ronkonkoma and Harbor Hills moraines, which form the spine of Long Island, represent the Terminal Moraine or maximum extent of the ice sheet. The Harbor Hill Moraine extends from Long Island into Staten Island. It blocked the Hudson River forming Glacial Lake Hudson behind it. Lake sediments composed of varved clays and silts accumulated within the extent of the lake. Around 12,000 to 13,000 years ago the moraine was ruptured at the site of the present day Verrazano-Narrows. The

waters of Glacial Lake Hudson drained away in an immense flood of waters that carved out the Hudson Submarine Canyon. Erosion subsequently removed most of the lake sediments except within the channel of the Hudson River where they were preserved by rising sea level and the subsequent development of the Hudson Estuary.

West of the Hudson River and bounded to the north and west by the Hudson-New Jersey Highlands is the Newark Basin. The basin extends from the west shore of the Hudson River to the escarpment of the Hudson Highlands. The two types of rock present determine the topography. The resistant igneous formations form ridges while the more easily eroded sedimentary formations form the lowlands.

The Newark Basin contains sediments that are largely fluvial arkosic sandstones and conglomerates, cyclic deposits consisting of gray, black and gray-red siltstones or sandstones which reflect the alternating climate during the time of formation. The rifting which formed the Basin also resulted in the periodic emplacement of magma into the sedimentary formations, both intrusions and extrusions. Later uplift left the entire group of formations inclined at a low angle, dipping  $5^{\circ}$  to  $15^{\circ}$  toward the northwest (Isachen, et al. 1991). Subsequent erosion has left the resistant igneous formations standing as ridges while the less resistant sedimentary formations form the lowlands and river valleys.

#### **Passaic, Hackensack and Raritan Basin: Landuse**

This basin is by far the most developed area in the Hudson-Raritan watershed. The total population in this area is 8,616,314 with an average density of 1162 people per square kilometer. Over 34% of land use is Urban, which includes residential, commercial and industrial. Table 2-4 lists land use/land cover in total area and fraction of the total watershed area for Anderson level 1

categories.

**Table 2-4 Land Use/Land Cover in the Passaic, Hackensack, Raritan and Direct Harbor Drainage Basin, by area and fraction of total basin area. Data is from MRLC Land Use Land Cover data.**

| Description | Fraction of Total Area | Area in km2 |
|-------------|------------------------|-------------|
| Water       | 0.0687                 | 485.0       |
| Urban       | 0.3473                 | 2451.0      |
| Bare        | 0.0019                 | 13.0        |
| Forest      | 0.3753                 | 2649.0      |
| Grasslands  | 0.0174                 | 123.0       |
| Agriculture | 0.1292                 | 912.0       |
| Wetlands    | 0.0603                 | 425.0       |

The urbanized area extends in a great arc around the Hudson Estuary. This basin includes much of the City of New York; Staten Island and parts of Brooklyn, as well as the City of Newark and many of the smaller cities, towns and suburbs that comprise the New York Metropolitan area. Industrial zones line the edge of the Hudson Estuary and extend significant ways up the major tributaries. Lining the Arthur Kill are petroleum storage facilities, refineries and chemical plants which make New Jersey the third leading chemical manufacturing state after Texas and Louisiana. On the west bank of Newark Bay are the container facilities of Port Newark and Port Elizabeth, the focus of shipping in the metropolitan area. Immediately behind the Ports is Newark Airport, one of the three major airports in the New York Metropolitan area. Virtually the entire shoreline of Brooklyn has been bulkheaded. Two tidal inlets, the Gowanus Canal and the Newtown Creek, are lined with crumbling industrial plants. These two areas were once leading manufacturing and trade areas. Newtown Creek was home to the earliest petroleum refinery in the Harbor. It is still home to a large number of petroleum bulk storage facilities that have leaked millions of gallons of oil into the groundwater, the creek itself and ultimately the Hudson Estuary.

Through all this development the Hudson Estuary is still home to extensive areas of tidal



wetlands. Jamaica Bay, the Hackensack Meadowlands and areas along the Arthur Kill still support abundant populations of birds, shellfish, fish and various invertebrates within the Spartina dominated marshes. Large areas of the extant wetlands are protected as part of the Gateway Recreational Area, managed by the Federal Parks Department. These areas include Jamaica Bay, Sandy Hook and other small pockets along the shoreline. The Hackensack Meadowlands Development Commission manages development in that heavily impacted area. The Commission has tried to create a system of granting development rights in return for protection and restoration of other heavily impacted areas that will remain undeveloped.

The Hackensack Basin contains the aforementioned Meadowlands as well as largely residential Northeastern New Jersey and Rockland County. The communities in these areas have had to strike a delicate balance between development and protection of open spaces, vital for ensuring the quality of water supplies, which are primarily surface water. The states of New York and New Jersey recently made a major purchase of private lands, generally known as Sterling Forest, adjacent to Harriman-Palisades Park. This area contains the headwaters of the Ramapo River, a major tributary to the Passaic River as well as the source for numerous reservoirs serving Northern New Jersey.

Patterson NJ was one of the earliest industrial areas in the United States. A series of waterworks, designed and set up by Pierre Charles L'Enfant and Alexander Hamilton in 1791, diverted water around the falls and through a series of industrial mills. Hamilton created the Society for the Establishment of Useful Manufactures (S.U.M.) to encourage industrial and mercantile activity in the young Republic.

Currently the greatest concentration of industrial activity in the New York Metropolitan area is on the New Jersey side of the Hudson Estuary. The west bank of the Arthur Kill is the

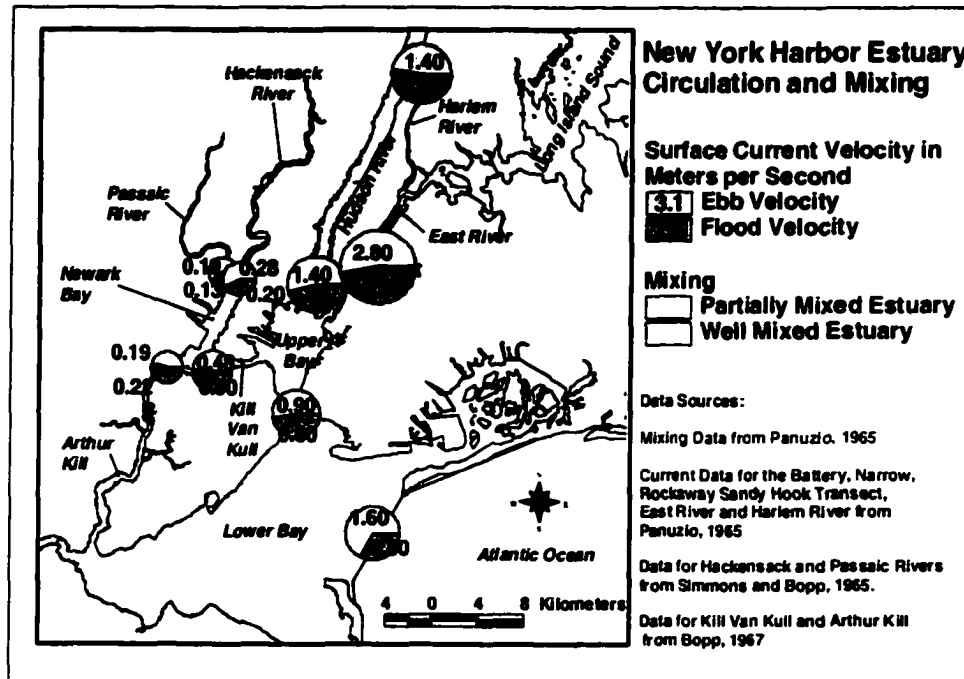
center of the areas petroleum refining industry as the oil soaked wetlands of the Kill attest. The city of Newark, bounded by it's namesake Bay and the Passaic River, has been a center of industry since the Civil War. Currently the dominant activities are paints, solvents and plastics with a number of power generating facilities, municipal and hazardous incinerators.

### **Hudson Estuary Circulation**

The bulk of fresh water input to the harbor is from the Hudson River, which empties into the harbor at the Battery. Panuzio (1965) estimates an average annual volume of fresh water runoff at the Battery of 635 cubic meters per second. Tidal circulation however dominates the overall flow pattern. Bokuniewicz and Arnold (1985) estimate a freshwater – tidal discharge ratio of 1:25 at the Battery and 3:2 at Troy, the tidal limit. Sewage treatment plants contribute additional fresh water to the system, some of this water originates in the watershed and some is brought in from the Delaware watershed. Estimates for sewage treatment plant contribution range between 10 and 25% of the freshwater input depending upon the time of year.

Besides receiving fresh water from the tributaries and sewage treatment plants, the harbor is also connected to the ocean and receives salt water via a series of tidal straits. The East River connects the harbor to the Long Island Sound, which is itself an estuary, open to the Atlantic Ocean through the Block Island Sound. The Lower Bay of the Harbor connects to the Atlantic Ocean through the Rockaway Sandy Hook Transect. The 25 to 1 ratio of tidal volume over freshwater volume creates a stratified flow in the lower Hudson River, which contributes by far the most freshwater flow. The remainder of the harbor is a partially mixed estuary due to the low input of freshwater and dominance of tidal circulation. Figure 2-9 shows the mixing characteristics of the major areas of the Hudson Estuary. Ebb and Flood tidal currents through the major straits are indicated.

**Figure 2-9 Hudson Estuary Circulation and Mixing. Ebb and Flood Currents.**



Numerous intra-harbor straits and bays further complicate the picture. The Harlem River connects the Hudson River to the East River (only one of the three is truly a river). The Spuyten Duyvil connects the Harlem River to the Hudson River, ebb currents through the strait averages 1.7 meters per second m/s while flood currents average 1.8 m/s s (Panuzio, 1965). The Hudson also connects to the East River around the tip of Lower Manhattan at the Battery. This creates a complex pattern where salt water flows into the lower Hudson and the East River from the Lower Bay at the same time that ebb flow from the Hudson is brought into the East River through the Harlem River (Panuzio, 1965). The East River is also connected to a second source of salt water, the Long Island Sound, through the Throgs Neck. Tidal currents in the East River are the strongest in the entire Hudson Estuary; flood current averages 2.7 m/s and ebb currents average 3 m/s (Panuzio, 1965). The Hudson enters the harbor at The Battery, which forms the northern boundary of the Upper Bay and mile 0 of the Hudson River (as well as the southern tip of Manhattan Island).

At the Battery ebb currents average 1.7 m/s while flood currents average 1.5 m/s (Panuzio, 1965).

The Upper New York Bay receives the discharge of the Hudson River. In addition it connects to the East River, the Kill Van Kull and to the Lower Bay through the Narrows. These multiple connections with varying ebb and flood currents, upper and lower density patterns, all flowing through a body of water just over 40 square kilometers in size make the Upper Bay one of the most treacherous areas of the harbor to enter or leave. Ironically it is crossed by the busiest ferry lines in the harbor, which connect lower Manhattan to Staten Island, Liberty Island and Ellis Island. The Kill Van Kull is a short, 2-kilometer strait, which connects the Upper Bay to Newark Bay and the Arthur Kill. Mean ebb velocity through the Kill is 0.48 m/s, mean flood velocity is 0.50 m/s (Bobb, 1967).

Ebb currents through the Narrows average 0.9 m/s while flood currents average 0.8 m/s (Panuzio, 1965). The Narrows is a break in the Harbor Hill Moraine, the furthest south extent of the continental glacier during the Wisconsin Glacial Period. Approximately 10,000 years ago glacial Lake Hudson, formed behind the moraine by melting glacial waters, burst through the moraine at the Narrows. This opened the Hudson River to the ocean and carved out a deep channel from the Narrows down the submarine Hudson Canyon to the edge of the continental shelf. In the Lower Bay and Bight Apex this channel has filled in, the strong currents through the Narrows itself scour the bottom nearly down to bedrock. (Coch, et al., 1986) This is the deepest area in the Hudson Estuary with depths over 40 meters.

The Lower Bay connects to the Upper Bay through the Narrows and to the Atlantic Ocean through the Rockaway Sandy Hook Transect. Currents through the Transect average 1.6 m/s on the ebb and 0.8 m/s on the flood s (Panuzio, 1965). The Lower Bay also connects indirectly to Newark Bay both through the Upper Bay-Kill Van Kull and through the Arthur Kill. On it's southeast flank it connects to Jamaica Bay through the Rockaway channel, the only outlet (or inlet)

for that Bay. On the southwest flank of the Lower Bay is the Raritan Bay. Raritan Bay receives fresh water flow from the Raritan River and the Cheesquake Creek. Behind the Sandy Hook peninsula is the Sandy Hook Bay, an area of restricted circulation that receives some freshwater input from the Navasink River (Coch, 1986).

The Passaic and Hackensack Rivers empty directly into Newark Bay. At Harrison Point, where the Passaic enters Newark Bay, surface mean flood current velocity is 0.13 m/s while ebb velocity averages 0.192 m/s. At a depth of 4.0 meters ebb velocity averages 0.104 m/s and flood velocity averages 0.183 m/s, bottom ebb velocity averages 0.046 m/s, bottom flood velocity averages 0.226 (Simmons and Bobb, 1965). Newark Bay connects to the rest of the harbor through the Kill Van Kull and the Arthur Kill. Where the Arthur Kill empties into Newark Bay mean ebb current velocity is 0.19 m/s, the flood velocity mean is 0.22 m/s (Panuzio, 1965).

This network of rivers, straits and bays creates a flow pattern, which has been extensively studied, recorded and modeled but is still not well understood. Panuzio (1965) refers to the estuary as "the most complex major estuarine system in the United States". In general terms the estuary is a sediment sink collecting a weight of sediment somewhere between 500,000 and 2,000,000 metric tons of sediment annually, depending on who is doing the estimate (see the following section on sedimentation). It is naturally shallow, without anthropogenic alteration, i.e. dredging, average depth would be around 4 meters. For the harbor to remain a major port, channels must be dredged to a depth of 12 meters or more. Due to natural hydraulics and chemical flocculation, areas such as Newark Bay and the Hudson shoreline of Manhattan act as sediment magnets requiring frequent maintenance dredging.

Extensive alterations of the harbor shoreline have taken place and are likely to continue taking place. The harbor has grown smaller and deeper due to human intervention. The shoreline

of lower Manhattan has been extended on average 400 meters into the harbor through landfill. Governors Island, at the junction between the East River and the Upper Bay, has doubled in land area (Squires, 1992). The shoreline of Bayonne New Jersey was extended out into the Upper Bay for the construction of railroad terminals and oil refineries when Standard Oil constructed new facilities at the terminal of it's Pennsylvania-New York pipeline (Chernow, 1998). Wards Island and Randalls Island, at the point where the Harlem River meets the East River and the East River narrows at the notorious Hell's Gate, have been joined to create one island (Squires, 1992). The course of the Harlem River was shortened and straightened back in the 19<sup>th</sup> century. The meander was filled in leaving a piece of Manhattan Island on the mainland (Coch, 1986).

Jamaica Bay has had many of the marsh areas on its mainland boundary filled in as garbage dumps and housing tracts. Plans by Robert Moses to completely fill it in were never carried out and it retains extensive wetland areas, which have been preserved as the Gateway National Recreational Area (Caro, 1975). Additional areas adjacent to Kennedy Airport and Floyd Bennett Field have been filled in to lengthen runways. Coney Island is no longer an island, the strait connecting Gravesend Bay to Jamaica Bay was filled in.

The Arthur Kill shoreline has largely been filled in and bulkheaded. Extensive areas of wetlands on the New Jersey side were filled in in the late 18<sup>th</sup> century for the construction of oil refineries and petroleum storage tanks (Squires, 1992). Wetlands have been preserved around Pralls Island and under the Goethals Bridge although these were severely impacted by the Bayway Oil Spill in 1991 and are currently undergoing restoration efforts by the New York City Parks Department. Freshkills Landfill, the world's largest, occupied 2100 acres of former wetlands. Newark Bay has experienced the greatest alteration in terms of the percent change in surface area and depth. Extensive filling took place beginning in the late 19<sup>th</sup> century and continuing until after World War II. Port Elizabeth and Port Newark, together one of the largest container cargo facilities

in the world, were created at the site of a former marsh. Large amounts of sand from the middle of the bay were dredged up and used to create the facility. These alterations resulted in a net loss of 25% of the surface area of pre-European settlement Newark Bay. Average depth of the Bay increased from 5 meters to 8 meters (Suszkowski, 1978).

### **Sedimentation in the Hudson Estuary**

Estuaries act as sinks for sediment due to chemical, physical, biological and anthropogenic factors. As fresh water enters the chemical estuary increased ionic concentration produces flocculation of fine-grained particles. Coch (1986) mapped sediment facies in the lower Hudson and noted a decrease in mean sediment size from the Battery, upriver to the Highlands gorge. Upstream from the Highlands mean grain size increased again. Coch and Bokuniewicz (1986) attributed this minimum point to location (during this study) of the upstream limit of saltwater intrusion. Tidal circulation results in periods of slack water when deposition can take place. Organisms remove sediments from the water column and then release agglomerated pellets, which have the mass to fall out of circulation (Bokuniewicz and Arnold, 1986). Physical alterations of the harbor have also changed sedimentation patterns. Wetlands along the edge of the harbor, which act naturally as sediment sinks, have largely been filled in. A general trend since the arrival of Europeans has been for the harbor to be reduced in area and increased in average depth, dramatically altering the hydrodynamics of the harbor (Suszkowski, 1978; Panuzio, 1965; Squires, 1992). Slips and piers along the harbor edge create areas of limited circulation, which facilitate sedimentation and shoaling. Dredged channels also act as sediment sinks in a similar manner by creating areas of disequilibrium in which sediment accumulation is rapid (Panuzio, 1965).

Sediment accumulation has a number of important implications for human use of the estuary. As mentioned earlier, the Hudson Estuary is naturally shallow, to function as a port the harbor must be constantly dredged. Dredging has a positive feedback on sedimentation, more frequent and deeper dredging results in higher sedimentation rates (Sandiford, 1996). Estuaries are sinks for fine-grained sediments and fine-grained sediments are sinks for contaminants. Metals, PAHs, PCBs, dioxins and other organic contaminants readily sorb to fine-grained material binding contaminants up in bottom sediments (Coch, 1986). These contaminants are readily re-released into the water column through biological activity, turbulence from storms or passing ships or by physical means such as dredging or construction activities. A pollution event such as spills or discharges can long outlast the natural flushing time of the water column (Waldman, 1999).

Various investigators have estimated the amounts of fine-grain suspended sediments deposited annually in the estuary from upstream sources. In a study of Hudson River pier slip shoaling, Panuzio (1965), gives an estimate of 752,000 MT/y. Olsen (1979) gave a figure of 1,000,000 MT/y while Ellsworth (1986) estimated 870,000 MT/y. Given the variation in annual freshwater discharge, methods used and sources of data, these deposition figures are within reasonable proximity. These studies estimated sedimentation rates from suspended sediment measurements. Using a drinking water sampling station in Poughkeepsie, Panuzio (1965) calculated a mean suspended sediment concentration of 33 parts per million (ppm) over a two year period. Bokuniewicz and Arnold (1986) measured an average of 30 milligrams per liter (~ppm). Seasonal variations due to annual cycles of freshwater discharge have been shown to be important only in the upper reaches of the watershed. The dominance of tidal flow below Poughkeepsie masks the variation in sediment delivery from the watershed through resuspension of sediment. Bokuniewicz and Arnold (1984) estimated that during summer months when freshwater input from the watershed is at a minimum, 85% to 97% of the suspended sediment in the Hudson



Estuary is due to tidal resuspension. During springtime freshet, or period of maximum runoff in the watershed due to snowmelt tidal resuspension is responsible for 15% to 50% of suspended particles.

An additional source sediment deposition data is dredging volumes. Dredging statistics vary greatly year-to-year and decade-to-decade due to technological changes in shipping, budgetary constraints and environmental regulatory changes (Sandiford, 1996). After changes in sediment testing were enacted in 1992 virtually no dredging of fine-grained material in the inner harbor took place (DeVicario, 1996). Dredging is a positive feedback mechanism for sediment deposition; increased dredging leads to increased sediment deposition by creating depositional areas.

Few studies have quantified coarse-grained inputs from upstream sources, largely due to the difficulties in quantifying and measuring bedload transport. Coch (1987) identified areas of sand within the Lower Hudson River at tributary junctions. The primary source of coarse material to the harbor is the Atlantic Ocean. Coarse sediments are brought in by the flood tide from the New York Bight. Coch et al. (1986), estimated 716,000 cubic meters per year (431,000 MT/y) supplied to the Lower Bay from long shore drift along Long Island and New Jersey. Coch and Bokuniewicz (1986) described large sand waves on the floor of the Ambrose Channel, the main shipping channel entering the Harbor from the New York Bight. The authors noted the orientation of the waves "suggests a net flux of sand landward" (Coch and Bokuniewicz, 1986).

Additional sediment accumulation is in the form of organic particles. A study in the Delaware Bay and River by Schubel and Meade (1977) measured equivalent volumes of in situ fine-grained organic material and fine-grained geologic material contributed by the watershed. Ellsworth, (1986) estimated 135,000 metric tons per year (MT/y) for the Hudson Estuary. Sewage

treatment plants also contribute fine-grained organic material to the Hudson Estuary. Ellsworth (1986) in an examination of data compiled by Mueller, et al. (1976) calculates a total of 58,000 MT/y contributed by municipal sewage treatment plants and industrial plants. The discharge figures used in these estimates are from a time period when only 9 of 12 sewage treatment plants in New York City treated to a secondary level. Significant discharges of raw sewage took place in all weather. As of 1996 with improvements to existing plants, and the opening of additional treatment works, all wastewater discharge is treated to a secondary level removing over 90% of the solid material. Currently raw sewage is discharged directly into the Hudson Estuary only during storm events when the combined sewage systems (sanitary and storm sewers) overflow and are released through outfall pipes.

A current estimate of sewage treatment plant contributed organic material was developed using the US Environmental Protection Agency's Permit Compliance System (PCS) database. PCS stores information on facilities that are required to hold a NPDES (National Pollution Discharge Elimination System) permit. All sewage treatment plants, as well as large industrial discharge facilities are required to hold a NPDES permit and provide monthly reports on permitted discharges. The EPA's National Office of Water calculates total annual loadings for all permitted discharge parameters on an annual basis, based on facility reported monthly discharges. Summing the entire Total Suspended Solid discharges directly into the harbor for 1996 yields a value of 25,000 MT/y. The total discharge into the Hudson Estuary for 1991 was 76,000 MT/y. This total represents discharge prior to the opening of the North River treatment plant and the upgrade to the Red Hook plant. This figure does not include contribution from Combined Sewage Overflow.

Atmospheric deposition of particulates is a small, but significant part of the fine-grained sediment load to the Hudson Estuary. Particulates include organic material such as pollen, inorganics such as soil and most importantly for dioxin assessment, soot. Ellsworth (1986)

estimated 4000 MT/y of atmospheric deposition of fine-grained material.

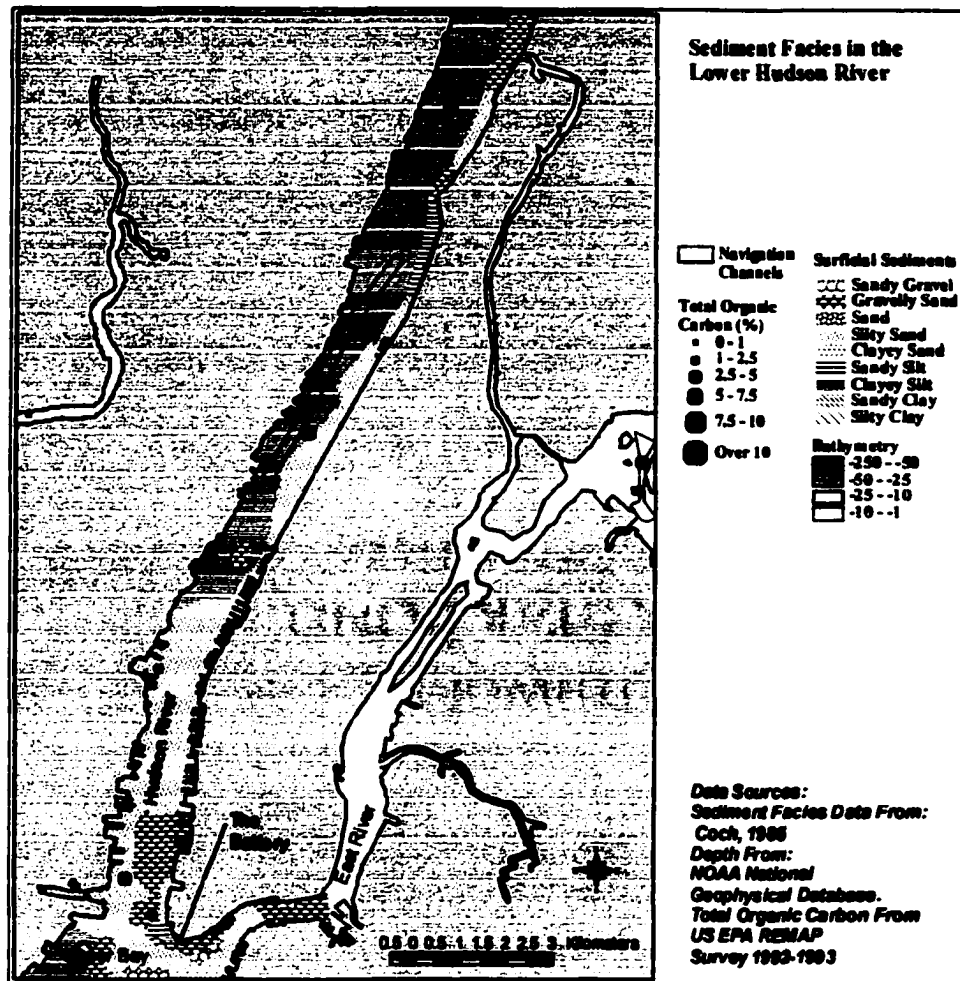
**Table 2-5 Sediment inputs to the Hudson Estuary**

| <b>Source</b> | <b>Metric Tons per Year</b> | <b>Investigators</b>       |
|---------------|-----------------------------|----------------------------|
| Tributaries   | 870,000                     | Ellsworth, 1986            |
| Biological    | 135,000                     | Ellsworth, 1986            |
| Sewage        | 25,000                      | EPA, PCS database          |
| NY Bight      | 1,100,000 - 1,600,000       | Coch and Bokuniewicz, 1986 |
| Atmosphere    | 4,000                       | Ellsworth, 1986            |
| <b>TOTAL</b>  | <b>2,134,000-2,634,000</b>  |                            |

### **Sediment Facies and Transport in the Hudson Estuary**

Due to the complex flow patterns within the Hudson Estuary, sediment facies are quite diverse. Coch (1986) conducted extensive sampling in the Lower Hudson and the Hudson Estuary. Maps from this study were digitized by the author and converted into Geographic Information System data layers. Suszkowski (1978) presents a similarly detailed description of sediment facies, hardcopy maps from this investigation were also digitized and merged with the Coch (1986) data. Bokuniewicz and Ellsworth (1986) developed a sediment transport budget for the Hudson Estuary. Suszkowski (1978) worked out a similar budget for Newark Bay. The following discussion is a summary of this information. Information on facies and sediment characteristics for the New York Bight and Bight Apex can be found in Frank and Friedman (1973) and Friedman and Sanders (1970).

**Figure 2-10 Sediment Facies in the Lower Hudson River. Sediment Data from Coch, 1986**

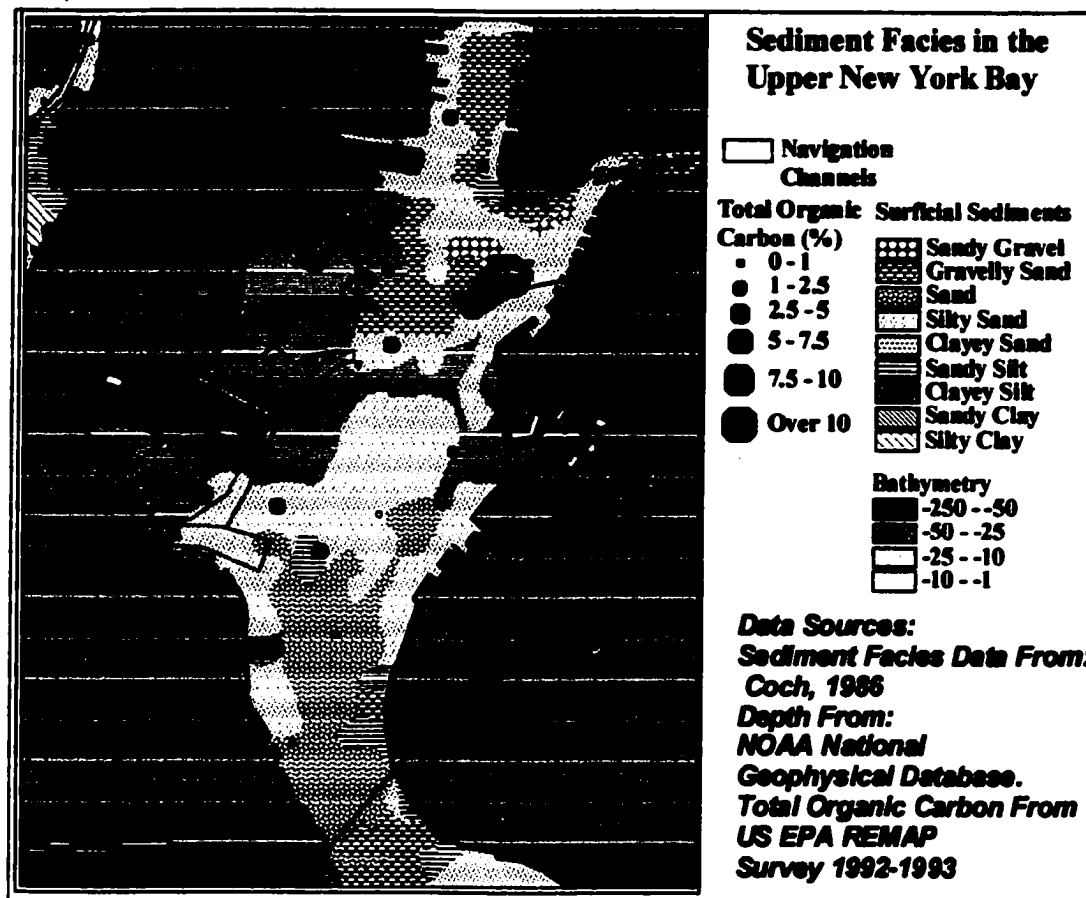


In the Lower Hudson sediment facies reflect the effects of the prevalent tidally driven density flow. Along the east bank the predominant transport is upriver movement of relatively coarser sediments resulting from bottom salinity currents diverted to the east bank by the Coriolis Effect (Figure 2-5). Sediments on the west shoreline are finer reflecting a dominant downriver deposition control. The general trend is for upstream fining, a trend which continues up to the Hudson Highlands (Coch and Bokuniewicz, 1986). Off the Battery is an area of gravelly sand, which gives way to sand. The west bank, dominated by downstream flow, is primarily sand. Around the

Around the Passenger Ship terminals, approximately kilometer 9, clayey silt dominates the entire river bottom. Upstream from this point the east bank is again sand while the west bank remains clayey silt. The fining trend upriver indicates that the relatively coarse grained material at the mouth of the Hudson must be derived from downstream sources, the Lower and Upper Bays and the ocean. Ellsworth (1986) calculated between 86,000 and 667,000 Metric Tons per year (MT/y) of sediments are transported into the Lower Hudson. The large uncertainty is due to the use of dredging volumes in deposition calculations and the uncertainty over dredged channel deposition rates and off channel deposition rates. Much of this material may have originally been transported downstream, past the Battery into the Upper Bay where it either remained in suspension or was deposited and resuspended. In fact Olsen (1979) estimated about 70% of the sediment deposited in the Upper Bay was derived from upstream sediments.

The Upper Bay, reflecting its complex hydrologic regime, is "*the most sedimentologically complex portion of the Hudson System*" (Coch, 1987). At the entrance to the East River, the location of the strongest currents in the Hudson Estuary, bottom sediments are primarily sands and gravel (Figure 2-6). These currents facilitate the sediment exchange between the East River and the Upper Bay. Bokuniewicz and Ellsworth (1986) calculated a net influx of 71,000 MT/y to the Upper Bay. Coarse sediments, gravelly sands, are also present in the main channel between Governors Island and Liberty Island. This facies is also present in the deep waters of the Narrows. The coarse sediments of the Narrows fine upward to sand in the as the Bay widens north of the Narrows between Brooklyn and Staten Island. At its widest extent, an east west axis between Gowanus Bay and the Kill Van Kull, the center of the Bay is silty sand.

**Figure 2-11 Sediment Facies of the Upper Bay. Sediment Data from Coch, 1986.**



On either flank of the Bay sediments are fine, clayey silts. On the west bank the area of silt is more extensive, comprising nearly a quarter of the Bay. This area, from Ellis Island south and west to Bayonne NJ, was formerly an area of extensive oyster beds, an important commercial enterprise until the late 1800's when pollution impacted and finally destroyed the beds. Currently efforts are underway to reintroduce oysters to the area. On the east side of the Bay is the Gowanus Bay leading to the Gowanus Canal. The Canal is one of the most polluted bodies of water in the Hudson Estuary, Coch (1987) measured organic carbon levels in the sediments as high as 25% a level that ensures the absence of Dissolved Oxygen. The Canal has very restricted circulation and until recently received direct discharge of raw sewage. A circulation pump at the head of the Canal, built in the early 1900's

Canal, built in the early 1900's but broken since 1920, has been repaired and will pump water through the Canal to relieve some of the organic accumulation.

The Upper Bay serves as a large traffic intersection for shipping in the Port of New York. Ships enter and leave through all four portals adding to the congestion of the ferry lines operating within the Bay. Because of this traffic over half the area of the Upper Bay is maintained as dredged channels. In the small area where sediment is allowed to accumulate, Bokuniewicz and Ellsworth (1986) estimated a deposition rate of 36,00 to 180,000 MT/y in areas where sediment accumulation is not removed by dredging. Annual average dredging volume is 560,000 MT/y (Schuble and Summers, 1985). As mentioned previously the Bay is a net exporter of sediment to the Lower Hudson. Bokuniewicz and Ellsworth (1986) calculated a net export of sediment from the Upper Bay to the Kill Van Kull, an annual average of 91,000 metric tons. The Upper Bay is a net importer of sediment with the East River. The Upper Bay also has a net influx of sediment from the Lower Bay through the Narrows. Olsen (1979) estimated that 250,000 MT/y of sediment deposited in the Upper Bay each year are derived from the ocean, through the Lower Bay.

The sediment facies of the Lower Bay are primarily sand (Figure 2-8). The coarsest sediments are around Breezy Point on the tip of the Rockaway Peninsula. Sandy gravel and gravelly sands form a coarse-grained flood delta. Gravelly sands are also found in the channel leading into the Narrows and off the Coney Island Peninsula. The center of the Bay is a vast extent of sand that extends from the south coast of Coney Island across the Bay to the Staten Island shore. Along the channel from Sandy Hook to the Arthur Kill the sediments fine somewhat to silty sand. Sand is brought into the Lower Bay from the Atlantic Ocean through the Rockaway Sandy Hook transect.

**Figure 2-12 Sediment Facies of the Lower Bay. Sediment Data from Coch (1986) .**



Between 1,100,000 and 1,602,000 MT/y of sediment are transported through the Transect by littoral drift, westward along Rockaway and northward past Sandy Hook (Coch and Bokuniewicz, 1986). Assuming an annual dredging volume of 840,000 metric tons, Bokuniewicz and Ellsworth (1986) calculated 328,000 MT/y are deposited in the Lower Bay. The sheltered Sandy Hook Bay is floored with sand and silty sand, indicating an absence of fluvial sediments and dominant ocean to bay sediment transport.

Raritan Bay, lying between the south shore of Staten Island and New Jersey, is dominantly fine-grained sediments. The Raritan River contributes fluvial sediments in addition to sediment from



from the Arthur Kill. Bokuniewicz and Ellsworth (1986) calculated a net transport of material from the Lower Bay (Raritan Bay) into the Raritan River, approximately 73,000 MT/y. Material is also transported into Jamaica Bay from the Lower Bay, an annual volume estimated by Bokuniewicz and Ellsworth (1986) to be between 15,000 and 29,000 MT. Sediment is also transported out of the Lower Bay into the Arthur Kill, a total of 75,000 MT/y (Bokuniewicz and Ellsworth, 1986).

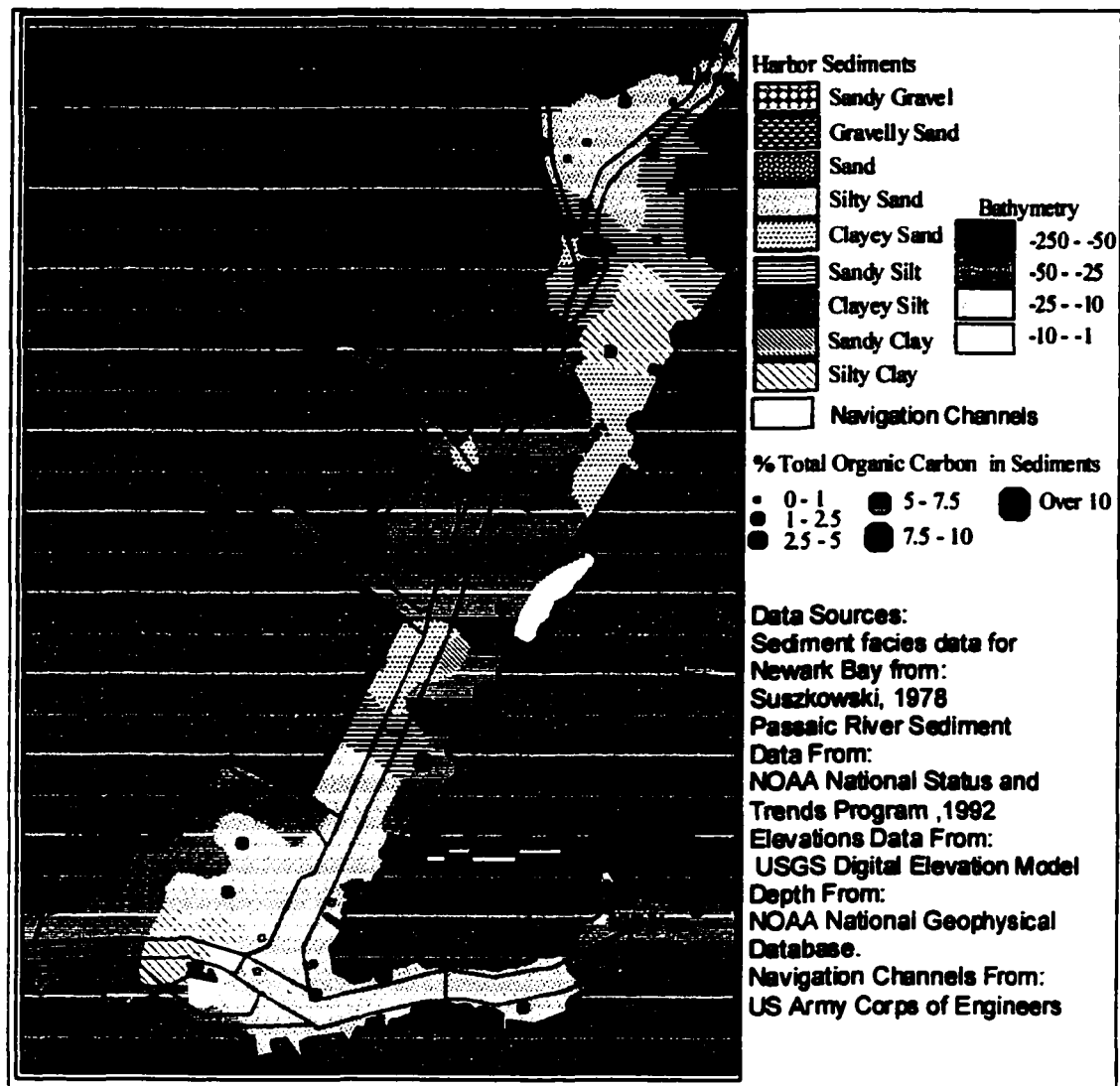
The Arthur Kill is quite narrow, averaging only about 300 meters in width. As mentioned in the section on landuse, the Arthur Kill is the focus of oil refining in the New York metropolitan area. The Federal Channel runs the entire extent of the Kill to allow access from either end. The dredged channel takes up much of the width of the waterway and extensive shoreline areas are privately dredged. The lower 2/3 of the Arthur Kill, below Pralls Island, is floored by fine clayey silts brought into the Kill from the Raritan Bay. From Pralls Island north the sediments coarsens to silty sands. This coarse of material would not be expected in an estuarine area of such restricted circulation. This facies may represent relic sediments mixed with finer estuarine sediments as a result of the extensive dredging which takes place. Around the mouth of the Elizabeth River the sediments are considerably finer, silty clays dominate. This facies extends from about one kilometer south of the Elizabeth River north to Howland Hook, which marks the boundary of the Arthur Kill and Newark Bay.

The sediments of Newark Bay were extensively sampled and described by Suszkowski (1978). The sediment facies map from his examination of sediment samples was digitized and converted to an Arcview GIS shapefile. The following description is drawn from this dataset, which is shown in Figure 2-8. Sediments at the southern west end of Newark Bay, where it meets the Arthur Kill, are clayey silts. This facies extends north, up the west side of the Bay to the South Elizabeth Channel the southern boundary of the Elizabeth Marine Terminal. The terminal area was

created by landfilling Newark Bay, partially with sediments dredged for the creation of Port Elizabeth. On the west and north side of Shooters Islands is a small area of very fine sediment, silty clays. This area is a natural deposition area; it is somewhat sheltered from the tidal currents by the island. Suszkowski (1978) characterized this area as one of rapid sedimentation, causing the North Shooters Island channel passing through it to require frequent dredging.

Newark Bay connects to the Kill Van Kull on the east side of the southern end of the Bay. The currents here are stronger than through the Arthur Kill so the facies is coarser, silty sands which extend from a point about 1/3 of the way through the Kill Van Kull, up the east side of the Bay until just past the bottom of the Elizabeth Marine Terminal. The construction of the terminal significantly narrowed the bay at this point. The Federal Channel is wide in this area, which is essentially the entranceway to one of the largest cargo terminals in the world. Due to extensive and ongoing human alterations of the Bay the sediment facies are a chaotic mixture of natural and anthropogenic material the distribution of which does not follow physical parameters, i.e. depth, salinity and currents. Clayey silts occupy most of the middle of Newark Bay including the berthing areas. Large patches of clayey sands are also present around the edges of the Bay. The coarser sediments found in this area are attributed by Suszkowski (1978) to relic sediments which have been excavated by the creation and maintenance of the navigation channels and berthing areas. The mouth of the Hackensack River is a silty sand facies (Suszkowski, 1978).

**Figure 2-13 Sediment Facies of the Newark Bay. Sediment Data from Suszkowski, 1978.**



Suszkowski (1978) calculated a sediment budget for Newark Bay based on suspended sediment load, top middle and bottom boundary currents and tidal prism volume. Newark Bay receives a net influx of sediment from the Arthur Kill, the Kill Van Kull and the Passaic River. The Hackensack River receives a net surplus in sediment from the Bay. The largest contributor of sediments to Newark Bay is the Kill Van Kull, which connects Newark Bay to the Upper Bay. The Kill Van Kull contributes 209,000 MT/y of sediments to Newark Bay and accepts 144,000 MT/y of

of sediments from Newark Bay for a net contribution to the Bay of 65,800 MT/y (Suszkowski, 1978). It was also calculated that Newark Bay receives 80,500 MT/y of sediments from the Arthur Kill while providing 48,800 to the Kill, a net gain to the Bay of 36,700 MT annually. The Bay's exchange with the Passaic River involves 41,500 MT/y moving from the Passaic into Newark Bay and 23,400 MT annually transported into the Passaic, a net gain to Newark Bay of 18,100 MT/y. The Hackensack River receives a net surplus of 28,000 MT each year, 98,500 MT/y are moved from the Hackensack to the Bay, 126,000 MT/y are moved from Newark Bay to the Hackensack.

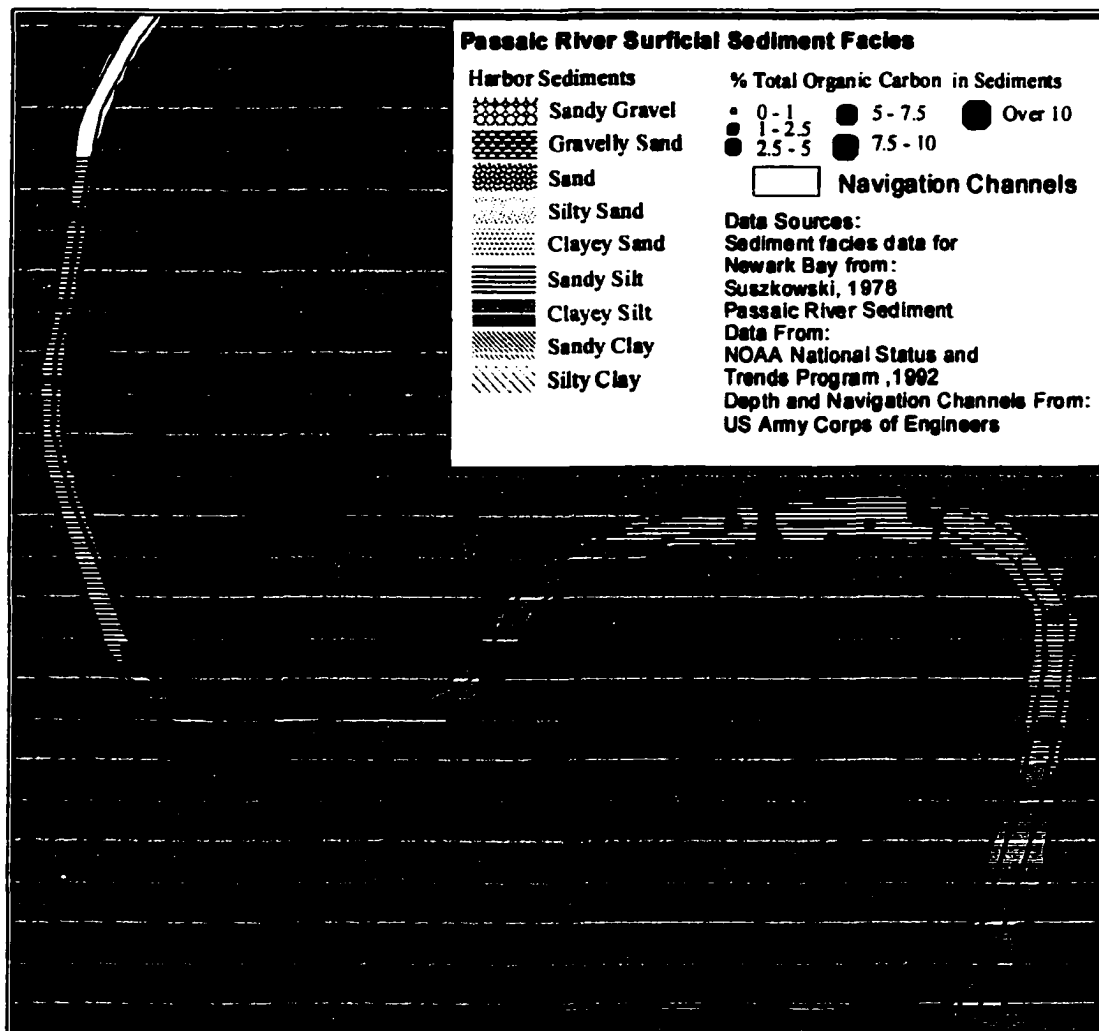
### **Passaic River Circulation and Sedimentation**

The Lower Passaic River is the focus of this investigation; this section will summarize much of the previous sections with their relevance to the Passaic and to its problem of contaminated sediments. The area has been heavily industrialized for over one hundred years, much of the activities producing large, toxic waste streams which until relatively recently were largely disposed of in or along the River. Extensive areas of bordering wetlands, which naturally function as sediment traps, were filled in, the shoreline is bulkheaded or covered in boulders or railroad riprap. Since 1880 the US Army Corps of Engineers had maintained a 30-foot deep (9 meter) navigation channel extending from Newark Bay up to Passaic New Jersey. The Lower Passaic is naturally a depositional area, the loss of bordering wetlands and deepening of the channel have likely increased the in and off channel deposition rate.

Fine-grained silts and clays make up the bulk of the bottom sediments. The Lower Passaic sediments contain significant organic material; concentrations are higher than anywhere else in the Hudson Estuary. For the surficial samples used in this study the total organic carbon (TOC) concentration in Lower Passaic sediments ranged from 0 to 40%. Mean TOC concentration was 8.5 %. For all Hudson Estuary samples the mean TOC concentration was 5.2%. Some organic

is probably produced in situ, but sewage treatment plants, industrial outfalls and combined sewage overflows, contribute the bulk. The Lower Passaic is shown in Figure 2-14.

**Figure 2-14 Passaic River Sediment Facies. Sediment Data from Suszkowski, 1978 and NOAA, 1992**



Physical and chemical parameters in the lower Passaic River indicate stratified estuarine circulation, similar to the lower Hudson River. At the mouth of the Passaic River, where it empties into Newark Bay, bottom flood current averages 0.226 meters per second (m/s) with an average duration of 7.4 hours while the bottom ebb current averages 0.046 m/s with a duration of 5.0 hours

(Simmons and Bobb, 1965). Ebb surface current averages 0.192 m/s for 7.2 hours while surface flood current averages 0.131 m/s for 5.2 hours. Water column salinity as measured by Suszkowski (1978) varied from 5.5 parts per thousand (ppt) at the surface to 11 ppt at the bottom. The previous study also measured suspended sediment concentration, which varied from 16 milligrams per liter (mg/l) in the upper layer to 13 mg/l at the bottom.

Current and Salinity profiles were recorded adjacent to the Diamond Alkali Site during the Passaic River Hydrographic Survey conducted by the IT Corporation for the EPA preliminary investigation. Recordings were taken throughout a single tidal cycle. Mean ebb velocity at the surface at 0.61 m/s while the mean bottom ebb velocity was 0.12 m/s. Mean surface flood velocity recorded was 0.2 m/s and mean bottom flood velocity was 0.2 m/s. Salinities ranged from 8 to 17 parts per thousand (ppt) at the surface and 14 to 18.5 ppt at the bottom (IT Corporation, 1985). These are significantly higher salinities than those found by Suszkowski in 1978 at a sampling station at the mouth of the Passaic while the IT station was 3 kilometers upstream. One explanation is that the figures given by Suszkowski represent an average of 15 cruises over one year, 1976. The IT study consisted of two days of sampling in February of 1985. Flow data from the USGS gaging station at Little Falls indicate an average flow volume of 26.1 M<sup>3</sup>/s for all of 1976 while early February of 1985 was a time of lower than normal flow at an average of 7.3 M<sup>3</sup>/s.

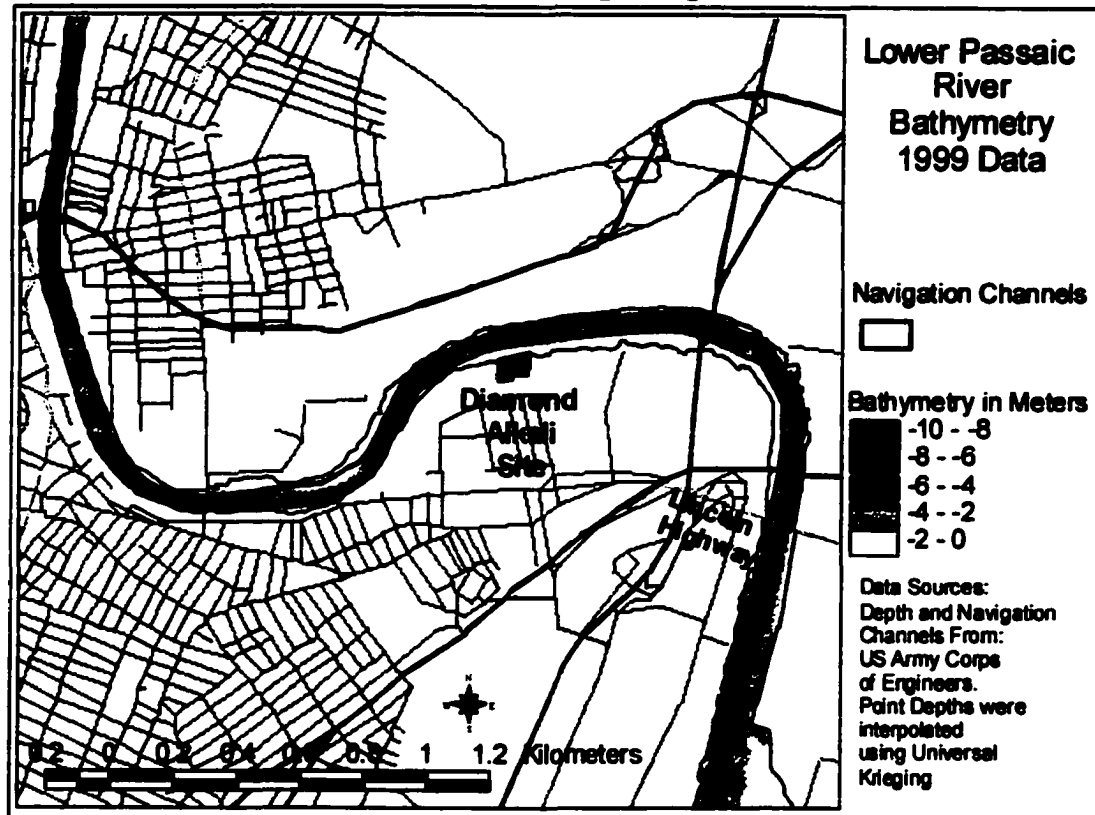
The large difference in ebb and flood currents as well as salinity, between the bottom and top of the water column, creates stratified flow in which bottom sediments are moved upstream while sediments entrained higher in the water column are moved downstream. Suszkowski (1978) noted a turbidity maximum at the mouth of the Passaic River, the location in his model where exchange takes place between the River and the Bay. Of the total sediment load at the Passaic Newark Bay boundary, 2/3 is transported downstream. Suspended sediment load is higher in the

upper, predominantly downstream flow layer. This downstream component represents sediment in the upper half of the water column, primarily from the Passaic Watershed with some resuspended sediment from the Hudson Estuary brought into surface waters by the turbidity maximum. Bottom flow, along the sediment water interface, moves in the upstream direction for a longer duration and at a higher velocity. Resuspended material from the Passaic River bottom would be expected to move primarily upstream as Panuzio (1965) noted with sediment transport in the Lower Hudson River.

#### **Passaic River Bathymetry**

Dredged channels have been maintained in the Lower Passaic River since the late 1800's. The reaches above the Lincoln Highway Bridge, about 1 kilometer upstream from the mouth of the Passaic and 1.5 kilometers downstream of the Diamond Alkali site, have not been dredged since 1949 (US EPA, 1995). The area below the Highway was dredged in 1961, 1964, 1971 and 1977. Figure 2-10 shows current bathymetry for the Lower Passaic. These data were obtained from the US Army Corps of Engineers; they were interpolated from point locations to a continuous surface layer.

**Figure 2-11 Lower Passaic River Bathymetry**

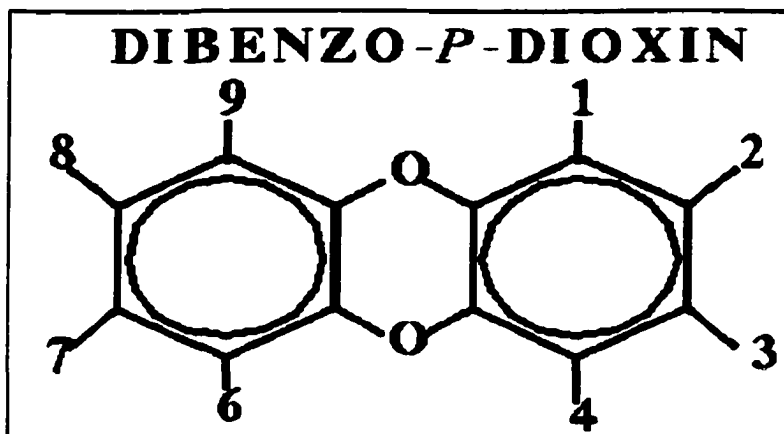




### Chapter 3 - Dioxins and Furans: Chemistry, Health Effects and Environmental Sources

The term dioxin refers to a family of compounds known chemically as dibenzo-p-dioxins. These molecules consist of a triple ring structure of two benzene rings connected by two oxygen atoms. The positions on the benzene rings available for substitution are numbered 1-4 and 6-9, they may be occupied by a chlorine or halogen atom, an organic radical or a hydrogen atom (US EPA, 1980). The structure of the Dioxin molecule is shown in Figure 3-1.

**Figure 3-1 Structure of the Dibenzo-p-Dioxin molecule. The numbered positions may be substituted by one or more chlorine atoms.**



Also of

environmental concern are dibenzo furans, structurally similar to dibenzo dioxins but having one direct carbon-to-carbon bond connecting the benzene rings and one oxygen atom connecting the rings.

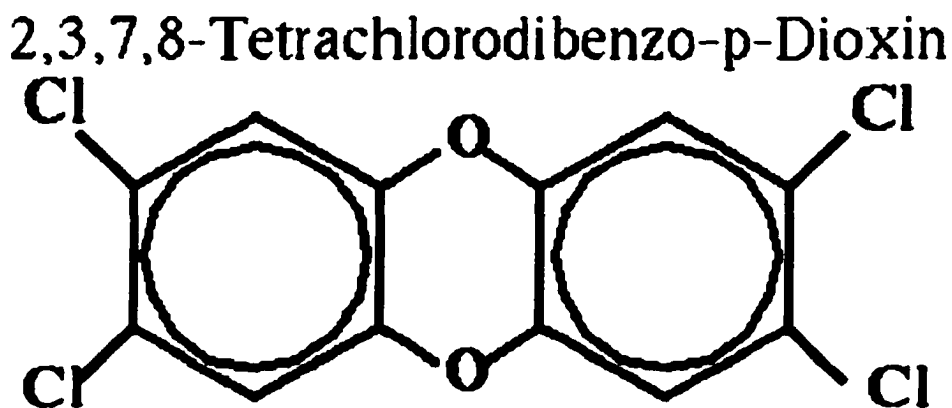
#### **Chemistry of Dioxins**

The chemicals that are of most environmental interest are chlorinated dioxins and furans, where one or more chlorine atoms replace the hydrogen atoms. Each molecule of either dioxins or furans can hold up to 8 chlorine atoms. Based upon the position and number of chlorine atoms

there are theoretically 75 different chlorinated dioxins and 135 different chlorinated furans. Not all of these combinations, known as congeners, are toxic, and the toxic ones are not equally toxic. Seven of the 75 dioxins and 10 of the 135 furans are toxic. These 17 different congeners all exhibit similar "dioxin-like toxicity", effects caused by a common mechanism: binding to a complex molecule found in the cells of living organisms known as the aryl hydrocarbon or "Ah" receptor. It is believed that the tighter the binding to the Ah receptor, the more toxic the chemical. The most potent or toxic congener is 2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD, which also has the greatest affinity for the Ah receptor. One key factor in toxicity is the number of chlorines in the molecule: a molecule with less than three chlorines lacks dioxin-like toxicity. Another key factor is where the chlorines are attached. In dioxins and furans chlorines occupying positions 2, 3, 7, and 8 result in a toxic molecule.

Only 40 of these combinations, or congeners, have been prepared and analyzed for their physical properties. The most toxic dioxin and the congener that has spurred the most interest is 2,3,7,8-tetrachlorodibenzo-p-dioxin. 2,3,7,8-TCDD is an unusual organic chemical, symmetrical across both horizontal and vertical axes (Figure 3-2).

**Figure 3-2 Structure of the 2,3,7,8-Tetrachlorinated Dibenzo Dioxin molecule**



It is extremely stable chemically and is sparingly soluble in water; the water solubility for 2,3,7,8-TCDD is estimated to be  $1.93 \times 10^{-5}$  mg/L (Marple et al., 1986). The Octanol-

Water Partition Coefficient ( $\log K_{ow}$ ) is between 6.15 and 7.28. This results in a tendency to sorb onto fine grained and organic material. It is a colorless crystalline at room temperature with a melting point of 305° C (EPA, 1980).

Dioxins are not formed biosynthetically by any living organism. They are generally not intentionally synthesized, but rather are by-products of a variety of chemical reactions, processes and combustions. The first intentional preparation of dioxins was in 1872. Two German chemists, Merz and Weith, produced what they called “perchlorophenylenoxyd” by thermolysis of potassium pentachlorophenate (EPA, 1980). Releases of dioxins into the environment occur primarily from chemical manufacturing, including production processes and end uses such as herbicide application, burning and other high temperature processes, and from chemical waste dumps.

Dioxin formation during chemical manufacturing is associated primarily with polyhalogenated phenols. The manufacturing process of these compounds involved reactions conducive to dioxin formation, high temperature plus alkalinity or the presence of free halogens. Chlorophenols are widely used as raw material in the synthesis of other organic compounds. Less highly chlorinated phenols (mono, di) are used with formaldehyde to make fire resistant plastics. Trichlorophenols (2,4,6 and 2,4,5) are used as fungicides, herbicides, in the textile industry and tanning industry as preservatives and as rubber gasket preservatives. Concerns over the presence of 2,3,7,8-TCDD in phenoxy herbicides such as 2,4,5-T (trichlorophenoxyacetic acid) led to an Environmental Protection Agency (EPA) restriction on the use of the herbicide 2,4,5-T in 1970 and ban on most uses in 1979.

Dioxins have been found in flue gasses and fly ash from municipal incinerators and industrial heating facilities. A study in the Netherlands estimated 21.6 kilograms of PCDDs in flue gases emitted by municipal incinerators annually. Only 24 grams were found to be 2,3,7,8-TCDD a low ratio compared with the 2,3,7,8-TCDD concentrations found in manufacturing processes. A Dow chemical study indicated the presence of dioxin in industrial refuse incinerators, fossil fuel powerhouses, even in fireplaces, charcoal grills and cigarette

smoke. The Dow study, called the "Trace Chemistry of Fire" has been widely criticized as an attempt to divert attention from high levels of dioxins in fish downstream Dow plant in Midland, Michigan (US EPA, 1980). Dioxins have been found in diesel truck exhaust and automobile exhaust, from both leaded and unleaded gasoline (Marklund et al. 1990).

Hooker chemical company disposed of approximately 200 tons of 2,4,5-trichlorophenol in Love Canal between 1940 and 1953. The presence of dioxins, along with a number of other toxic chemicals at this site, led to the creation of the Federal Superfund Program for the cleanup of toxic waste sites.

### **Health Effects of Dioxins**

Dioxins, especially 2,3,7,8-TCDD are toxic in extremely small quantities, according to Silbergeld & Gasiewicz (1989) "a millionth of a gram will kill a guinea pig". The toxicity of dioxin is associated with the cellular response to the dioxin molecule. Due to its unique shape the 2,3,7,8-TCDD molecules within cells binds strongly to the Aryl Hydrogen (AH) Receptor site. The AH Receptor is a natural protein "messenger" synthesized within animal cells. Thousands of such receptors exist within the body carrying out necessary tasks such as protein synthesis, binding to DNA or triggering hormones. The function of the AH receptor is not well understood; it may be an evolutionary relic matching to a growth regulating hormone no longer synthesized (Silbergeld & Gasiewicz, 1989).

Within humans the Ah receptor functions as a binding site for removing contaminants brought into the body. The receptor bind an number of contaminants, such as benzene and other aromatic hydrocarbons. numerous naturally occurring plant toxins as well as most organochlorine compounds. The receptor - contaminant complex activates enzymes that break down the contaminant converting them to water-soluble components, which can be flushed from the body. One such enzyme is called aryl hydrocarbon hydroxylase (AHH), it plays an important role in the toxicity of dioxins. When the bound contaminant is broken down and removed from the receptor enzymatic production is halted.

2,3,7,8-TCDD has a very strong affinity for the AH receptor site, binding more tightly than most molecules, it is this action that leads to dioxins' toxicity and other adverse effects. Dioxins have no effect on cells that do not possess Ah receptors (Silbergeld & Gasiewicz, 1989). When the dioxin molecule binds to the AH receptor it triggers enzyme production, especially AHH production. Since the dioxin molecule binds so tightly to the receptor molecule, enzymatic action is often unable to break down and remove the dioxin. Enzyme production is therefore not turned off, a process termed "enzyme induction". In addition to the production of enzymes the dioxin-AH receptor complex triggers the release of hormones which regulate cellular growth and division (Silbergeld & Gasiewicz, 1989).

Enzyme induction produces a number of side affects within the cell. These enzymes begin to break down other molecules within the cell, many of which are necessary for proper cellular functions such as hormones and proteins. Many of the breakdown products have been shown to be mutagens, causing genetic alterations or mutations. These mutations often lead to the cancerous growth making 2,3,7,8-TCDD the most potent cancer promoter known (Silbergeld and Gasiewicz, 1989).

Dioxins produce a range of toxic effects:

- Mortality: test animals die from a wasting disease in two to six weeks
- Damage to the thymus gland resulting in changes in cell immunity. This immune system damage has been found at similar levels in all animals examined. The effects are more likely in children
- Damage to the liver, kidneys and digestive tract
- Reproductive effects: miscarriage, sterility
- Teratogenic; Causes birth defects, including neurological effects
- Cancer Promoter; Dioxin is considered the most potent cancer promoter
- Evidence of tumor initiation in animals

- Chloracne - persistent skin eruptions in humans and some animals

(Goldstein & Safe, 1989; Silbergeld and Gasiewicz, 1989)

The Lethal Dosage for dioxin varies from species to species. Lethal dosage is considered to be the amount of a substance, per body weight of the test organism, which produces death in 50% of the organisms exposed. It is termed **LD<sub>50</sub>**. The most sensitive animal tested is guinea pigs, **LD<sub>50</sub>** is 1 µg/Kg. Hamsters are far less susceptible to the effects of dioxin with an **LD<sub>50</sub>** of 5 mg/Kg.

Immune system effects are more consistent between species for similar doses and occur at much lower levels of exposure. In mice, a dose 4000 times lower than the lethal dose will significantly alter the ability of mice to produce cell-killing T-lymphocytes, a white blood cell important for immunity. (Silbergeld & Gasiewicz, 1989). Tests on hamsters and mice show dioxin induced changes in the thymus and liver occur at the same dose levels even though the **LD<sub>50</sub>** for these two species differs by 2 orders of magnitude (Silbergeld & Gasiewicz, 1989).

Dioxins affect a wide range of organs in the body, this results from the action of dioxin on growth regulation. Organ and tissue growth occurs by cellular division. The attachment of the dioxin-AH receptor complex to cellular DNA appears affect the process by which cells develop individual characteristics. In the fetus this action results in birth defects. This activity can also cause uncontrolled growth of cells, a mechanism by which dioxins act as a cancer promoter. The observed dioxin effects are all on epithelial cells, cells that form the lining of organs and parts of the body. The damage done by dioxin to the thymus gland, urinary tract, liver and bile ducts results from disruption of the growth of epithelial cells in these organs.

Chloracne is a skin disease, often accompanied by severe disfiguration, severe joint pain, headaches, fatigue, irritability and chronic weakness; and it can persist in the body for at least 30 years after exposure (US EPA, 1985). Chloracne often results from low levels of exposure and was prevalent among workers at plants producing chlorinated phenols and similar products. At

the Diamond Alkali Facility workers were tested for health effects in February of 1969. Forty-eight of seventy-eight workers showed evidence of chloracne (Poland, et al., 1971). Chloracne results from overgrowth and altered differentiation of skin cells, which are epithelial cells.

#### **Toxic Equivalence Factors**

The toxic effects of dioxins result from the binding action to the AH receptor. The 2,3,7,8-TCDD molecule binds the most tightly and is therefore the most toxic of the dioxins with a Lethal Dosage (LD50) of 0.022 mg/kg in rats and even higher toxicity in guinea pigs (EPA, 1980). The toxicities of other dioxin components are measured relative to 2,3,7,8-TCDD using Toxic Equivalency Factors (TEF) or Toxic Equivalence Quotient. The TEF for 2,3,7,8-PeCDD is 0.5 meaning any Penta- substituted dioxins with chlorine atoms occupying the 2 3 7 and 8 position (and one other position) are half as toxic as 2,3,7,8-TCDD. As the number of chlorine atoms per molecule increases, the toxicity equivalence decreases. Table 3-1 lists the Toxic Equivalence Factor for 16 dioxin-furan congeners. TEFs are a gross estimator of the effect of the given mixture and quantity of dioxins. Many investigators consider them to be overused at best and useless at worst. However they are widely used and reported, estimates of dioxin loadings to the environment are routinely made in TEFs rather than actual total dioxin quantities.

**Table 3-1 Dioxin and furan Toxic Equivalence Factor, toxicity of dioxin-furans as a ratio of 2,3,7,8- tetrachlorodibenzo dioxin toxicity. From Van den Berg et al. (1998).**

| <b>Dioxin/Furan</b>                     | <b>TEF</b> |
|-----------------------------------------|------------|
| 2,3,7,8-tetrachlorodibenzo dioxin       | 1          |
| 1,2,3,7,8-pentachlorodibenzo dioxin     | 1          |
| 1,2,3,4,7,8-hexachlorodibenzo dioxin    | 0.1        |
| 1,2,3,6,7,8-hexachlorodibenzo dioxin    | 0.1        |
| 1,2,3,7,8,9-hexachlorodibenzo dioxin    | 0.1        |
| 1,2,3,4,6,7,8-heptachlorodibenzo dioxin | 0.01       |
| octachlorodibenzo dioxin                | 0.001      |

|                                        |       |
|----------------------------------------|-------|
| 2,3,7,8-tetrachlorodibenzo furan       | 0.1   |
| 1,2,3,7,8-pentachlorodibenzo furan     | 0.05  |
| 1,2,3,4,7,8-hexachlorodibenzo furan    | 0.1   |
| 1,2,3,6,7,8-hexachlorodibenzo furan    | 0.1   |
| 1,2,3,7,8,9-hexachlorodibenzo furan    | 0.1   |
| 2,3,4,6,7,8-hexachlorodibenzo furan    | 0.1   |
| 1,2,3,4,6,7,8-heptachlorodibenzo furan | 0.01  |
| 1,2,3,4,7,8,9-heptachlorodibenzo furan | 0.01  |
| octachlorodibenzo furan                | 0.001 |

### **Human Exposure to Dioxins**

There have been a number of incidences of human exposure to dioxins. One of the most well known cases occurred at an ICMESA plant in Meda Italy. On July 10, 1976, a safety disc on a pressurized 2,4,5-TCP reactor ruptured, releasing a cloud of 2,4,5-TCP, which contained 2,3,7,8-TCDD. More than three thousand animals died within a few days, there was one human fatality in the immediate aftermath and 135 cases of chloracne were reported, primarily among children (EPA, 1980). The dispersal of the population has hindered studies of the long-term effect of dioxin exposure especially concerning the possibility of birth defects a widely held assumption as yet unproven.

In Verona Missouri waste oils containing dioxins were sprayed on horse arenas and private roads to control dust in May and June of 1971. Seven people developed various illnesses due to exposure. A six-year-old girl was the most seriously affected developing inflammation of the kidneys and hemorrhaging of the bladder (EPA, 1980).

The use of herbicides containing 2,4,5-T has resulted in numerous cases of human exposure to dioxins. In Oregon application of silvex and 2,4,5-T by Forest Service and timber companies brought charges of miscarriages by women living near sprayed areas. More than 12 million gallons of Agent Orange, a 50:50 mixture of 2,4,5-T and 2,4-D were used in Vietnam between 1962 and 1970. Studies done on US Army veterans exposed to herbicides in Vietnam showed after 10 years concentrations of PCDDs in fat tissue of up to 173 ppt. Based on a half-life of 1 year this would mean original concentration of 100 ppb to result in 100 ppt after ten years. This would require an exposure rate of 2-4 grams per day. Studies released under an Air Force



report indicate numerous deformities have been found in children 6 -14 years old (as of 1978) among Vietnamese living in areas where Agent Orange was applied (EPA, 1980).

The previous examples of dioxin exposure represent highly publicized yet rare events. Most people are exposed to low levels of dioxins continuously through their lives. This is the "background" exposure resulting from the ubiquitous presence of dioxins in air, soil and food. These levels are largely the result of anthropogenic activity, studies of lake sediments dating back to the 18<sup>th</sup> century show a continuous increase in environmental dioxin levels. The US EPA has developed estimates of exposure to dioxins, furans. Adult daily intakes through inhalation and ingestion are estimated to be 41 picograms of dioxin TEFs per day (US EPA, 1998a). These estimates are based on the numerous studies of dioxin levels in food, the primary media of exposure. For most Americans, about 90% of dioxin exposure results from consumption of foods, especially meat, fish and dairy products. Variations in diet may result in exposures at least three times higher than the mean value (US EPA, 1998a). Vegetarian diets result in significantly lower exposure. Dioxin bioaccumulates and as it is very slightly soluble in water it accumulates in adipose tissue.

The daily intake of dioxin by infants and nursing children is significantly higher than adults. Dioxin has been shown to cross from the placenta from the mother to the fetus. After birth dioxins are transmitted through mother's milk, very high in fat, to the nursing baby. Babies fed with breast milk are exposed on a daily basis to about 50 times more dioxin than adults per kilogram of body weight. On a daily basis, toddlers are exposed to about three times more dioxin than adults on a body weight basis due to their higher metabolic rate and high consumption versus body weight (Patandin, et al. 1999).

In addition to early developmental stages and infants, other highly exposed groups include subsistence farmers, people who fish for a living and for sport, and indigenous people.

Indigenous people who eat fish and sea mammals from the Arctic regions are exposed to dioxin at higher than average levels because dioxin and PCB levels are particularly high in these foods (Papke, 1998).

As mentioned previously dioxins are extremely hydrophobic and tend to sorb to fine-grained and organic material. Estuaries act as sinks for fine-grained material and therefore are sinks for contaminants. Dioxin has been shown to accumulate over time to concentrations over ambient levels in the fatty tissues of aquatic organisms. In addition some studies have shown that dioxins can be biomagnified at higher trophic levels. A National Oceanic and Atmospheric Administration (NOAA) study of benthic and fish tissue bioassays showed elevated body burden levels of dioxins in crabs and fish from the Passaic River (NOAA, 1995). Benthic organisms such as mussels and blue crab showed a correlation between contaminant levels in tissue and sediments. A National Marine Fisheries Service study transplanted blue crabs from the Chesapeake Bay into the Newark Bay. The crabs had no detectable levels of dioxins before their introduction, but within a few weeks showed levels more than 100 ppt within a few weeks (Draxler, 1996).

Fishing in the Lower Passaic River has been banned due to high levels of contamination, especially dioxins. The neighborhoods along the lower stretch of the River are characterized by a high percentage of immigrants and people who are not fluent in English. Due to a lack of understanding of health issues, a distrust of authority, cultural traditions and extreme need, the warnings against consumption of fish from the Passaic are routinely ignored. The US Food and Drug Administration has issued a consumption advisory for fish, and other foods, known to contain dioxins. The recommendation is to avoid food containing over 1 ng /kg 2,3,7,8-TCDD . The New Jersey Department of Environmental Protection conducted an extensive sampling of fish and shellfish in the Lower Passaic River. The findings demonstrated that fish and shellfish taken exceed the standards for human consumption. The US EPA recently issued draft dioxin

exposure cancer risk levels, finding that exposure to 6.4 femtograms ( $6.4 \times 10^{-15}$  grams) of 2,3,7,8-TCDD per kilogram of body weight per day would cause cancer in one in a million people (US EPA, 1999)

The Agency for Toxic Substances and Disease Registry (ATSDR) has issued a policy on exposure potential from soils contaminated with dioxins. A concentration level between 50 ppt and 1 ppb is considered an Evaluation Level. Site specific factors such as availability, pathways and demographics should be evaluated to determine if a risk to human health exists. Toxic Equivalent levels over 1 ppb area considered to represent a risk to human health and warrant further action and research (ATSDR, 1999)

#### **Dioxin Sources**

The US Environmental Protection Agency developed a National Inventory of dioxin-like compounds (US EPA, 1998a). The estimated releases of dioxins were compiled from a variety of studies and source materials. Total loadings were estimated for two reference years, 1987 and 1995, the sources and magnitudes including upper, middle and lower estimates are listed in Table 3-2

| <b>Table 3-2 Inventory of Sources of Dioxin in the United States (gm TEQ/year). From USPEA Inventory of Dioxin in the United States (1998)</b> |                       |                        |                       |                       |                        |                       |
|------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------|-----------------------|-----------------------|------------------------|-----------------------|
|                                                                                                                                                | <b>1987</b>           |                        |                       | <b>1995</b>           |                        |                       |
| <b>Air Releases</b>                                                                                                                            | <b>Lower Estimate</b> | <b>Middle Estimate</b> | <b>Upper Estimate</b> | <b>Lower Estimate</b> | <b>Middle Estimate</b> | <b>Upper Estimate</b> |
| Municipal waste incineration                                                                                                                   | 492                   | 1,100                  | 2,460                 | 3,540                 | 7915                   | 17,698                |
| Secondary copper smelting                                                                                                                      | 171                   | 541                    | 1,710                 | 96                    | 304                    | 960                   |
| Medical waste incineration                                                                                                                     | 151                   | 477                    | 1,510                 | 781                   | 2,470                  | 7,810                 |
| Forest, brush and straw fires                                                                                                                  | 64.5                  | 208                    | 645                   | 53.8                  | 170                    | 538                   |
| Cement kilns (hazardous waste burning)                                                                                                         | 48.4                  | 153                    | 484                   | 37                    | 117                    | 370                   |
| Coal combustion                                                                                                                                | 32.6                  | 72.8                   | 163                   | 28                    | 62.6                   | 140                   |

|                                             |               |               |               |               |               |               |
|---------------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Wood combustion - residential               | 19.8          | 62.8          | 198           | 28.3          | 89.6          | 283           |
| Wood combustion - industrial                | 13.0          | 29.1          | 65            | 12.3          | 27.5          | 61.5          |
| Vehicle fuel combustion - diesel            | 10.6          | 33.5          | 106           | 8.3           | 26.3          | 83.2          |
| Cement kilns (non hazardous waste burning)  | 5.6           | 17.8          | 56.3          | 4.3           | 13.7          | 43.3          |
| Secondary aluminum smelting                 | 5.4           | 17            | 53.8          | 3.0           | 9.5           | 30            |
| Oil combustion - industrial/utility         | 2.9           | 9.3           | 29            | 4.9           | 15.5          | 49            |
| Sewage sludge incineration                  | 2.7           | 6             | 13.4          | 2.7           | 6             | 13.4          |
| Hazardous waste incineration                | 2.6           | 5.7           | 12.8          | 2.2           | 5             | 11.2          |
| Vehicle fuel combustion - unleaded          | 2             | 6.3           | 20            | 1.2           | 3.8           | 12            |
| Kraft recovery boilers                      | 1             | 2.3           | 5             | 0.9           | 2             | 4.5           |
| Secondary lead smelters                     | 0.73          | 1.63          | 3.65          | 0.55          | 1.22          | 2.73          |
| Cigarette combustion                        | 0.25          | 0.81          | 2.5           | 0.31          | 1             | 3.1           |
| Boilers/industrial furnaces                 | 0.12          | 0.38          | 1.2           | 0.24          | 0.77          | 2.4           |
| Crematoria                                  | 0.07          | 0.24          | 0.75          | 0.05          | 0.16          | 0.51          |
| <b>Total For Air Releases</b>               | <b>1,026</b>  | <b>2,745</b>  | <b>7,541</b>  | <b>4,616</b>  | <b>11,274</b> | <b>28,220</b> |
| <b>Products:</b>                            |               |               |               |               |               |               |
| Pentachlorophenol-treated wood              | 17,700        | 25,000        | 35,400        | 25,500        | 36,000        | 51,957        |
| Bleached chemical wood pulp and paper mills | 17.0          | 24.1          | 34.0          | 375           | 505           | 714           |
| Dioxazine dyes and pigments                 | 0.11          | 0.36          | 1.1           | 20            | 64            | 200           |
| 2,4-Dichlorophenoxy acetic acid             | 13.0          | 18.4          | 26.0          | 15.1          | 21.3          | 30.2          |
| Non-incinerated municipal sludge            | 4.0           | 7             | 12.5          | 4             | 7             | 12.5          |
| <b>Total</b>                                | <b>17,734</b> | <b>25,050</b> | <b>35,474</b> | <b>25,914</b> | <b>36,597</b> | <b>51,957</b> |
| <b>Land:</b>                                |               |               |               |               |               |               |
| Non-incinerated municipal sludge            | 120           | 207           | 375           | 120           | 207           | 375           |
| Bleached chemical wood pulp and paper mills | 1             | 1.4           | 2             | 10            | 14.1          | 20            |
| <b>Total</b>                                | <b>121</b>    | <b>208</b>    | <b>377</b>    | <b>130</b>    | <b>221</b>    | <b>395</b>    |
| <b>Water:</b>                               |               |               |               |               |               |               |

|                                             |      |      |      |     |     |     |
|---------------------------------------------|------|------|------|-----|-----|-----|
| Bleached chemical wood pulp and paper mills | 13.8 | 19.5 | 27.6 | 252 | 356 | 504 |
|---------------------------------------------|------|------|------|-----|-----|-----|

#### **Dioxin Sources in the Hudson Raritan Watershed**

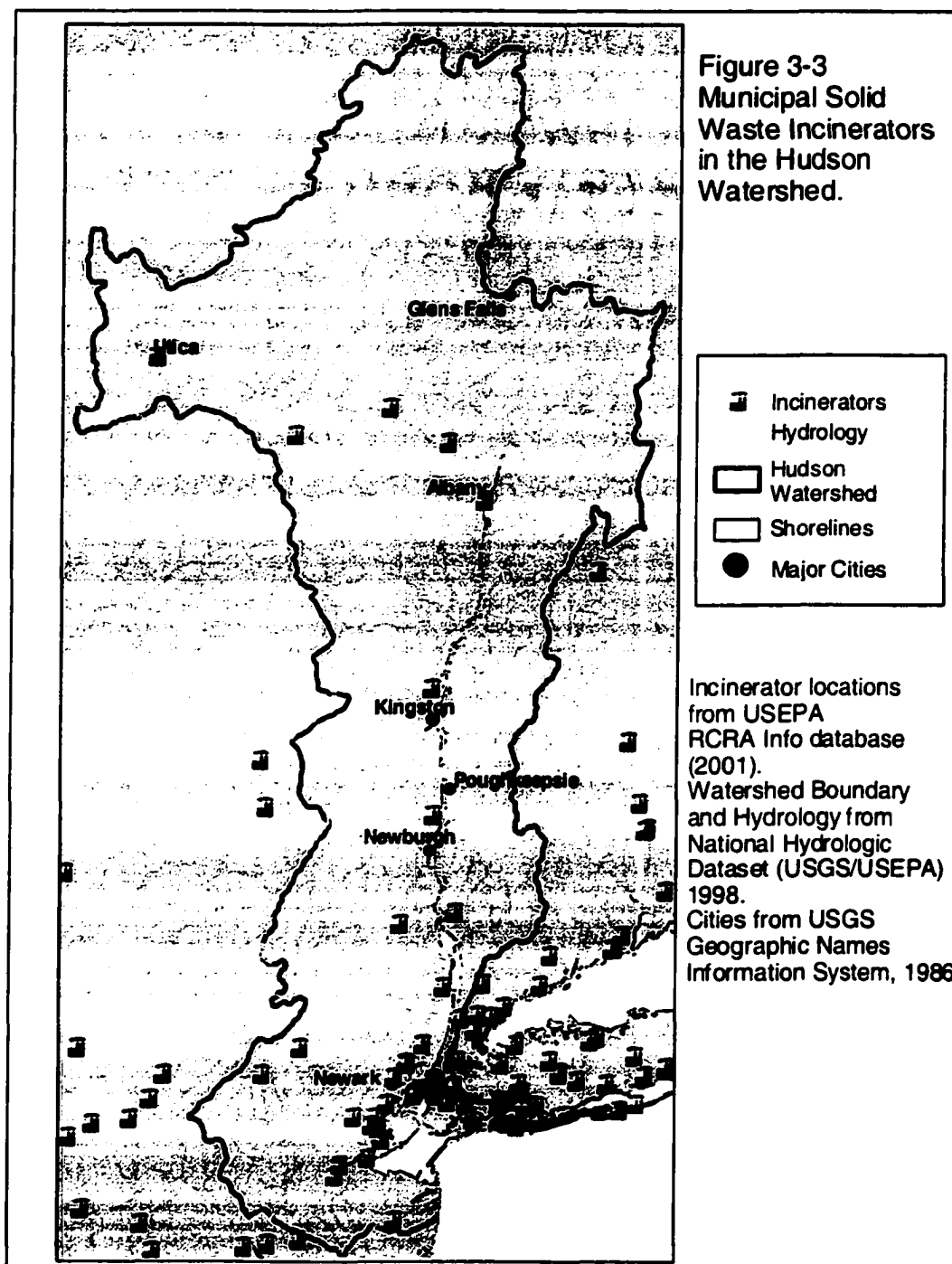
The sediments of the Harbor Estuary show a heavy impact by dioxin sources with evidence for diverse and widespread sources both spatially and temporally (See Chapter 4). Sources are concentrated around the New York Metropolitan Area where population and industrial development are densest. Historical studies of dioxin contamination over the past century show an initial increase in deposition associated with the Industrial Revolution. A second significant increase took place in the early 20<sup>th</sup> century with the widespread use of automobiles and railroads. Finally the most recent increase took place in the mid 20<sup>th</sup> century, coinciding with the development of the chlorinated chemical industry (Rose, et al., 1997).

The results of this analysis, summarized in chapter 4, as well as studies by other investigators such as Wenning, et al. 1993, Ehrlich et al. 1994, indicated that the largest current source of dioxins in the Hudson Watershed are from combustion sources. For historical dioxin sources, i.e. contamination found in core samples, chemical production such as 2,4,5-T, Chlorophenols, PCBs and other dioxin-containing chemicals represent a substantial component. This is especially true in some stretches of the Lower Passaic adjacent to facilities where industrial accidents and uncontrolled discharges took place.

#### **Combustion Sources**

The EPA National Dioxin Inventory identified municipal incinerators as the major source of airborne deposition of dioxins. In the New York Metropolitan area incinerators were at one time the primary means of garbage disposal. Until the mid 1960's New York City sanitation regulations required on-site garbage incinerators in apartment buildings with over 6 units. The large volume of particulates resulting from the operation of these inefficient units resulted in their ban in 1976. Since that time the trend has been toward large, centrally located units which are required to adhere to air pollution standards. New York City briefly entertained the idea of constructing large capacity incinerators for each of the 5 boroughs in an effort to divert a

significant percentage of solid waste from the Fresh Kills Landfill. Tighter regulations of disposal of ash as well as concerns of dioxin discharge prompted the abandonment of this effort. Figure 3-3 shows the location of municipal waste incinerators and hazardous waste incinerators in the Hudson Watershed area.



Trucks and automobiles are a ubiquitous part of the human landscape. US EPA estimates indicate that motor vehicles account for 82% of the discharge of air pollution in the New York City Metropolitan area (US EPA, 1998). The number of miles driven per person has shown a nearly continuous increase (save for the occasional Gas Crisis) since the end of World War II. Current estimates from the US Department of Transportation indicate that the distances driven per person per year increased at a rate of 2.7% per between 1970 and 1995 (FHA, 1994). Americans use automobiles, rather than mass transit, for 86% of their travel distance, a per capita average of 20,040 kilometers (km). In the New York Metropolitan area the ratio of car distance to total travel is lower at 65%, equaling a distance per capita of 15,000 km. Given a total watershed population of 13 million this totals  $19 \times 10^{10}$  vehicle kilometers per year. Using the EPA dioxin Source Inventory estimates of 91 picograms of dioxins emitted per kilometer driven gives the gross estimate of 17 grams of dioxin emissions within the watershed per year.

#### **Wastewater Treatment Facilities**

Dioxins have been measured in both the effluent from sewage treatment plants and the sewage sludge remaining after processing. In sewage discharge dioxins occur in very low concentrations. Yet due to the immense volume of discharge, sewage outflow makes up an average of 15% of the freshwater input to the Hudson Estuary, they represent a potentially significant source. One of the problems in quantifying the contribution of sewage outflow is that the low concentrations lead to greatly varying results. The New York State Department of Environmental Conservation has developed a sampling instrument capable of processing large volumes of water, concentration any contaminants present in order to make more accurate assessment of concentration levels. The instrument, called the Trace Organic Platform Sampler (TOPS) measured dioxin concentrations ranging from non-detects to 4.8 picograms per liter (parts per quadrillion) for effluent from wastewater treatment facilities (NYDEC, 1997).

**Chemical Manufacturing Sources**

Chemical manufacturing is a historically important source of dioxins in the environment, especially along the Passaic River. Dioxin production during chemical synthesis occurs in a large number of products, as mentioned previously most prevalently in the production of chlorophenol and chlorophenol derivatives. Many of the chemicals associated with dioxins, 2,4,5-T for example, are no longer in production, but were produced in large quantities prior to their ban.

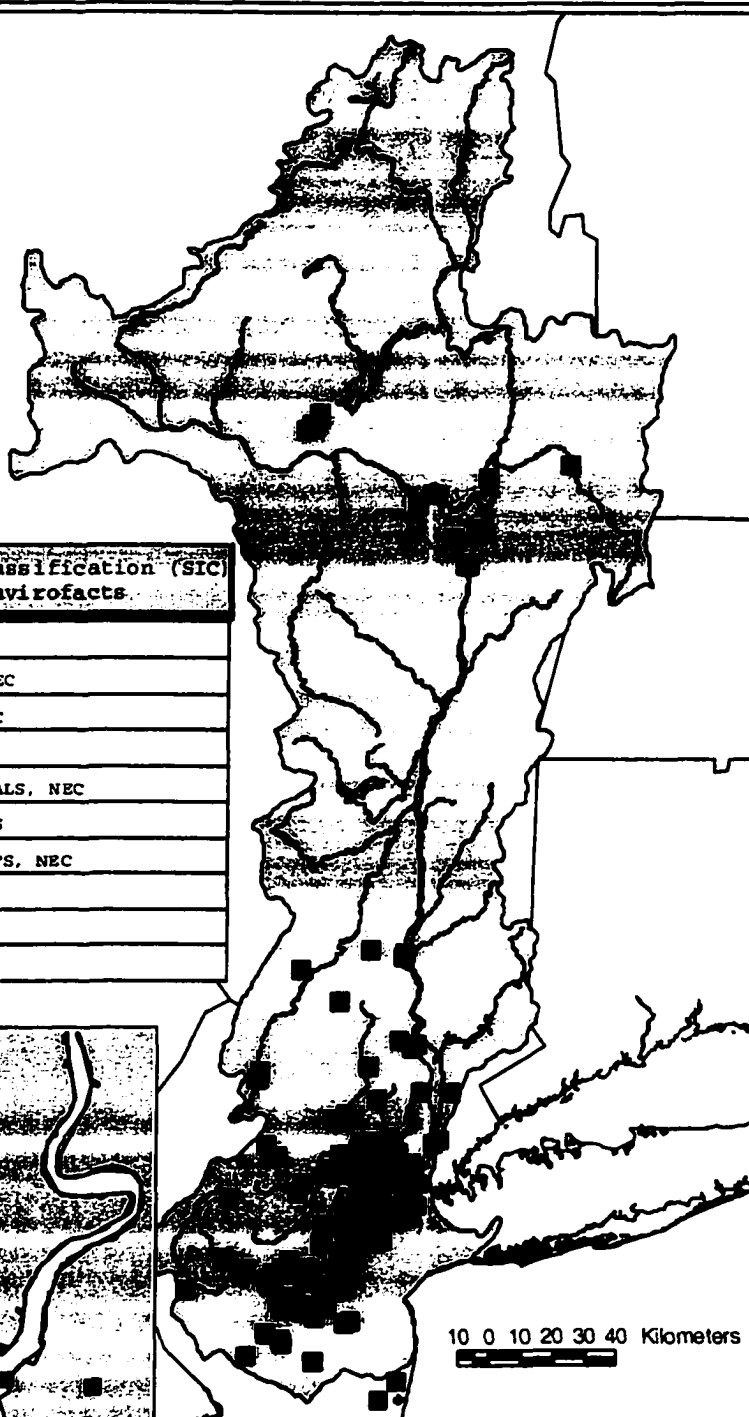
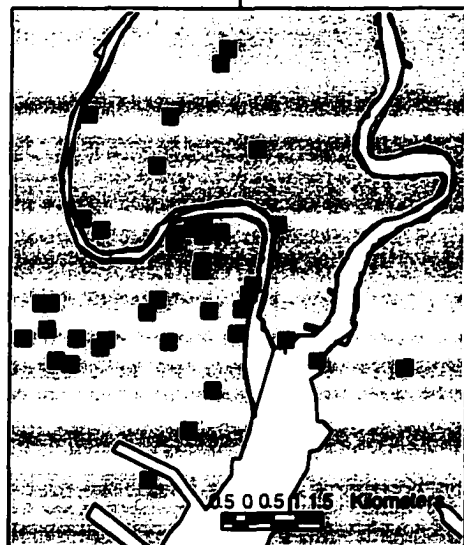
Figure 3-4 shows the location of currently permitted chemical manufacturing facilities operating under permits from the US Environmental Protection Agency. The facilities were selected using the Standard Industrial Code descriptions shown on Figure 3-4. The Lower Passaic River contains a very dense accumulation of these facilities. Additional sites in this area are former chemical manufacturing sites, which have been closed, sometimes due to contamination. This was the case with the Diamond Alkali Site, a plant that manufactured 2,4,5-T from the mid-1950s through 1969.



**Figure 3-4  
Chemical  
Production  
Facilities in the  
Hudson Watershed.**

Facility locations  
from USEPA  
Envirofacts database.  
Watershed Boundary  
from National Hydrologic  
Dataset (USGS/USEPA,  
1998)

| Standard Industrial Classification (SIC)<br>Codes-Extracted From Envirofacts |
|------------------------------------------------------------------------------|
| ADHESIVES AND SEALANTS                                                       |
| AGRICULTURAL CHEMICALS, NEC                                                  |
| CHEMICAL PREPARATIONS, NEC                                                   |
| GUM AND WOOD CHEMICALS                                                       |
| INDUSTRIAL ORGANIC CHEMICALS, NEC                                            |
| PAINTS AND ALLIED PRODUCTS                                                   |
| PETROLEUM AND COAL PRODUCTS, NEC                                             |
| PETROLEUM REFINING                                                           |
| PRINTING INK                                                                 |
| SURFACE ACTIVE AGENTS                                                        |



- Chemical Facilities
- △ Major Hydrology
- Hudson Watershed

### **Agricultural Chemical Use**

The major class of chemicals associated with dioxin contamination is the phenoxy herbicides. The end-use of these products is another environmental source of dioxins. Herbicides were widely used by the US military in Vietnam resulting in heavy exposure of US servicemen. The US Forest Service and power companies employed silvex for weed and brush control until its use was restricted in 1978. A number of herbicides still in current use are considered to be associated with dioxin formation during manufacturing. The US EPA classifies these chemicals as Class 1 or Class 2 based on the likelihood dioxin formation during synthesis. Class 1 pesticide chemicals are "highly likely to be associated with the presence of halogenated dibenzo-p-dioxins because of the presence of an ortho-halogenated phenol in the reaction sequence" (US EPA, 1980). Class 2 pesticides are considered less likely to contain dioxin, contamination might result from "irregular operating conditions" (US EPA, 1987) which would include improper temperatures, pressures or reactants.

The US Geological Survey compiled an Agricultural Chemical Use Survey for the United States (Battaglin and Goolsby, 1995). The report compiled the use of 96 herbicides in 1989 with the data compiled by county. The data is distributed on the USGS web site as a GIS data layer. It was downloaded and projected into the coordinate system used for the analysis, Universal Transverse Mercator Zone 18 datum NAD83. The individual herbicides were compared with the US EPA list of Class 1 and Class 2 chemicals associated with dioxin formation. The releases of these chemicals were summed for the counties within the watershed. For counties partially within the watershed a ratio of the total releases was used based on the percentage of agricultural land within each county, within the watershed.

For Class 1 compounds the total estimated usage within the watershed was 46,454 kilograms (102,199 pounds). The chemicals, in order of use, were 2,4-Dichlorophenoxy acetic acid, 2,4-Dichlorophenoxybutyric acid and 3,4-Dichloro-2-methoxybenzoic acid (Dicamba). For Class 2 chemicals the total was 18,719 kilograms (41,183 pounds).

### **Chemical Accidents and Spills**

Releases of dioxins as a result of industrial accidents such as explosions or fires have resulted in the most serious cases of human exposure, as well as the highest environmental levels of dioxins. The highest measured ambient levels of dioxin occurred in the soils of an agricultural chemical manufacturing plant along the Lower Passaic River. The site is located at 80 Lister Avenue in Newark NJ. on the south bank of the Passaic River approximately 3 kilometers from where the Passaic empties into the northern end of Newark Bay. This location has been a chemical-manufacturing site for over 100 years. In the mid 1940's the site began producing chlorinated pesticides such as DDT. The 80 Lister Avenue site was purchased in March of 1951 by Diamond Alkali, a subsidiary of Diamond Shamrock Corporation. Diamond Shamrock operated the plant as an agricultural chemical manufacturing operation. The plant began manufacturing 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) in early 1951 (US EPA, 1995).

The main manufacturing building was used for the synthesis of feedstock for 2,4,5-T production including sodium 2,4,5 Trichlorophenate (NaTCP) and 1,2,4,5-tetrachlorobenzene. 2,4,5-T production was carried out in a separate, smaller building on the site. Initial production rates between 1951 and 1953 averaged 500,000 pounds of TCP per year and 650,000 pounds of 2,4,5-T per year (EPA, 1983). A larger (1000 gallon) reactor vessel was installed in 1953 increasing production to 1.5 and 2.0 million pounds of TCP and 2,4,5-T respectively. In 1956 a pipe was constructed to link discharge from the plant to the Passaic Valley Sewerage Authority Industrial Sewer System, wastewater averaged around 30,000 gallons per day (US EPA, 1995).

During the time period between 1951 and 1960 other chemicals were produced on the site including dichlorophenyl trichloroethane (DDT), Hexachlorobenzene and 1,1,1-trichloroacetaldehyde (Chloral). Manufacture of these products was discontinued after 1960. In February of 1960 an explosion occurred rupturing the 1000-gallon TCP reactor vessel. The resulting fire destroyed the main manufacturing building and dispersed material from the reactor vessel around the site.

The main building was rebuilt and used exclusively for the production of NaTCP and 2,4,5-Trichlorophenol. Manufacturing began again within one year. The drainage system was altered to have all wastes flow through trenches into a sump and out to the Industrial Sewer (EPA, 1983).

Workers at the facility were tested for health effects in February of 1969. Forty-eight of seventy-eight workers showed evidence of chloracne (Poland, et al., 1971). The plant ceased production of 2,4,5-T in 1969, it was sold that year by Diamond Shamrock.

In 1983 a soil sample taken by the New Jersey Department of Environmental Protection (NJDEP) measured 1.2 parts per million 2,3,7,8-TCDD (Belton, et al., 1985). The NJDEP and the USEPA conducted a joint investigation of the soils and sediments in the Passaic River. A series of sediment samples were taken in the River, adjacent to the site as well as upstream and downstream from the site. The highest concentration measured was immediately adjacent to the site, 2,3,7,8-TCDD concentration was 6.9 parts per billion (Belton, et al., 1985). Fish tissue sampling was done in the Passaic River and Newark Bay for blue crab, striped bass and carp. Levels in these species in this area were compared with levels in the same organisms in the Hudson River. Passaic-Newark tissue samples showed detectable levels of 2,3,7,8-TCDD, greater than 0.6 parts per trillion (ppt) (Belton, et al., 1985). Blue crab levels ranged between 10 and 1063 ppt, only one sample from the Hudson River was above detectable levels. Striped bass from 20 to 56 ppt, levels similar to Hudson River samples.

In September of 1984 the site was added to the EPA's National Priority List of Superfund sites (US EPA, 2000). The initial remediation strategy was to isolate the site, a guarded fence was installed and the soil on the site was covered with an impermeable geotextile to prevent further offsite movement of contamination. Subsequently the process buildings were dismantled and are currently being stored in containers at an adjacent property, 120 Lister Avenue, property

also owned by Diamond Shamrock, now Occidental Chemical Corporation. The contaminated soil was then placed into containers at 120 Lister Avenue.

The Passaic River was made into Operable Unit II of the site. Both the US EPA and Occidental Chemical Corporation (Maxus Energy Corporation) performed sediment sampling of the Passaic River and Newark Bay. The results of these studies are the subject of the next two chapters.

## Chapter 4 Sediment Sampling and Analysis

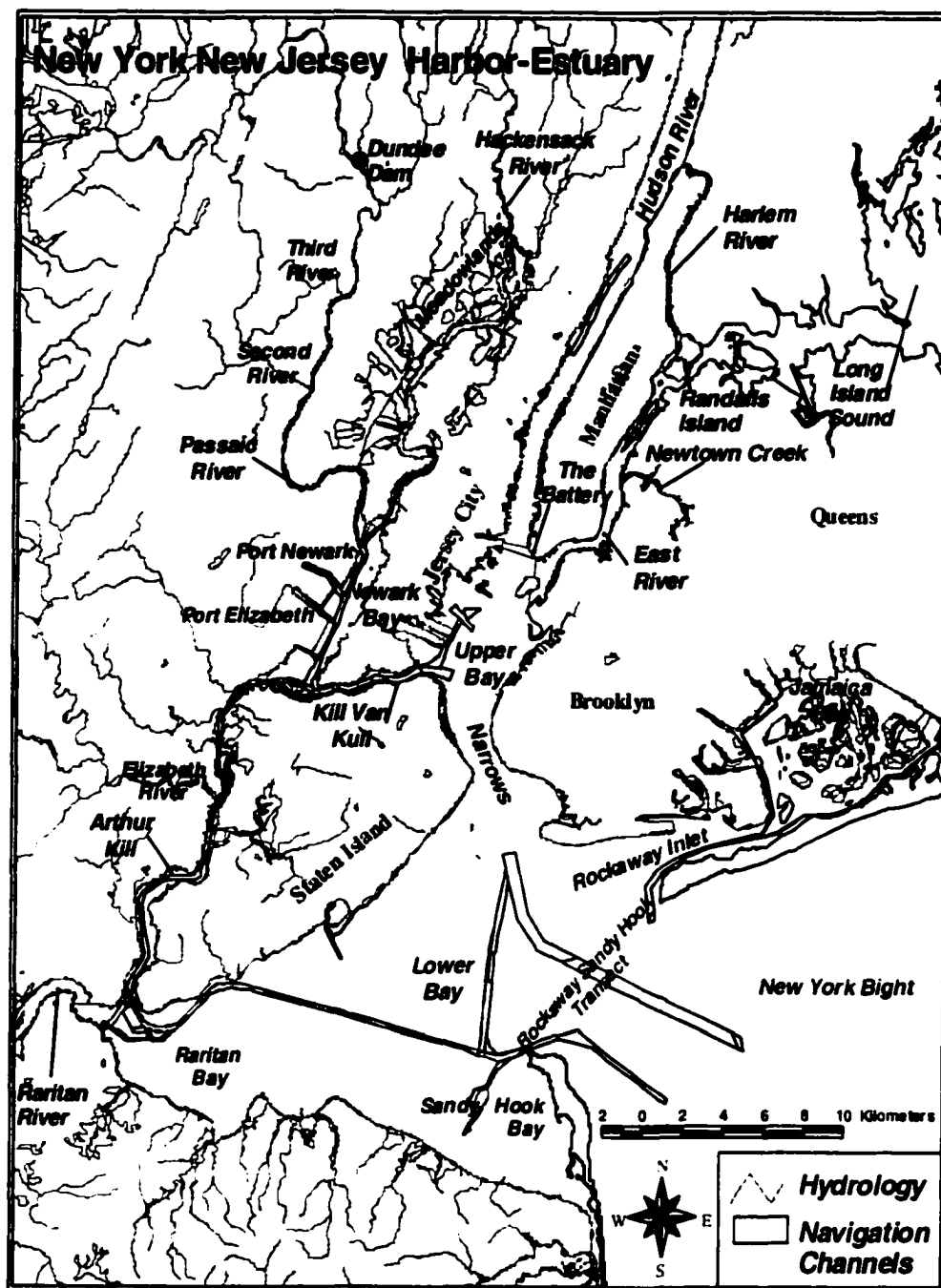
### Sampling

The sediment samples used in this analysis were collected by the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA) and private consultants working for the Maxus Energy Corporation. Samples were collected between 1991 and 1995. These data represent a comprehensive collection of sediment contamination information for the New York Harbor complex (see Figure 4-1). It includes studies with sampling stations distributed throughout the harbor (The EPA's Regional Environmental Mapping Analysis Program, REMAP) as well as a dense sampling network in the Newark Bay - Passaic River system, one of the most polluted waterways in the United States. The studies used are listed in Table 4-1. The spatial distribution of sampling locations displayed by study name are shown in Figure 4-2. the 6 Mile Study Area and sampling location for the 1995 EPA Remedial Study is shown in Figure 4-3. The studies span a time when advances in laboratory instruments such as high-resolution gas chromatography / high-resolution mass spectroscopy provided the ability to quantify dioxin-furan contamination at the parts per trillion levels at which they are commonly present in the environment.

**Table 4-1 Sediment Sampling Studies in the Harbor-Estuary**

| Agency/Consultant and Study Name                   | Year    | Total Number of Samples |
|----------------------------------------------------|---------|-------------------------|
| Maxus Passaic River sediment study                 | 1991    | 120                     |
| Maxus Passaic River sediment study                 | 1992    | 47                      |
| Maxus Passaic River sediment study                 | 03/1993 | 40                      |
| Maxus Passaic River sediment study                 | 07/1993 | 8                       |
| Maxus Passaic River Combined Sewage Overflow study | 1994    | 40                      |
| NOAA NS&T Hudson-Raritan Phase II                  | 1993    | 54                      |
| EPA Region 2 REMAP Study                           | 1993    | 42                      |
| EPA Region 2 REMAP Study                           | 1994    | 45                      |
| EPA Passaic River Remedial Investigation (RI)      | 1995    | 408                     |
| EPA Passaic River RI Maxus Supplement              | 1995    | 29                      |
| EPA Passaic River RI Nearshore Supplement          | 1995    | 60                      |

**Figure 4-1 Water Bodies and Rivers in the New York New Jersey Harbor Area.**



#### **Studies Used**

The studies used in this analysis were carried out by Maxus, NOAA, EPA Region 2 REMAP program and the EPA Region 2 Passaic Remedial Investigation. The REMAP and

NOAA studies were done to assess the overall “health” of the harbor and included extensive toxicity studies. The EPA Region 2 Remedial Investigations was specifically targeted to examine the impact of the 80 Lister Avenue Site on the Passaic River. Results from all of the studies except the EPA Region 2 Remedial Investigations have been published in the literature. The studies are described below including references to published material for further information. A longer description of the sampling design, methods and analysis has been done for the EPA Region 2 Remedial Investigation as this material has not previously been published. The locations of the sampling stations are shown in Figure 4-2.

The combination of studies shows great usefulness to quantifying and spatially identifying the extent of dioxin contamination in the New York Harbor. Some of the studies were specifically constructed for this purpose albeit in limited areas of the New York Harbor. An ideal dataset for the purposes of this examination would include core samples throughout the harbor. The industrial development of the New York Metropolitan Area (See Chapter 3) has created temporal and spatial variations in the distribution of contaminants including dioxin-furans. A wider distribution of core locations would help quantify harbor-wide distribution, especially in the confined, heavily impacted inlets such as the Newtown Creek, Gowanus Canal, Arthur Kill and fringe areas of the Lower Bay. The harbor-wide studies, REMAP 1993 and 1994 were designed to assess overall levels of surficial contamination. The sampling pattern is random within a distributed grid. For quantifying dioxin contamination a more focus approach would be more suitable. Core samples should be taken in depositional areas removed from locations of dredging and heavy ship traffic. All samples should be examined for grainsize distributions and total organic carbon (TOC) content. TOC was collected in all the studies used but grainsize was either not collected or not provided. This information is useful in examining the relationship between dioxin-furan concentration and physical sediment characteristics. Organic carbon content can be an indicator of impact by anthropogenic waste as well as reducing conditions. Data on



Radioisotopes should also be measured for all core samples to allow dating of the sample. This was done for the core samples used in this analysis, but only the results from the EPA 1995 study were provided for inclusion in the NOAA dataset. The sampling should be done over a limiting time period rather than spread out over 5 years, as are the studies used in this analysis.

#### **Dioxin Analysis Method 1613a**

The dioxin analytical procedures for all of the studies followed US EPA Guidelines for laboratory analysis of tetra through octa-chlorinated, 2,3,7,8 substituted dibenzo-p-dioxins and dibenzofurans. This procedure, known as method 1613a, is mandated for all analyses falling under the National Pollution Discharge Elimination System permit system. The method is described in detail in the Federal Register, volume 62 no 178 published September 15, 1997. The procedures were initially proposed in February of 1991 (Federal Register, 1997) and were further refined for the 1993 Pulp and Paper Industry Wastewater study, which looked at the presence of dioxins and furans in discharge from pulp and paper processing plants.

Method 1613 applies to aqueous solutions, semi-solid, solid and multi phase samples. For solid samples the material is spiked into a 10-gram dry weight of solids, usually sand. The sample is pressure filtered to remove any liquid material. The extracted liquid is separated into aqueous and non-aqueous material. Large particles in the sample are ground up and any non-aqueous liquid is added back into the sample. At this point in the process 15 labeled 2,3,7,8-substituted dioxin and furan standard analogs are added to the solution to quantify the extraction and analysis. The labeled analogs include all the dioxin furan congeners used in this analysis except octa-chlorinated dibenzofuran(OCDF) and 1,2,3,7,8,9-HxCDD. OCDF labeled analogs have the potential to interfere with identification of other congeners while 1,2,3,7,8,9-HxCDD is used as an internal standard for the High Resolution Gas Chromatograph/ High Resolution Mass Spectrograph (HRGC/HRMS). The sample is then mixed with sodium sulfate to remove any remaining water and allowed to dry for 12 to 24 hours. The samples are then extracted in a

methylene chloride:hexane solution for 18-24 hours in a Soxhlet/Dean Stark apparatus (Federal Register, 1997).

After extraction and evaporation to dryness the sample is digested in hydrochloric acid (HCl). 200 mL of HCl and 200 mL of methylene chloride:hexane are added to the extract, the solution is agitated for 12 – 24 hours. After extraction with  $^{37}\text{CL}_4$ -2,3,7,8-TCDD is added to the solution to provide quality assurance for the cleanup procedure.

Cleanup procedures are required for solid phase samples such as sediments. The extract is processed in one or more of the following ways

- Chromatographic column packed with alternating layers of neutral silica gel, basic silica gel, neutral silica gel, acid silica gel and neutral silica gel.
- Chromatographic column packed with Acid or basic alumina.
- Gel Permeation Chromatography.
- Carbopak/Celite Column

Extracts from the cleanup procedure are again evaporated to dryness and then spiked with 1,2,3,7,8,9-HxCDD- $^{13}\text{C}_{12}$  recovery standard and concentrated to a final volume of 20uL. Before any analyses are performed the column is calibrated against dioxin and furan standards and the labeled standards. The extracts are then analyzed by high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) on a DB-5 capillary column. Concentrations of the 15 congeners for which labeled spikes are added are determined by isotope dilution concentration ratio, comparing the congener with the known value of its labeled counterpart. Recovery of the labeled compound must fall within the acceptance criteria outlined in EPA Method 1613, Final Rule Table 9 (Federal Register, 1997). The concentration of 1,2,3,7,8,9-HxCDD is determined by comparison with the labeled 1,2,3,7,8,9-HxCDD- $^{13}\text{C}_{12}$  used as an internal standard. OCDF

concentration is calculated based on the recovery of OCDD as no labeled standard is used for OCDF. Other standards for the analysis include.

- Static Mass Spectral resolving power of 10,000
- M/z abundance ratio must fall within limits in EPA Method 1613, Final Rule Table 9 (Federal Register, 1997)
- Retention time of labeled analytes must be within  $\pm 15$  seconds of retention time during calibration.
- Method blank must be analyzed with each sample batch to ensure the column has not retained analytes.
- Blind duplicates must be performed for each batch of samples.

Variations from the method are permitted only for solvents used and cleanup material.

In the following description of studies the variations from the above procedure for dioxin furan analysis will be noted.

The Maxus Energy Corporation, successor to the Diamond Alkali Corporation, conducted a series of sediment studies in the Newark Bay - Passaic River complex. These are listed in table 4-1 as Maxus Passaic River sediment studies and Maxus Passaic River Combined Sewage Overflow Study. The 4 sampling events took place between 1991 and 1994. These sampling efforts were focused on the Passaic River, but included samples in other areas of the harbor for comparison with Passaic results. The Maxus Passaic River Combined Sewage Overflow (CSO) study took samples only in the Passaic. Descriptions of the sampling studies, handling of the samples, laboratory methods and analysis and conclusions have been published in a series of papers including; Wenning, et al. (1991), Wenning, et al. (1992), Wenning, et al. (1993), Ehrlich et al. (1994), Huntley et al. (1995) and Huntley et al. (1998). Much of the analysis and publishing of the Maxus samples was done by the Chemrisk Corporation. The body of work produced by

these authors includes analyses of dioxins in the study area as well as other contaminants such as pesticides, PCBs, PAHs and metals.

Sampling was done at 31 stations for the Maxus 1991 study. The station locations included the Passaic River (with one station above the Dundee Dam), the Hackensack River, Newark Bay, the Kill Van Kull and the Arthur Kill. Cores were taken at all locations. A total of 122 samples from this study were used in the analysis. This study is described in Ehrlich et al. (1994). Further analysis of this sampling effort was done in Huntley et al. (1998). In 1992 Maxus collected samples from 16 stations, 3 cores samples were obtained at each location. Sampling was done in the Passaic River, the Hackensack River and Newark Bay.

The dioxin furan analysis for the Maxus 1991 study was done by the Enesco/CAL Analytical Laboratory of West Sacramento California. The lab used a modified version of EPA Method 1613a, changes were made in solvents and acids used. During the Soxhlet extraction benzene was used as the solvent rather than methylene chloride:hexane. During the cleanup sulfuric acid was used in the digestion process in place of hydrochloric acid. Recoveries of the internal standards ranged from 52% to 110% (Ehrlich et al. 1994).

In 1993 sediments were collected at 14 stations in the Passaic River, the Third River, a tributary to the Passaic River, Newark Bay including the landward head of Port Newark and Port Elizabeth, the Kill Van Kull and the Upper Bay. Eleven of the locations had core samples taken, 37 of the samples used in the analysis were taken from this study. Descriptions of the sampling method, handling and laboratory methods are given in Ehrlich et al. (1994).

Alta Laboratory Inc. of El Dorado Hills California performed the dioxin furan analysis for the Maxus 1993 studies. Changes to method 1613a were made in solvents and acids used, during the Soxhlet extraction benzene was used as the solvent rather than methylene chloride:hexane. During the cleanup sulfuric acid was used in the digestion process in place of

hydrochloric acid. Recoveries of the internal standards ranged from 55% to 106% (Ehrlich et al. 1994).

In 1994 Maxus took a series of samples in the vicinity of Combined Sewer Overflow (CSO) outfalls along the Passaic River. A total of 40 samples were taken, all surficial sediments, at four locations. All 40 of the samples were used in this analysis. The sewage system of the City of Newark and some of the surrounding towns is a combined storm and sanitary system. In addition to domestic waste the system receives input from approximately 5000 industrial plants (Huntley et al. 1997). During storm events, routine maintenance and equipment failure the system diverts raw sewage directly into the Lower Passaic River through a series of outfall pipes. The Maxus CSO study focused on sediments around these outfalls as a possible source of dioxin-furan contamination.

Alta Laboratory Inc. of El Dorado Hills California did the dioxin furan analysis for the Maxus 1994 CSO study. The lab used a modified version of EPA Method 1613a, changes were made in solvents and acids used. During the Soxhlet extraction benzene was used as the solvent rather than methylene chloride:hexane. During the cleanup sulfuric acid was used in the digestion process in place of hydrochloric acid (Huntley et al. 1997). Recovery rates were not reported.

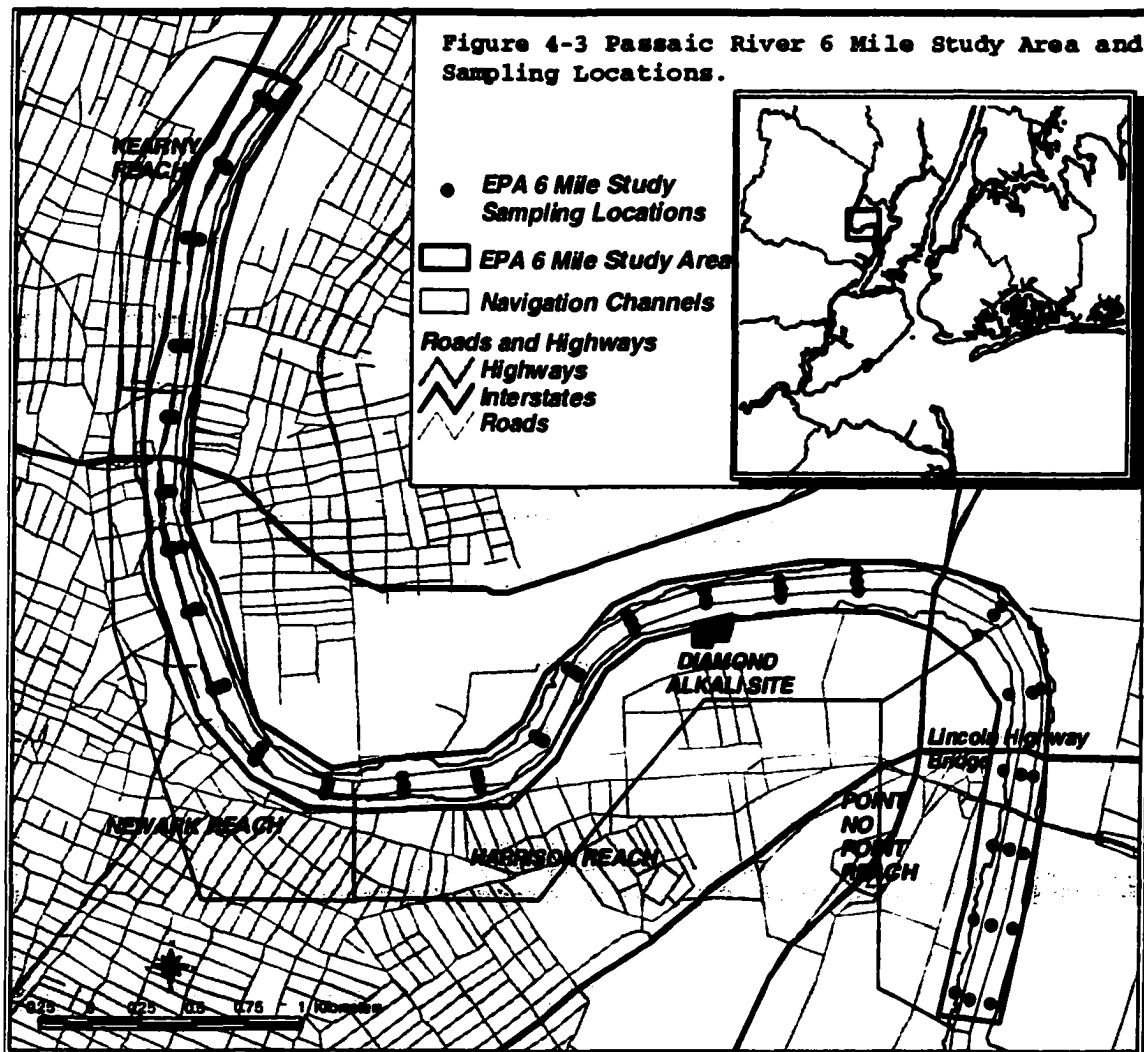
The NOAA National Status and Trends (NST) 1993 study (Phase II), consisted of 117 surficial sampling stations in Newark Bay, the Passaic and Hackensack Rivers. Phase I of the NST study assessed the toxicity of sediments in the overall New York Harbor area. Phase II of the Status and Trends study focused in on the Newark Bay, Passaic River complex which was found to have high toxicity levels during Phase I. The NOAA studies looked at the relationship between sediment toxicity and levels of contamination. Toxicity was determined using four parameters; Amphipod survival, Bivalve larvae survival, Bivalve larvae development and Microtox bioluminescence. A significant finding of the NOAA study was a strong correlation between levels of dioxin-furan concentration, and toxicity of the sediment (NOAA, 1995).

Twenty-one of the stations sampled during Phase II were used in this analysis; all consisted of surficial sediments. Sampling methods and results for all the data analyses in this study are described in NOAA Technical Memorandum NOS ORCA 88: Magnitude and Extent of Sediment Toxicity in the Hudson Raritan Estuary (NOAA, 1995). The National Biological Service, Midwest Science Center Laboratory, using EPA method 1613a, carried out the dioxin-furan analysis. Sediment was extracted with methylene chloride. Sample cleanup, removal of chlorinated co-contaminants, was done on an activated basic alumina column. High Resolution Gas Chromatography was done on a Ultra-1 column, the equivalent of the DB-5 column.

The REMAP study (Regional Environmental Mapping and Analysis Program) was carried out in 1993 and 1994. It consisted of 168 stations throughout the New York Harbor, the Western Long Island Sound and the New York Bight Apex. All samples taken were surficial sediment samples. Dividing the study area into hexagonal grids and then creating within each grid a randomly generated location established sampling stations. Sampling methods, laboratory results and analyses of these data are described in EPA/902-R-98-001 Sediment Quality in the NY/NJ Harbor System, An Investigation under the Regional Environmental Monitoring and Assessment Program (R-EMAP) (Adams and O'Connor, 1998). Dioxin-furan analysis was done by Battelle Labs of Columbus Ohio, following EPA method 1613a. Soxhlet extraction was done using toluene as a solvent rather than a methylene chloride:hexane solution. Cleanup procedure used acid/base silica, basic alumina, and carbon AX-21/Celite cleanup columns. The carbon AX-21 Celite columns were back eluted with 30ml toluene.

The EPA 1995 Remedial Investigation sampling survey consisted of 89 stations; all had core samples taken. A total of 482 of the samples taken were used in this analysis. The study consisted of 26 transects, each transect ran perpendicular to the riverbank and consisted of 3 stations at which core samples were taken. Additional supplemental cores were taken at mudflat areas, the river segment adjacent to the Diamond Alkali site and close to the inner bank at curved

sections of the river. The transects ran at approximately 1200 foot (375 meter) intervals from the mouth of the Passaic to a point 10 kilometers (6 miles) upstream. Some transects were not at precise 1200-foot intervals due to obstructions such as bridges and sewer outfalls, which would affect depositional patterns. Actual distances between sampling stations ranged between 800 (250 meters) and 1400 feet (440 meters). The three stations for each transect were established as the left channel bed, the thalweg or deepest natural channel of the river, and the right channel bed. Figure 4-3 shows the sampling design and the navigation reaches of the Passaic River.



Generally the stations were in the limits of the US Army Corps of Engineers Federal Project Limits for the Passaic River dredged channel. The project limits define the width of the

channel to be maintained by dredging, and the depth to which it is to be dredged. The navigation channel above the Lincoln Highway Bridge, located 1 kilometer above the mouth of the Passaic, has not been dredged since 1949. Berthing areas along the banks of the Passaic have been dredged periodically during this time. The upstream limit of the sampling is the transect 300 meters upstream from the boundary between the Kearney Reach and the Arlington Reach, 1.5 kilometers below where the 2<sup>nd</sup> river empties into the Passaic. The EPA calls this study area the Passaic River 6 Mile Site. It is part of the Diamond Alkali Superfund site, the remediation effort addressing the contamination of the Diamond Alkali manufacturing site and an adjacent stretch of the Passaic River. It has been given the procedural title of Operable Unit 2 of the site study as the cleanup issues and determination of the responsible party or parties is distinctly different from the upland part of the site. Figure 4-3 shows the location of the sampling sites and the 6 Mile study area.

Depths of the individual cores were established with the goal of obtaining time stratigraphic samples providing decade long snapshots of sediment and contaminant history going back to the 1940's plus a sample from the biological activity zone (BAZ). The biological activity zone is the depth of loose unconsolidated sediment into which marine creatures can burrow and live. A depositional regime was established for the potential coring sites using bathymetric surveys done over the past half century by the US Army Corps of Engineers. Surveys used were the pre-1949 dredging survey, the post 1949 dredging survey, 1966, 1976, 1986 and 1989. The US Army Corps of Engineers maintains these surveys on microfiche in the New York District Surveying Branch. Depth for individual cores was established to reach the 1940 time period sediments. This was accomplished by taking the average sediment deposition rate between 1949 and 1989 and by extrapolating back to 1940. For cores in areas of little or no bathymetric information or areas where significant deposition did not take place a 5-foot core depth was taken.



Before use in the field all sampling equipment was cleaned using the EPA Region II, CERCLA Quality Assurance Manual procedure for decontamination. Sampling equipment was washed and scrubbed with a low phosphate detergent and rinsed with tap water. It was then rinsed with ultra pure 10% nitric acid ( $\text{HNO}_3$ ) followed by another rinse with tap water. The equipment was then rinsed with pesticide grade methanol and then hexane followed by a rinse with deionized water. It was then air dried and wrapped in aluminum foil for transport to the sampling site.

Station locations were determined onboard the sampling ship using a Global Positioning System (GPS) receiver. The coordinates of the desired station locations were interpolated off of NOAA 1:20,000 navigation charts and entered into the GPS receiver units as way stations. These were used to navigate the ship to the location. Actual coordinates of the core locations were then obtained. Coordinates were later recalculated using differential correction. The Global Positioning System signal at the time of sampling was still in "Selective Availability" mode. In selective availability the signal is intentionally altered for military reasons. Using the satellite signal coordinates recorded by a fixed base station, differential correction can be done to GPS coordinates at a later point to restore the high (down to centimeter) accuracy of the system. The signal distortion magnitude and direction is determined from the known coordinates of the base station and applied to the field points to move them to their true location.

Cores were collected by vibracoring using a stainless steel coring tube lined with 4 inch outside diameter Lexan liners. Water depth and actual core depth were recorded for each core. Lexan tubes were removed from vibracore and examined for gaps in sediment recovery. Cores were placed into labeled boxes with a chain of custody form and transported in an upright position. In the laboratory cores were sliced open longitudinally using a circular saw. A ¼ inch "smear" zone, sediment on the outer edge of the core deformed by liner, was removed using a stainless steel blade. Using bathymetry-established depths, decadal interval "slices" of samples

were extracted from the core. Pre-labeled sampling containers for volatiles were filled immediately after opening the core to minimize loss of contaminant. Cores were next visually inspected for consistency and a written description of color and texture of the sediments was then recorded. From the top of each predefined decade interval a thin 3-inch section of sediment was removed for radioisotope examination. The remaining interval section sediments were mixed and then partitioned into separate containers for contaminant testing. Sediments were tested for metals, PCBs, dioxins and furans, PAHs and pesticides.

Alta Laboratory Inc. of El Dorado Hills California did the dioxin furan analysis, following EPA Method 1613 Revision A, outlined above. Samples were extracted by Soxhlet extraction and concentrated by Dean-Stark azeotropic distillation. Labeled analogs of 15 congeners were added before extraction and  $^{37}\text{Cl}_4$ -labeled 2,3,7,8-TCDD is added to the extracted solution to quantify efficiency of the extraction method and instrument performance. Dioxins and furans were identified using high-resolution gas chromatography based on comparison of retention rate and ion abundance with known standards for dioxins and furans. Concentrations were determined from high-resolution mass spectroscopy using selected ion current profile (SICP) areas by comparison with labeled analogs.

Teledyne Isotope Laboratory carried out the radioisotope analysis. Testing was done for Beryllium 7, Cesium 137 and Lead 210. Beryllium 7 has a half life of 53 days, it is used verify recent sedimentation in surficial samples.

A summary of the studies used including analytical methods and other parameters measured is included in table 4-1a.

**Table 4-1a Sampling Studies: Parameters and Analytical Methods**

| <b>Agency/Consultant and Year</b> | <b>Cores Collected</b> | <b>Dioxin Analytical Method</b> | <b>Radio-isotopes (Y/N)</b> |
|-----------------------------------|------------------------|---------------------------------|-----------------------------|
| Maxus 1991                        | Y                      | EPA Method 1613a                | Y                           |
| Maxus 1992                        | Y                      | EPA Method 1613a                | Y                           |
| Maxus March 1993                  | Y                      | EPA Method 1613a                | Y                           |

|                                  |   |                  |   |
|----------------------------------|---|------------------|---|
| Maxus July 1993                  | Y | EPA Method 1613a | Y |
| Maxus Passaic River CSO 1994     | N | EPA Method 1613a | N |
| NOAA NS&T 1993                   | N | EPA Method 1613a | N |
| EPA REMAP 1993                   | N | EPA Method 1613a | N |
| EPA REMAP 1994                   | N | EPA Method 1613a | N |
| EPA RI 1995                      | Y | EPA Method 1613a | Y |
| EPA RI 1995 Maxus Supplement     | Y | EPA Method 1613a | Y |
| EPA RI 1995 Nearshore Supplement | Y | EPA Method 1613a | Y |

### **Congeners Examined and Non-Detect Treatment**

The dataset used in this study is taken from a compilation done by NOAA that is available on the NOAA Emergency response Web site. This database includes over 300 chemicals, which were measured in the various studies. 19 dioxin-furan congeners were measured for one or more of the studies. 17 of the 19 dioxin-furan congeners measured for the studies are 2,3,7,8 substituted congeners; meaning chlorine atoms are present on the 2<sup>nd</sup>, 3<sup>rd</sup>, 7<sup>th</sup> and 8<sup>th</sup> position on the dioxin-furan or furan molecule. 2,3,7,8-substituted congeners own the highest toxicity and therefore are of most concern in the environment. The two non-2,3,7,8 substituted congeners, 1,2,4,7,8-PCDD and 1,2,4,7,8-PCDF, were only analyzed for the Maxus 1993 study and so were excluded from this analysis. The congener 2,3,4,7,8-PCDF was not analyzed during the 1993 and 1994 REMAP studies. These studies were the only studies that included data for the entire harbor, precluding their use would not allow for the examination of harbor-wide trends. Therefore these three congeners, although part of the NOAA dataset, were omitted from the analysis. 16 congeners were used in this study; they were measured at stations throughout the harbor estuary to provide a consistent comparison between water bodies. The dioxin-furan congeners used are shown in Table 4-2.

**Table 4-2 Dioxin-Furan Congeners used in this study**

| <b>Dioxin/Furan</b>                  | <b>Field name(in dataset)</b> |
|--------------------------------------|-------------------------------|
| 2,3,7,8-tetrachlorodibenzo dioxin    | Pd2378                        |
| 1,2,3,7,8-pentachlorodibenzo dioxin  | Pd12378                       |
| 1,2,3,4,7,8-hexachlorodibenzo dioxin | Pd123478                      |
| 1,2,3,6,7,8-hexachlorodibenzo dioxin | Pd123678                      |
| 1,2,3,7,8,9-hexachlorodibenzo dioxin | Pd123789                      |

|                                         |           |
|-----------------------------------------|-----------|
| 1,2,3,4,6,7,8-heptachlorodibenzo dioxin | Pd1234678 |
| octachlorodibenzo dioxin                | Pd8       |
| 2,3,7,8-tetrachlorodibenzo furan        | Pf2378    |
| 1,2,3,7,8-pentachlorodibenzo furan      | Pf12378   |
| 1,2,3,4,7,8-hexachlorodibenzo furan     | Pf123478  |
| 1,2,3,6,7,8-hexachlorodibenzo furan     | Pf123678  |
| 1,2,3,7,8,9-hexachlorodibenzo furan     | Pf123789  |
| 2,3,4,6,7,8-hexachlorodibenzo furan     | Pf234678  |
| 1,2,3,4,6,7,8-heptachlorodibenzo furan  | Pf1234678 |
| 1,2,3,4,7,8,9-heptachlorodibenzo furan  | Pf1234789 |
| octachlorodibenzo furan                 | Pf8       |

The chemistry of dioxins and furans has been described in Chapter 3. The 2,3,7,8 substituted dioxins and furans result from similar processes and show similar effects in living organisms. For this reason they are often analyzed together in ambient samples and anthropogenic and natural sources. The inclusion of furans in a dioxin analysis provides a more accurate assessment of the toxic effects of contamination, as furans can be the majority contributors to the toxicity of a given sample. In addition the larger number of variables provides more information for separating sources and tracing back contamination. For example dioxins are present in very low concentrations in PCB derived sources while furans are much more abundant. At low concentrations the examination of just dioxins would not permit the identification of PCBs as a source.

The statistical analysis for this study was performed using the 16 congeners listed in table 4-2. Additional statistical information on these analytes is given in table 4-2a. In addition to congener concentrations some studies measure the concentration of homolog groups, i.e. all the 2,3,7,8 substituted hexa-chlorinated dioxins. Statistical analyses can then be performed on the homolog groups rather than individual congeners. There are a number of disadvantages to this approach in general and in particular to this analysis. Homolog groups reduce the number of variables under analysis; in this analysis 10 would be used rather than 16. This allows simpler direct interpretation of the data and reduces the complexity of statistical analysis. It does mean however a loss of information. The principal component analysis and clustering performed on the

dataset showed significant differences between congeners in the same homolog group. In addition to the dioxin source dataset, the National Dioxin Inventory released by the EPA analyzes dioxin sources as individual congeners. The dioxin-furan congener pattern for the soil samples from the Diamond Alkali site given by Wenning et al. (1993) are in individual congeners.

The methods of determining the homolog groups were not fully explained in the literature for the Maxus datasets, whether they were directly measured or calculated. Some of the studies did not report homolog groups. Calculating homolog groups, given the uncertainty inherent in any measurement and variation in non-detect levels, would introduce additional error. Using congeners provides 16 variables with a given set of uncertainties while homolog groups provide 10 variables with an uncertain amount of uncertainties. Other studies have used Toxic Equivalence Quotient values as the starting point for analyses. Each congener is multiplied by its TEQ and those values are then used. Analytical procedures for determining dioxin and furan concentrations have similar resolution for different congeners with the exception of OCDF due to interference of the labeled analog. Multiplying these values, which have a comparable base, into derived values introduces additional ambiguity, as with homologs. In addition TEQ is a biological phenomena, the theoretical response of an organism to different configurations of dioxin molecules. Under analysis in this examination is physical behavior in the environment. The behavior of OCDD in sediments is a function of its concentration, not 0.001 times its concentration. For these reasons actual concentrations were used in the analysis.

To compare the overall magnitude of dioxin-furan concentration a summed dioxin-furan concentration was calculated by summing the 16 dioxin-furans used in the study. These values are reported as summed dioxin-furan concentrations. Dioxin-furan Toxic Equivalence Factors are based on summation and calculations also using only these 16 congeners. A complete list of the samples used and the dioxin-furan congener measurements at each station is given in Appendix 1.

**Table 4-2a Statistics for Dioxin Furan Congeners Analyzed; Mean and Maximum concentrations and Mean value of the ratios of the congener concentration to the summed dioxin-furans and the Mean value of the ratios of the congener's Toxic Equivalence to the Summed Toxic Equivalence for the sample. See chapter 3 for a description of Toxic Equivalence.**

| Congener   | Concentrations in ppb |        |         | Mean Ratio of Congener to Summed Dioxin Furans |                   |
|------------|-----------------------|--------|---------|------------------------------------------------|-------------------|
|            | Mean                  | Median | Maximum | Concentration                                  | Toxic Equivalence |
| PCD1234678 | 1.08                  | 0.535  | 200     | 0.16                                           | 0.24              |
| PCD123478  | 0.021                 | 0.007  | 4.47    | 0.0021                                         | 0.003             |
| PCD123678  | 0.09                  | 0.033  | 15.8    | 0.0082                                         | 0.012             |
| PCD12378   | 0.047                 | 0.006  | 17.7    | 0.0017                                         | 0.014             |
| PCD123789  | 0.034                 | 0.018  | 4.7     | 0.0046                                         | 0.008             |
| PCD2378    | 12.06                 | 0.20   | 5300    | 0.135                                          | 0.608             |
| PCD8       | 3.86                  | 1.42   | 802     | 0.3696                                         | 0.012             |
| PCF1234678 | 0.72                  | 0.36   | 124     | 0.0512                                         | 0.012             |
| PCF123478  | 0.97                  | 0.036  | 727     | 0.012                                          | 0.026             |
| PCF1234789 | 0.162                 | 0.025  | 83.1    | 0.0075                                         | 0.0011            |
| PCF123678  | 0.185                 | 0.18   | 125     | 0.0053                                         | 0.0106            |
| PCF12378   | 0.035                 | 0.01   | 15.6    | 0.0024                                         | 0.0023            |
| PCF123789  | 0.061                 | 0.01   | 16.4    | 0.0132                                         | 0.015             |
| PCF234678  | 0.134                 | 0.031  | 50.2    | 0.0104                                         | 0.015             |
| PCF2378    | 0.085                 | 0.036  | 17.8    | 0.0125                                         | 0.023             |
| PCF8       | 2.532                 | 0.45   | 183     | 0.2015                                         | 0.0057            |

The congener with the highest mean concentration was 2,3,7,8-TCDD with a mean of 12.06 parts per billion (ppb). This value was skewed by some extraordinarily high concentrations measured in core samples adjacent to the Diamond Alkali Site. The highest single concentration measured in the studies was the 2,3,7,8-TCDD concentration measured at station 285a in the sample taken at the depth interval 137 – 165 cm. The concentration was 5.3 parts per million. A dataset with 2,3,7,8-TCDD as the most abundant dioxin-furan is unique among dioxin furan datasets as this congener is rarely the major component. The median concentration was only 0.2 ppb indicating it was present in a small number of samples at very high concentrations and in a large number of samples at only low concentrations. This is further indicated by the mean ratio of 2,3,7,8-TCDD concentrations to the summed dioxin-furan concentration. This ratio is 0.135,

lower than OCDD. The contribution of 2,3,7,8-TCDD to the toxicity of the sample is very high at 0.608, not surprising given that toxicities of all the other congeners is a fraction of 2,3,7,8-TCDD toxicity.

The next highest congener in mean concentration was OCDD at 3.86 ppb with a median of 1.42. In the majority of dioxin-furan measurements OCDD is the major component. The mean ratio of OCDD to summed dioxin-furans in this dataset was 0.36, given that 16 congeners comprised the summed dioxin-furan total, OCDD nearly always was one of the primary congener. In 378 of the 893 samples OCDD was present in a concentration greater than any other congener. The contribution of OCDD to the overall Toxic Equivalence of the samples was low as its TEF is the lowest of the 2,3,7,8 substituted congeners.

OCDF had the third highest mean concentration at 2.53 ppb, median concentration was 0.45 ppb, more skewed than OCDD but not to the degree of 2,3,7,8-TCDD. OCDF was present in each sample at an average ratio of 0.2015 congener concentration to summed congener concentration. This value was the highest after OCDD. The ratio of the contribution to the summed toxic equivalence by OCDF averaged 0.0057. The congener with the next highest mean concentration was 1,2,3,4,6,7,8-HpCDD at 1.08 ppb. Median concentration was 0.535 ppb. The mean ratio of the contribution of 1,2,3,4,6,7,8-HpCDD to the summed dioxin-furan concentration was 0.16 the third highest of the congeners, greater than 2,3,7,8-TCDD and exceeded only by the two octa-chlorinated congeners. The contribution of this congener to the toxicity of the samples was very high, second only to 2,3,7,8-TCDD at a ratio of 0.24, on average one-quarter of the toxicity in the congeners used in the analysis resulted from 1,2,3,4,6,7,8-HpCDD.

These four congeners previously described; 2,3,7,8-TCDD, OCDD, OCDF and 1,2,3,4,6,7,8-HpCDD form the bulk of the dioxin-furans present in the samples. The principal component analysis described in a subsequent section further bears out this point. The remaining 12 congeners constitute on average no more than 10 percent of the dioxin-furans in the samples.

These four account for 92% of the dioxin-furan concentration in the samples and congeners used in this study.

The congener with the fifth highest mean concentration was also a furan, 1,2,3,4,7,8-HxCDF. Mean concentrations was 0.97 ppb with a median of 0.036 ppb, a highly skewed distribution of values. This congener comprised an average ratio of 0.012 of the total dioxin-furans and a contribution of 0.026 to the overall toxic equivalence of the samples. The only other congener, which even approached a mean concentration of 1 ppb, was 1,2,3,4,6,7,8-HpTCF at 0.72 ppb. The median concentration was 0.36 ppb while the mean ratio of congener concentration to summed dioxin-furan concentration was 0.05. The mean contribution to Toxic Equivalence ratio was 0.012.

Three other congeners had a mean summed dioxin-furan concentration over 0.01 ppb, 1,2,3,6,7,8-HxCDF, 1,2,3,4,7,8,9-HpCDF and 2,3,4,6,7,8-HxCDF at 0.185, 0.162 and 0.134 respectively. The mean ratio of concentration to summed dioxin-furan concentration was 0.0053 for 1,2,3,6,7,8-HxCDF, 0.0075 for 1,2,3,4,7,8,9-HpCDF and 0.0104 for 2,3,4,6,7,8-HxCDF.

The remaining 7 congeners each were found at an average concentration less than 0.1 ppb and accounted for less than 1 percent of the total dioxin-furans concentration for the congeners used in this analysis. Together these congeners accounted for less than 1.7 percent of total dioxin-furans concentration for the congeners used in this analysis.

The congener measured in some of the studies, but not used in the analysis was 2,3,4,7,8-PeCDF. The mean concentration of this congener was 0.26 ppb, making it the sixth highest congener in terms of mean concentration. At a median value of 0.061 it would have ranked 7<sup>th</sup> among the congeners. This value is actually inflated, as this congener was not measured in the REMAP study, which measured the lowest concentrations for virtually all the congeners. For the samples which measured 2,3,4,7,8-PeCDF it contributed an average ratio of



0.006 to the total dioxin-furans including 2,3,4,7,8-PeCDF. Therefore its significance is low and does not affect to outcome of the analysis.

The original dataset included samples for which certain congeners were not present in concentrations above the detection limit of the laboratory analysis. Various means have been used to treat such results, some studies have reported concentrations at the detection limit for non-detects, and others favor assigning a concentration of one half of the detection limit. For this study non-detects were assigned a concentration of 0.0. Sufficient samples with measured concentrations provided enough data for a useful analysis. The no-detect concentration was consistently low throughout the various studies, under 25 parts per trillion (ppt).

#### **Areal Extent of Sampling**

The area covered by the samples include the Passaic and Hackensack Rivers, Newark Bay, the Arthur Kill, the Kill Van Kull the Upper and Lower New York Bay, the East River, Western Long Island Sound and Jamaica Bay (Figures 4-1 and 4-2). A number of studies have characterized these areas in terms of contamination and toxicity. They include Squibb et al. (1991) NOAA Status and Trends studies (NOAA, 1995) and the US EPA REMAP studies (US EPA, 1996). These studies all found the sediments in Newark Bay, the Passaic and Hackensack Rivers and the Arthur Kill to be highly toxic. The NOAA studies found 85% of the area sampled to be toxic to amphipods. The REMAP studies compared contaminant levels with biological effects guidelines developed by Long et al. (1995). An Effects Range-Low (ER-L) indicates a level at which adverse effects begin to be seen while Effects Range-Medium (ER-M) are contaminant levels which are associated with adverse biological response. The Newark Bay sampling area, which included the Lower Passaic, Hackensack and Arthur Kill, had the highest percentage of adverse conditions. 92% of the area survey in this sub-basin exceeded the ER-M for at least one of the chemicals tested.

Conditions in other areas of the harbor were found to be more variable; the other water bodies are more heterogeneous and not amenable to generalizations. Squibb et al. (1991) found a number of moderately toxic areas in the Upper Bay and a number of confined inlets and bays such as the Gowanus Canal and Newtown Creek. The NOAA studies found that 38% of the areas sampled in 1992 and 1993 were highly toxic, including the Newark-Passaic-Arthur Kill complex. Highly toxic areas outside this complex included some areas in the East River and Sandy Hook Bay. The NOAA study reported the highest correlation between toxicity and any class of contaminant was between toxicity and 2,3,7,8-TCDD in the Newark Bay – Lower Passaic River (NOAA, 1995).

The number of samples in each water body is shown in Table 4-3 along with summary statistics on the summed dioxin-furan levels found. The summed dioxin-furan value represents the sum of all the congeners of dioxins and furans used in the cluster analysis at each station. This figure provides an indication of the overall level of contamination from dioxins for the sample; the concentration of the individual congeners varies even at stations with the same overall summed dioxin-furan concentration. Summed dioxin-furan concentration is also used to normalize the dioxin-furan values for statistical analysis. The minimum, maximum and standard deviation statistics indicate the variability of dioxin-furan contamination for a given group of samples. These values are good indicators of the extent of contamination; are “hot spots” present in the area or is the contamination well distributed.

The station locations are mapped in Figure 4-2. The bulk of the 893 points analyzed are located in the Passaic River. One reason for this sampling focus, as shown in the table, is that the mean summed dioxin-furan concentration for all the samples taken in the Passaic is nearly four times the next highest mean concentration (East River contains only a single sampling location and was therefore ignored). In part this is due to the preponderance of subsurface core samples, which compose 488 of the 672 Passaic River samples. The higher dioxin-furan levels are due to

the high concentration of industrial activity along the Passaic River and in particular industrial activity that produced waste containing dioxin-furan contamination, such as the Diamond Alkali Site. The Arthur Kill samples also consisted of a number of buried sediment samples, 12 out of 24. The Kill is home to a concentration of chemical facilities, oil refineries and waste treatment facilities. In addition the Arthur Kill has been subjected to numerous oil and hazardous waster spills from tank farms, ships and ship offloading operations. Yet dioxin-furan concentrations, higher than the rest of the harbor, are not as high in the Arthur Kill as in the Passaic River.

**Table 4-3 Summed dioxin-furan Summary Statistics in parts per billion by Harbor Water body**

| Water body        | # of Samples | Mean Summed dioxin-furan | Min Summed dioxin-furan | Max Summed dioxin-furan | Std. Dev. Summed dioxin-furan | Mean Total Organic Carbon |
|-------------------|--------------|--------------------------|-------------------------|-------------------------|-------------------------------|---------------------------|
| Arthur Kill       | 18           | 4.18                     | 0.073                   | 13.06                   | 3.87                          | 1.64                      |
| Elizabeth River   | 6            | 2                        | 0.009                   | 5.0                     | 1.95                          | 0.95                      |
| Hackensack River  | 25           | 2.79                     | 0.026                   | 9.48                    | 3.59                          | 1.44                      |
| Hudson River      | 8            | 3.04                     | 0.629                   | 5.77                    | 1.67                          | 2.20                      |
| Jamaica Bay       | 28           | 2.3                      | 0.027                   | 29.24                   | 5.50                          | 2.07                      |
| Kill Van Kull     | 8            | 2                        | 0.002                   | 4.66                    | 1.64                          | 0.74                      |
| Long Island Sound | 6            | 1.69                     | 0.52                    | 4.93                    | 1.73                          | 2.89                      |
| Lower Bay         | 27           | 2.1                      | 0.036                   | 8.22                    | 2.89                          | 1.77                      |
| Newark Bay        | 81           | 3.1                      | 0.91                    | 17.98                   | 3.18                          | 1.16                      |
| Passaic River     | 672          | 14.2                     | 1.48                    | 1081.2                  | 48.12                         | 7.95                      |
| Upper Bay         | 14           | 1.6                      | 0.073                   | 4.14                    | 1.48                          | 2.14                      |

A comparison of the Passaic River with other water bodies of the Harbor complex in mean concentrations of other types of pollutants does not show a similar difference in magnitude. Table 4-4 displays the mean concentrations for all the sample points for 4 pollutants of concern in the Harbor, PCBs (as total PCBs), Cadmium, Total PAHs, and DDT. PCBs or Polychlorinated Biphenyls are a class of chemicals widely used in the electrical industry due to their stability and high heat capacity. As mentioned earlier in the discussion of historical pollution sources, PCBs

have been found in high concentrations in the Hudson River, primarily due to discharge from two General Electric facilities on the Upper Hudson River. The distribution of PCBs within the Harbor would indicate additional local sources. PAHs, Polyaromatic Hydrocarbons, are a class of pollutants resulting from a variety of activities. PAHs include such chemicals as chrysene, anthracene and naphthalene. Cadmium is a heavy metal widely distributed in sediments throughout the Harbor. Very high levels of Cadmium have been found in Hudson River sediments in the Highlands area associated with the Foundry Cover Superfund Site located near Cold Spring Harbor NY. DDT is a pesticide widely used beginning in the 1940's through the late 60's. It was banned for use in the United States in 1972 although it was still manufactured for export overseas. Sources include non-point source runoff from areas of DDT application as well as point sources from Pesticide manufacturing plants. The Diamond Alkali site was used for manufacturing DDT in the late 1940's and 1950's.

These, and other pollutants, have been studied by a number of investigators. As mentioned previously the US EPA 1992 and 1993 REMAP study report compared the levels of contaminants with benchmark standards for each contaminant, the standards quantified potential effects on exposed organisms. The following discussion includes samples not analyzed in this investigation either because dioxin-furans were not measured or too few congeners were over the detection level. The REMAP study found that 8% of the Harbor area exceeded the Effects Range-Medium level for DDT, the rate increase to 65% for Newark Bay complex samples (Newark Bay, Passaic and Hackensack Rivers and the Arthur Kill). For total PCBs, 26% of the harbor wide sample area exceeded the ER-M level, 63 percent of samples in the Newark Bay complex exceeded the level. The Upper Bay also had a high level of total PCB exceedances, 54%. Total PAH levels showed few exceedances, harbor wide only 3% of samples were over the ER-M, the Newark Bay complex was even lower at 1%. Only the Upper Bay show significantly high levels with 11% of the samples over the ER-M. Cadmium was also low throughout the harbor, only 1%

of the areas exceeded ER-M, all the samples at this level were taken in the Newark Bay complex (US EPA, 1996).

The NOAA Status and Trends study, especially Phase I, looked at the distribution of contaminants and levels of toxicity throughout the harbor. As mentioned previously the NOAA study found large areas of Newark Bay, the lower Passaic River and the Arthur Kill to have sediments that were highly toxic to test organisms (NOAA, 1995).

Bopp et al. (1998) examined trends in the level of certain pollutants at various places in the harbor since the 1950's using dated core samples. This investigation showed a decrease in levels of DDT, PCBs, chlordane and dioxin between samples taken in the 1960s and samples taken in the 1980s and 1990s. Certain chemicals showed spatial variation, which could be linked to sources, DDT in the Passaic River and Arthur Kill and PCBs in the Upper Hudson River (Bopp et al. 1998)

These comparisons indicate that the Arthur Kill and the Passaic River show a similar level of anthropogenic impact from these widely distributed pollutants. These analyses provide only a gross quantitative comparison due to the differences in density of sampling, sampling patterns and inclusion of buried sediments. It does provide a crude measure of the inordinately high levels of dioxin-furan contamination in the Passaic River. This is further supported by the results of the cluster pattern, discussed in the next section, which yielded a number of dioxin-furan congener patterns found only in the Passaic River sediments.

**Table 4-4 Summary Statistics for 5 Priority Pollutants  
(Concentrations indicated) by Harbor-Estuary Water body**

| Water body        | # of<br>Samples | Mean<br>Total<br>DDT (ppb) | Mean<br>Total<br>PCBs (ppb) | Mean<br>Total<br>PAHs (ppb) | Mean<br>Cadmium<br>(ppm) |
|-------------------|-----------------|----------------------------|-----------------------------|-----------------------------|--------------------------|
| Arthur Kill       | 18              | 685.39                     | 597.47                      | 33006                       | 11.04                    |
| Elizabeth River   | 6               | 93.30                      | 305                         | 15583                       | 14.53                    |
| Hackensack River  | 25              | 67.78                      | 587.1                       | 15697                       | 2.86                     |
| Hudson River      | 8               | 15.41                      | 326.1                       | 26969                       | 1.20                     |
| Jamaica Bay       | 28              | 4.92                       | 53.4                        | 3183                        | 0.98                     |
| Kill Van Kull     | 8               | 63.55                      | 586.8                       | 11304                       | 5.64                     |
| Long Island Sound | 6               | 16.26                      | 163.9                       | 26096                       | 0.78                     |
| Lower Bay         | 27              | 8.29                       | 60.1                        | 1387                        | 0.52                     |
| Newark Bay        | 79              | 138.18                     | 1086.7                      | 17290                       | 3.75                     |
| Passaic River     | 662             | 544.28                     | 2072                        | 48038                       | 10.49                    |
| Upper Bay         | 14              | 22.66                      | 214.2                       | 7674                        | 0.77                     |

#### **Study Comparison**

Differences in dioxin-furan concentration between water bodies would be expected due to differences in sediment accumulation and transport, direct and indirect discharge of industrial and municipal waste and physical and chemical properties of the area. Variations in dioxin-furan concentration between the studies used however should result only from differences in the areal extent and distribution of the sample points due to previously mentioned properties of the harbor areas. When combining different sampling studies in a single analysis care must be taken to ensure that methods of dioxin-furan determination are uniform and the measured concentrations are consistent. Table 4-5 shows the mean and maximum summed dioxin-furan concentrations in parts per billion for the samples from the 10 sampling efforts used in the analysis.

The study samples with the highest mean summed dioxin-furan concentrations are in the 1995 EPA Remedial Investigation (RI), Nearshore Supplement. This study sampled at five locations on the inner bank of the three bends in the river on Lower Passaic. The two Nearshore Supplement stations offshore of the Diamond Alkali site were responsible for the extraordinarily high concentration for the 9 core samples of 156 parts per billion (ppb) summed dioxin-furans.

The 1995 EPA Remedial Investigation (RI) study consisting of 407 cores had a mean summed dioxin-furan concentration of 13.61 ppb. This sampling effort as with the supplemental studies, were done exclusively in the Lower Passaic River in the area designated by the EPA as the 6-Mile Study (Figure 3). The Maxus studies included cores and surficial samples taken in other areas of the harbor. For the Maxus 1992 studies the Passaic River samples had a mean summed dioxin-furan concentration of 38.19, higher than the EPA 1995 RI study. The 1993 Maxus study had a mean summed dioxin-furan concentration of 15.0 ppb for samples taken in the Passaic River. The study included samples taken in the upper tidal portion of the river in addition to a sample above the Dundee Dam. The Maxus 1993 study samples within the 6 Mile Study had a mean summed dioxin-furan concentration of 32.6 ppb, within 10% of the value for the EPA 1995 RI Nearshore Supplemental Study. The two studies are similar in that they were both targeted to depositional areas especially near the Diamond Alkali site. The Maxus 1991 study was more comprehensive than the later Maxus studies, 140 of the samples from that study were used in this analysis. For the samples within the 6 Mile Study Area the mean summed dioxin-furan concentration was 7.91 parts per billion.

The REMAP 1993 and 1994 and the NOAA Status and Trends study consisted of only surficial samples. The two REMAP studies, consisting of stations scattered through all areas of the harbor, were very consistent in terms of mean summed dioxin-furan concentrations. The REMAP Studies did not include samples collected in the Passaic River. The NOAA study had an average concentration about twice the REMAP for all the sample points. The samples taken outside the Passaic River, a more reasonable set to compare with the REMAP samples, had a mean summed dioxin-furan concentration of 3.41 ppb.

**Table 4-5 Summed dioxin-furan Summary Statistics in parts per billion by Sampling Study**

| Study name                                          | # of Samples | Mean Summed dioxin-furan | Max Summed dioxin-furan | Mean Pcd2378  |
|-----------------------------------------------------|--------------|--------------------------|-------------------------|---------------|
| Maxus Passaic R. sediment study 1991                | 120          | 5.4                      | 0.093                   | 1             |
| Maxus Passaic R. sediment study 1992                | 47           | 13                       | 0.396                   | 2.2           |
| Maxus Passaic R. sediment study 03/1993 and 07/1993 | 48           | 9.7                      | 172.61                  | 0.35          |
| Maxus Passaic R. CSO study 1994                     | 40           | 8.51                     | 17.39                   | 0.035         |
| NOAA NS&T Hudson-Raritan Phase II 1993              | 54           | 4.91                     | 14.11                   | 0.137         |
| EPA REMAP 1993                                      | 42           | 2.3                      | 29.24                   | $5 * 10^{-3}$ |
| EPA REMAP 1994                                      | 45           | 2.4                      | 13.07                   | $6 * 10^{-3}$ |
| EPA Passaic RI 1995                                 | 408          | 13                       | 210.2                   | 4.6           |
| EPA Passaic RI 1995 Maxus Sup.                      | 29           | 6.8                      | 26.3                    | 1.7           |
| EPA Passaic RI 1995 Nearshore Sup.                  | 57           | 29.7                     | 5505                    | 21.1          |

#### **Surficial vs Buried Sediments**

Sediment concentrations measured within core samples at depth showed consistently higher dioxin-furan concentrations than the surficial samples. Mean surficial summed dioxin-furan concentration for the entire harbor for all the studies used was 7 ppb. Table 4-6 breaks out the surficial summed dioxin-furan concentration by water body.

**Table 4-6: Surficial Summed dioxin-furan Concentration Summary Statistics in parts per billion listed by Water body**

| Water body        | # of Samples | Mean Summed dioxin-furan | Min Summed dioxin-furan | Max Summed dioxin-furan |
|-------------------|--------------|--------------------------|-------------------------|-------------------------|
| Arthur Kill       | 10           | 6.42                     | 0.94                    | 13.06                   |
| Elizabeth River   | 2            | 2.19                     | 1.8                     | 2.54                    |
| Hackensack River  | 12           | 3.83                     | 0.2                     | 9.48                    |
| Hudson River      | 8            | 3.04                     | 0.62                    | 5.77                    |
| Jamaica Bay       | 28           | 2.2                      | 0.02                    | 29.2                    |
| Kill Van Kull     | 4            | 3.1                      | 0.92                    | 4.66                    |
| Long Island Sound | 6            | 1.6                      | 0.52                    | 4.93                    |
| Lower Bay         | 27           | 0.21                     | 0.03                    | 8.22                    |
| Newark Bay        | 45           | 4.6                      | 0.13                    | 17.9                    |
| Passaic River     | 174          | 10                       | 0.06                    | 172.6                   |
| Upper Bay         | 14           | 1.6                      | 0.07                    | 4.14                    |



Previous comparisons of dioxin-furan concentrations were made between the Arthur Kill and the Passaic River, the two most heavily impacted areas of the Harbor. Considering the surficial samples only, the degree of difference between the two locations is much less, 10 ppb in the Passaic and 6.4 ppb in the Arthur Kill. Current sources of dioxin-furans are not concentrated in the Passaic River. In fact this likely represents a change in media of present day dioxin-furan loadings. The ban on production of herbicides, pesticides and other dioxin-furan containing chemicals has significantly decreased the dioxin-furan loading from industrial discharge (Kjeller et al. 1991). Estimates made by the EPA on national dioxin-furan loadings point to airborne deposition resulting from municipal waste incineration and other combustion sources as the primary current source of dioxins (EPA, 1998). These sources are dominated by octa-chlorinated dioxin, which is the primary dioxin-furan in the most common surficial cluster identified in this study. The slightly elevated levels of dioxin-furans in surficial Passaic River sediments over the surficial sediments in other harbor water bodies may result from two factors; reactivation and re-suspension of buried sediments and the greater rate of deposition in the Passaic. The re-suspension of buried sediment is still an important source in the lower Passaic and Upper Newark Bay where a large number of the surficial samples show a congener pattern found predominately in buried sediments. The Hackensack River and Newark Bay are, like the Passaic, largely depositional. The higher concentration of dioxin-furan in buried and subsequently re-suspended sediment would account for the higher surficial dioxin-furan concentration in the Passaic. Table 4-7 shows the mean summed dioxin-furan concentration by water body for subsurface core samples.

**Table 4-7: Subsurface Summed dioxin-furan Concentration in parts per billion by Waterbody**

| Water body       | # Samples | Mean Summed dioxin-furan | Min Summed dioxin-furan | Max Summed dioxin-furan |
|------------------|-----------|--------------------------|-------------------------|-------------------------|
| Arthur Kill      | 8         | 1.3                      | 0.073                   | 4.41                    |
| Elizabeth River  | 4         | 2                        | 0.009                   | 5.0                     |
| Hackensack River | 13        | 1.8                      | 0.026                   | 8.75                    |
| Kill Van Kull    | 4         | 1.4                      | 0.020                   | 3.22                    |
| Newark Bay       | 34        | 1                        | 0.001                   | 9.48                    |
| Passaic River    | 488       | $2 \times 10^{-2}$       | 0.001                   | $5.5 \times 10^{-1}$    |

The subsurface comparisons highlight the greater degree of dioxin-furan contamination in the Passaic River. The mean subsurface dioxin-furan concentration is an order of magnitude higher in the Passaic River than the other water bodies. In all areas of the Harbor except the Passaic River, dioxin-furan concentration decreases down core. In the four Arthur Kill core samples the highest dioxin-furan concentration was found in the surficial sample. Six other surficial samples were taken in Arthur Kill; four of the six had higher summed dioxin-furan concentrations than the highest individual core sample taken in the area. All were higher than the mean summed dioxin-furan concentration for all the Arthur Kill cores. A similar trend was observed in Newark Bay core samples where 13 of the 15 core stations had the highest dioxin-furan concentration in the surficial sample. In the Hackensack River all 4 of the core sampling locations had the highest dioxin-furan concentration in the surficial sample. In the Passaic River however, 60 of the 101 core locations had the highest summed dioxin-furan concentration found at depth. Fifty-one of the Passaic River coring stations had the highest dioxin-furan concentrations in the surficial sample. None of the locations with a surficial maximum were in the area immediately adjacent to the Diamond Alkali Site.

The trend for areas of the harbor, other than the Passaic River, was for decreasing summed dioxin-furan concentration down core. Core samples for dioxins are taken with the goal of capturing vertical segments, which include the lower limit to which dioxins are abundant. Some studies of ancient sediment cores and ice cores have shown the presence of dioxins prior to the onset of widespread human industrial activity (Czuczwa, et al. 1984). Those measurements indicate very low concentrations. Most chronological dioxin-furan sampling shows significant concentrations in the environment beginning in the early 20<sup>th</sup> century with the burgeoning use of motor vehicles and, perhaps most importantly, the development of the organic chemical industry and widespread production and use of chlorinated chemical products (Rose, et al., 1997) (Kjeller, et al., 1991). Environmental regulations over the past 30 years have outlawed the

discharge of waste containing dioxin, mandated reduction and scrubbing of smokestack discharges which have been shown to contain dioxins, and banned the use of herbicides pesticides and other chemicals containing dioxin-furan residue (US EPA, 1998a). Yet other than the Passaic River, surficial dioxin-furan concentrations are shown to have increased over the past 40 years. Mean core concentrations represent an aggregation of past dioxin-furan deposition, high and low, so values lower than surficial concentrations do not by themselves indicate increased dioxin-furan deposition. However a majority of core samples outside the Passaic showed the maximum summed dioxin-furan concentration for the entire core segment to be the surficial sample. Clearly the dioxin-furan loadings have not significantly decreased yet the patterns of congeners in present and past deposition have changed. This is demonstrated by the shift in the derived dioxin-furan clusters, to be discussed in the section, as well as the changes in summed dioxin-furan Toxic Equivalence Factors.

Bopp et al. (1998) found an increase in 2,3,7,8-TCDD concentration between surficial sediments and sediments dated to the 1960s in cores taken in the Passaic River. This trend was also present in a core taken in the Upper Bay. In the same two cores the change in OCDD between surface and buried sediment did not show a significant change. Bopp et al. (1998) reached a similar conclusion that the decrease in 2,3,7,8-TCDD has resulted from reduction in chemical manufacturing discharge while OCDD, resulting from combustion sources, has not shown a similar decrease.

Toxic Equivalence Factor (TEF) is a controversial yet environmentally important measure of dioxin-furan contamination. The TEF is comparison of the toxicity of dioxin-furan congeners compared with the most toxic of the congeners, 2,3,7,8 TCDD. Toxicity factor vary between 0.1 (1 for 2,3,7,8-TCDD itself) and 0. The TEFs for dioxins and furans are shown in table 2-2. Toxic Equivalence Factors were first used in the later 1970's to carry out a risk assessment of a building contaminated with PCBs. They were formally accepted by the World

Health Organization (WHO) in 1993 and reassessed and modified slightly at a WHO meeting in 1998 (USEPA, 1999).

Multiplying each congener by the TEF ratio of that congener and then summing the results calculated the Dioxin Toxic Equivalence Factor, for each sample. The mean TEF by water body for surficial and core samples are shown in Table 4-8. Mean TEF values in most areas of the harbor show a very slight change between surficial and buried sediments. The Arthur Kill, Newark Bay and the Hackensack River show almost negligible differences. Kill Van Kull showed a slight increase while the Elizabeth River and Passaic River show an increase down core of an order of magnitude. A common characteristic of these waterbodies is that both were the location of major pesticide and herbicide manufacturing operations.

The comparisons between surficial samples and buried sediments show that for most of the harbor areas summed dioxin-furan concentration is lower in buried sediments (Tables 4-5 and 4-6) but the toxicity due to dioxins has not changed greatly (Table 4-9). The Passaic River is the one area of the harbor estuary that shows a significant increase in toxicity down core, a greater change than between surficial and buried summed dioxin-furans. This reflects a change in the congener patterns down core from the low toxicity octa-chlorinated dioxins and furans in recent sediments, to the more toxic 2,3,7,8 substituted dioxins in buried sediments. These indicators signal a shift in the dominant dioxin-furan sources away from the lower chlorinated chemical sources such as herbicides and other chlorinated phenols, to combustion sources such as incineration and motor vehicles. The Passaic River was a focus for these low-chlorinated chemicals; the TEF of buried sediments in the Passaic is around 100 times greater than other areas of the Harbor Estuary.

**Table 4-8 Surficial vs. Subsurface Dioxin-furan Toxic Equivalence Factor in PPT of 2,3,7,8-TCDD by Water body**

| Water body       | # Surficial Samples | Mean Surficial TEF | # Core Samples | Mean Core TEF         |
|------------------|---------------------|--------------------|----------------|-----------------------|
| Arthur Kill      | 10                  | 65                 | 8              | 56                    |
| Elizabeth River  | 2                   | 5                  | 4              | 62                    |
| Hackensack River | 12                  | 87                 | 13             | 73                    |
| Kill Van Kull    | 4                   | 30                 | 4              | 79                    |
| Newark Bay       | 45                  | 102                | 34             | 93                    |
| Passaic River    | 174                 | 688                | 488            | 6.8 * 10 <sup>3</sup> |

### **Sample Analysis**

Determining possible sources of dioxin-furan contamination for a given ambient sample or samples of soil, sediment sewage sludge or water involves analyzing the distribution of the various dioxin-furan congeners within the sample. For multiple samples in a system that is likely to have numerous sources of dioxins, the problem is approached as one of pattern recognition. Pattern recognition, a category of multivariate statistical analysis, is the process examining multiple samples composed of multiple variables to find regularities or similarities in the data which may yield information on the underlying relationships between samples and variables. In the analysis of dioxin-furan distributions the technique involves correlating the ratio of the congeners as measured in the environment with congener ratios of one or more known sources of dioxins such as waste incineration or TCP synthesis. The process is further complicated in that an ambient location is likely to be subject to multiple sources of dioxins. Rappe, et al., (1997) found similar congener patterns upstream and downstream from a major pulp and paper plant, what was expected to be a significant single source seemed to be overwhelmed by multiple inputs. The contamination may have been in the environment for a number of years or even decades and so been selectively dechlorinated (Adriaens et al., 1995). Temporal analysis of the samples can be performed on core samples to determine the date of deposition. This allows patterns within the core to be matched to historical trends in pollution and contaminant discharges. Changes in manufacturing procedures, regulatory changes, accidental spills and discharges and trends in

atmospheric concentrations can be examined. Temporal changes in dioxin-furan congener patterns can be discerned and matched to known events and trends. Dating of aqueous sediments can be done using radioisotopes such as lead 210, cesium 137, beryllium 7 or americium 240.

Investigators have used a variety of statistical methods in order to match ambient patterns with measured sources or correlate formation mechanisms between dioxin-furan sources. Strategies include Principal Component Analysis (Ehrlich et al. 1994, ), factor analysis (Fattore et al., 1997), Polytopic Vector Analysis (Ehrlich et al. 1994) hierarchical cluster analysis (Buekens, 2000, Fiedler, et al., 1990) k-means cluster analysis (Gotz, et al. 1998, Rainer, et al., 1998), regression analysis (Rigo et al., 1995) and correlation analysis (Bopp et al. 1991). Principal Component Analysis (PCA) is often used as a first step to simplify the number of variables and compare ambient samples with known source samples. Cluster and vector analyses separate the samples into groups of statistically similar congener ratios. The spatial and temporal distribution of these groups can be used to determine sources and magnitude of dioxin-furan loadings. Accurate assessment requires knowledge of potential dioxin-furan sources in the area.

In this study Principal Component Analysis and k-means cluster analysis were used to “fingerprint” the dioxin-furan patterns found in samples from the Harbor Estuary. Principal Component Analysis creates, from the variables and samples, a reduced set of variables or components, which contain most of the underlying variance within the original variables. PCA also provides a measure of the relationships between variables in the calculation of a loading factor for each of the output components on each input variable. K-means cluster analysis partitions the samples into groups, or clusters, based on statistical similarities in the variables under examination. Principal component analysis was used to determine the number of clusters that are contained in the dataset and then validate the separation and influence of the input variables on the output clusters.

### **Previous Analyses of Dioxin-furan Contamination in the Estuary**

Previous investigations of dioxin-furan contamination in the Hudson Estuary include Bopp et al. (1992), Wenning et al. (1993), Ehrlich et al. (1994) and Huntley et al. (1998). Bopp et al. (1991) looked at the correlation between 2,3,7,8-TCDD and OCDD in sediment samples taken in the Passaic River, Newark Bay and the Upper New York Bay, to determine the effect of contamination from the Diamond Alkali Site on dioxin-furan contamination in the Estuary. The study concluded that the Diamond Alkali Site was the major source of 2,3,7,8-TCDD contamination in the Hudson Estuary. The total discharge of 2,3,7,8-TCDD from the Diamond Alkali Site was estimated to be 2.2 kilograms.

Wenning et al. (1993) examined the 1991 and 1992 Maxus investigations. Their analysis indicated the existence of numerous sources of dioxin-furan contamination in the Estuary. For surficial sediments the analysis found that the Diamond Alkali Site was a minor dioxin-furan source, Combined Sewer Overflows (CSOs) and PCBs were identified as major contributors to dioxin-furan contamination.

Ehrlich et al. (1994) used Polytopic Vector Analysis on the surficial samples from the 1991, 1992 and 1993 Maxus samples. This investigation reached a similar conclusion to Wenning et al. (1993) in finding CSOs, PCBs and combustion sources to be the major contributors of dioxins to surficial sediments in the Passaic River, Newark Bay and Hackensack River.

Huntley et al. (1998) examined the Maxus core samples from 1991, 1992 and 1993. Radioisotope analysis for dating the core sections was carried out and is described in Huntley, et al. (1995). The investigators used Polytopic Vector Analysis to separate samples into fingerprint patterns or end-members. Each sample may consist of one or more end-member, which would represent a specific source of dioxin-furan contamination. The radioisotope dating results were used to divide the samples into time period groups for separate processing. Significantly the time period 1965 – 1970 was excluded from the analysis because an insufficient number of samples

fell within 1965 – 1970 time frame” (Huntley et al., 1998). This time period is likely to contain the most significant impact of the 1960 explosion and fire at the Diamond Alkali Site. The number of samples representing an insignificant number of samples is not reported.

The conclusion of the Huntley, et al. (1998) investigation is that the dominant sources of dioxin-furan contamination to the subsurface sediment of the study area are combustion sources, combined sewage overflow and PCBs. Two samples fall into an end-member described as from an “unknown source”. The samples are located adjacent to former 2,4,5-T manufacturing sites. One of these samples is adjacent to the Diamond Alkali Site, the other to the Givaudan Chemical Company facility.

### **Principal Component Analysis**

Principal Component Analysis (PCA) is used to reduce a large dataset containing many variables to a smaller number of variables, which can more easily be analyzed and explained. In most investigations in the Earth Sciences some of the variables will be positively correlated, some negatively correlated and some are uncorrelated. PCA reprojects the samples into a series of new data planes or variables, in which the overall variance of the new variables is equal to the overall variance of the underlying variables. However the calculation proceeds so that the first data plane, or component will contain the maximum variance. Subsequent components are calculated to maximize variance with the constraint of being uncorrelated with any previously calculated components. For most multivariate datasets, over 90% of the variance can be accounted for by the first three components. Generally five or fewer components will account for 99% of the variance. The higher the degree of correlation in the original dataset the more effectively a small number of components will contain the maximum variance. If the original variables are totally uncorrelated, Principal Component Analysis will essentially do nothing but create a new set of variables with well-distributed variance.



The congener samples, originally in parts per trillion (ng/kg), were normalized to the summed dioxin-furan-furan concentration for the sample. Normalization removes the effects of individual sample variations in concentrations making direct comparisons between congener distributions possible. Concentration of dioxins in these studies varied by a number of orders of magnitude, without normalization the variance would be skewed in the direction of higher concentration. Measured levels of dioxins in aqueous sediments are primarily due to physical transport factors such as depositional patterns, total organic carbon content, water depth, flocculation, proximity to discharge sources and other factors.

The Principal Component Analysis was performed using the statistical program S-Plus version 4.5 Standard Edition from MathSoft Inc. It was run on a Dell 610 personal computer operating under Windows NT. The input matrix consisted of 893 samples and 16 congener variables. The algorithm requires as an input a matrix consisting of only the normalized data fields. The file was prepared using Arcview GIS software running on the same platform. The data were normalized by dividing each congener value by the sum of all the dioxins and furans for that sample. The data were written out to a dBase file and loaded into an S-Plus data window. Component predictions were written out to the individual sample records in the input file, variable loadings were saved to a separate file. The resulting components are shown in table 4-9.

The loadings of the first three principal components, accounting for about 95% of the total variance, are shown in table 4-10.

**Table 4-9 Principal Component Scores showing Standard Deviations, Percent of Variance and Cumulative Percent of Variance.**

| <b>Statistic</b>                      | <b>Component 1</b> | <b>Component 2</b> | <b>Component 3</b> | <b>Component 4</b> | <b>Component 5</b> |
|---------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| <b>Standard deviation</b>             | 0.3223             | 0.2003             | 0.1605             | 0.0786             | 0.0514             |
| <b>Percent of Variance</b>            | 57.71              | 22.28              | 14.31              | 3.43               | 1.46               |
| <b>Cumulative Percent of Variance</b> | 57.71              | 80.00              | 94.31              | 97.75              | 99.22              |

**Table 4-10 Principal Component Congener loadings.**

| <b>Congener</b> | <b>Component 1</b> | <b>Component 2</b> | <b>Component 3</b> |
|-----------------|--------------------|--------------------|--------------------|
| PD1234678       | 0.24078            | -0.72956           | -0.38723           |
| PD123478        | 0.00110            | -0.00339           | -0.00119           |
| PD123678        | 0.00696            | -0.00942           | -0.00042           |
| PD12378         | 0.00089            | 0.00049            | 0.00069            |
| PD123789        | 0.00288            | -0.00970           | -0.00338           |
| PD2378          | 0.32424            | 0.67798            | -0.47226           |
| PD8             | -0.86182           | 0.06572            | -0.01363           |
| PF1234678       | -0.05469           | 0.01881            | 0.04897            |
| PF123478        | -0.01053           | -0.00331           | 0.00504            |
| PF1234789       | 0.00674            | -0.00276           | 0.01419            |
| PF123678        | 0.00019            | -0.00457           | 0.00730            |
| PF12378         | 0.00018            | -0.00142           | 0.00206            |
| PF123789        | 0.02344            | -0.02290           | -0.00591           |
| PF234678        | 0.01083            | -0.00513           | 0.01281            |
| PF2378          | 0.00846            | -0.01857           | 0.00308            |
| PF8             | 0.30035            | 0.04771            | 0.78989            |

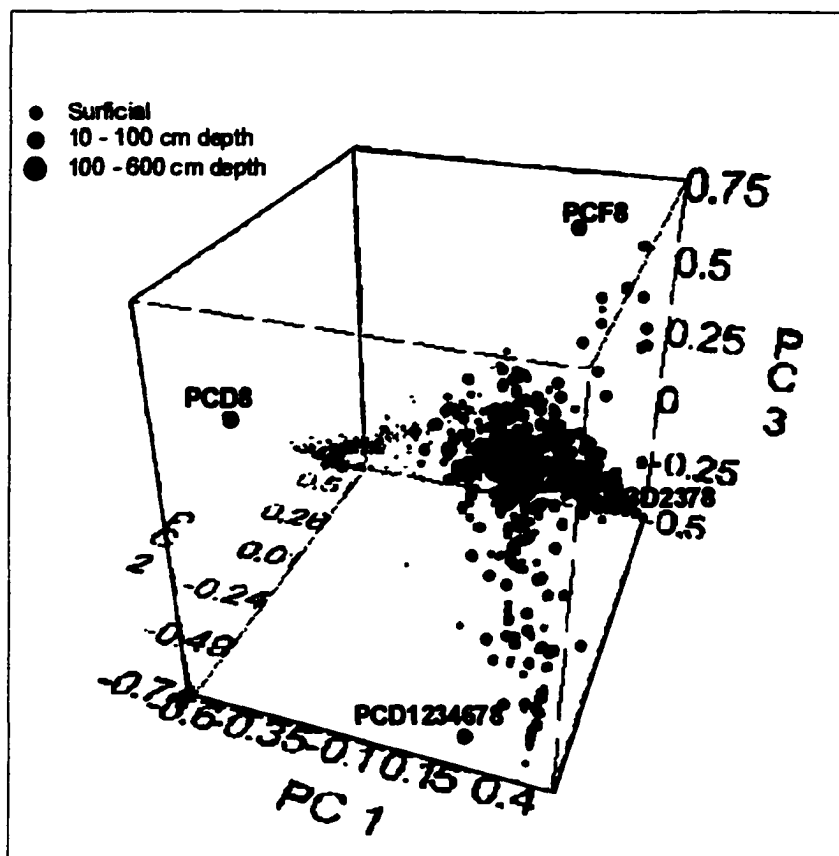
The first principal component had a standard deviation of 0.322, representing 57.7% of the total variance in the dataset. The second principal component contained 22.3% of the total variance, with a standard deviation of 0.20. Component three had 14.31% of the variance, a standard deviation of 0.16. The cumulative percentage of variance for the first three components was 94.3%, essentially all of the variance contained in the 16 original variables. The discussion of the results will focus on these 3 components.

Principal component 1 is strongly negatively correlated with the proportion of octa-chlorinated dioxin-furan (PCD8) in the sample. It is moderately, positively correlated with the proportion of 2,3,7,8-TCDD, octa-chlorinated furan (PF8) and 1,2,3,4,6,7,8-HpCDD (PD1234678) in that order. Component 2 is strongly negatively correlated with 1,2,3,4,6,7,8-HpCDD and strongly positively correlated with 2,3,7,8-TCDD. Component 3 was moderately negatively correlated with 2,3,7,8-TCDD and 1,2,3,4,6,7,8-HpCDD and strongly positively correlated with octa-chlorinated furan. From these results four congener: octa-chlorinated dioxin, 2,3,7,8-TCDD, 1,2,3,4,6,7,8-HxCDD and octa-chlorinated furan, are responsible for the vast bulk of the variance in the dioxin-furan congener proportions for this study. No other congener-

component loading for the first three components, which contain about 95% of the variance, exceeded  $\pm 0.06$ . One implication of this is that congener analyses can be done using fewer congeners. This would result in significant cost savings in dioxin-furan sampling studies, as the laboratory costs of congener analyses are quite high. It also supports the validity of analyses such as Bopp et al. (1991), which used the ratio of 2,3,7,8-TCDD and OCDD to trace the source of dioxin-furan contamination found in the Passaic River and Newark Bay to the Diamond Alkali Site. The first principal component showed the highest variable separation for the congeners OCDD (-0.86) and 2,3,7,8-TCDD (0.32) an indication that a large percentage of the overall variation in the data is associated with the inverse relationship of these two congeners. This relation represents the change in dioxin-furan sources over the past 3 decades. The growth of the chlorinated chemical industry and relatively unregulated discharge and release of these products created a contamination pattern dominated by lower chlorinated dioxins. More recent dioxin-furan contamination is primarily associated with combustion sources as these have proliferated while environmental controls and regulations reduced the discharge from the chemical industry.

Figure 4-4 shows the sample points displayed by principal component plot scores. Sample points are symbolized by depth with the surficial samples shown in the smallest symbol.

**Figure 4-4 Three-dimensional Principal Component Plot Scores for Sample Points. Samples are symbolized by depth. Congeners are displayed by Component Loadings.**



893 points make for a very cluttered diagram, however some clear trends can be noted. The distribution of points has a four-armed configuration where the arms extend out from a central mass or cluster of sample points. One arm extends along the component 1 axis from the central cluster toward increasing negative values of component 1 with slightly varying values of components 2 and 3, to the left in Figure 4-4. A second arm extends toward the bounds of the axes at maximum positive values of components 1 and 2 and negative maxima for component 3, toward the middle left part of Figure 4-4. The third arm extends out from the central cluster

toward the minimum (negative) values of components 2 and 3 and maximum positive values of component 1, toward the bottom of Figure 4-4. The fourth arm, containing the fewest points, extends out from the central cluster toward the maximum positive values of component 3, low values of component 2 and high positive values of component 1, toward the top of Figure 4-4.

The majority of surficial points are grouped around negative values of Principal Component 1 with low values of Components 2 and 3, the “first arm” of the sample diagram. Component 1 is strongly negatively correlated with the proportion of OCDD (PCD8) in the sample, OCDD had a component 1 loading of  $-0.86$ . The variance of this component seems to be controlled by the depth of the sediment sample, the sediment depth, component 1 correlation  $R^2$  is  $0.533$ . This is likely due to two factors, octa-chlorinated dioxin-furan has become more prevalent in environmental loading as controls on releases of chlorinated compounds improve, while combustion sources increase and dechlorination has acted on buried sediments. The positive congeners in this component are those that are prevalent at depth, particularly 2,3,7,8-TCDD.

The second “arm” of the sample distribution extends to a maximum of components 1 and 2 and a minimum value of component 3. This is correlated with the loading on 2,3,7,8-TCDD, which projects out to this region of component space. The sample points in this area of the diagram are buried core sediment samples high in 2,3,7,8-TCDD. Wenning et al. (1993) published the dioxin-furan congener concentrations from three soil samples and one sump pump sample for the Diamond Alkali site. The congener concentrations from the soil and sump samples were normalized by the summed dioxin-furan-furan concentration and then converted into principal component coordinates using the congener loading from this analysis. These are plotted with the sub-aqueous sediment samples in Figure 4-5. This figure shows the samples in principal component space from the “north”, toward decreasing component 2. In this figure samples are displayed symbolized by toxic equivalence factor. The soil and sump samples from the Diamond

Alkali project along this 'arm' of principal component space, the area of the diagram where the variance controlled by 2,3,7,8-TCDD concentrations.

The sediment samples in this area of the diagram are found only in the Lower Passaic River, at depth. Figure 4-6 shows the sample point locations displayed by distance from the Diamond Alkali Site. Figure 4-7 shows the points displayed by only the first two principal components, which account for 80% of the variance. All the sample points that fell in this area of principal component space are within 5 kilometers of the Diamond Alkali Site. The only exception is one sample point located about 15 kilometers upstream from the site at the junction of the Third River. This is the location of the Givaudan Chemical Company facility, which manufactured 2,4,5-Trichlorophenol used in the production of hexachlorophene (Belton et al., 1985). The New Jersey Department of Environmental Protection, Office of Science and Research measured dioxin-furan contamination present in the soils of the site, and found concentrations of 2,3,7,8-TCDD ranging from 0.09 to 9.7 parts per billion (Belton et al., 1985). The dioxin-furan concentration in the river sediments at this location is an order of magnitude less than the Lower Passaic. It is 8 kilometers above the upstream-most sample point falling in this area of component space. This indicates that there are two possible explanations for this sample; the contamination is derived from the Third River site and confined to this local area or the contamination is derived from the Diamond Alkali Site. This sample will be discussed again in the section on cluster analysis results.

The contamination of the remainder of the samples in this area seems clearly to be derived from the Diamond Alkali Site. The samples show only slight congener pattern differences with the site samples, which would be expected due to the river sediments being submerged and buried rather than subaerial and exposed to further dioxin-furan deposition from airborne sources. In fact the site soil samples are skewed toward the negative values of component 1, the area of the diagram where surficial samples are found.

**Figure 4-5 First 3 Principal components with sample points displayed by Toxic Equivalence Factor in 2,3,7,8-TCDD parts per thousand.**

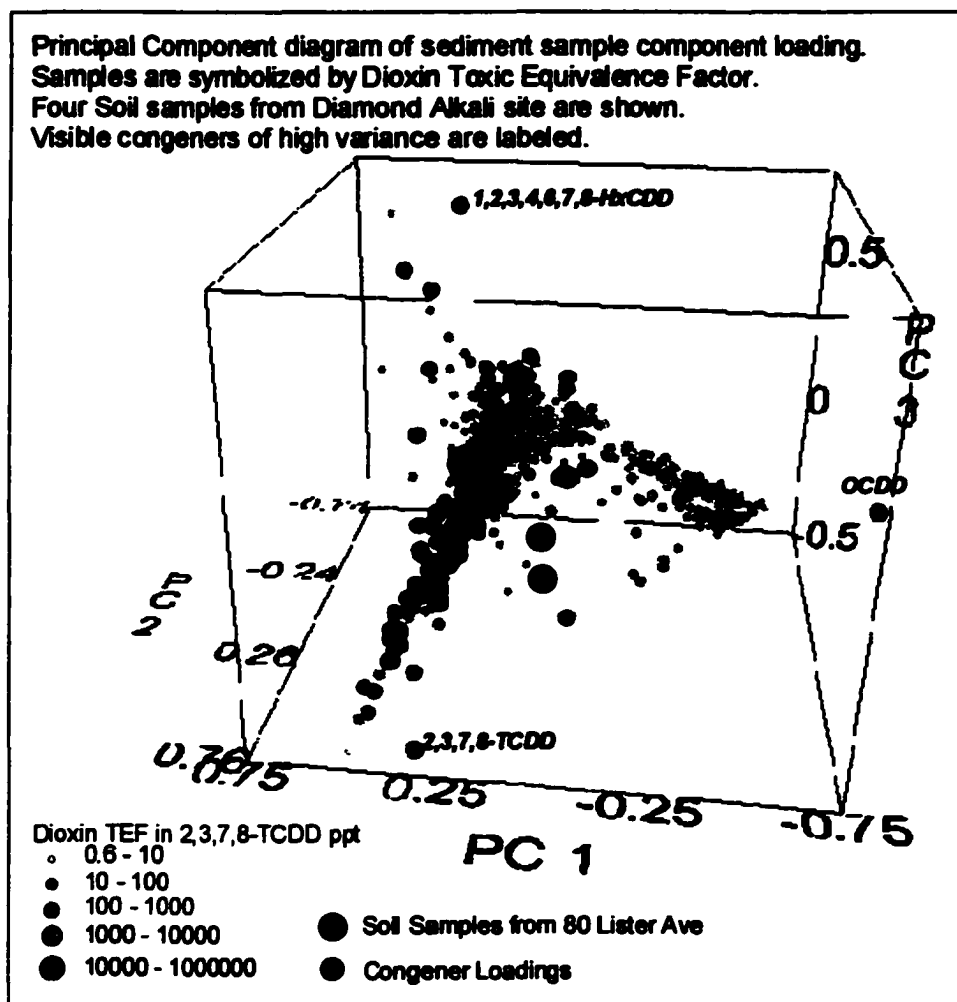


**Figure 4-6 First Three Principal Components, Samples displayed by distance from the Diamond Alkali Site with Soil Samples from the Diamond Alkali Site**

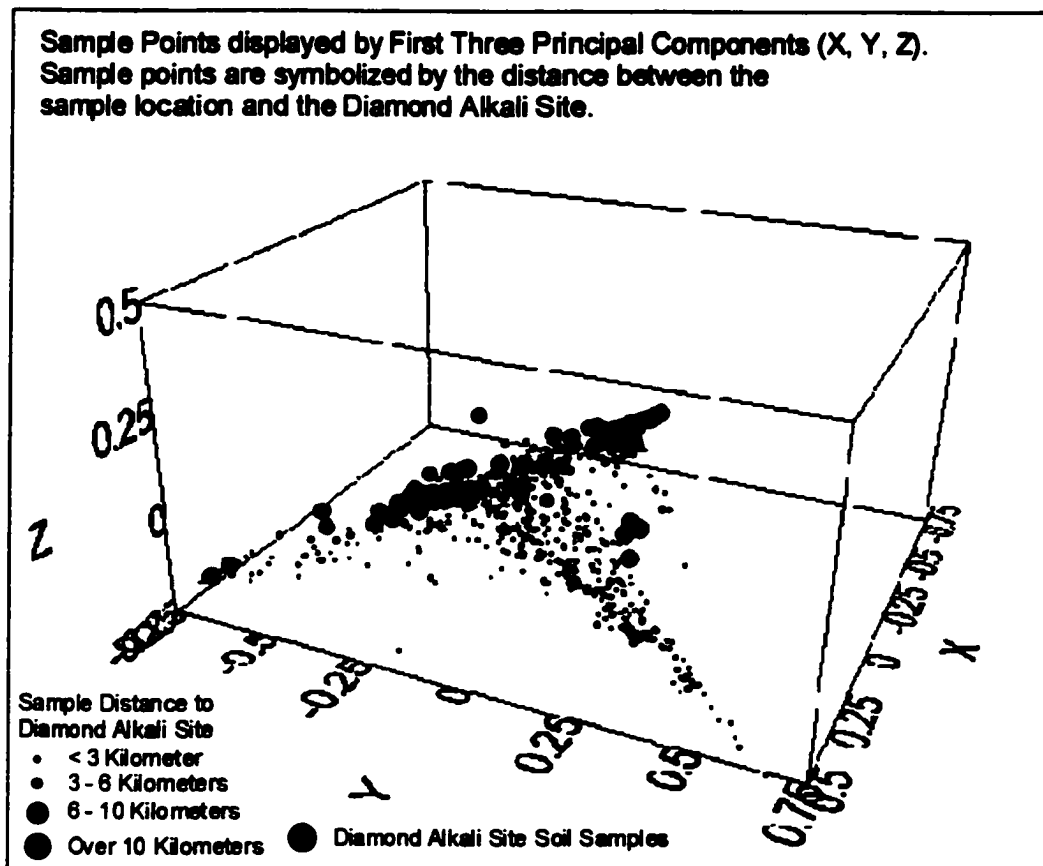
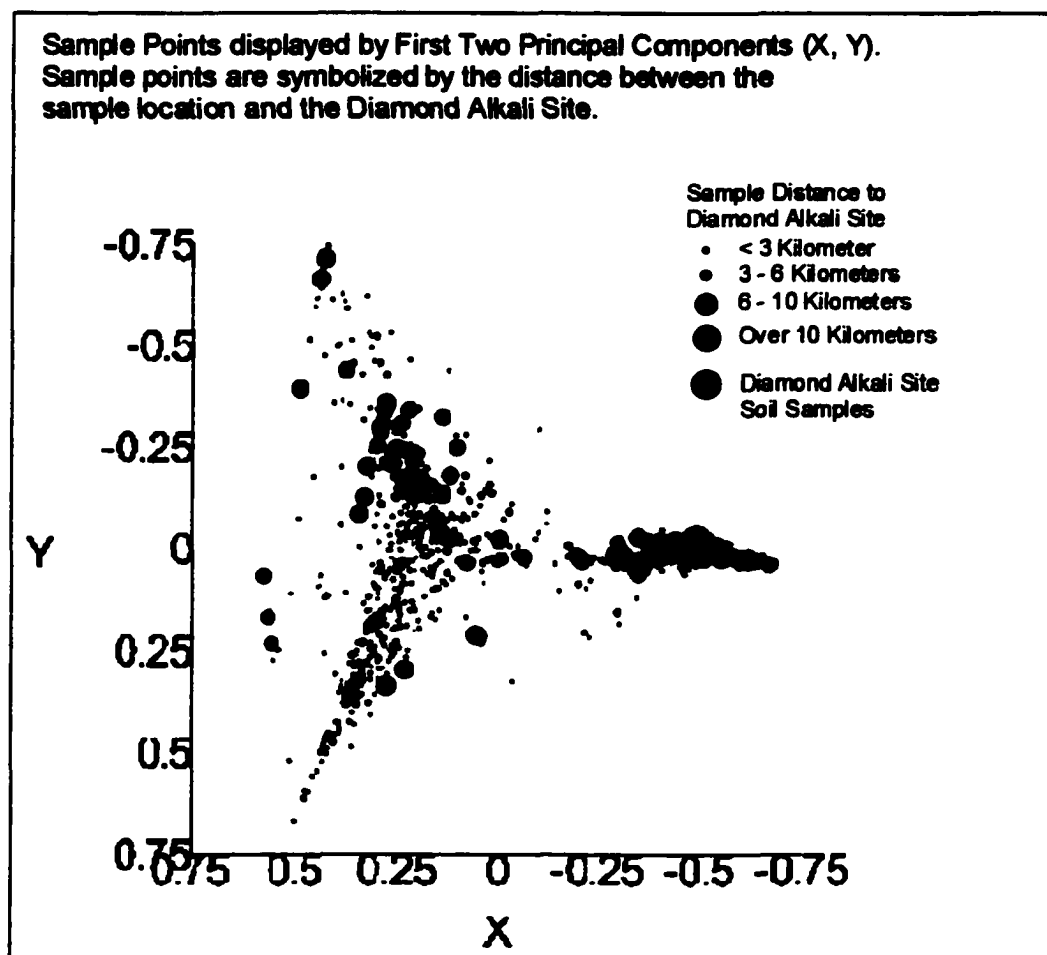




**Figure 4-7 First Two Principal Components, Samples displayed by distance from the Diamond Alkali Site with Soil Samples from the Diamond Alkali Site.**



The third arm of point clusters extends toward maximum values of component 1 and minimum values of component 2 (Figures 4-4 through 4-7). The congener of interest in this region of component space is 1,2,3,4,6,7,8-HpCDD as shown in figure 4-4. These samples are all found at depth within the core samples (Figure 4-5) and are spatially distributed throughout the Harbor-Estuary areas for which core samples were taken. The sample points falling into this region of component space will be discussed again in the following section on cluster analysis results.

Table 4-10a summarizes the principal component characteristics for the first three components. A large percentage of the variance in the dataset is due to the depth of the sample. The depth of the sample shows a positive correlation with component 1. Octa-chlorinated dioxin is found primarily in the surficial samples so it displays a negative relationship with component 1. The congeners that show a positive relationship with component 1 are those associated with chemical manufacturing, which would seem to be the major source of buried dioxin-furans. That the bulk of the variance is related to the depth, and oppositely loaded onto 2,3,7,8-TCDD and OCDD supports the conclusion of Bopp, et al., 1991 in using the 2,3,7,8-TCDD/OCDD ratios to determine dioxin sources.

The range of the second component concerns the relationship between 2,3,7,8-TCDD and 1,2,3,4,6,7,8-HpCDD the two congeners prevalent in buried samples. The fact that this relationship is a driving force behind such a large percentage of the variance in a dioxin-furan dataset is unique. 2,3,7,8-TCDD is always an important congener, due to its toxicity, but is rarely present in such great abundance. 1,2,3,4,6,7,8-HpCDD is similar in that it is generally at low concentrations in ambient dioxin-furan distribution and in dioxin source measurements (US EPA, 1998a). These congeners are present in elevated levels in dioxin-furan distributions resulting from chemical manufacturing activities. Since they behave inversely this component may be highlighting changes in manufacturing trends or simply the appearance and disappearance of sources in the study area.

The third component is negatively loaded on the congeners 1,2,3,4,6,7,8-HpCDD and 2,3,7,8-TCDD and positively loaded on octa-chlorinated furan. The two negatively loaded congeners are those associated with chemical manufacturing, trichlorophenol and derivative products for 2,3,7,8-TCDD and trichlorobenzene for 1,2,3,4,6,7,8-HpCDD (Wenning, et al., 1993). Octa-chlorinated furan is primarily associated with combustion sources such as incineration, coal burning and vehicle emissions (US EPA, 1998a). The absolute value of the

loading for each sample is moderately correlated with depth, meaning this component is important for buried samples and not as important for surficial samples. The variance is likely due to general historical sources, combustion versus chemical manufacturing.

**Table 4-10a Principal Component Characteristics, including primary congeners (positive or negative loading) and likely control.**

| <b>Component<br/>(Percent of<br/>Variance)</b> | <b>Primary Congeners</b>           | <b>Control</b>                                                                                                          |
|------------------------------------------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| <b>1</b> (57.71)                               | +PD1234678, +PD2378,<br>-PD8, +PF8 | Depth of Sample indicating increasing restrictions over the last 30 years on chlorinated manufacturing waste discharge. |
| <b>2</b> (22.28)                               | -PD1234678, +PD2378                | Differences in chemical manufacturing discharge spatially and temporally in buried sediment.                            |
| <b>3</b> (14.31)                               | -PD1234678, -PD2378,<br>+PF8       | Differences in general source types for buried sediment.                                                                |

Principal component analysis serves as a useful tool for separating multivariate data into fewer variables. In this analysis three new variables contain 94% of the original variance in a dataset composed of 16 variables. Visual representation of these variables: as in Figures 4-4 through 4-7 give important information about the relationship between sample points. A summary of the major findings from the principal component analysis is given below.

- Over half the variance is due to differences in depth of the sample reflecting the changing pattern of dioxin emission and discharge over the past 40 years.
- Most of the remaining variance concerns three congeners; 1,2,3,4,6,7,8-HxCDD, 2,3,7,8-TCDD and Octa-chlorinated furan. The pattern of sample points in component space around these congeners suggests a limited number of point sources or a spill event is responsible.
- A majority of samples are clustered in the center of component space indicating strong mixing and significant transport of sediment within the New York Harbor.

## **K Means Cluster Analysis**

Cluster analysis statistically classifies a set of samples or observations into two or more mutually exclusive groups based on combinations of variables. K Means cluster analysis classifies observations into a  $k$  number of groups whose properties are unknown prior to the analysis. Hierarchical cluster analysis operates without a predefined number of groups and determines levels or hierarchies, at which there is strong similarity between samples. For each individual sample it determines the hierarchy of samples or groups of samples, most statistically similar to that sample. Hierarchical cluster analysis becomes progressively more computationally intensive as the number of samples increases. Interpretation of the results with large datasets is infeasible; slicing the data at certain levels in the hierarchy for comparison with known groupings (such as dioxin-furan source profiles) is also not practical with such a volume of samples. The literature suggests a cutoff of 300 samples for performing hierarchical clusters: since 893 samples were used in this analysis k means clustering was used.

Computationally k-means cluster analysis operates as an analysis of variance "in reverse". The program starts with  $k$  number of random clusters initialized as centroids of variable values. The algorithm then moves objects between those clusters with the goal to minimize variability within clusters and maximize variability between clusters. As objects are moved between clusters the centroids of the clusters are recalculated. In k-means clustering, the algorithm moves objects or samples in and out of groups (clusters) to get the most significant ANOVA results.

The cluster analysis was run against the normalized dioxin-furan congener values. The goal in congener fingerprinting is to match the pattern of distribution of the congeners within a

sample, to that of one or more known source patterns. Normalization removes the effects of individual sample variations in concentrations making direct comparisons between congener distributions possible. The K-Means cluster analysis was performed using the statistical program S-Plus version 4.5 Standard Edition from MathSoft Inc. It was run on a Dell 610 personal computer operating under Windows NT. The input matrix consisted of 893 samples and 16 congener variables. The algorithm requires as an input a matrix consisting of only the normalized data fields. The file was prepared using Arcview GIS software running on the same platform. The normalized fields were then written out to a dBase file and loaded into an S-Plus data window. The inputs to the K-means clustering are the number of clusters, the maximum number of iterations during processing and an option of whether to add the cluster ID to the data window.

The clustering algorithm was run iteratively, increasing the number of clusters to minimize the total sum of squares and the individual clusters' sum of squares versus cluster size total. The principal component plots did not show clear separation of the sample points into a definable number of points, rather there was a continuum of sample points. One reason for this is the large number of points used in the analysis. Other studies such as Ehrlich et al. (1994), Norwood et al., (1992) Fiedler, et al., (1996) used samples from different geographic locations while Gotz, et al. (1998) used samples from the entire length of the Elbe River. Initial specification was 5 clusters resulting in cluster sizes of 329, 35, 403 and 159 samples with maximum sum of squares of 38.84 for the largest cluster. The second largest cluster had a sum of squares of only 6.97, an indication that the largest cluster was likely composed of smaller clusters. The  $k$  number of clusters was increased for additional iteration. When 8 clusters was specified the maximum sum of squares was 12.59 for a cluster size of 344, still significantly greater than the cluster size/ sum of squares for the second largest cluster 328 and 5.53. A specification of 10 clusters yielded a maximum sum of squares of 6.09 for a single cluster and a total sum of squares of 37.668. With a specified cluster size of 12 the greatest sum of squares for

an individual cluster was only 2.14 for 118 observations, total sum of squares was 17.01.

Subsequent increases in the number of clusters did not significantly decrease the maximum sum of squares or the overall sum of squares; with 12 clusters total sum of squares was 14.67. The clustering operation was then run once again with the cluster IDs written to the data window. The 16 mean congener values for each cluster were written out to an ASCII text file for loading into dBase. The cluster sizes and sum of squares are shown in Table 4-11.

**Table 4-11 Calculated Clusters Summary Statistics**

| Cluster#       | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   |
|----------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Sum of Squares | 1.91 | 0.44 | 1.91 | 2.05 | 0.47 | 1.11 | 2.14 | 1.65 | 1.42 | 0.39 | 1.24 | 0.03 |
| # of Samples   | 92   | 5    | 114  | 148  | 16   | 217  | 118  | 72   | 46   | 9    | 56   | 2    |

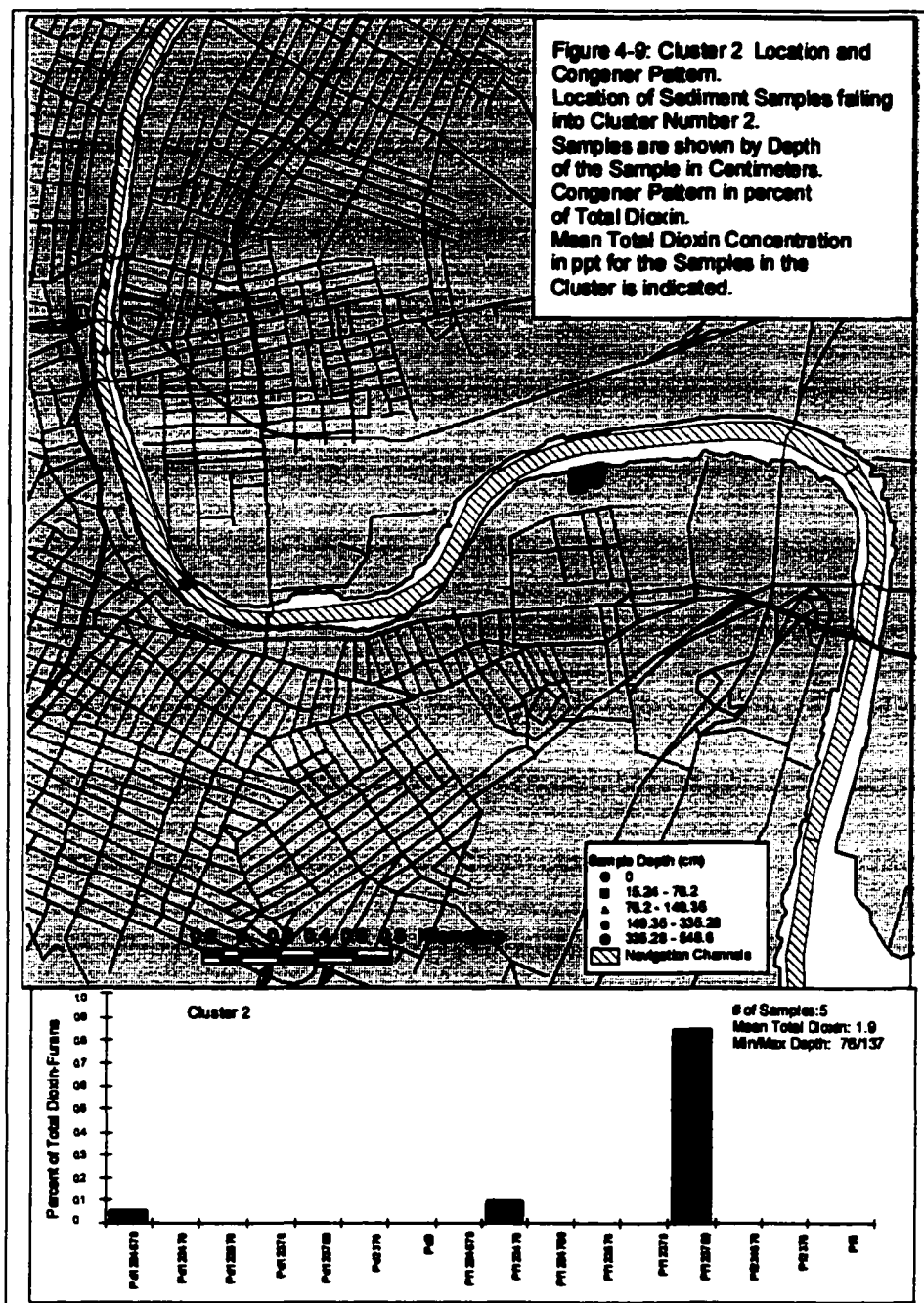
The congener centroids for the twelve output clusters used in the subsequent analysis are shown in Table 4-12. The clusters are shown graphically in figures 4-8 through 4-19. Each figure shows a bar chart of the cluster congeners' ratio of summed dioxin-furan along with a map of the locations of the samples that fell into each cluster.

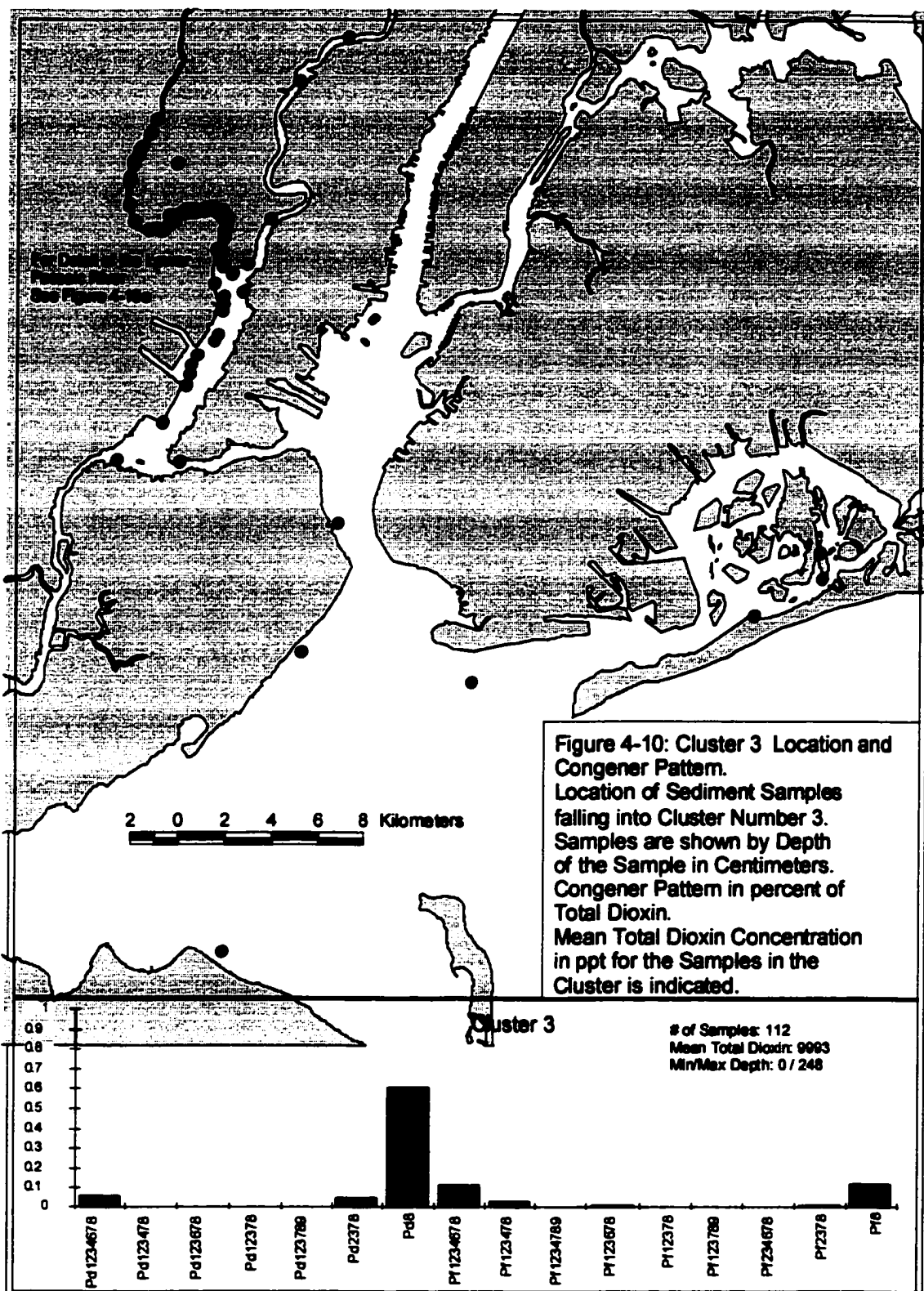
**Table 4-12 Cluster Centroids for Dioxin-furan Furan Congeners**

| Table 4-12 Cluster Centroids for DNNs from Top Components |           |          |           |          |          |          |          |
|-----------------------------------------------------------|-----------|----------|-----------|----------|----------|----------|----------|
| Cluster                                                   | Pd1234678 | Pd123478 | Pd123678  | Pd12378  | Pd123789 | Pd2378   | Pd8      |
| 1                                                         | 0.08799   | 0.00273  | 0.00717   | 0.00267  | 0.00428  | 0.05944  | 0.29214  |
| 2                                                         | 0.05565   | 0.0      | 0.0       | 0.0      | 0.0      | 0.0      | 0.0      |
| 3                                                         | 0.06013   | 0.00142  | 0.00385   | 0.00129  | 0.00242  | 0.04268  | 0.60508  |
| 4                                                         | 0.02145   | 0.00871  | 0.00789   | 0.00818  | 0.00203  | 0.01717  | 0.21359  |
| 5                                                         | 0.01224   | 0.00026  | 0.00064   | 0.00041  | 0.00040  | 0.094542 | 0.02954  |
| 6                                                         | 0.07460   | 0.00136  | 0.00439   | 0.00105  | 0.00318  | 0.016137 | 0.77157  |
| 7                                                         | 0.12184   | 0.00195  | 0.01014   | 0.00216  | 0.00354  | 0.333199 | 0.16111  |
| 8                                                         | 0.06432   | 0.00107  | 0.00458   | 0.00172  | 0.00194  | 0.630945 | 0.09216  |
| 9                                                         | 0.78033   | 0.00443  | 0.00724   | 0.00108  | 0.00905  | 0.027957 | 0.03582  |
| 10                                                        | 0.41557   | 0.00388  | 0.04195   | 0.00201  | 0.02334  | 0.13821  | 0.20282  |
| 11                                                        | 0.39440   | 0.00327  | 0.01542   | 0.00163  | 0.00801  | 0.04162  | 0.14531  |
| 12                                                        | 0.07962   | 0.00106  | 0.00108   | 0.00821  | 0.00051  | 0.12897  | 0.15591  |
| Cluster                                                   | Pf1234678 | Pf123478 | Pf1234789 | Pf123678 | Pf12378  | Pf123789 | Pf234678 |
| 1                                                         | 0.08038   | 0.014693 | 0.01635   | 0.00883  | 0.00407  | 0.01096  | 0.01467  |
| 2                                                         | 0.0       | 0.09588  | 0.0       | 0.0      | 0.0      | 0.848468 | 0.0      |
| 3                                                         | 0.11206   | 0.02610  | 0.00391   | 0.00693  | 0.00235  | 0.001898 | 0.00451  |
| 4                                                         | 0.04299   | 0.00971  | 0.01435   | 0.00811  | 0.00359  | 0.01777  | 0.02460  |
| 5                                                         | 0.00457   | 0.00058  | 0.00205   | 0.00025  | 0.00018  | 0.000615 | 0.00082  |
| 6                                                         | 0.05310   | 0.01133  | 0.00234   | 0.00339  | 0.00168  | 0.000919 | 0.00333  |
| 7                                                         | 0.03494   | 0.00583  | 0.00880   | 0.00343  | 0.00205  | 0.011938 | 0.01307  |
| 8                                                         | 0.01858   | 0.00298  | 0.00420   | 0.00157  | 0.00115  | 0.003889 | 0.00685  |
| 9                                                         | 0.00705   | 0.00633  | 0.00328   | 0.00200  | 0.00182  | 0.011803 | 0.00294  |
| 10                                                        | 0.03494   | 0.00558  | 0.00791   | 0.01110  | 0.00353  | 0.03192  | 0.01075  |
| 11                                                        | 0.00261   | 0.01001  | 0.00265   | 0.00542  | 0.07427  | 0.012613 | 0.01851  |
| 12                                                        | 0.41735   | 0.07349  | 0.00720   | 0.01297  | 0.00150  | 0.01909  | 0.00464  |
| Cluster                                                   | Pf2378    | Pf8      |           |          |          |          |          |
| 1                                                         | 0.01039   | 0.38316  |           |          |          |          |          |
| 2                                                         | 0.0       | 0.0      |           |          |          |          |          |
| 3                                                         | 0.00791   | 0.11730  |           |          |          |          |          |
| 4                                                         | 0.02199   | 0.30427  |           |          |          |          |          |
| 5                                                         | 0.00354   | 0.84935  |           |          |          |          |          |
| 6                                                         | 0.00784   | 0.04377  |           |          |          |          |          |
| 7                                                         | 0.00945   | 0.27643  |           |          |          |          |          |
| 8                                                         | 0.00706   | 0.15698  |           |          |          |          |          |
| 9                                                         | 0.00903   | 0.08973  |           |          |          |          |          |
| 10                                                        | 0.02626   | 0.04013  |           |          |          |          |          |
| 11                                                        | 0.03644   | 0.27538  |           |          |          |          |          |
| 12                                                        | 0.01589   | 0.07247  |           |          |          |          |          |











**Location of Sediment Samples falling into Cluster Number 4. Samples are shown by Depth of the Sample in Centimeters. Congener Pattern in percent of Total Dioxin. Mean Total Dioxin Concentration in ppt for the Samples in the Cluster is indicated.**

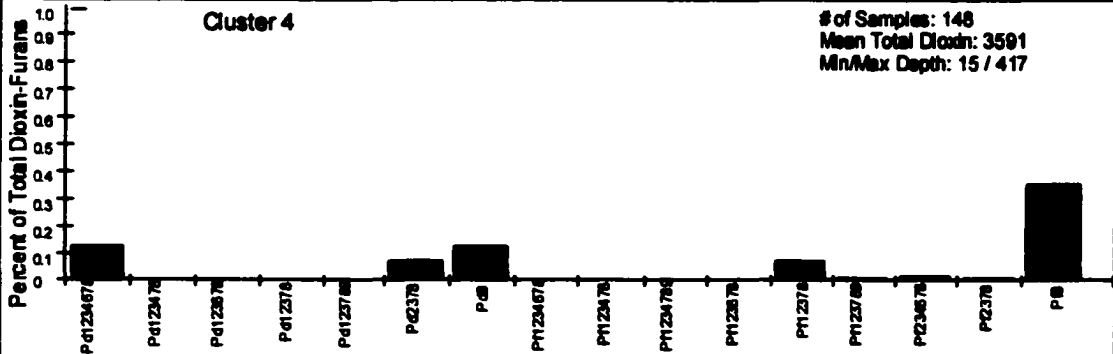


**Figure 4-12: Cluster 5 Location and Congener Pattern.**  
 Location of Sediment Samples falling into Cluster Number 5. Samples are shown by Depth of the Sample in Centimeters. Congener Pattern in percent of Total Dioxin. Mean Total Dioxin Concentration in ppt for the Samples in the Cluster is indicated.

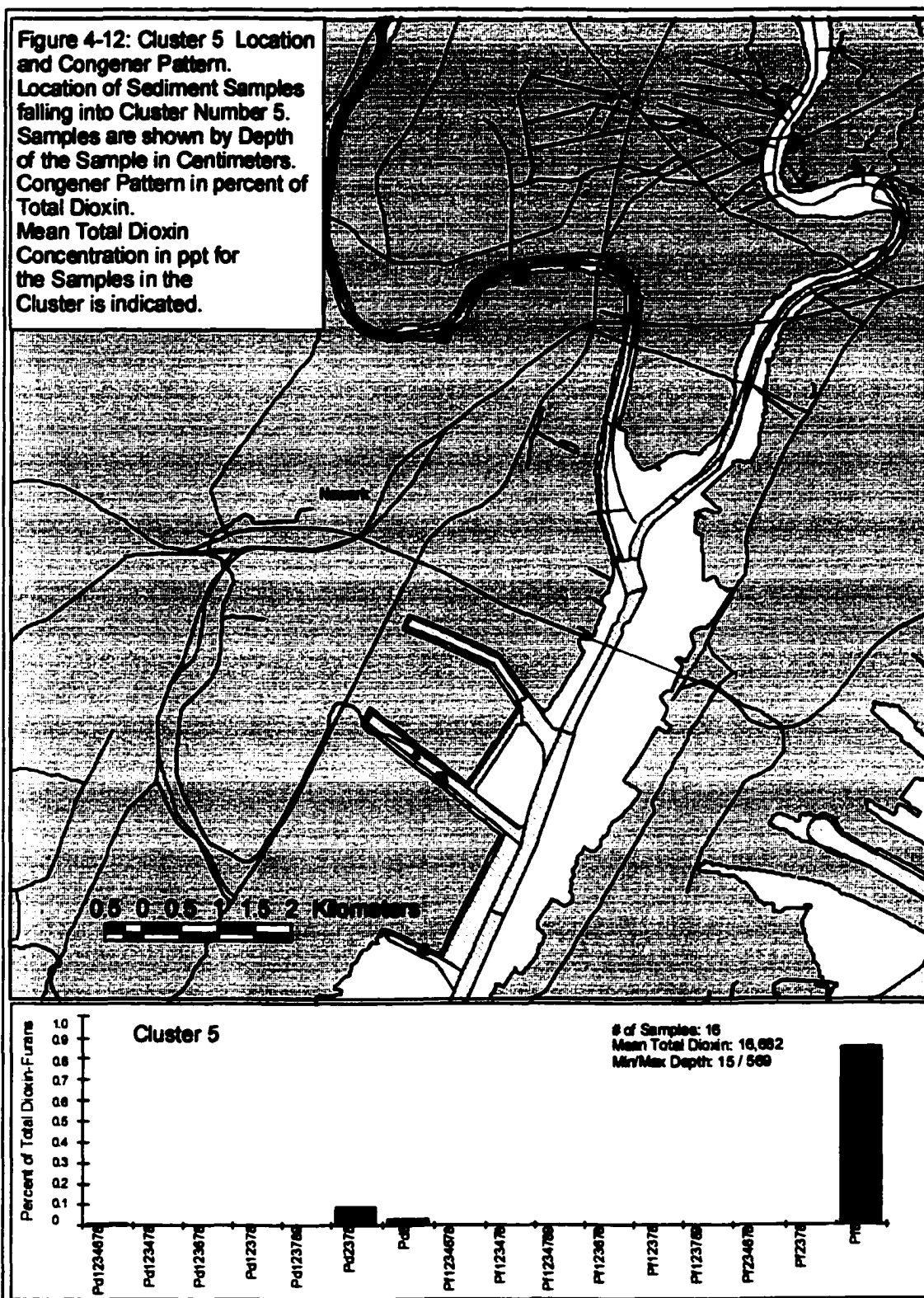


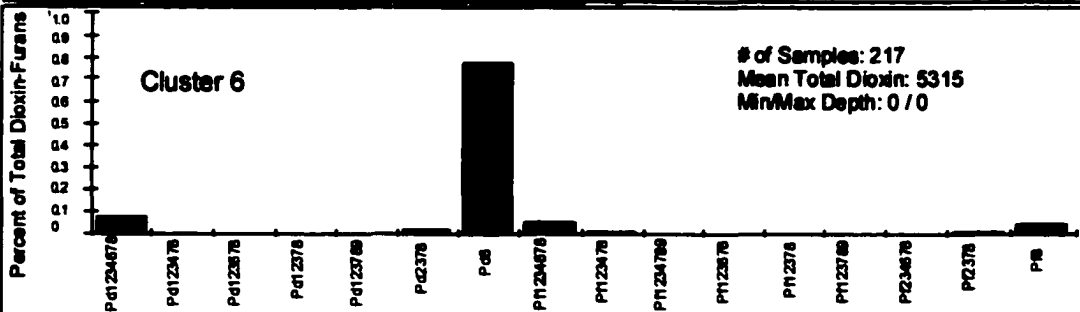


**Figure 4-13: Cluster 6 Location and Congener Pattern.**  
Location of Sediment Samples falling into Cluster Number 6. Samples are shown by Depth of the Sample in Centimeters. Congener Pattern in percent of Total Dioxin. Mean Total Dioxin Concentration in ppt for the Samples in the Cluster is indicated.

Sample Depth (cm)

- 0
- 15.24 - 76.2
- ▲ 76.2 - 149.35
- ◆ 149.35 - 335.28
- ⊕ 335.28 - 548.6

2 0 2 4 6 8 Kilometers



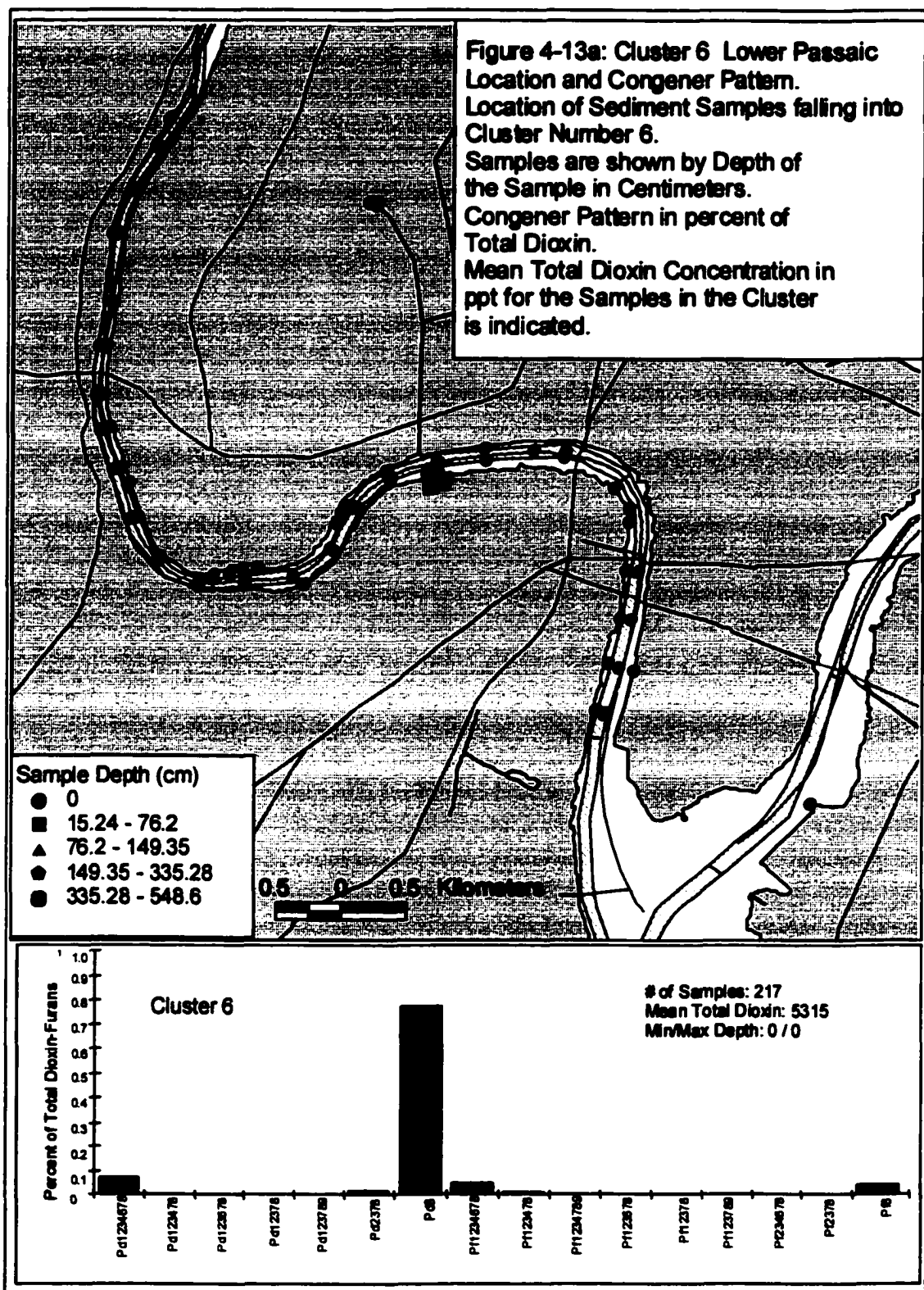


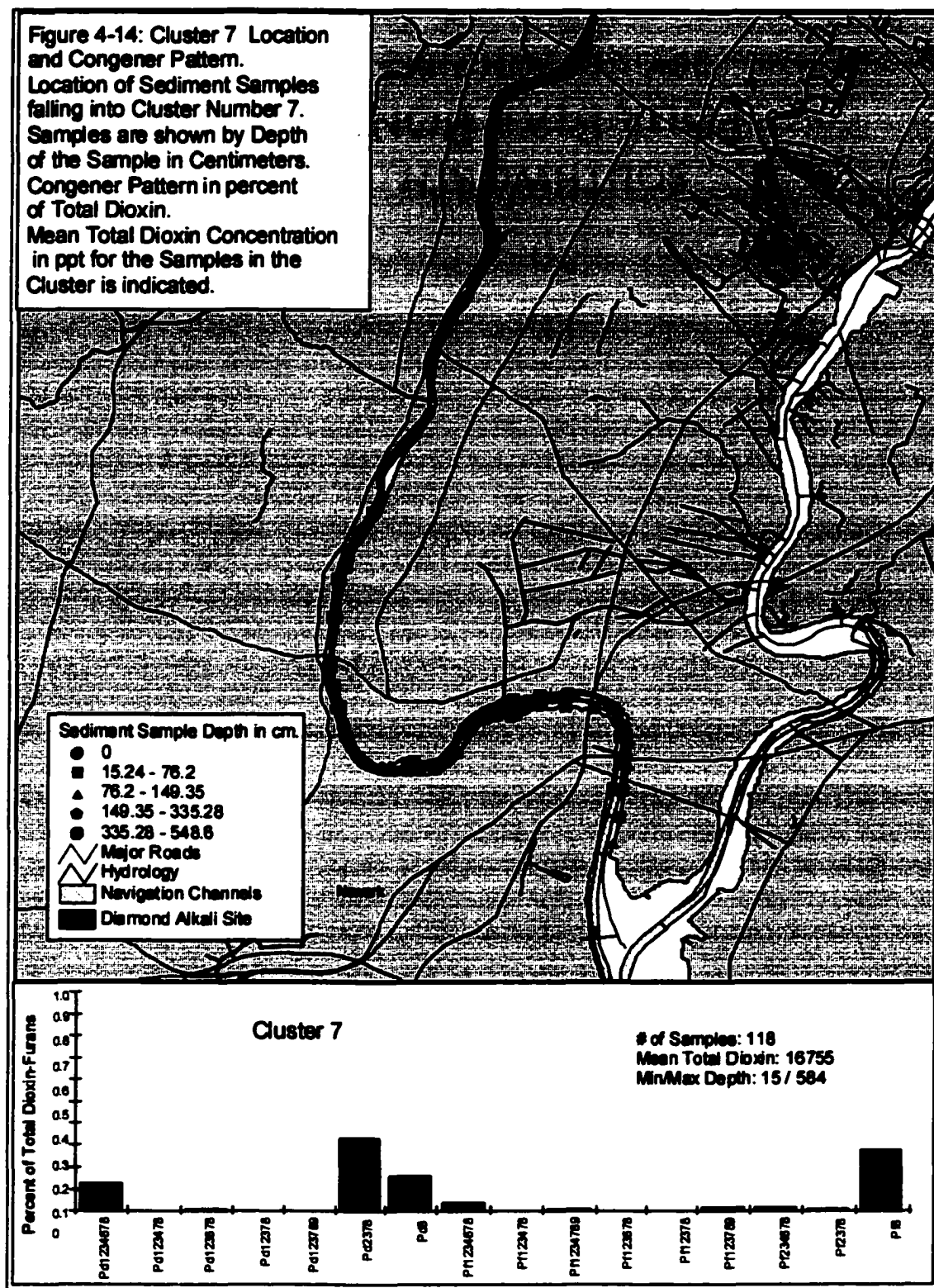
**Figure 4-14: Cluster 7 Location and Congener Pattern.**

Location of Sediment Samples falling into Cluster Number 7.

Samples are shown by Depth of the Sample in Centimeters.

Congener Pattern in percent of Total Dioxin.

Mean Total Dioxin Concentration in ppt for the Samples in the Cluster is indicated.





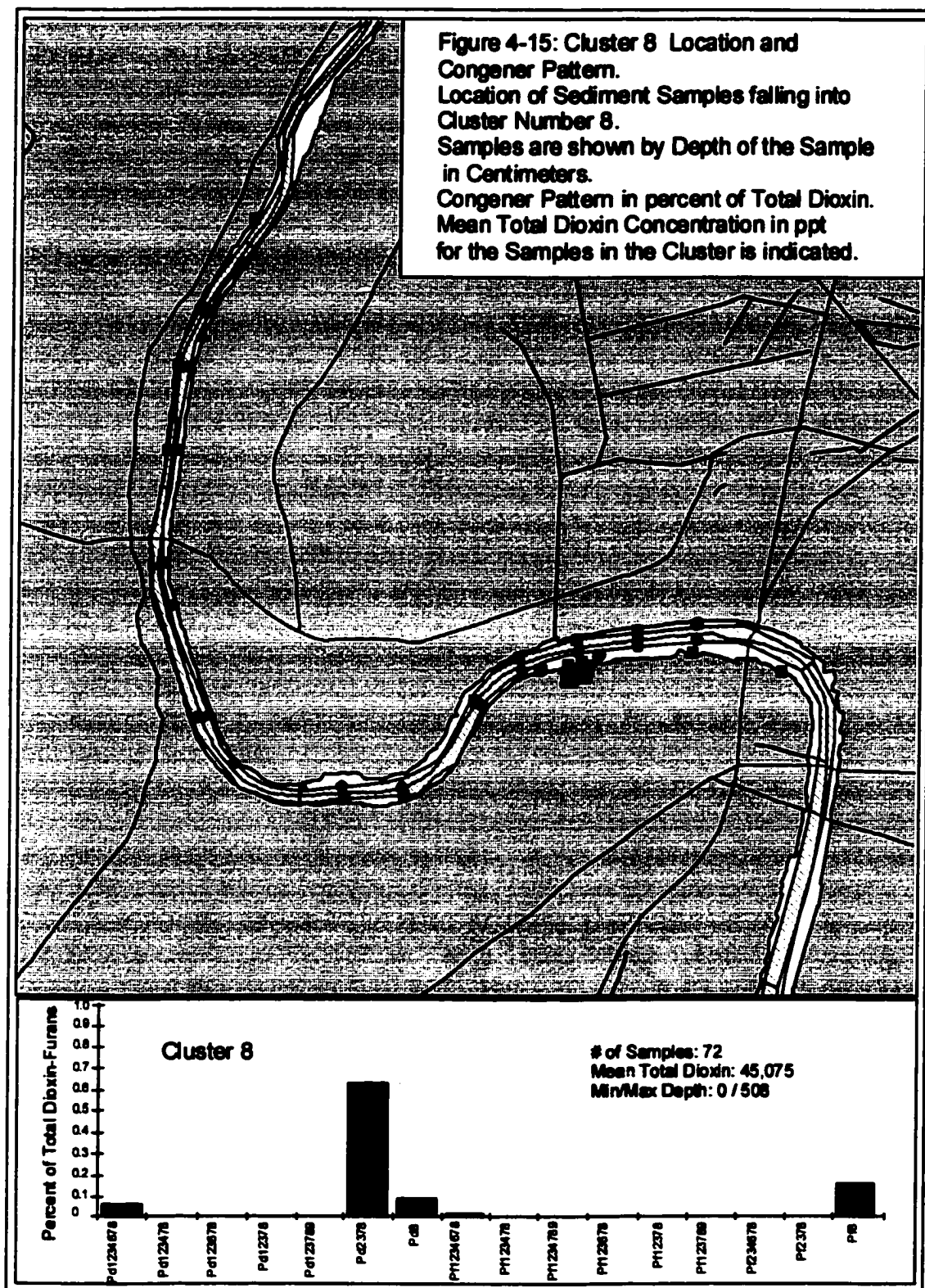
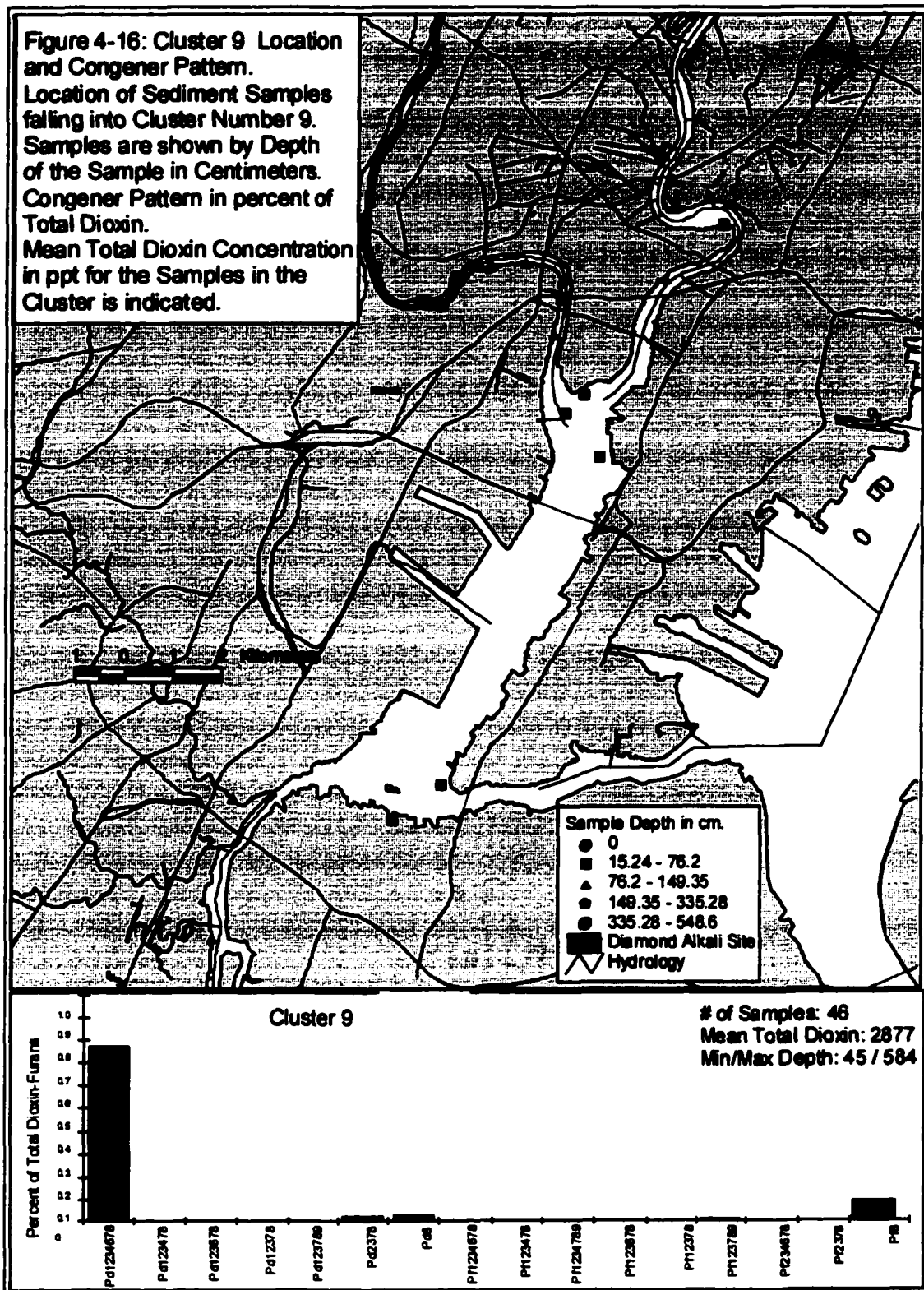
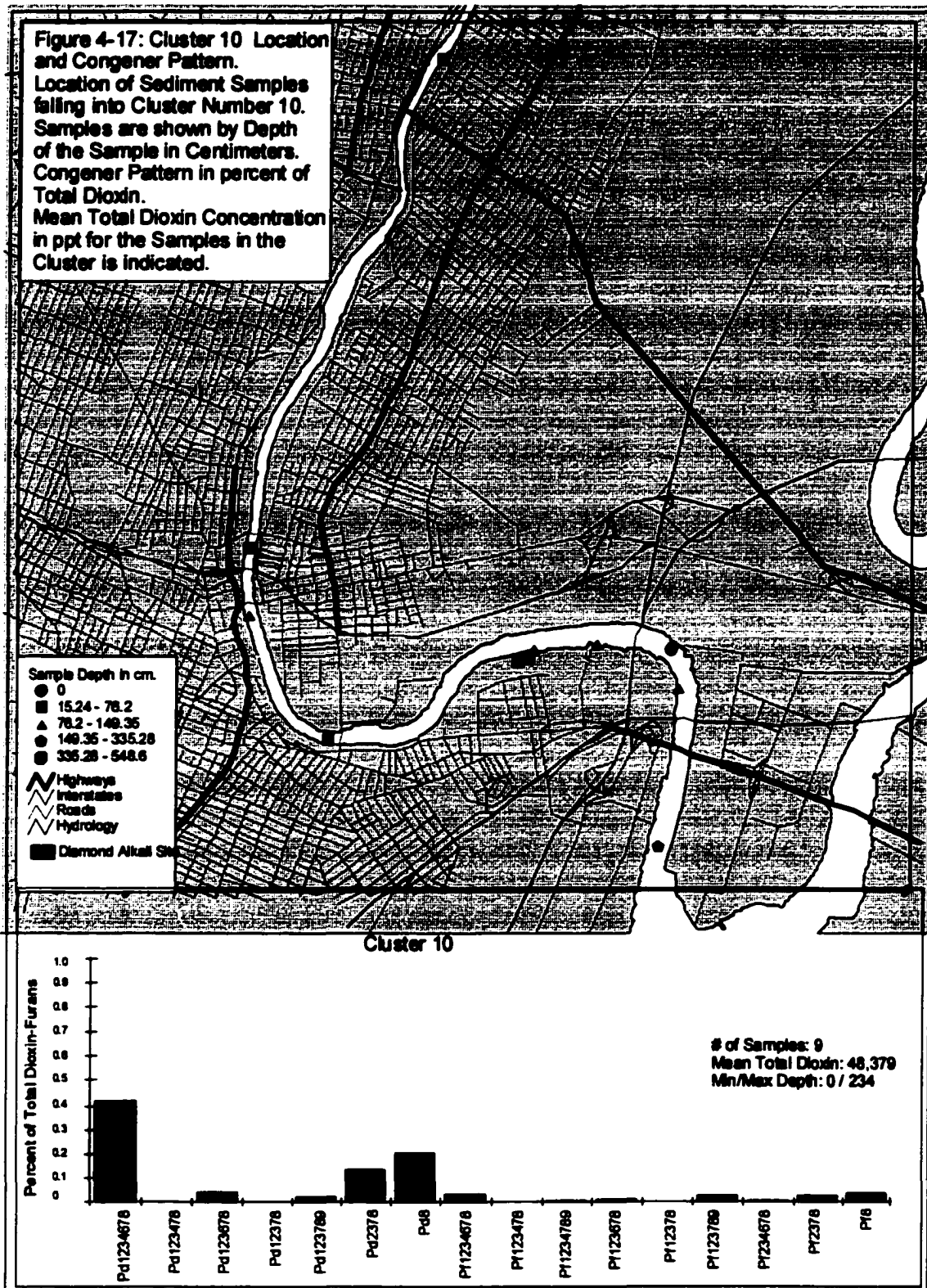


**Figure 4-16: Cluster 9 Location and Congener Pattern.**  
 Location of Sediment Samples falling into Cluster Number 9. Samples are shown by Depth of the Sample in Centimeters. Congener Pattern in percent of Total Dioxin. Mean Total Dioxin Concentration in ppt for the Samples in the Cluster is indicated.





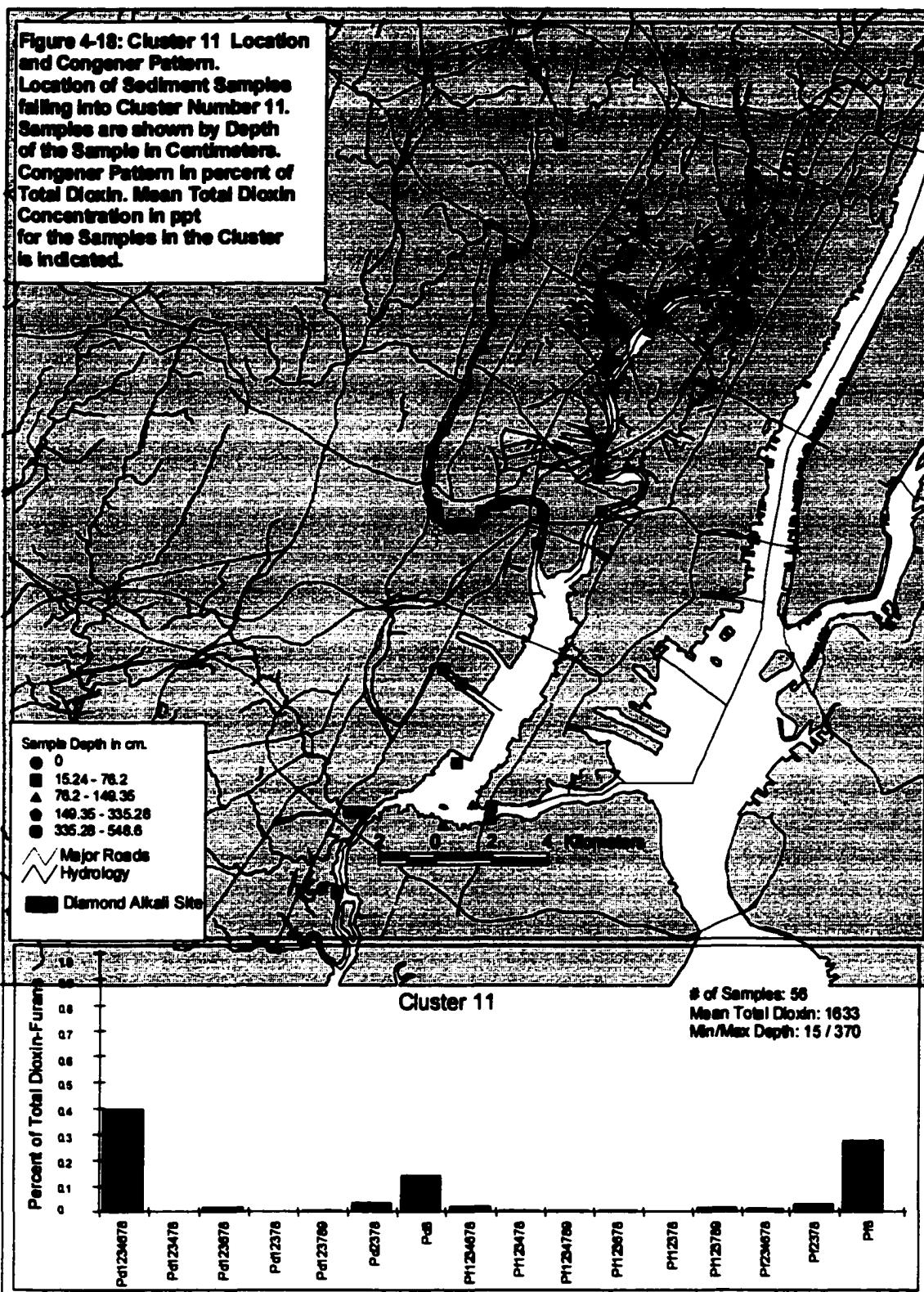
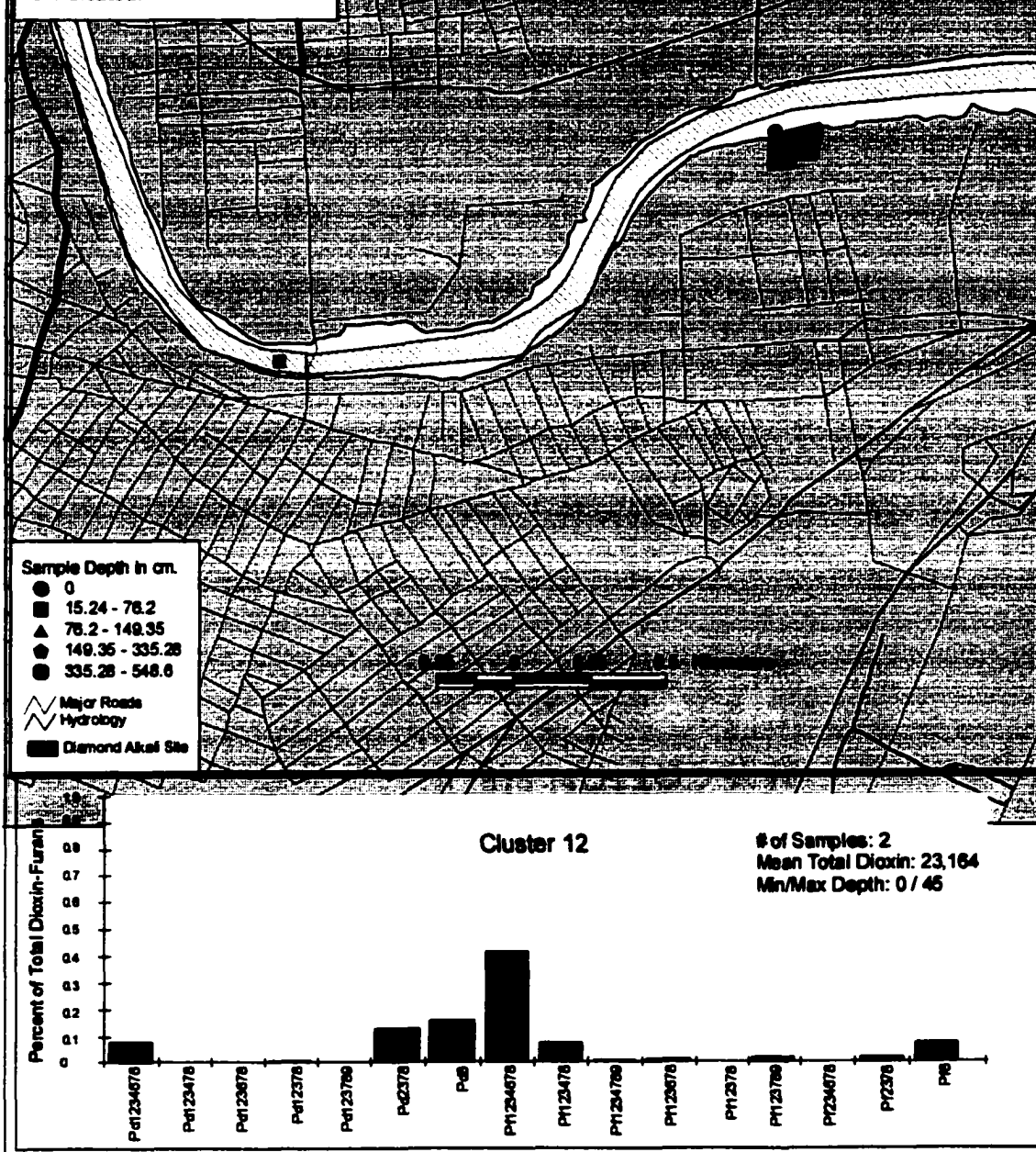


**Figure 4-19: Cluster 12 Location and Congener Pattern.**  
**Location of Sediment Samples**  
 falling into Cluster Number 12.  
 Samples are shown by Depth  
 of the Sample in Centimeters.  
 Congener Pattern in percent of  
 Total Dioxin. Mean Total Dioxin  
 Concentration in ppt  
 for the Samples in the Cluster  
 is indicated.



### **Cluster Descriptions and Co-Chemical Comparison**

The goal of dioxin-furan congener fingerprinting is to draw a relationship between the resulting statistically reduced numbers of observations; in this analysis the data are reduced to 12 clusters, and sources of dioxins in the study area. The inclusion of core samples in the analysis allows an examination of temporal changes in the emission rates of dioxins and activity of sources of dioxins. The literature contains abundant information on dioxin-furan signatures for the various sources of dioxins. Figure 4-20 shows the sample points symbolized by cluster number as a principal component plot. Along with the sample points the plot shows the soil samples from the Diamond Alkali Site and dioxin-furan congener patterns compiled by the Environmental Protection Agency as part of the National Dioxin-furan Inventory. In the literature these plots are used to identify sources by examining where the sample points plot in relation to sources. Wenning et al. (1992) compared sediment samples from a number of water bodies in North America and Europe with published source concentrations. Wenning et al. (1993) plotted some of the surficial samples from the Maxus studies along with source signatures from the literature. Yunker and Cretney (1994) examined dioxin-furan and furans in crab hepatopancreas sampled in British Columbia and plotted the results against known local sources. Although this approach has been widely used it is prone to uncertainty. In a study by Fiedler et al (1996) of sediments in the Leaf River in Mississippi soil samples upstream from a suspected pulp mill showed as close an association to measured effluent as did sediment samples downstream. Ambient signatures are often a mixture of mixtures, lending them the appearance of a known source. For this reason additional contaminant information will be used.

All of the sampling studies measured a large number of other common contaminants including metals, PAHs, PCBs, pesticides and organics. Some of these contaminants are associated with the formation of dioxins, or the mechanism for their abundance is associated with dioxins. The concentrations of these chemicals were examined for correlation with the summed



dioxin-furan concentrations for each cluster. As noted earlier the dioxin-furan congener patterns are related to various sources of dioxin-furan while the actual concentrations are the result of other factors such as proximity to the source(s), physical transport, depositional conditions as well as chemical and biological conditions. If dioxin-furan contamination concentration varies with the concentration of another contaminant, which is associated with dioxins, then the contaminant can be considered a likely source. Since multiple sources of dioxins are likely for a given cluster moderate correlation can be considered significant. In addition a lack of correlation is also significant. A number of authors have identified sources of dioxin-furan contamination for the samples in this study; these claims will be noted in the discussion. The contaminants used in this analysis are; total PCBs, total chlorobenzenes, total PAHs, total chlorobenzenes, total organic carbon and total DDT. Totalled contaminants were used for consistency with the dioxin-furan measurement and to allow for contaminant decomposition. Total DDT represents the sum of DDT, DDE and DDD.

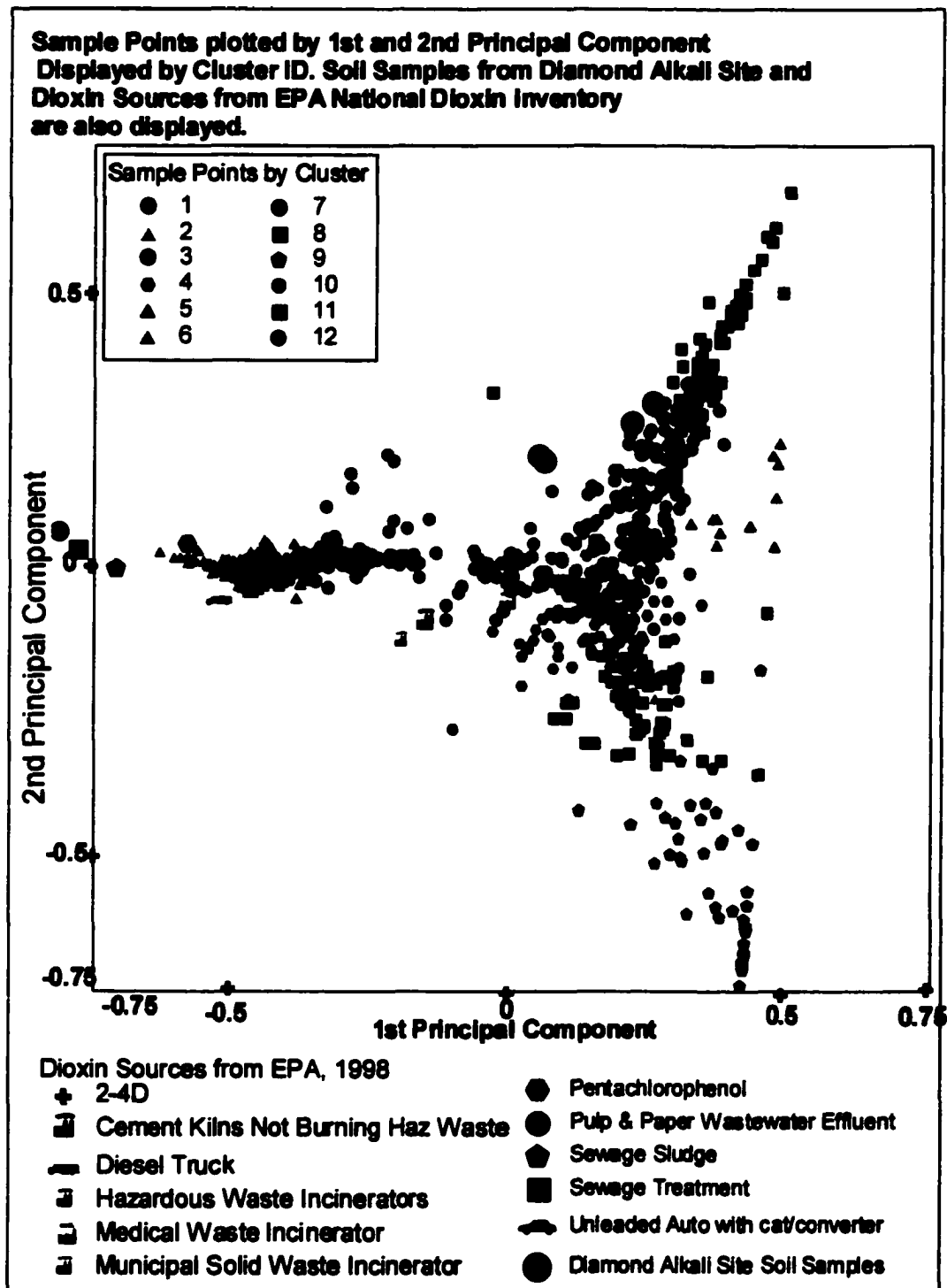
Since dioxins occur as trace contaminants in a number of widely used chemicals the concentrations should co-vary and the overall concentration of the contaminant should be high for those dioxin-furan samples. To ascertain this summary statistics were calculated for each contaminant for the output clusters. The circulation patterns in the Harbor Estuary (Chapter 2) would tend to spread the contaminants, but concentrations should be highest adjacent to the initial area of discharge.

The problem of deriving meaningful conclusions from the resulting spatial and temporal patterns can be approached as an exercise in stratigraphy. Horizontal and vertical changes in dioxin-furan patterns and concentrations can be tied to dioxin-furan source emission rates and proximity to the core samples. Figures 4-8 through 4-19 show the spatial distribution of the samples falling into each of the clusters. The sample locations are symbolized by core depth, in centimeters, to show the patterns of depth level at which the clusters were found. Figure 20 shows

the sample points in Principal Component space displayed by cluster number. This demonstrates close agreement between the two methods in separating the sample points for source examination. This distribution of sample points is a statistical continuum without large gaps separating the clusters, which in fact grade into each other. This gradation is in fact a significant expression of the spatial and temporal changes in dioxin-furan contamination in the Harbor-Estuary, the result of factors that have been examined and will be examined. The Harbor-Estuary is a connected system so the emplacement of dioxin-furan contamination operates in a manner similar to the deposition of sedimentary facies. In the absence of unconformities, erosion from flooding, removal by dredging, congener patterns grade into one another laterally and vertically.



**Figure 4-20 Sample Points in Component Space Symbolized by Cluster ID. Also Shown are Soil Samples from Diamond Alkali Site and Major Dioxin-furan Sources compiled by the US EPA National Dioxin-furan Inventory (1998).**



Although the clusters are separated into statistically unique classes similarities exist between a number of the clusters. Clusters 3 and 6, the two primary surficial clusters, are dominated by octa-chlorinated dioxin. Similarly clusters 7 and 8 each have high percentages of 2,3,7,8 TCDD, the congener of most environmental concern due to its high toxicity. Clusters 1, 4 and 11 have three dominant congeners; 1,2,3,4,6,7,8 HCDD, Octa-Chlorinated dioxin-furan and Octa-Chlorinated Furan. Clusters 9 and 10 are very high in 1,2,3,4,6,7,8 HCDD. Clusters 2, 5 and 12 are unlike each other or any other cluster. Clusters 2 and 5 are only found in only 5 and 16 of the 893 samples respectively.

### **Clusters 3 and 6**

Cluster number 6 (Figure 4-13) was found exclusively in surficial samples throughout the harbor. It was the dominant surficial cluster, found in 217 of the 342 surficial samples. The higher chlorinated dioxins and furans dominate the congener profile of the cluster. The bulk of the profile is octa-chlorinated dioxin-furan (OCDD), this congener ranged from 68 to 94 percent of the summed dioxin-furans in the samples. The cluster centroid for OCDD is 77.157 percent of the summed dioxin-furans. No other cluster centroid exceeded 10 percent; the second most abundant congener was 1,2,3,4,6,7,8-Hexa-chlorinated dioxin-furan at 7.46 percent of summed dioxin-furans ranging from about 2.55% to 12.5%. 1,2,3,4,6,7,8-Hexa and octa-chlorinated furans each comprised about 5% of the summed dioxin-furans. The mean summed dioxin-furan concentration for the samples in this cluster was 5.3 parts per billion (ppb), ranging from 0.005 to 29.2 ppb. The highest concentration was found in Fresh Creek, a confined inlet off of Jamaica Bay.

Cluster 3 (Figure 4-10) is also largely confined to surficial samples, it is found throughout the harbor. This cluster is similar to cluster 6 in that it is dominated by OCDD with a cluster centroid value of 60% of the congeners. Cluster 3 is enriched in 2,3,7,8-TCDD, octa-

chlorinated furan and 1,2,3,4,6,7,8-TCDF with respect to cluster 6. The mean summed dioxin-furan concentration of these sample points was 9.9 ppb ranging from a minimum of 0.02 to a maximum of 172.7 ppb. The sample point with the maximum concentration was located in the Lower Passaic adjacent to the Monsanto plant. The ratio of cluster 3 to cluster 6 is higher in the Passaic River than in the rest of the Harbor Estuary, cluster 3 comprises 46% of the surficial points in the Passaic River but only 17% of the surficial points elsewhere in the Harbor-Estuary. This distribution is even more concentrated in the Lower Passaic River where 55% of the surficial points fall into cluster 3.

Clusters 3 and 6 comprise the OCDD dominated 'arm' of the distribution of sample points in the first three principal components (Figure 4-4). A signature composed of the higher chlorinated dioxins and furans is indicative of combustion sources (EPA, 1998). Automobile exhaust, diesel emissions from trucks and buses and incineration of municipal waste all produce characteristic signatures dominated by OCDD and OCDF. The high population density of the Lower Hudson and especially the Harbor Estuary area (See Chapter 3) means millions of cars, trucks and buses spewing out exhaust each day. The EPA National Dioxin-furan Inventory (see chapter 3) indicated that airborne deposition of dioxins is the dominant environmental loading of dioxins for most areas of the US. Deposition occurs by fallout of dry particulates as well as particulates washed out of the atmosphere by precipitation. These materials are brought into the harbor estuary by natural drainage as well as through sewage treatment plants. Figure 4-19 shows the principal component plot of the sample points along with the Diamond Alkali Site Soils and the congener pattern of common dioxin-furan sources also plotted by principal components. Automobile and diesel truck source signature plots within the area of the sample points of clusters 3 and 6. The summed dioxin-furan concentration in clusters 3 and 6 are uncorrelated with any of the chemicals, or the metal, examined. Both show a slight correlation between the Summed

dioxin-furan concentration and the Total Organic Carbon (TOC) content of the samples. Cluster 6 had an  $r^2$  value of 0.351; cluster 3 had an  $r^2$  value of 0.356.

The two clusters are statistically similar save for the slight enrichment of cluster 3 with congeners generally found in sample points found at depth, especially 2,3,7,8-TCDD and 1,2,3,4,6,7,8 HpCDD which are rarely found at significant levels in incineration sources. Cluster 3 may then represent remobilization of buried dioxins. Figure 4-17 shows the principal component plot with sample points displayed by cluster number. Cluster 3 is shifted toward the positive end of component 1 with respect to cluster 6. Component 1 is correlated with depth indicating the shift from cluster 6 to 3 is either due to current sources similar to historical sources resulting in the pattern found in buried sediments, or deeper sediments are being remobilized and resuspended. The shift in the 6/3 ratio is more pronounced in the Lower Passaic where the buried sediments are high in dioxins such as 2,3,7,8-TCDD and 1,2,3,4,6,7,8 HpCDD. An additional mechanism for dioxin-furan enrichment of surficial sediments is contaminant migration. The sediments of the Lower Passaic River are extremely high in organic material including high concentrations of PAHs. Dioxins would not be transported in interstitial waters but could move through or with organics. Studies of the contamination at the Love Canal Superfund Site showed migration of 2,3,7,8-TCDD from the landfill into nearby sewers through the organics present in the landfill. (Czuczwa and Hites, 1986)

Although TOC and summed dioxin-furans show only a slight correlation, combined sewage overflows (CSOs) are important contributors of dioxins to surficial sediments in the Lower Passaic. CSO discharges occur through a series of pipes which discharge directly into the Passaic and divert sewage when the system is overloaded due to rainfall or closed for repair or maintenance. CSO discharges contain significant organic material and are the major contributors of TOC to the harbor (NYCDEP, 1996). Any dioxins present in the discharge would likely be sorbed onto organic particles. Shear et al., 1996 examined the contribution of CSOs in the Lower

Passaic River. The CSOs are part of the Passaic Valley Sewage System, the authors noted that numerous industries are connected to the Passaic Valley so the overflows would discharge industrial waste as well as domestic sewage directly into the Passaic. Influent at the Passaic Valley Sewage Treatment Plant was evaluated for the presence of organic pollutants and showed measurable quantities of PCBs and chlorophenols, both of which are associated with dioxin-furan formation (Shear et al., 1996). The Maxus CSO study sample points were taken at these outfalls. These surficial stations show a higher ratio of cluster 3, which is enriched with lower chlorinated dioxins, to cluster 6.

#### **Clusters 1, 4 and 11**

Clusters 1 (Figure 4-8), 4 (Figure 4-11) and 11 (Figure 4-18) formed a statistically similar group dominated by the three congeners 1,2,3,4,6,7,8 HpCDD, Octa-Chlorinated dioxin-furan and Octa-Chlorinated Furan. They are differentiated by which of these three congeners forms the largest proportion of the summed dioxin-furans. These clusters all occur in the central area of the plot of the first two principal components, Figure 4-20.

Cluster 1 contained 91 samples at 46 stations, eleven cluster 1 sample were surficial samples. The average depth at which this cluster was found was 101 centimeters (cm), although it was found throughout the cores, as the shallowest cluster in certain cores or as the deepest cluster in the cores. The standard deviation of the average core sample depth for cluster 1 was 114 cm, the highest of the clusters comprised of more than 20 samples. This indicates that the sources of the dioxin-furan contamination represented by this cluster are ongoing sources. The depth – age relationship will be discussed more in subsequent sections. The average summed dioxin-furan concentration for this cluster was 11.3 ppb, ranging from a low value of  $1.6 \times 10^{-2}$  ppb to a maximum of 115.7 ppb. The maximum summed dioxin-furan sample was located in the Lower Passaic in a near surface core sample at a depth interval of 15-94 centimeters. The station that

contained this sample was located in the main channel of the Passaic between the Diamond Alkali Site and the NJ Turnpike Bridge.

This cluster contained octa-chlorofuran as the primary congener, the OCDF mean ratio was 0.38. The Octa-Chlorinated Furan (OCDF) component of summed dioxin-furans in these samples ranged from 0.55 to 0.15. The congener mean ratio of cluster 1 for OCDD was 0.29; the range for the samples was 0.44 to 0.08 of the summed dioxin-furans. For 1,2,3,4,6,7,8-HpCDD the mean congener value was 0.087, the range was 0.18 to 0.0 (Table 4-11). Other congeners forming a significant percentage of the summed dioxin-furans for this cluster were 1,2,3,4,6,7,8-HpCDF with a mean of 0.08 and 2,3,7,8-TCDD at 0.06.

The samples in this cluster were concentrated in the lower Passaic River (Figure 4-8); only 4 of the 91 samples were not found in this area. One sample was located in the Arthur Kill at the confluence of the Rahway River. One of the samples in this cluster was located in the Hackensack River near Berrys Creek. Two of the sample points were found in the same core, station 1A from the Maxus 1992 study, located above the Dundee Dam. The Dundee Dam marks the tidal limit of the Passaic, any contaminants above the Dam must have their source upstream.

The summed dioxin-furan concentrations for cluster 1 was compared to the concentrations of the contaminants described above. The concentrations of summed dioxin-furans and total PCBs computed to an  $r^2$  value of 0.62, a significant correlation. No other contaminants; total chloropenols, total PAHs, total chlorobenzenes, total organic carbon or total DDT showed any degree of similarity in concentrations. Polychlorinated Biphenyls have been shown to be associated with the formation of furans. (See Chapter 2, the section on dioxin-furan sources) Cluster 1 has a slight majority of furans over dioxins, PCB associated dioxin-furan congener profiles are dominated by furans. Cluster 1 was the only abundant cluster (occurring in more than 10 samples) to have over 50% of the summed dioxin-furans resulting from furans. The average total PCB concentration for the samples in cluster 1 was 1190.0 parts per billion. This

concentration level is too low to support PCB derived dioxin-furan as the major part of this cluster; the average summed dioxin-furan concentration was 11.3 ppb, which would require a parts per thousand concentration of dioxins in the PCB formulation. The large presence of OCDD in the signature of cluster 1 indicates that combustion sources are also an important contributor. In the principal component plot the source signature of Hazardous Waste Incineration falls into the cluster 1 area of the plot. The summed dioxin-furan values for cluster 1 were not correlated with any contaminant other than total PCBs or with the total organic carbon content of the sample.

Cluster 4 was found at 89 stations in 148 samples. The majority congener for cluster 4 was OCDF with a mean ratio of 0.30, and a ratio range of 0.14 to 0.55 of summed dioxin-furans. The mean ratio for OCDD was 0.21 with a ratio range of 0.37 to 0.08. 1,2,3,4,6,7,8-HpCDD was present at a mean ratio of 0.21 the ratio ranged from 0.33 to 0.11 for the samples in this cluster. 2,3,7,8-TCDD was also a significant component of this cluster with a mean value of 0.09, ranging from 0.21 to 0.0 (Table 4-11) Furans comprised 46% of the congener profile, the second highest percentage of the abundant clusters. Of the other contaminant comparisons, only total PCBs showed any degree of correlation with the summed dioxin-furan-furan concentrations in this cluster with an  $r^2$  value of 0.51. The high OCDF and OCDD concentration indicate incineration sources are an important component of the dioxin-furan contamination in this cluster. The dioxin-furan summed concentrations were uncorrelated with the other organic chemicals, cadmium or total organic carbon.

Cluster 4 was present in all areas of the harbor where core samples were taken; the Passaic River, the Hackensack River, Newark Bay and the Arthur Kill. As with cluster 1 cluster 4 was found throughout the depth of the core, in sections just below the surface as well as the deep cores. The average depth of the samples for this core was 92 centimeters. This indicates that the source of this contamination is or was a long-term event. The average summed dioxin-furan

concentration for this cluster was 3.5 ppb, ranging from a low value of  $3 \times 10^{-3}$  ppb to a maximum of 15.2 ppb.

Clusters 4 and 1 were closely related both statistically and spatially. They occupy the core of principal component space, the central area between the three "arms" of the plot. Cluster 1 or 4 occurred at 111 stations; at 26 of those stations both occurred together.

Cluster 11 was found in 56 samples at 41 coring stations. It was always found in buried samples, at an average depth of 78 cm and a standard deviation of 69 cm, more confined in range than clusters 1 or 4. The primary congener in this cluster was 1,2,3,4,6,7,8-HpCDD at a ratio of 0.39 of the summed dioxin-furan-furan concentration. The ratio range for 1,2,3,4,6,7,8-HpCDD was 0.56 to 0.25. The next most abundant congener was OCDF at 0.27 with a range of 0.48 to 0.14 OCDD was present in an average ratio of 0.14 ranging from 0.32 to 0.0. The furan component of cluster 11 was 41%. Average summed dioxin-furan concentration for the samples in this cluster was 1.6 ppb, ranging from a low value of  $3 \times 10^{-3}$  ppb to a maximum of 14.5 ppb. This cluster had the highest average concentration of Total PAHs, a contaminant associated with combustion and incineration. There was however no correlation between the summed dioxin-furan concentration of the samples in this cluster and their total PAH concentration. A moderate correlation with Total Organic Carbon (TOC),  $r^2$  value of 0.48, was present in these samples. Cadmium, total DDT, total chloropenols, total PAHs, total chlorobenzenes and PCBs showed no correlation with the summed dioxin-furan concentration.

Spatially cluster 11 is more narrowly distributed than 1 and 4. It occurs predominantly in the Lower Passaic River, half of the cluster 11 points are in a 6-kilometer stretch of the river from the Diamond Alkali Site upstream to the upstream limit of the Kearney Reach. There is also a concentration of cluster 11 samples in the northern Arthur Kill- southern Newark Bay area.

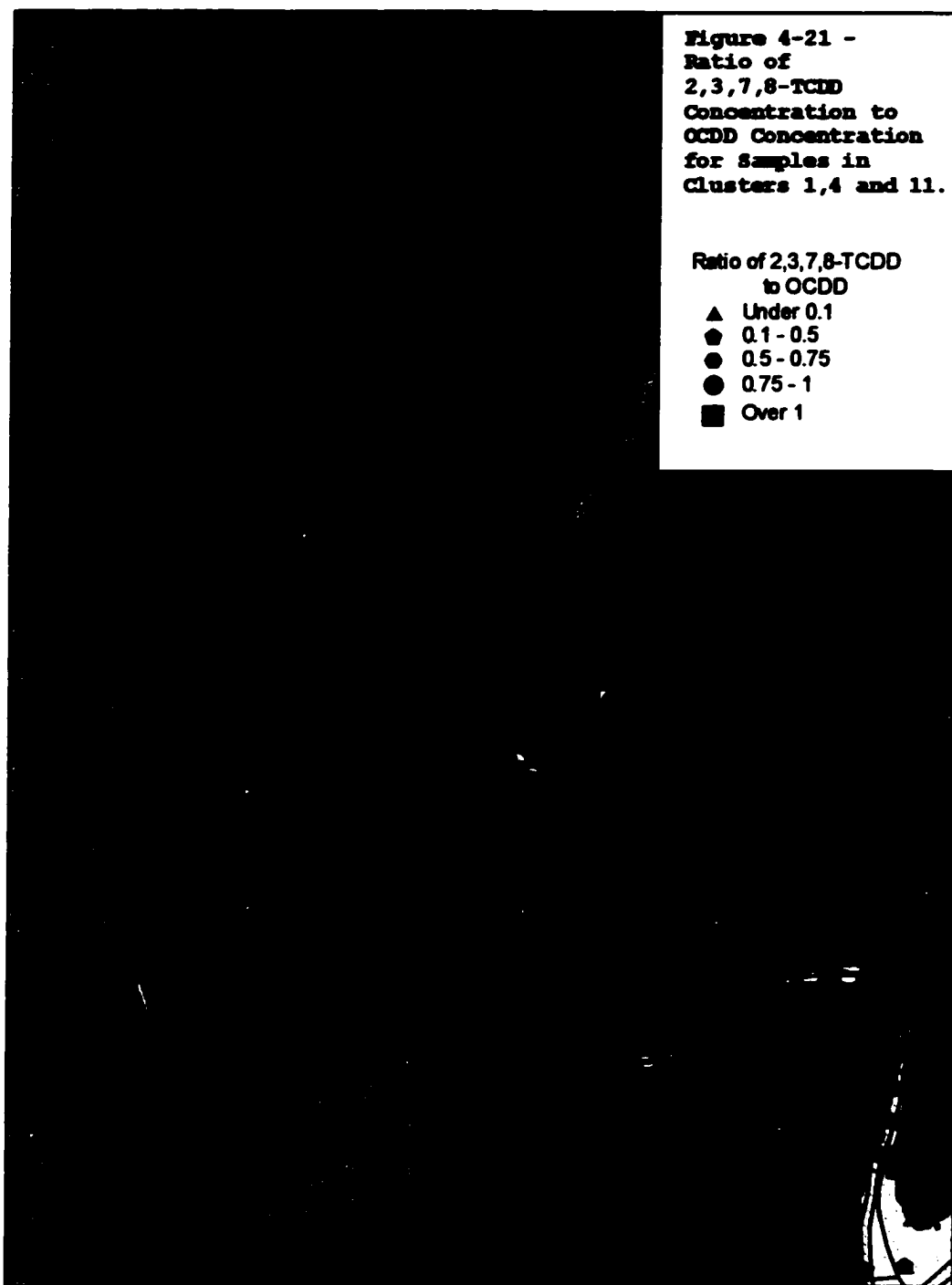
The high 1,2,3,4,6,7,8-HpCDD ratio was similar to cluster 9. Cluster 11 is found on the 1,2,3,4,6,7,8-HpCDD influenced arm of the principal component plot (Figure 4-20). The tip of



this arm is occupied by cluster 9 which grades into cluster 11 near the core of the sample point distribution. In 15 of the 41 stations in which cluster 11 was found, cluster 9 was present also, always in the sample immediately up or down core from the cluster 11 sample.

The source of dioxin-furan contamination for these three clusters cannot easily be identified. Given the industrial nature of the Lower Passaic River, and the variable depth at which they are found, the samples in these clusters have multiple sources. The lower-chlorinated substitution pattern suggests chemical manufacturing sources. The Newark Bay Complex; Newark Bay, the Lower Passaic and Hackensack Rivers and the Arthur Kill, are home to the majority of the metro area chemical manufacturing facilities. The distribution pattern of the patterns high in 1,2,3,4,6,7,8-HpCDD, clusters 9, 10, 11 and 12, suggest a limited number of sources.

One of the goals of this examination is to trace the influence of contamination from the Diamond Alkali Site on the Passaic-Newark Bay system. As will be discussed subsequently, clusters 7 and 8 are clearly derived from on-site contamination. 2,3,7,8-TCDD, a congener present in low concentrations in most other dioxin-furan sources, dominates the dioxin-furan “signature” from the Diamond Alkali site. Most dioxin-furan source patterns are primarily OCDD, 2,3,7,8-TCDD is generally a minor, albeit highly toxic component. The ratio of 2,3,7,8-TCDD to OCDD has been used by Bopp, et al. (1991) to trace contamination from the Diamond Alkali Site. This ratio ranges from 0.85 to 52.46 for the samples in clusters 7 and 8. For clusters 1, 4 and 11 a ratio approaching 1 is an indicator of a significant contribution of contamination from the Diamond Alkali Site. Figure 4-21 shows the samples in clusters 1, 4 and 11 displayed by the 2,3,7,8-TCDD / OCDD ratio. All the sample points in these clusters that have a ratio over 0.75 are found only in the Lower Passaic River within 6 kilometers of the Diamond Alkali Site.



### **Cluster 9**

Cluster 9 was found at 26 stations in 41 samples (Figure 4-16). It was found only in subsurface core samples at an average depth of 129 centimeters (cm). This depth was the greatest

of any of the abundant clusters. The shallowest core depth at which it was found was 45 cm. In 19 of the 26 cores in which it was found, cluster 9 was in the bottom sample. 1,2,3,4,6,7,8-HpCDD, with an average ratio of 0.78 of the summed dioxin-furan concentration dominated this cluster. The ratio range for this congener was from 0.98 to 0.57. Octa-Chlorinated Furan (OCDF) contributed an average ratio of 0.09 to the summed dioxin-furan concentration. this congener ranged from 0.32 to 0.0.

Cluster 9 showed a huge variation in summed dioxin-furan concentration. Two of the samples in this cluster were measured at over 50 parts per billion (ppb), a concentration putting them in the upper 3% of summed dioxin-furan concentration. Another sample had a summed dioxin-furan concentration of 7.1 ppb while the remaining 38 samples were under 0.3 ppb. Essentially all the variance is contained in two or three points making correlation with other contaminants somewhat meaningless. The two points of high summed dioxin-furan concentration were in the Lower Passaic River. One point is adjacent to the Diamond Alkali site while the other is 1.25 kilometers upstream from the mouth of the Passaic, adjacent to a Getty Oil bulk storage facility.

### **Clusters 7 and 8**

Clusters 7 and 8 also form a statistically similar group lying along the component region controlled by congener 2,3,7,8-TCDD. These sample points are statistically and spatially similar strongly suggesting they originate from the same source. The sample points in these two clusters area located exclusively in the Lower Passaic River, all but one of them within 10 kilometers of the Diamond Alkali Site. Soil sample points from the Diamond Alkali Site (Wenning, et al. 1992) plot in this area of component space.

74 samples fell into cluster 8 (Figure 4-15) these samples were found in 43 stations. The samples in this cluster are located exclusively in the Lower Passaic River. The area in which they are found extends from a point approximately 1.3 kilometers downstream from the Diamond Alkali Site (2.1 kilometers upstream from the mouth of the Passaic River) to a point 6.1 kilometers upstream from the Diamond Alkali Site (9.5 kilometers from the mouth of the Passaic). All of the samples in the cluster are found in buried sediments except for two stations located within the main channel of the river adjacent to the Diamond Alkali Site. Summary statistics for the samples classified as cluster eight show it having the highest mean summed dioxin-furan concentration as well as the highest dioxin-furan Toxic Equivalency Factor. The mean summed dioxin-furan concentration for the samples in this cluster was 136 ppb, the maximum summed dioxin-furan concentration for any one sample was 5.5 parts per million (ppm). This sample, station 285A sample 5, was located immediately adjacent to the Diamond Alkali Site. This is one of the highest dioxin-furan concentrations ever measured in the ambient environment. This core shows the congener profile of cluster 8 from a depth of 45 centimeters to the bottom of the core at 165 centimeters.

This cluster occupies the tip of the 2,3,7,8-TCDD arm of the principal component diagram shown in Figure 4-20. 2,3,7,8-TCDD is the dominant congener in this cluster comprising a mean ratio of 0.63. The ratio of 2,3,7,8-TCDD for this cluster ranges from 1.0 to 0.47. The only other congener exceeding a ratio of 0.10 was OCDF at 0.15, with a range of 0.29 to 0.0. OCDD was present in an average ratio of 0.09 with a range of 0.43 to 0.0. The congener distribution pattern of cluster 8 is similar to the pattern called end member 5065-3 identified by Huntley et al. (1998) in their examination of Maxus samples collected in 1993. The designation 5065 indicates it was dated using radioisotope profiles to the time period 1950 to 1965. Cluster number 8 appears to be higher in 2,3,7,8-TCDD although the authors do not give precise quantitative definitions to their end-members. The authors identified this pattern in station 17A, Sample 4, it is

classified as an “unidentified end member” adjacent to a “two former 2,4,5-T manufacturing sites” (Huntley et al. 1998). One of the former 2,4,5-T manufacturing site is the Diamond Alkali Site, the other is Givaudian. The dense sampling network of the EPA 1995 Remedial Investigation Study shows this pattern to be more widespread than is evidenced by the Maxus 1991 Sediment Study.

The co-chemical comparisons on cluster 8 showed strong correlation with Trichlorophenol ( $r^2$  value of 0.98) and total DDT ( $r^2$  value of 0.95). The relatively small number of samples in this cluster and the presence of a single sample point with extraordinarily high DDT and dioxin-furan concentration skew the correlation of DDT and dioxins. The samples that were part of cluster 8 had a high level of contamination of total DDT, an average concentration of 3959 parts per billion (ppb). Average concentration of trichlorophenol was also high at 17,328 ppb. The association of these two contaminants supports the Diamond Alkali Site as the source of the dioxin-furan contamination of cluster 8. DDT was manufactured at the Diamond Alkali site until 1960. 2,4,5-T was manufactured there from the mid 1950s on and became the primary product after the explosion and fire in 1960. Trichlorophenol was manufactured onsite as the primary feedstock for the synthesis of 2,4,5-T.

None of the other chemicals examined for co-contamination; cadmium, total PAHs, total chlorobenzenes or total organic carbon, showed correlation with the summed dioxin-furan concentration. Average total PCB concentration for this cluster 8 was high compared with other clusters, at 4047.4 ppb. This concentration is too low for PCB contamination to be a significant contributor given that the average summed dioxin-furan concentration was 136.3 parts per billion. The high concentration is due to the limited temporal range of cluster 8, which overlaps the period of high domestic PCB production (Bopp et al., 1991).

Cluster 7 was found in 119 samples at 73 stations. Cluster 7 showed the second highest average summed dioxin-furan concentration at 34 parts per billion (ppb). The sample with the

highest concentration, 2,073 ppb, was at the station 286B located adjacent to the Diamond Alkali Site at a depth between 137 and 167 centimeters. Cluster 7 was also dominated by the congener 2,3,7,8-TCDD. The cluster centroid for this congener is 0.33; the range is 0.49 to 0.20. Cluster 7 is enriched with OCDF with respect to cluster 8 with a mean ratio of 0.27 and a range of 0.52 to 0.0. It is also higher in OCDD compared with cluster 8, the mean ratio of OCDD was 0.16, ranging from 0.27 to 0.06. 1,2,3,4,6,7,8-HpCDD was also an important congener in this cluster with an average ratio of 0.12 of the summed dioxin-furan concentration. The ratio range for this congener was from 0.32 to 0.0. Cluster 7 also overlaps end member 5065-3 identified by Huntley, et al., 1998), it is slightly enriched in 1,2,3,4,6,7,8-HpCDD with respect to this pattern. All three patterns share a high concentration of the 2,3,7,8-TCDD, a congener that is generally rare in dioxin-furan contamination. None of the congener patterns published by the EPA National Dioxin-furan Inventory, or cited by Wenning, et al. (1994) in their exhaustive examination of the literature, contains 2,3,7,8-TCDD as the dominant congener. The one exception is the soil samples taken from the Diamond Alkali Site and published by Wenning et al. (1992)

Cluster 7 is found in a spatial extent that overlaps the extent of cluster 8 (Figure 4-14). Cluster 7 is slightly more widespread in distribution; the furthest sample point downstream is located at the top of Newark Bay where the Passaic River empties into it. Upstream a high density of sample points is found up to 6.2 kilometers above the Diamond Alkali Site. A single sample point in cluster 7 is located at the confluence of the Third River, 13 kilometers above the Diamond Alkali Site. There is a large gap of 7 kilometers in which no samples fall into cluster 7. Sampling density is not as high in this area, it is above the EPA 6 mile sampling transect area. There are samples taken in this area, a total of 21, 7 of which were core samples. This indicates a probable secondary source of cluster 7 in the Lower Passaic. Located on the Third River is the Givaudan Roure Corporation site, a former manufacturer of 2,4,5-T. Soil samples on the site were found to be contaminated with 2,3,7,8-TCDD by the New Jersey Department of Environmental

Protection (Belton et al, 1986). The summed dioxin-furan concentration of this sample is 1.8 ppb, an order of magnitude lower than the mean summed dioxin-furan concentration for subsurface samples in the Passaic River (Table 4-4). No other samples in this area fall into cluster 7 or 8. The production of 2,4,5-T on this site has not resulted in extensive and high level contamination of the adjacent river sediments. The facility on this site manufactured 2,4,5-Trichlorophenol as an intermediary in the production of hexachlorophenol. Specific production figures are not available for this facility, but it was not in the group of three largest manufacturers cited by the UN Environmental Program Report (IARC, 1979) for the specific year 1973. The combined production of the three largest facilities was 300 tons or 600,000 pounds; this alone was less than the annual production at the Diamond Alkali site for 2,4,5-T, which exceeded 1,000,000 pounds during the 1960's. Production at the Diamond Alkali site was at least an order of magnitude higher than the Givaudian site on the Third River.

At 38 of the 73 stations where cluster 7 was found, cluster 8 was also present in the core. The two clusters were nearly always adjacent to one another within the cores. Spatially, statistically and temporally these two clusters bear a strong similarity. Both clusters group around the Diamond Alkali Site, samples are found 4.5 kilometers downstream from the site to 6.1 kilometers upstream from the site. The upstream extent may exceed 6.1 kilometers as this point, this is the upstream limit of the EPA 1995 Remedial Investigation transect cores. Cluster 7 or 8 is not found in the core samples taken 1.6 kilometers upstream, the contamination may not have spread that far or the single point may be an area where no deposition took place during the contamination event and subsequent migration. Erosion may have removed any contamination that was deposited. The contamination extends further upstream than downstream due to the stratified circulation pattern present in the Lower Passaic River. Bottom tidal currents are stronger and last longer in the upstream (flood) direction.

The pattern of distribution of cluster 8 suggests a massive spill was responsible for the contamination. The magnitude of concentration varies from parts per million to parts per billion. The area of extremely high concentrations is found in a limited extent close to the area of the suspected discharge. The summed dioxin-furan concentration was compared to distance from the Diamond Alkali Site and yielded an  $r^2$  value of 0.36. This value is low in part due to the sampling method. The core sections measured for dioxins were thick extents intended to show decadal patterns of dioxin-furan contamination. Contamination from a spill event may only be present in the very top of the core leading to a low summed dioxin-furan value for the entire core section. What is significant is that the extremely high concentration values are found only adjacent to the Diamond Alkali Site

Cluster 7 results from long term operation of the Diamond Alkali site. It is found in a greater horizontal range within core samples. The contamination represents long-term accumulation of dioxin-furans from normal Trichlorophenol synthesis. The dioxin-furan pattern is slightly enriched in congeners other than 2,3,7,8-TCDD with respect to cluster 8. Contamination discharge was much less massive and over a long time period for cluster 7 than 8. The signature shows some mixing with the more widespread dioxin-furan patterns found in subsurface samples.

### **Cluster 5**

Cluster 5 (Figure 4-12) was found in 16 samples at 11 core locations. It had the greatest average depth of any cluster at 217 centimeters (cm). The shallowest depth it was found at was 15 cm. In 8 of the 11 core stations it was the cluster found at the bottom of the core. Spatially it was found only in the lower Passaic River within the bounds of the EPA 6 Mile Study Area. The mean summed dioxin-furan concentration for the samples in this cluster was 16.6 ppb. The highest summed dioxin-furan concentration was 210.2 ppb in sample 230A core section 7. This



sample was at a depth of 170 – 219 cm. This cluster occupied the fourth, sparsely populated “arm” of the principal component plot.

This cluster was very high in octa-chlorinated furan (OCDF), the cluster centroid was 0.84. The OCDF ratio ranged from 1.0 to 0.62. The second highest congener present in this cluster was 2,3,7,8-TCDD at 0.09 with a range of 0.29 to 0. OCDD and 1,2,3,4,6,7,8-HpCDD were minor constituents at 0.03 and 0.01 respectively. This cluster showed a high correlation with total DDT concentration,  $r^2$  value of 0.91. As with cluster 8 this high value is due largely to a single sample point with concentrations of total DDT and summed dioxin-furan an order of magnitude greater than the rest of the samples.

#### **Cluster 10**

Cluster 10 was found in 9 samples at 9 stations (Figure 4-17). It was found at an average depth of 90 cm ranging from a surficial sample to a sample at a depth of 234 cm. The stations with cluster 10 were found only in the Lower Passaic River dispersed between the mouth of the Passaic and a point 13 kilometers upstream. The average dioxin-furan concentration of this cluster was 48.3 ppb. This was the second highest average summed dioxin-furan concentration of any cluster. The samples range from a concentration of 396.6 ppb to 7 ppt. The high concentration sample is located 61A in core section 3. This sample is located adjacent to the Diamond Alkali Site.

The primary congeners of this cluster are 1,2,3,4,6,7,8 HpCDD, Octa-Chlorinated dioxin-furan (OCDD) and 2,3,7,8-TCDD. The centroid value for 1,2,3,4,6,7,8 HpCDD is 0.43 with a range of 0.52 to 0.30. The dominance of this congener in the pattern is similar to cluster 9. The second highest congener ratio is OCDD present at a mean value of 0.20, with a range of 0.43 to 0.07. 2,3,7,8-TCDD comprised an average ratio of 0.13, with a maximum of 0.29 and minimum

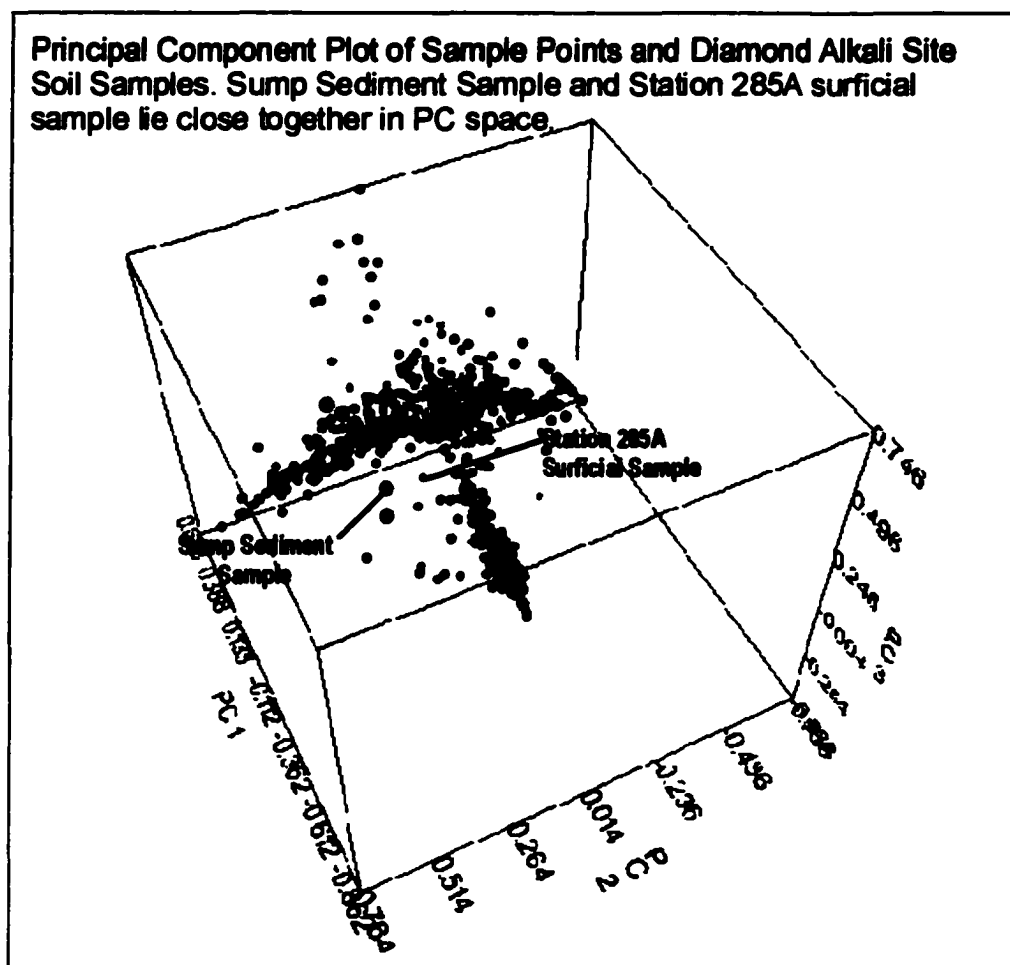
of 0. OCDF makes up a minor component of this cluster with an average ratio of 0.04 and a range of 0.12 to 0.0. This cluster is found near the center of the principal component plot (Figure 4-20). It is found within the range of cluster 11, but contained elevated levels of 2,3,7,8-TCDD and OCDD compared with cluster 11, and less OCDF than cluster 11.

Cluster 10 and cluster 9 contain high levels of 1,2,3,4,6,7,8 HpCDD. As is the case with 2,3,7,8-TCDD congener patterns dominated by these two compounds are not found in the published literature. The spatial distribution of the pattern and the spatial variation in concentrations of these two congeners suggest that a spill or single point source of dioxin-furan is responsible.

## **Cluster 12**

Cluster 12 is found in only 2 sample points at two station locations (Figure 4-19). It was found at core station 285 one of the stations located adjacent to the Diamond Alkali Site. It was present in the surficial core section. The second location where cluster 12 was found was at station 247A located in the bottom core section. In the principal component diagram this point lies extremely close to one of the Diamond Alkali Site soil samples from Wenning et al. 1992. Figure 4-21 shows the proximity of the two points in principal component space. The sample point was taken from a sump pump installed in 1962 to gather waste material from the processing building before the material was transported to the Passaic Valley Sewage System. The summed dioxin-furan concentration in sample 285 in the top core section was 46.26 ppb. This is the second highest summed dioxin-furan concentration for a surficial sample.

**Figure 4-22 Sample Points in principal component space. Sample 285-1 is indicated along with the Diamond Alkali Site Sump Sample.**



The primary congeners of this cluster are 1,2,3,4,6,7,8 HpCDF, Octa-Chlorinated dioxin-furan (OCDD) and 2,3,7,8-TCDD. 1,2,3,4,6,7,8 HpCDF was present at a mean ratio of 0.41, the mean ratio of OCDD was 0.16. 2,3,7,8-TCDD mean ratio was 0.13. There were too few sample points to perform a correlation with co-contaminants. The mean value of co-contaminants was low, consistent with clusters 3 and 6 the two surficial clusters. One contaminant, which was elevated with respect to other surficial points, was total DDTs. DDT was manufactured at the Diamond Alkali Site from the early 1940's until the fire in 1960 so it is likely to be associated with soils from the site. The statistical and spatial association of this surficial sample with the

sump sediment sample indicates that contamination from the site may still be migrating off site, albeit in a very limited area.

**Table 4-13 Clusters with Major Congeners and Likely Sources.**

| <b>Cluster<br/>(Number<br/>of<br/>Samples)</b> | <b>Primary<br/>Congeners<br/>(&gt;10% of<br/>summed dioxin-<br/>furans)</b> | <b>Vertical and<br/>Spatial Extent</b>                        | <b>Primary Sources</b>                                                                                     |
|------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| 1 (91)                                         | OCDF<br>OCDD                                                                | Surficial and<br>Core Samples/<br>Upper Newark Bay<br>Complex | Chemical<br>Manufacturing, PCB<br>releases                                                                 |
| 2 (5)                                          | 123789-HxCDF                                                                | Core Samples /<br>Lower Passaic                               | Unknown Source                                                                                             |
| 3 (112)                                        | OCDD                                                                        | Surficial/Entire<br>study area                                | Combustion Sources                                                                                         |
| 4 (148)                                        | OCDF<br>OCDD<br>1234678-HpCDD                                               | Core Samples/<br>Upper Newark Bay<br>Complex                  | Chemical<br>Manufacturing, PCB<br>releases                                                                 |
| 5 (16)                                         | OCDF                                                                        | 6 Mile Study Area                                             | Chemical<br>Manufacturing,<br>statistical<br>association with DDT                                          |
| 6 (215)                                        | OCDD                                                                        | Surficial/Entire<br>Study area                                | Combustion sources                                                                                         |
| 7 (119)                                        | 2378-TCDD                                                                   | Core<br>Samples/Lower<br>Passaic                              | Long term 2,4,5-T<br>production at former<br>Diamond Alkali Site                                           |
| 8 (74)                                         | 2378-TCDD                                                                   | Core<br>Samples/Lower<br>Passaic                              | Contamination<br>Released due to<br>Explosion and Fire<br>at former Diamond<br>Alkali Site in Feb.<br>1960 |
| 9 (46)                                         | 1234678-HpCDD                                                               | Core Samples/<br>Newark Bay<br>Complex                        | Unknown Chemical<br>Source.                                                                                |
| 10 (9)                                         | 1234678-HpCDD<br>OCDD<br>2378-TCDD                                          | Core<br>Samples/Lower<br>Passaic                              | Diamond Alkali<br>contamination and<br>same unknown source<br>as cluster 9                                 |
| 11 (56)                                        | 1234678-HpCDD<br>OCDF<br>OCDD                                               | Core Samples/<br>Newark Bay<br>Complex                        | Chemical<br>Manufacturing,<br>contribution from<br>unknown source for<br>cluster 9                         |

|        |                                    |                                  |                                                                            |
|--------|------------------------------------|----------------------------------|----------------------------------------------------------------------------|
| 12 (2) | 1234678-HpCDD<br>OCDD<br>2378-TCDD | Core<br>Samples/Lower<br>Passaic | Diamond Alkali<br>contamination and<br>same unknown source<br>as cluster 9 |
|--------|------------------------------------|----------------------------------|----------------------------------------------------------------------------|

Cluster analysis provides an additional tool, along with principal component analysis, in separating multiple sample points and variables into smaller, more easily analyzed groups. The results of the cluster analysis were consistent with those of the component analysis. Clustering takes the entire fingerprinting process a step further in assigning sample points to discrete groups based on statistical similarities. The following points summarize the cluster analysis results.

- The highest level of dioxin contamination (as summed dioxin-furans) and highest toxicity was found in clusters 7 and 8. These clusters are associated with the former Diamond Alkali Site and result from both long-term production (cluster 7) and a one-time spill event, which took place in February of 1960 (cluster 8). This single source is the major contributor of dioxin-furan toxicity in the New York Harbor.
- An unknown source of dioxin contamination has resulted in a series of congener patterns unlike any reported in the literature (cluster 9). This source is likely a small number of chemical manufacturing sites or some spill event. This pattern is present in 3 other clusters and is a significant contributor to dioxin-furan toxicity in New York Harbor.
- There is a significant difference between the patterns found in recent, surficial sediments (clusters 3 and 6) and those found in buried sediments. This reflects better controls on the discharge of chemical waste and an increase in combustion sources.

#### **Radioisotope dating**

A common technique for dating recent (<50 y.a.) cores is to compare two isotopes that have well documented sources and depositional characteristics, Lead 210 and Cesium 137. Lead

210 is derived only from the decay of unstable isotopes such as Uranium 238, a common component in igneous rock. It decays through a series of products, one of which is Radon-222. Radon is a gas that can escape from the soil and be carried by atmospheric currents. It has a half-life of 3 days, it then decays through a number of short-lived daughter products, which are solids and quickly fall out of the atmosphere. These isotopes decay to Pb-210 with a half-life of 23 years. Lead 210 resulting from fallout is incorporated into sediments in the same manner as other deposition such as ash, pollen or dioxins. Lead 210 in sediments can also be derived from the underlying bedrock, this component is known as supported Lead 210. The accuracy of dating using Lead 210 is most accurate if the supported lead 210 activities can be quantified and removed from the dating calculation. Cesium 137 deposition results from atmospheric fallout produced by above ground testing of nuclear weapons. Atmospheric testing began in the early 1950's and peaked in 1963 before the treaty between the US and Soviet Union banning atmospheric testing went into effect (Faure 1986).

In addition to the two isotopes used for dating Beryllium 7 was also measured in the core samples. As mentioned previously Beryllium 7 is a short-lived isotope with a half-life of 56 days. Beryllium is used to verify that sediment, primarily surficial sediment, has been recently deposited. Due to the high activity in urban waterways, bioturbation and dredging, the upper layer of sediments may not always be of recent origin. Out of all the samples taken in the EPA 1995 Remedial Investigation, including those not used in this analysis, Beryllium was found above the detection limit in 17 samples out of 1043. Only 14 of 93 surficial samples, and 3 of the 950 samples taken at depth showed measurable Beryllium activity.

A core that represents a constant deposition area will have a distinctive pattern of radionuclide concentration. Pb-210 concentration decreases logarithmically with increasing depth. Cesium-137 concentration increases down core to a peak, which can be dated to 1963-

1964. It then decreases within the core and is undetected if the core extends far enough. Onset of Cesium 137 deposition occurred in 1954 with the initial above ground testing of fusion weapons.

The analytical results from the radioisotope analysis for the EPA Remedial Investigation of 1995 and the Remedial Investigation Nearshore Supplement were examined for temporal signatures. The greatest accuracy is provided when both Lead 210 and Cesium 137 yield useful results, this however is not always the case. Radioisotope samples are collected from a much narrower slice of the core section, the goal being to establish a specific marker rather than a broad generalization as with contaminant analysis. This makes the possibility of poor results greater. The area examined may not be a zone of continuous deposition, but is characterized by periodic inputs of sediment. Even in a depositional area the radioisotope signature may be disturbed by bioturbation, long recurrence intervals, erosional/depositional events or anthropogenic actions; such as dredging. The federal channel of the Lower Passaic above the Lincoln Highway was last dredged in 1949, however pier and slip maintenance dredging occurred frequently in this area over the past four decades (EPA, 1998). The transects for the 1995 Remedial Investigation were designed to capture the sedimentation in the federal channel since 1949, expected to be rapid with the cessation of dredging. Parts of the channel are the natural thalweg of the river, areas that are characterized by scouring and the deposition of coarse material. Coarse-grained sands and gravels do not sorb radioisotope particles as readily as clays, silts and organic particles. Variations in these materials interfere with accurate dating. Anthropogenic inputs in this area are high, especially organic material from Combined Sewage Overflows (CSOs). This area is a busy commercial waterway; the frequent passing of boats and barges produces turbulence that affects deposition pattern.

Radioisotope profiles of the EPA 1995 RI and Supplement were examined for useful signatures. The majority of the cores showed profiles that could not be accurately dated, not surprising given the design of the study. The cores that showed typical depositional profiles were

graphed and the Lead 210 activity depth values were analyzed to establish time intervals. The graph of Cesium 137 activity was examined to denote the peak of Cesium activity and the limit of Cesium activity, dating the core section to 1964 and 1954 respectively. The stations used are shown in Figure 4-23.

Lead 210 activities in core sections can be correlated to specific dates using the decay function of Lead 210 and the change in unsupported Lead 210 activity between the surficial sample and the core section. Equation 4-1 is adapted from Faure (1986).

**Equation 4-1**

$$\text{Age (years)} = 1 / 0.0311 * \text{Log}_{10}(\text{Pb}_{\text{s}}\text{unsup} / \text{Pb}_{\text{c}}\text{unsup})$$

where

0.0311 - Decay constant for Lead 210

$\text{Pb}_{\text{c}}\text{unsup}$  - Unsupported Lead 210 activity in core section

$\text{Pb}_{\text{s}}\text{unsup}$  - Unsupported Lead 210 activity in surface layer

Unsupported Lead 210 activity is calculated from the measured Lead 210 activity by subtracting the supported lead 210 activity. Supported activity can be determined from deep core sections where Lead 210 activity reaches a consistent background level. If the core does not extend enough to determine a leveling off of Lead 210 activity the background level from nearby cores can be substituted. One of the important problems in using Lead 210 for dating is the determination of this supported activity. The core sample must extend deep enough to capture sediments over 50 years in age.

Additional temporal information was provided by bathymetric surveys obtained from the US Army Corps of Engineers Surveying Branch, New York District and the Diamond Alkali Site, Passaic River Operable Unit Remedial Investigation files. Bathymetric surveys were available for certain stretches of the River for 1999, 1986, 1976, 1966 and 1949. The Corps maintains historical surveys on microfiche between 1880 and 1996. Subsequent surveys are maintained



digitally as Intergraph drawing files. The 1999 survey was converted to Arcview format and used as the closest representation to the bathymetry at the time of the EPA 1995 sampling. This baseline information was then compared to the historical bathymetric record. The IT Corporation conducted a bathymetric survey in 1986 for the Passaic River sampling design study. This information was on map sheets contained in the Investigation files. These sheets were scanned and then rectified using Arcview's Image Analysis Extension. For the image rectification process a control layer representing mean high water level shoreline was used. The shoreline file was compiled by the New Jersey Department of Environmental Protections at a scale of 1:24,000 from aerial photos.

Bathymetry was also compiled from Corps of Engineers' microfiche historic survey repository. The microfiche were printed out onto plain bond paper and then scanned into digital images. The digital images were rectified following the procedures described above. This procedure was done for 1976, 1966 and 1949 survey. None of the surveys completely covered the area of interest. The 1966 survey extended from 0.5 kilometers upstream from the Diamond Alkali Site to 6 kilometers upstream from the site. The 1976 survey covered an area from 1.5 kilometers below the site, up to 4 kilometers above the Diamond Alkali Site. The 1949 survey included the greatest extent of the Lower Passaic, 4 kilometers below the Site to 4 kilometers above the site, however it recorded depths only for the limits of the Federal Channel. The digitized bathymetry sheets were used to estimate the bathymetric surface for that time period at the sample point locations used for dating by locating the closest survey location or estimation based on multiple nearby points.

Water depths for the time of the 1995 EPA sampling study was determined by a comparison of the digital 1999 interpolated bathymetry and the digitized 1986 interpolated bathymetry. The bathymetric change in the cores used ranged from 150 cm of deposition to 67

cm of erosion. The mean was 23 cm of deposition. The 1995 surface was calculated as in Equation 4-2.

**Equation 4-2**

$$Srf_{1995} = Srf_{1999} - ((Srf_{1999} - Srf_{1986}) / (t_{99-95} / t_{99-86}))$$

**Where**

**Srf<sub>1999</sub> = 1999 Bathymetric Depth in centimeters (cm)**

**Srf<sub>1986</sub> = 1986 Bathymetric Depth in centimeters (cm)**

**t<sub>99-95</sub> = Time interval 1999 - 1995: 4 years**

**t<sub>99-86</sub> = Time interval 1999 - 1986: 13 years**

### **Core Sections Dating and Cluster Sequence**

The results of the temporal analyses are described in the following section, along with the cluster results and summed dioxin-furan concentrations within selected cores. The two procedures for dating sediment samples each have advantages and disadvantages. Any dating technique contains inherent inaccuracy, largely due to the variability in an estuarine environment and the anthropogenic disturbances present in an urbanized one. Radioisotope dating requires a continuous deposition of chemically and physically similar sediment in an environment that has been subject to consistent levels of radiogenic fluxes over the time period in question. The design of the Remedial Investigation focused on characterizing as fully as possible the post 1940 sediment mass in the 6-mile study area. For this reason few of the cores showed useful results. Bopp et al. (1998) related that in a decade of collecting cores in the Hudson Estuary "of the several hundred cores we have collected in the Hudson River Basin fewer than 40 exhibit the complex, undisturbed profile of Cs<sup>137</sup>". Unlike the core samples taken during the EPA 1995 study, the studies reported in Bopp et al. (1998) focused on finding areas of continuous deposition.

Historical bathymetric data provides corroboration for radioisotope dating as well as a substitute in areas where radioisotope data was unusable. An advantage to historical bathymetry is the greater scope in coverage; the surveys provide information beyond just the immediate sample vicinity. This is useful in ascertaining how representative the samples are of common

conditions in the study area. The primary problem with the use of historical data is the difficulty in accurately determining the sample location on the bathymetric sheet given the source of data. The sheets were originally paper maps with survey points locations determined by Loran. These sheets were converted to microfiche, for this study, individual sections were written back out onto 8 ½ x 11 paper by a microfiche reader then taped together in sequence and scanned on a large scale drum scanner. The scanned images were then rectified using a 1:24,000 scale shoreline digital dataset. Each step introduces further spatial inaccuracy in an environment where cross channel depth can change dramatically over a short distance.

Accumulation rates for this study were calculated for the stations used in dating clusters. Accumulation ranged between 0.25 centimeters (cm) per year and 8.5 cm per year using changes in historical bathymetry and averaging rates where multiple years' charts were available. The average value for the stations used was 3.35 cm per year. Estimates of accumulation rates based on the Cs<sup>137</sup> peak show a range between 0.9 cm per year and 7.5 cm per year. The mean value was 3.9 cm per year. This was calculated only for the stations used in the dating which had an identifiable Cs137 peak. A map of the stations used for dating showing accumulation rates from both methods is shown in Figure 4-22a.

Results from both methods fall within the range of values reported by other investigators. Suszkowski (1978) estimated an average deposition rate of 5.5 cm per year in the lower Passaic River based on suspended sediment concentrations. The EPA report from the 1986 hydrographic survey found both erosion and deposition in the proposed transects area. Deposition ranged from 2.1 cm per year to 17.5 cm per year while erosion averaged 9 - 10 cm per year in spots (US EPA, 1995). A core sample described by Bopp, et al. (1991) showed a Cs<sup>137</sup> peak at 48-51 cm, this yields an accumulation rate of approximately 2 cm per year. Huntley et al. (1995) dated a number of the Maxus cores using Lead 210 and Cesium 137. That study found a range of accumulation rates of 4.1 to 10.2 for Lead dating and 3.8 to 8.9 for Cesium dating. This wide range of rates is

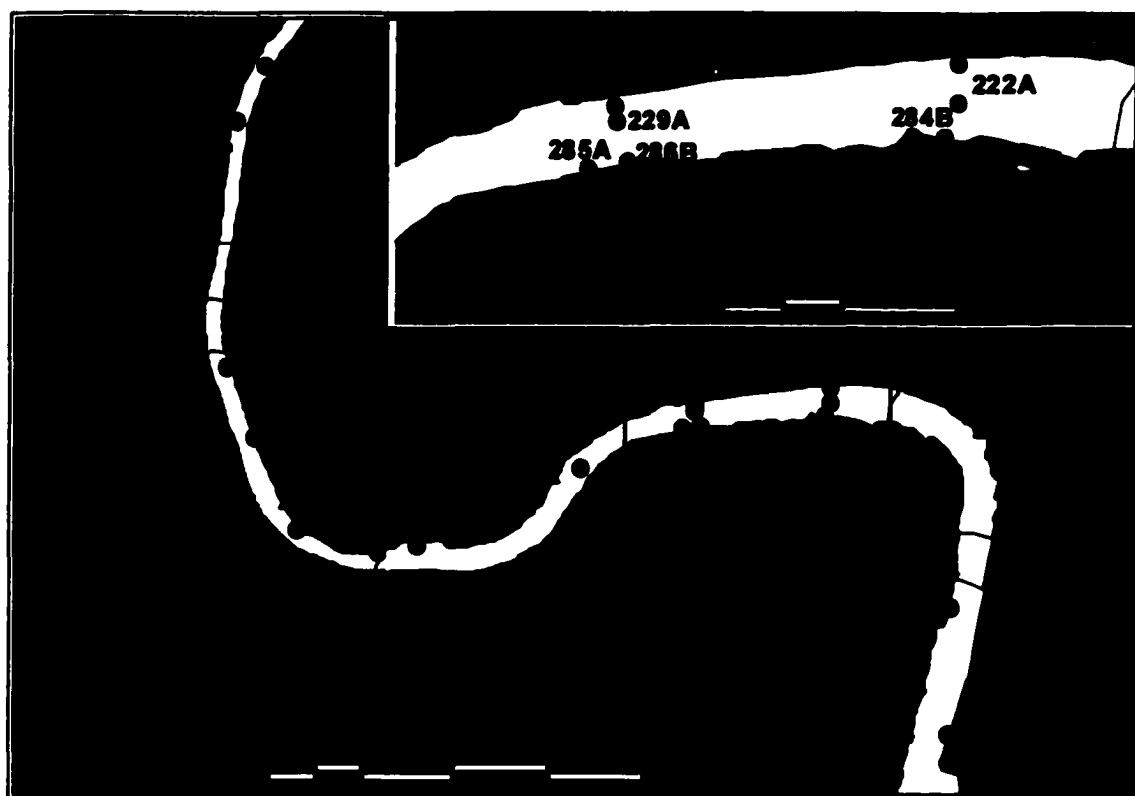
consistent with an environment such as the Lower Passaic River. An estuary is naturally dynamic and this area is even more so due to anthropogenic alterations and activities. With the cessation of dredging the river bottom is returning to a natural equilibrium, a process that has not been extensively examined. Huntley et al. (1995) dispute the low accumulation rates found by Bopp et al. (1991) and postulates that the Bopp et al. (1991) cores did not reach the Cesium maxima. This study however, supports the findings of Bopp et al. (1991). Accumulation rates under 1 cm per year were found in the general vicinity of the Bopp et al. and Huntley et al. cores. The rates of sediment accumulation varied from 0.1 to 5 cm/year over a distance less than 50 meters (Figure 4-22a).

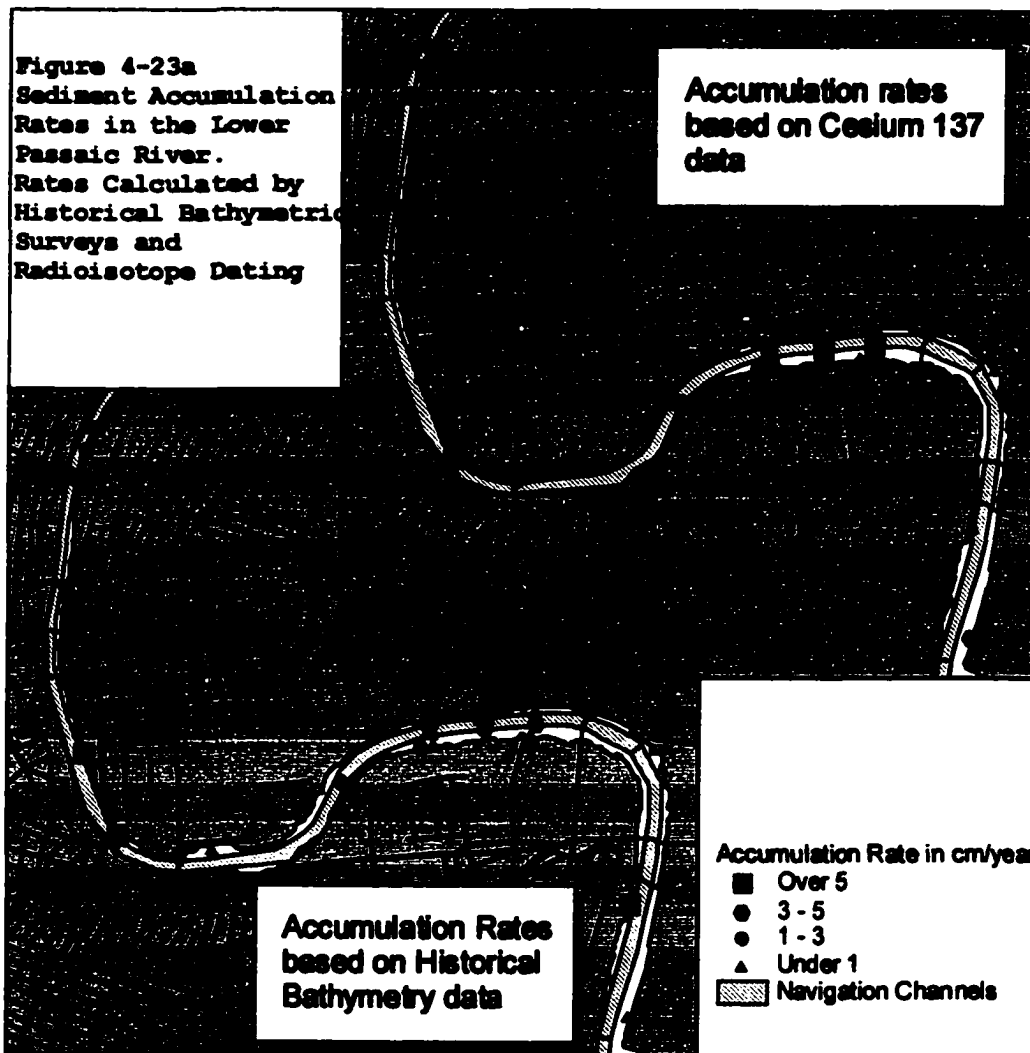
The following discussions examine each of the core sections used in the temporal analysis. The stations examined showed usable radioisotope profiles either for Cesium 137 activity or Lead 210 activity, or were located in areas where overlapping historical bathymetric information was available. Figure 4-22 shows the location of the cores used for time horizon determination. Four of the cores were taken immediately offshore from the Diamond Alkali site (it was the location of the highest density of samples). Figures 4-22 to 4-39 show radioisotope profiles, historical bathymetry and dioxin-furan cluster results and total concentrations for the cores found to be datable. The radioisotope plots include samples with non-detects; they are assigned a value of one-half the detection limit and are noted in the text. Along with the Lead 210 and Cesium 137 values the charts show the sequence of dioxin-furan congener signatures within the core, all plotted against the depth in centimeters of the sample. The age surfaces determined by bathymetric examination are also shown on each chart.

Within the previous discussion of the clusters the average depth intervals of the individual clusters was noted. More meaningful to the analysis is the timeframe in which the clusters occurred. The samples used in the contaminant analysis averaged 30 centimeters in thickness, even in the areas of most rapid sediment deposition this represents a number of years'

accumulation. The sampling intervals were established to provide decadal slices of sediments, as well as provide sufficient material for analysis. Given the inherent error in radioisotope dating each core section will have a wide range in dates. Fortunately for this analysis the time period of most interest, the time of the explosion and fire at the Diamond Alkali site, occurred in close proximity to one of the easily identifiable radioisotope markers. The Cesium 137 peak occurred in the 1964 time frame, 4 years after the Diamond Alkali fire.

**Figure 4-23 Core Stations From 1995 EPA Remedial Investigation used for temporal analysis of dioxin-furan clusters.**

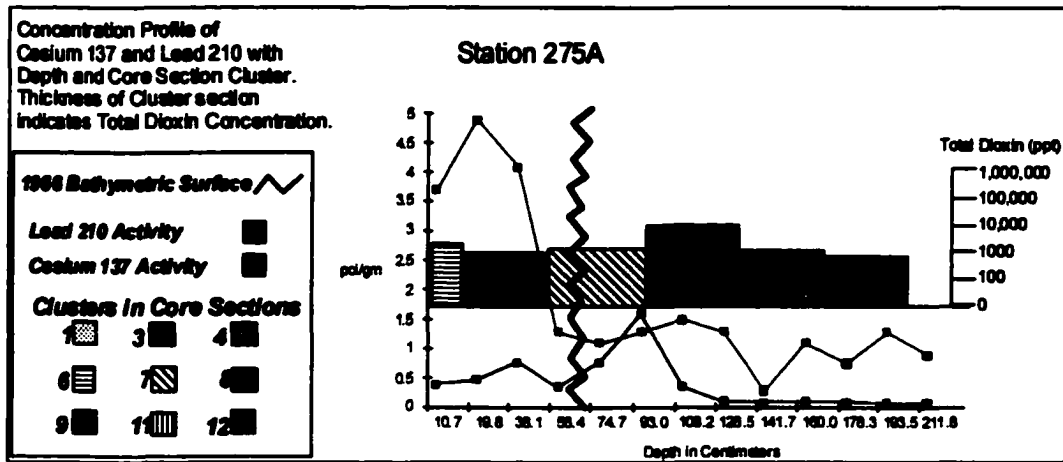




#### Station 275A

Station 275A is located 5.5 kilometers upstream from the Diamond Alkali Site. It is the furthest upstream station used in the dating analysis. The station is on the east edge of the Federal Channel. Water depth as of the 1999 bathymetric survey was 3.5 meters. Figure 4-30 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-24, Core Station 275A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



The 1966 bathymetric surface is found in this core at a depth of 54 cm. Sediment accumulation between this point and the 1995 surface averaged 1.8 cm per year. The peak of the Cesium 137 activity is found at a depth of 94 cm, which correlates with the 1966 bathymetric surface. Lead 210 activity within the core is highly variable; concentration initially increases in the first buried sample, decreases and then fluctuates around 1.5 pCi/gm. The resulting dates from equation 4-1 do not correlate with the Cesium profile or with the bathymetric surface depth.

The surficial sample in this core falls into cluster 6, the most common surficial cluster. The summed dioxin-furan concentration is 9.5 ppb. Below this core section, from 15 to 54 cm the section is part of cluster 4, summed dioxin-furan concentration is 4.2 ppb. This was a common occurrence for the summed dioxin-furan concentration to drop from the surficial core to the initial buried core. It is likely due to dioxin-furan enrichment from the higher total organic carbon (TOC) concentration in the surficial layer. In this core section TOC was measured at 18.5% in the surficial core and 10.6% in the first buried core. The next core in the section was part of cluster 7, it extended from 54 cm down to 94 cm, straddling the 1966 bathymetric surface. Summed dioxin-furan concentration in this sample was 4.2 ppb. The section from a depth of 94 to 134 cm was

classed as cluster 8. This sample contained the highest summed dioxin-furan concentration in the core at 22.8 ppb. This sample is located just below the Cesium peak, dating it to the early 1960's. The two bottom sections in this core are members of cluster 4, summed dioxin-furan concentration is 3.2 ppb and 1.8 ppb moving down core.

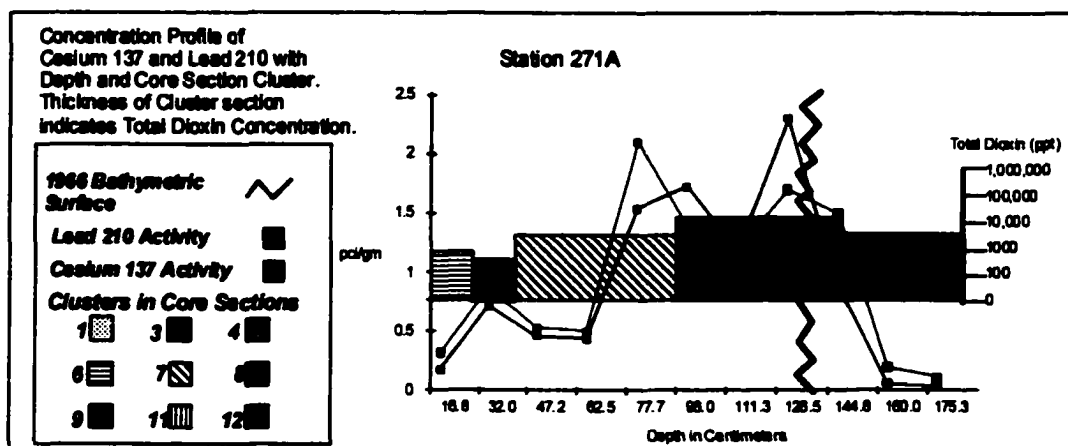
Cluster 4 was the most common profile in this core, found at the bottom and just below the top of the core. This represents the long-term dioxin-furan profile in this section of the River. The accumulation is interrupted only by the contamination from the Diamond Alkali Site associated with the 1960 explosion and fire. This event emplaced a large body of highly contaminated sediments in the Lower Passaic River.

#### **Station 271A**

Station 271A is located 5.25 kilometers upstream from the Diamond Alkali Site. It is located in the middle of the Kearney Reach of the Federal Navigation Channel. Water depth as of the 1999 bathymetric survey was 3.6 meters. Figure 4-31 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.



**Figure 4-25, Core Station 271A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



The 1966 bathymetric surface is found at a depth of 134 cm within this core. This calculates to a sediment accumulation rate of 4.6 cm per year from 1966 through 1995. The Lead 210 profile shows a very unusual curve, activity is very low in the near surface samples and then increases down core. After the 77 cm depth activity again decreases. These fluctuations make the activities useless for dating purposes; they result from variations in meteorological conditions, hydrologic changes and variations in sediment grain size delivery. This core station is located in mid-channel where current is strongest and grain size generally the highest. The Cesium 137 activity shows a more typical profile of a depositional area with a peak at the 126 cm mark, which agrees with the historical bathymetric results for this area.

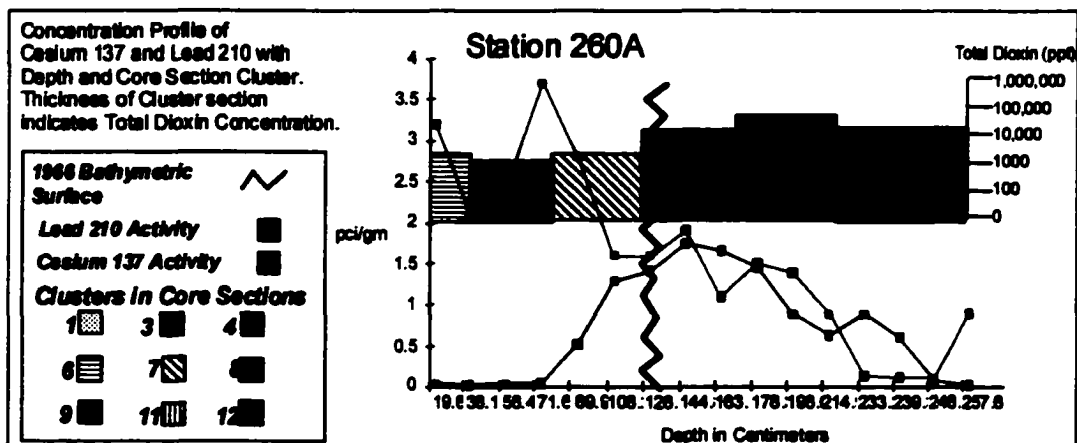
The surficial sample falls into cluster number 6, summed dioxin-furan concentration was measured at 1.3 ppb. The next sample down core was part of cluster 4; summed dioxin-furan concentration was low for the Lower Passaic at 0.9 ppb. The next core fell into cluster 7 it extended from 27 cm to a depth of 94 cm. Summed dioxin-furan concentration was 4.9 ppb. The core from 94 cm to 143 cm had the highest summed dioxin-furan concentration for the core at

14.7 ppb. This core was in cluster 8. It includes the depth of both the 1966 bathymetric surface and the Cesium maximum, dating it to the 1960's.

#### Station 260B

Station 260B is located 3.6 kilometers upstream from the Diamond Alkali Site. It is outside of the Newark Reach of the Federal Navigation Channel along the east bank of the Passaic. Water depth as of the 1999 bathymetric survey was 2.9 meters. Figure 4-32 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-25, Core Station 260B showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



The 1966 bathymetric surface for the area of this core is located at 124 cm, this averages out to 4.3 cm of sediment accumulation per year for the 29 year period of 1966 to 1995. The Lead 210 profile shows a steady decline down core, with some anomalously high samples. The dates computed from the Lead 210 activities are not in agreement with the bathymetric surface or Cesium activity, the results from equation 4-1 yield much later dates. The Cesium profile shows

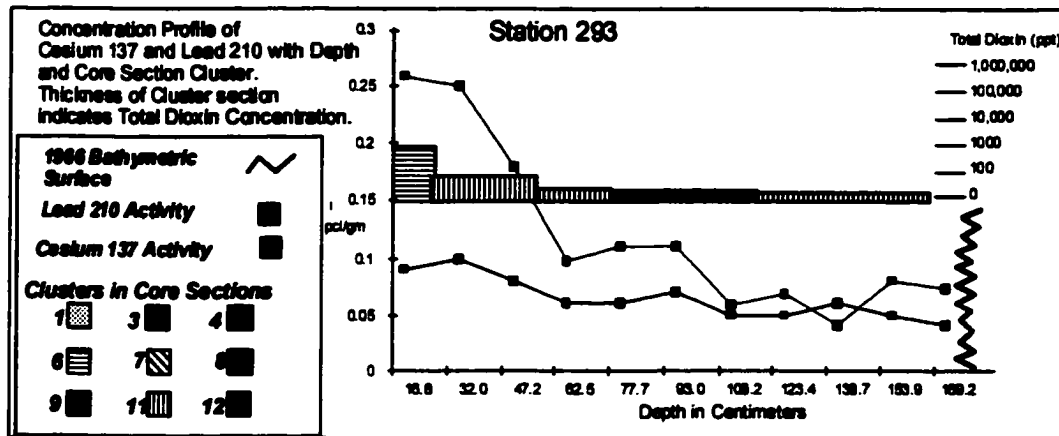
agreement with the historical bathymetric surface. The peak, associated with 1964, occurs between the depth of the 144 cm and 163 cm radioisotope samples.

The surficial sample in this core is in cluster 6, summed dioxin-furan concentration was 7.1 ppb. The initial subsurface core was part of cluster 4 and showed a decrease in dioxin-furan concentration to 3.6 ppb compared with the surficial sample. The core section from 64 cm to 112 cm was in cluster 7; summed dioxin-furan concentration was 7.6 ppb. This cluster dates from the late 1960s to the late 1970s based on the historic bathymetric surface and the sediment accumulation rate. The next three core sections below this sample are in cluster 8. The top sample has a dioxin-furan concentration of 20.4 ppb. The 1966 bathymetric surface and the Cesium 137 peak are located within this core section, dating it the early part of the 1960's. The next sample down core has a very high dioxin-furan concentration, 76.9 ppb. This top of this sample dates to the beginning of the 1960's, the timeframe of the Diamond Alkali Site explosion. The bottom core section has a lower dioxin-furan concentration, 30.6 ppb. This core dates to a time period prior to the explosion, but a time when the Diamond Alkali Site was producing 2,4,5-T.

### **Station 293A**

Station 293A is located about 3 kilometers upstream from the Diamond Alkali Site on the east bank of the Passaic. It is outside the Federal Channel, water depth as of the 1999 bathymetric survey was less than 2 meters in depth. Figure 4-26 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-27, Core Station 293A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



The 1966 bathymetric surface occurs at a depth of 177 cm in this core. This yields an average sedimentation rate of 6.1 cm per year for the 1966 – 1995 time period. The 1949 bathymetric surface is not shown in the diagram, it is at a depth of 209 cm, which falls below the bottom of the core. Sediment accumulation between these two datable points averaged 1.8 cm per year. Lead 210 activity shows a continuous decrease and yields some usable dates. The core did not penetrate far enough to determine the supported Lead 210 activity. Leaving this out of the calculation increases the uncertainty of the dating; the uncertainty increases with age when the measured activity converges with the supported activity. The Cesium 137 activity does not show a peak, not surprising, as the core does not penetrate past the 1966 bathymetric surface.

The bottom core section falls into cluster 11. The bottom of the section is dated by the 1966 bathymetric surface. The top of the core dates, using Lead 210 activity, to 1971. Uncertainty with this date is +9 years without the determination of supported Lead 210. The midrange date correlates well with the bathymetric surface given the average deposition rate. The dioxin-furan

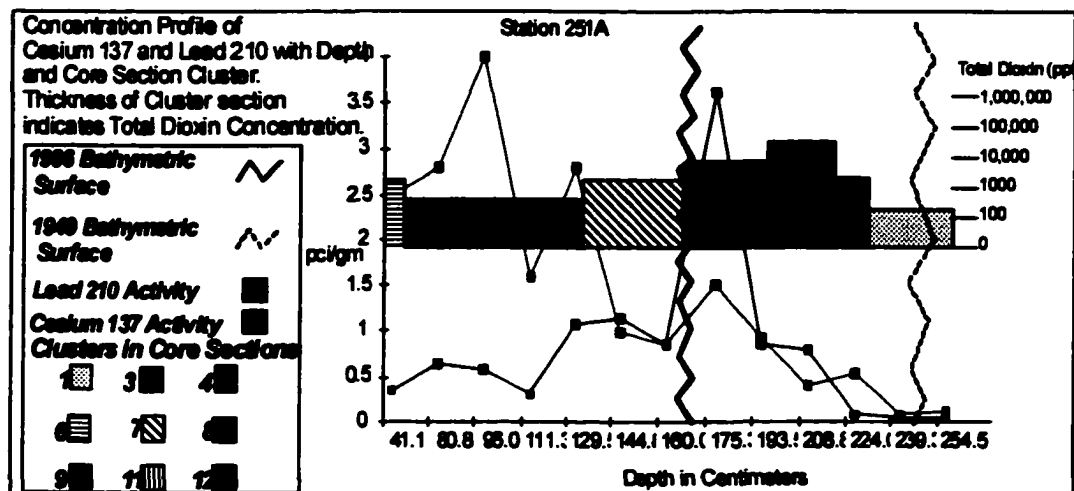
concentration of this section is barely measurable at 6 parts per trillion (ppt). The core section above this is classed as cluster 9; dioxin-furan concentration is 10 ppt. at this depth. The next two core sections fall into cluster 11, summed dioxin-furan concentration is 0.3 and 0.03 ppb for the upper and lower cluster 11 sections respectively. The surface sample falls into cluster 6, it contained a high summed dioxin-furan concentration, 1.9ppb.

This core section did not extend deep enough to show evidence of contamination from the Diamond Alkali Site. The summed dioxin-furan concentration throughout the core is very low, due to the high sedimentation rate at this location.

#### **Station 251A**

Station 251B is located 2.5 kilometers upstream from the Diamond Alkali Site on the right edge of the Federal Channel. Figure 4-23 shows the radionuclide activity within the core section by depth. The core section cluster results are also shown with summed dioxin-furan concentration. The 1966 bathymetric surface is found at a depth of 180 cm. The 1949 bathymetric surface is also present in the core at a depth of 241 cm. This gives an average sedimentation rate of 6.01 cm per year for the time period 1995 – 1966 and 3.6 cm per year between 1949 and 1966. For the total core sedimentation averaged 5.2 cm per year. The core extends deep enough to estimate the supported Lead 210 activity at 0.1 pci/gm. Four of the twelve Lead 210 samples show elevated levels and dates with respect to the correlating data, Cesium 137 and the bathymetric surface, the remainder yielded useful ages.

**Figure 4-28 Core Station 251A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



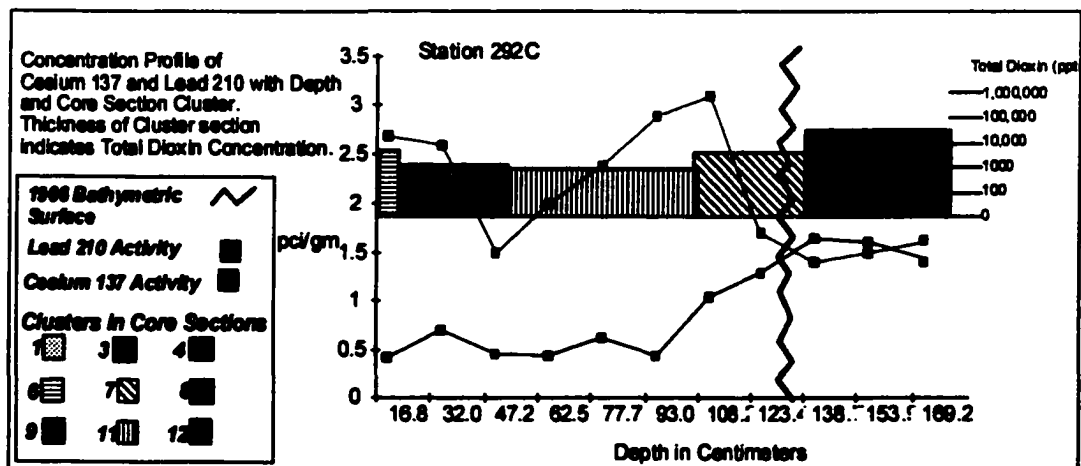
This cluster configuration in this station is similar to station 235A. Cluster 6 is present in the surficial layer at a relatively high concentration. Below this section is a thick extent classified as cluster 4, dioxin-furan concentration is half that of the surface sample. Lead 210 activity dates the bottom of this core section to 1970-72. The section below the two cluster 4 sections falls into cluster 7, it extends from a depth of 128 cm to 152 cm, the summed dioxin-furan concentration is twice that of the core section above. This is slightly above the 1966 bathymetric surface. The two core section below this show a large increase in average dioxin-furan concentration; 34 ppb for the 152 – 198 section and 58 ppb for the 173 – 210 cm section. The sample with the Cesium 137 maximum is found at a depth of 175 cm, which correlates with the 1966 bathymetric surface. The maximum Cesium 137 sample ostensibly indicates a date of 1964, but the true maximum may not be captured by the sampling interval. It lies somewhere between the two samples bounding this maximum sample. The 173 – 210 cm core section dates from 1967 to 1959 using sedimentation rates and 1968-69 to 1959-60 using Lead 210 activity. Both these time periods fit with the time of the explosion on the Diamond Alkali site.

The core section below this extends to a depth of 222 cm, it overlaps the core above containing sediments up to a depth of 198 cm. This upper limit dates to 1960 using the 1966-1949 average sedimentation rate and 61-62 using Lead 210 activity. The bottom core section, from 222 cm to 259 cm, measured a very low summed dioxin-furan concentration, 3.5 ppb. The section extends below the 1949 surface, when the area was last dredged. Lead 210 activity dates the bottom of the core section to 1925, Cesium was not detected at this point and it extends below the limits of the bathymetric data.

#### Station 292C

Station 292C is located about 2 kilometers upstream from the Diamond Alkali Site on the north bank of the Passaic. It is outside the Federal Channel in shallow water less than 2 meters in depth. Figure 4-24 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-28, Core Station 292C showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



The 1966 bathymetric surface occurs at a depth of 130 cm in this core. This yields an average sedimentation rate of 4.5 cm per year for the 1966 – 1995 time period. The 1949

bathymetric surface is not shown in the diagram, it is at a depth of 217 cm, below the bottom of the core. Sediment accumulation between these two datable points averaged 5.1 cm per year. Lead 210 activity decreases to a depth of 47 cm and then increases, inconsistent with a datable profile. The Cesium 137 activity does yield usable results, the peak occurs at a depth of 138 cm, consistent with the 1966 bathymetric surface.

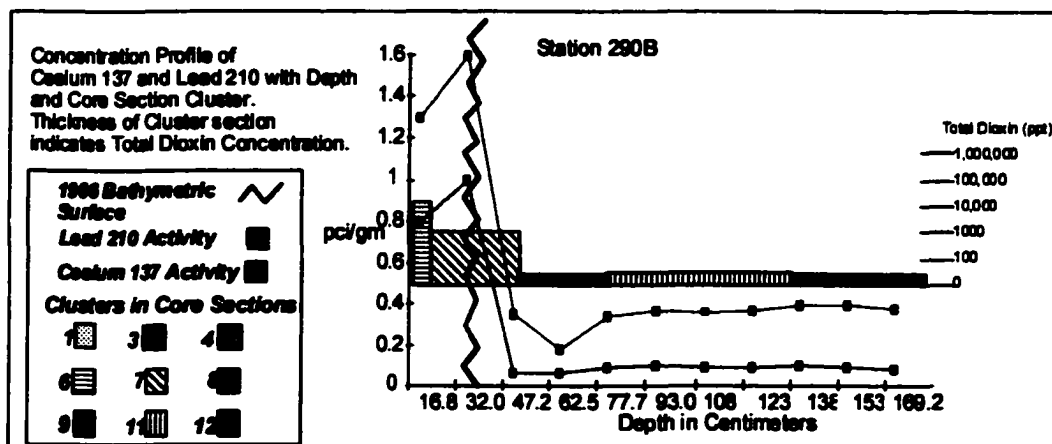
The bottom core section, marked at the top by the Cesium 137 peak, falls into cluster 8. This section dates between 1958 and 1963. The dioxin-furan concentration is the highest within the core at 26 ppb. The core section above this is classed as cluster 7, dioxin-furan concentration falls to 7.3 ppb. at this depth. The next two core sections fall into cluster 11, summed dioxin-furan concentration is 5.4 and 4 ppb for the upper and lower cluster 11 sections respectively. The shallowest core section is part of cluster 4; summed dioxin-furan concentration is 5.2 ppb. The surface sample falls into cluster 6, it contained a high summed dioxin-furan concentration. 11.4 ppb.

#### **Station 290B**

Station 290 B is located less than 2 kilometers upstream from the Diamond Alkali Site on the north bank of the Passaic. It is located on the inside bank of one of the meanders in the Lower Passaic, outside the Federal Channel. The Passaic widens in this area, the station is in shallow water less than 1 meter in depth. Figure 4-25 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.



**Figure 4-30, Core Station 290B showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



This station showed a very low rate of sediment accumulation. The 1966 bathymetric surface is found at a depth of only 33 centimeters. This computes to an average sediment accumulation rate of just over 1 cm per year for this time period. The 1949 bathymetric surface could not be determined for this sample point; the survey consisted of soundings only for the Federal Channel. The Lead 210 profile is not useful for dating, the majority samples hover around a value of 0.4 pci/gm. This represents the Lead 210 supported level, contributed by the underlying sediment. The Cesium 137 activity shows a peak around the 1966 bathymetric surface. This is based on only two points; the remaining samples are at the detection level.

The surficial sample falls into cluster number 6, it contains the highest summed dioxin-furan concentration for the core at 20.3 ppb. The second core section from the top, 15 – 45 cm, falls into cluster number 7, summed dioxin-furan concentration is 7.8 ppb. This core does not contain cluster 8. Cluster 7 is statistically similar to cluster 8, it represents long-term accumulation of contamination from 2,4,5-T production at the Diamond Alkali Site. Due to the slow sediment accumulation at this site the 15 – 45 cm core section represents 30 years of

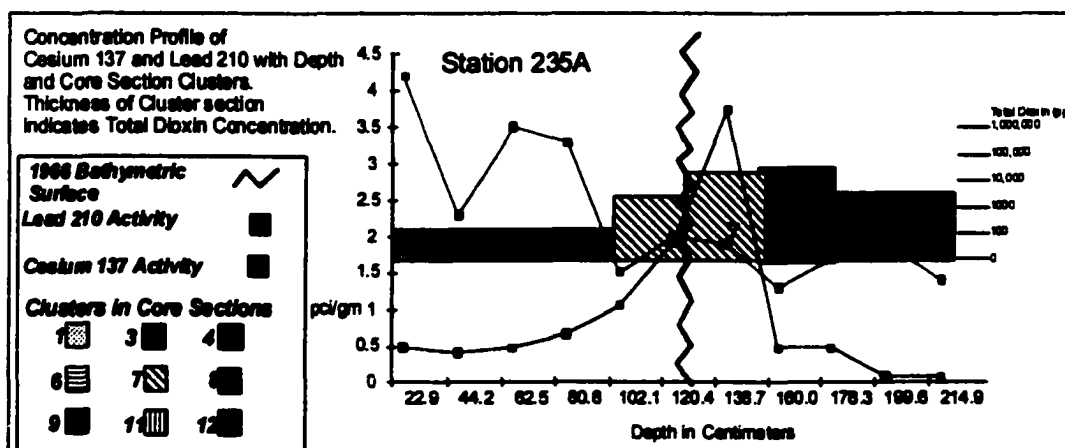
sediment accumulation, this accounts for the dilution of the Diamond Alkali Site signature and the low summed dioxin-furan-furan concentration.

The core section from 45 to 76 cm falls into cluster 4, summed dioxin-furan concentration is very low at  $9 \times 10^{-2}$  ppb. The core section below this falls into cluster 11, also with a low summed dioxin-furan concentration. The bottom core section falls into cluster 9, statistically similar to cluster 11. These two clusters represent a unique congener pattern, one dominated by 1,2,3,4,6,7,8-HpCDD. As mentioned in the discussion of cluster 9 congener patterns dominated by this congener are not found in the literature.

#### Station 235A

Figure 4-23 shows core Station 235A, this station is located in mid channel of the Lower Passaic River 0.6 kilometers upstream from the Diamond Alkali Site. The figure shows the Activity Profile of Lead 210 and Cesium 137, with the core sections symbolized by cluster and summed dioxin-furan concentration. Also shown are age surfaces determined by bathymetric survey analysis.

**Figure 4-31 Core Station 235A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



The Lead 210 activity curve is quite chaotic making age range determination of the individual sections useless. This station is located in the middle of the dredged channel, an area prone to accumulation of coarse material, which does not readily sorb radionuclides. Cesium 137 activities show a much smoother curve with the peak occurring at a depth of 138 centimeters. This sample shows no unusually high Lead 210 activity indicating it represents a true activity peak, not one driven by physical factors such as grain size, organics or meteorological events. The Cesium 137 peak, corresponding to a date of 1964, correlates well with the 1966 bathymetric surface, located at a depth of 118 centimeters (cm). This yields an average sedimentation rate of 4.01 cm per year between 1966 and 1995.

The core section showing the highest dioxin-furan contamination is the interval 149 cm to 173 cm. This is immediately prior to the Cesium 137 peak and the 1966 bathymetric surface. The lowermost core section also falls into cluster 8 extending to a depth of 214 cm. This depth coincides with the Cesium 137 activity falling to zero indicating a date prior to 1954. This is well before the accident at the Diamond Alkali Site. Due to the thickness of the core section the dioxin-furan contamination concentration could be very high in the top of the sample. The top of the core section is at 173 cm, assuming a constant rate of deposition from the 1966 surface to the 1954 Cesium horizon, the top of the core dates to 1959, with enough uncertainty to push the date beyond 1960. Prior to the explosion the site was producing 2,4-T, before 1958 there was no connection to the Passaic Valley Sewerage System so presumably waste was discharged directly into the Passaic River.

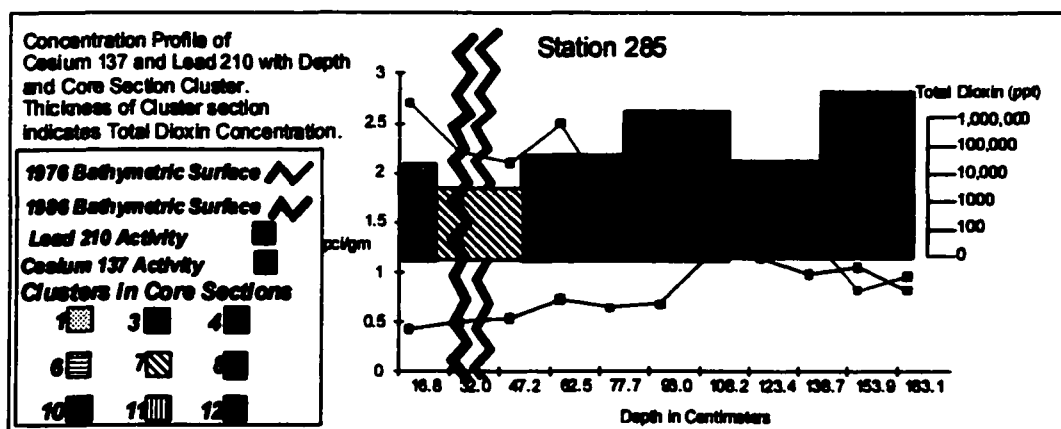
The two core sections above cluster 8 fall into cluster 7. The lower of these two sections is high in summed dioxin-furan contamination, at a level similar to the core section immediately below it. The upper section measured a summed dioxin-furan concentration slightly over half of the lower section. The top section of the core falls into cluster number 4, present in two core sections extending from a depth of 100 cm up to 15 cm. This region of the core shows a large

decrease in summed dioxin-furan concentration, both from the sediments above and below. Assuming a constant deposition rate between 1966 and 1995 the bottom of this section dates to around 1970. The surficial section of the core falls into cluster 6. The high surficial dioxin-furan concentration is likely due to enrichment from the high organic carbon content of the sediment water interface.

#### Station 285A

Station 285A is located approximately 15 meters from the bulkhead line immediately offshore of the Diamond Alkali Site. This station is along the south bank of the Passaic River, water depth as of the 1999 bathymetric survey was under 0.5 meters. Figure 4-34 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-32, Core Station 285A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



This core measured the highest dioxin-furan concentrations in any of the studies and some of the highest dioxin-furan concentrations ever measured in the ambient environment. Two historical bathymetric studies are available for this area, 1986 and 1976, these are plotted in Figure 4-34. The 1986 study showed a depth of 26 cm, the 1976 study measured a depth of 32

cm. The Lead 210 activity does not show a "smooth" activity profile, large variations occur down core. The core section does not extend deep enough to estimate supported Lead 210 activity, further precluding the use of Lead 210 dates. The Cesium 137 activity shows a plateau rather than a peak between the depths of 108 and 153 cm. The core also does not extend down to the depth where Cesium 137 activity ceases, marking the 1954 time horizon.

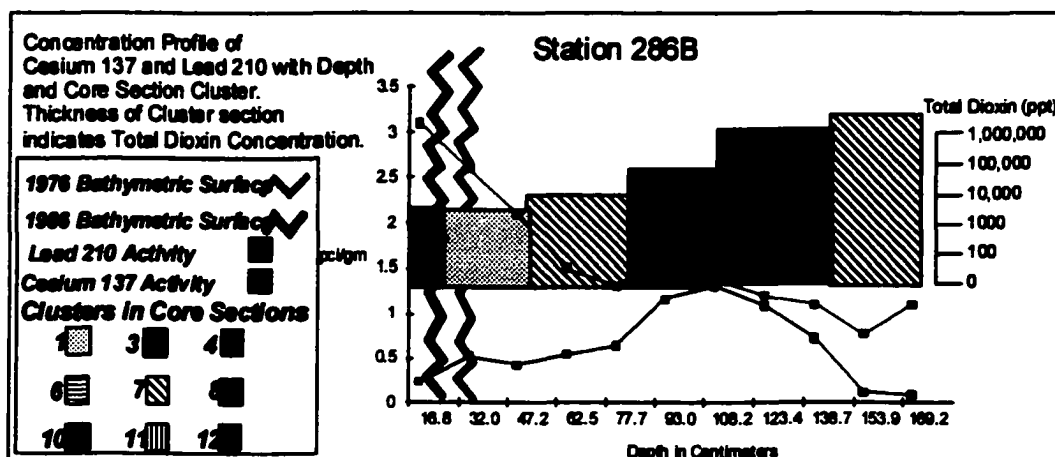
The surficial sample for this core fell into cluster 12. As mentioned in the section on core descriptions cluster 12 is the closest cluster in principal component space to the sump sediment sample taken from the Diamond Alkali Site. The sump was installed after the explosion on the site when the new 2,4,5-T manufacturing building was constructed. The summed dioxin-furan concentration of this sample was 46.2 ppb, the second highest value of any surficial point. The sample from 15 to 45 cm. straddles both the 1986 and 1976 bathymetric surfaces, this would date the sample to a time period between 1970 and 1990. The summed dioxin-furan concentration is 16,882, the lowest for the core. The sample from 45 to 76 cm is in cluster 8, summed dioxin-furan concentration was 94.2 ppb. The core section below this, from 76 cm to 106 cm, included the depth at which Cesium 137 activity begins to decline, marking the mid 1960's. The Cesium activity maximum occurs as a plateau rather than a single peak. This implies rapid sedimentation in the time period 1960 – 1964. The core section from 106 cm to 137 cm had a lower summed dioxin-furan concentration (43 ppb.) than the sample either above or below it. It fell into cluster 8 as did the bottom core sample. The bottom sample, depth interval 137 to 165 cm, measured a summed dioxin-furan concentration of 5,505 ppb, an extraordinarily high accumulation of dioxins. This is likely the highest dioxin-furan concentration ever measured in the ambient environment, this sample alone contained a quarter gram of summed dioxin-furans at such a concentration. The Cesium 137 activity at a depth of 154 cm, the midpoint of this core section, is only 10% lower than the highest activity in the core. This value indicates a date of no earlier than 1960 when atmospheric levels of Cesium 137 began to rise to their highest level. The date

connects the sample with the only possible source for such a massive amount of dioxins, the explosion of a 1000-gallon 2,4,5-T reactor vessel at the adjacent Diamond Alkali Site.

#### Station 286B

Station 286B is located less than 20 meters from the bulkhead at the northeast corner of the Diamond Alkali Site. Water depth as of the 1999 bathymetric survey was around 0.5 meters. Figure 4-35 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-33, Core Station 286B showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



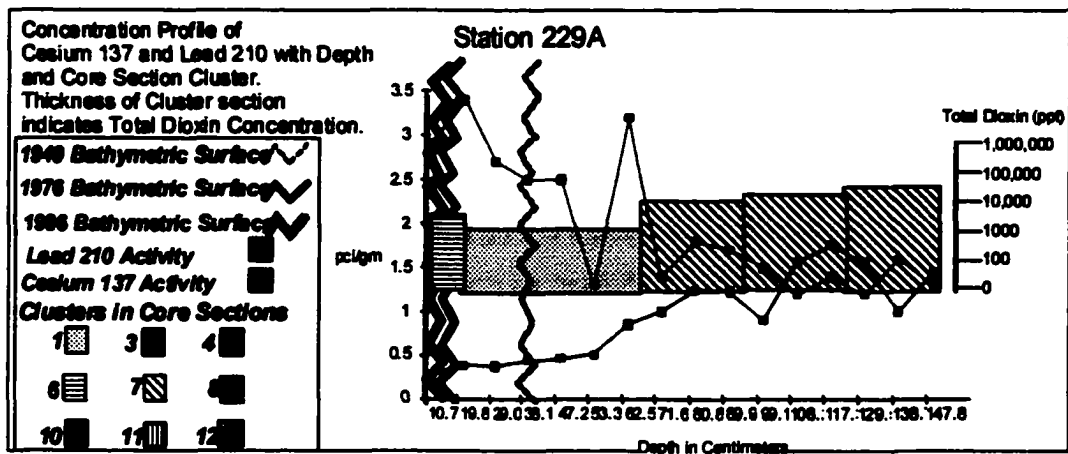
The only historical bathymetry available for the area of station 286 was the EPA survey of 1986 and the Corps of Engineers survey of 1976. The 1986 surface occurs at a depth of 15 cm while the 1976 surface is at 22 cm. The Cesium 137 activity curve shows a smooth depositional curve peaking at a depth of 108 cm and reaching the non detect level at a depth of 154 cm. The Lead 210 activity shows a nearly constant decrease down core, it does not reach a level where the supported Lead 210 activity can be pinpointed with confidence. Supported Lead 210 can also be estimated from values at adjacent station, however core station 285A also does not extend deep enough to make this estimation.

The surficial sample in this core is part of cluster 3; summed dioxin-furan concentration was 13 ppb. The top buried core, extending from 15 to 45 cm, falls into cluster 1 with a summed dioxin-furan concentration of 12.4 ppb. This sample dates between approximately 1985 and 1972 based on the historic bathymetric data and the resulting depositional rate. The sample below this is part of cluster 7; summed dioxin-furan concentration is 19 ppb. This core section falls into the late 1960 to early 1970 time horizon based on Cesium 137 activity and the historical bathymetry. The Lead 210 activity in the bottom of this core section dates to a range of 1985 – 1976, this is inconsistent with the historical bathymetric information. The core section from 76 to 106 cm is part of cluster 8, summed dioxin-furan concentration was 86 ppb. The peak of Cesium 137 activity marks the bottom of this core dating it to the 1964 time horizon. The core section below this, 106 to 138 cm, also falls into cluster 8, this core section measured a summed dioxin-furan concentration of 1,341 ppb. The top of the core dates to around 1964 while the bottom dates to approximately 1958, 2/3 of the way between the 1954 no-detect level and the 1964 peak of Cesium 137. The bottom core section extended from 138 to 167 cm fell into cluster 7. The summed dioxin-furan concentration in this sample was 2,073 ppb, the second highest dioxin-furan concentration in all the samples used in this analysis. This core section dates to a time horizon prior to the 1960 explosion on the Diamond Alkali Site. The site was manufacturing 2,4,5-T since 1951 so a spill or discharge during the 1950's could be responsible for the high 2,3,7,8-TCDD concentration in this sample. The sample contains a large amount of a congener which is rare in most samples, 1,2,3,4,7,8-TCDF. This sample also contains the highest concentration of pp-DDT, it was measured at a concentration of 9,520 parts per million (ppm). DDT was manufactured at the Diamond Alkali Site until the explosion in 1960 with peak production occurring during the 1940's.

### Station 229A

Station 229A is located mid channel in the Lower Passaic River, directly across from the Diamond Alkali Site. It is located within the limits of the Federal Channel. Water depth as of the 1999 bathymetric survey was just over 4 meters. Figure 4-37 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-34, Core Station 229A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth**



This core is located in one of the deeper sections of this area of the Lower Passaic. The pattern of historical bathymetry and radioisotopes indicate an area that has alternated between deposition and erosion, a phenomenon to be expected in the middle of the channel along a bend in the River. The 1986 and 1976 bathymetric surfaces differ by only 1 cm, indicating either a lack of deposition for a decade or, more likely, periodic erosion and deposition. The 1949 bathymetric surface is found at a depth of 33 cm. Cesium 137 activity peaks at a depth of 117 cm. Since this is below the 1949 surface this area must have experienced erosion between 1949 and the early 1960's. Lead 210 shows a number of buried spikes in activity levels that are likely due to changes in grain size, common in the thalweg.

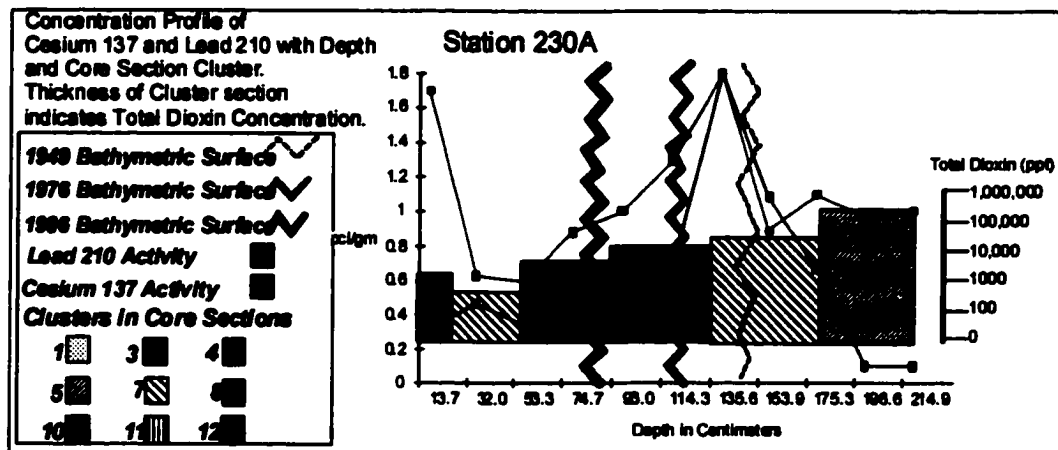


The dioxin-furan congener patterns reflect these depositional changes. Cluster 8 is not present within this core although it is immediately offshore of the Diamond Alkali site. The turbulence in this area mixed the sediments to obscure any strong signal. The surficial core is cluster 6, indicating that recent deposition has taken place. Summed dioxin-furan concentration for this sample was 9.9 ppb. The first two subsurface samples were part of cluster 4, summed dioxin-furan concentrations were 3.9 and 4.7 ppb moving down core. The remaining samples in this core were part of cluster 7. Summed dioxin-furan concentration increased down core; 6.9 ppb from 70 - 97 cm, 12 ppb from 97 – 124 cm and 25 ppb from 127 – 149 cm. The Cesium 137 peak occurs in the middle core section of these 3 samples. The temporal pattern of the cluster sequence and summed dioxin-furan sequence correlates well with the Cesium 137 peak, dating the bottom sample to the early 1960's.

#### **Station 230A**

Station 230A is located on the north bank of the Lower Passaic River, directly across from the Diamond Alkali Site. It is located within the limits of the Federal Channel. Water depth as of the 1999 bathymetric survey was slightly less than 4 meters. Figure 4-35 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-35, Core Station 230A showing Radioisotope Activity Profiles, Furan Cluster results and Summed dioxin-furan concentrations by depth.**



This station is located on the outer edge of the meander, generally an area of strong currents, deposition of coarse material and frequent erosion. The historical bathymetric record shows very variable deposition rates. The 1949 bathymetric surface was found at a depth of 138 cm, 24 cm below the 1976 bathymetric surface located at 114 cm. This indicates an average deposition rate under 1 cm per year. The 1986 surface is found at a depth of 77 cm, this calculates to a deposition rate of 3.7 cm per year. The radioisotope profiles also show an erratic pattern. Lead 210 drops precipitously from the surficial sample to the first two buried samples and then rises down core to a peak at 122 cm. This 22 cm level is the peak for the Cesium 137 activity.

The surficial sample falls into cluster 3, summed dioxin-furan concentration was 7.1 ppb. The core section from 15 to 42 cm was part of cluster 7 with a summed dioxin-furan concentration of 3.7 ppb. The next two samples, from 48 to 85 and 85 to 121, are classed as cluster 8. Mean dioxin-furan concentration is 15.8 ppb for the upper sample and 25.2 for the lower sample. Samples in cluster 8 are primarily associated with the early 1960 time horizon; these samples contain the 1986 and 1976 bathymetric surfaces and are therefore much younger. This results from the turbulence of this area, sediments churned by the stronger currents along the

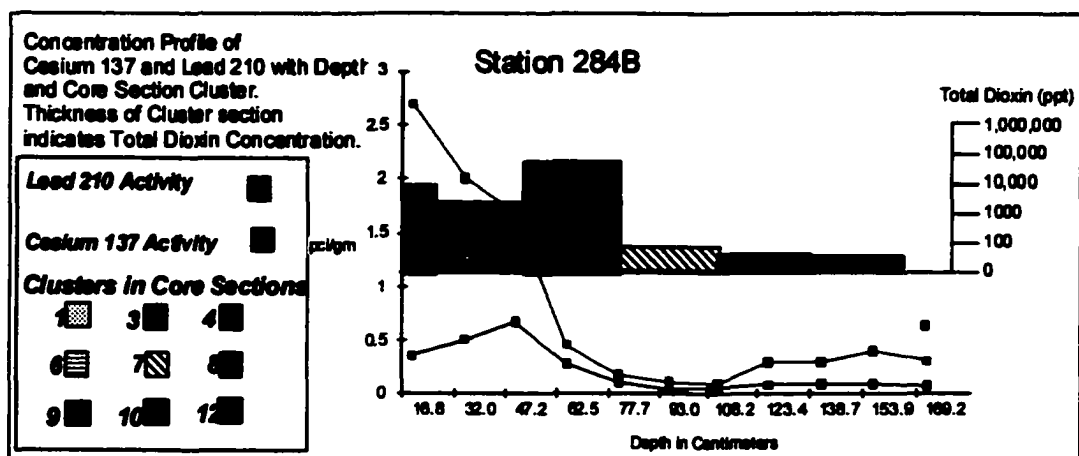
outer bend corrupting the radioisotope activities. Periodic erosion may have scoured out the sediments below the 1949 surface at some point after the survey, and then deposition filled in the area with newer sediments uncorrelated with the established time horizon.

The core section from 121 to 170 cm is classified as cluster 7; it contains a summed dioxin-furan concentration of 25 ppb. This cluster generally occurs above or below cluster number 8, it appears to represent long-term contamination from the production of 2,4,5-T. This signature matches soil samples and a sump sediment sample taken on the site. The bottom sample in this cluster was classed as cluster 5, found in only 16 other samples. Summed dioxin-furan concentration was very high at  $2.1 \times 10^2$  ppb. The dioxins in this cluster may result from a spill event, a number of other cores show cluster 5 in a similar position below the Diamond Alkali sequence of clusters 7 and 8.

#### **Station 284B**

Station 284B is located 0.5 kilometers downstream from the Diamond Alkali Site and 0.3 kilometers upstream from the New Jersey Turnpike bridge. This station is along the south bank of the Passaic River. Water depth as of the 1999 bathymetric survey was just over meter. Figure 4-33 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-36, Core Station 284B showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



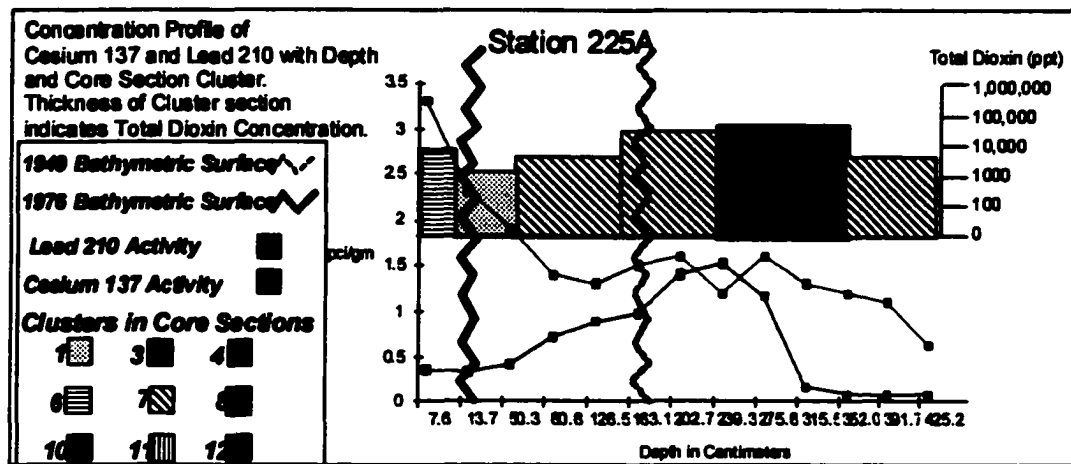
This area was not surveyed during the 1976 or 1949 bathymetric cruises, the area is shallow and close to shore. A comparison of the 1999 and 1986 bathymetry shows that erosion took place during this time period. The radioisotope activities showed depositional profiles for the sequence below this. Lead 210 steadily declined down core and Cesium 137 increased and then declined. The Cesium 137 maximum occurred at a depth of 45 cm. The surficial core fell into cluster 3 with a summed dioxin-furan concentration of 11.4 ppb. Cluster 3 was the most common surficial cluster in this stretch of the river. The 15 to 45 cm core section was in cluster 4, summed dioxin-furan concentration was 8.4 ppb. The bottom of this core contains the sample that measured the maximum Cesium 137 activity; this would date it to approximately 1964. The Lead 210 activity shows a much younger date, the mid 1980s. The core section from 45 to 76 cm falls into cluster 8, it had the highest summed dioxin-furan concentration in the core at 87 ppb. The Lead 210 activity of the radiometric sample within this core section, at a depth of 62 cm, calculates to a date in the mid 1960's.

The core section from 72 to 106 cm fell into cluster 7, summed dioxin-furan concentration was very low at 0.4 ppb. At the bottom of this core Cesium 137 was not detected, this dates the depth to pre-1954. The bottom two samples showed very low summed dioxin-furan concentration, which would be expected from samples of this age. The sample from 106 to 137 cm was in cluster 10; summed dioxin-furan concentration was  $9 \times 10^{-2}$  ppb. The bottom sample, extending from 137 to 167 cm, was classed as cluster 9 with a summed dioxin-furan concentration of 0.03 ppb.

#### **Station 225A**

Station 225A is located 300 meters downstream from the Diamond Alkali Site. It is at the south edge of the Federal Channel. Water depth as of the 1999 bathymetric survey was just over 2 meters. Figure 4-38 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-37, Core Station 225A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth**



The 1986 bathymetric surface was found at a shallower depth than the 1999 bathymetry, indicating erosion between these time periods. The 1976 surface is at a depth of 12 cm, the 1949 surface was at 178 cm. The other temporal data for this station, radioisotope dating, is not in agreement with this data. The Cesium peak is found at a depth of 239 cm. The 1949 bathymetric surface was measured soon after the last dredging episode in this section of the River. The channel would have been dredged to approximately its project depth of 20 feet (609 cm). This edge area was measured to be 201 cm shallower, creating a slope toward the middle of the channel where erosion was likely to take place. The Cesium drops to undetectable levels at a sediment depth of 315 cm, indicating a pre 1954 time horizon. Lead 210 did not show a smooth decay curve, between a depth of 90 and 315 cm the activity level reached a plateau. The time periods yielded by Lead 210 fluctuated between 1975 and 1985 for this area of the core, in disagreement with the 1976 bathymetric surface.

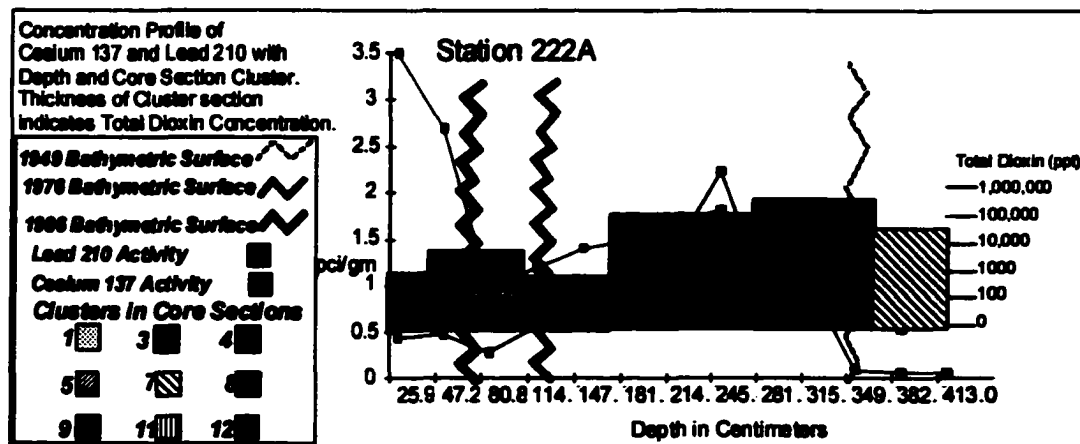
The surficial sample was part of cluster number 6, summed dioxin-furan concentration was 8.8 ppb. The bottom of this sample was marked by the 1976 bathymetric surface. The initial subsurface core section fell into cluster 4; summed dioxin-furan concentration was roughly half of the surficial sample at 4.9 ppb. the core section from 64 to 140 cm was part of cluster 7,

summed dioxin-furan concentration was 8.4 ppb. Summed dioxin-furan concentration showed a large increase down core; the section extending from a sediment depth of 140 cm down to 268 cm had a summed dioxin-furan concentration of 43 ppb. This sample was also part of cluster 7. The next two core sections were in cluster 8, dioxin-furan concentration was 73 ppb for the 204 – 268 cm section and 73 ppb for the 268 to 338 cm section. The maximum Cesium 137 sample marked the top of these two sections; at the bottom of the sections Cesium 137 was undetected. This dates this segment to the 1954 – 1964 time horizon. The bottom core section, at a depth interval of 338 – 426, had a summed dioxin-furan concentration of 6.9 ppb, an order of magnitude drop from the section above. It was classed as cluster 7. This Cesium activity within this sample was undetected, this indicates a time period prior to 1954.

#### **Station 222A**

Station 222A is located 0.75 kilometers downstream from the Diamond Alkali Site, in the middle of the River near the south edge of the Federal Channel. Water depth as of the 1999 bathymetric survey was just over 2 meters in depth. Figure 4-28 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-38, Core Station 222A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



The 1949 bathymetric surface is located at a depth of 334 cm within the core. Due to the rapid accumulation of sediment this time period surface may actually be deeper. Compaction of deposited sediment has not been accounted for previously, but with the deep accumulation in this core it is likely to be significant. The 1976 bathymetric surface is at a depth of 110 centimeters, and the 1986 surface was at a depth of 48 centimeters. The Lead 210 profile does not yield useful results, it activity decreases down to 80 centimeters then shows an increases in the next 5 samples down core. The Cesium 137 activity shows a peak at a depth of 245 centimeters.

The bottom sample in the core is statistically in cluster number 7; it extends from a depth of 335 to 411 cm. This depth dates the sample to before 1949 based on the bathymetric surface. As mentioned this may be an overestimation of the age of this cluster. The core section above, from 268 to 335 cm falls into cluster 8. This sample has a very high summed dioxin-furan concentration at 142 ppb. This sample is below the Cesium peak, dating it prior to 1964, and above the 1949 bathymetry surface. The sample above this is also in cluster 8, summed dioxin-furan concentration is slightly lower, but still quite high, at 70 ppb. This sample straddles the Cesium 137 peak. Summed dioxin-furan concentration in the sample extending from 97 to 158 cm drops by an order of magnitude to 8 ppb, the sample is statistically part of cluster 4. This

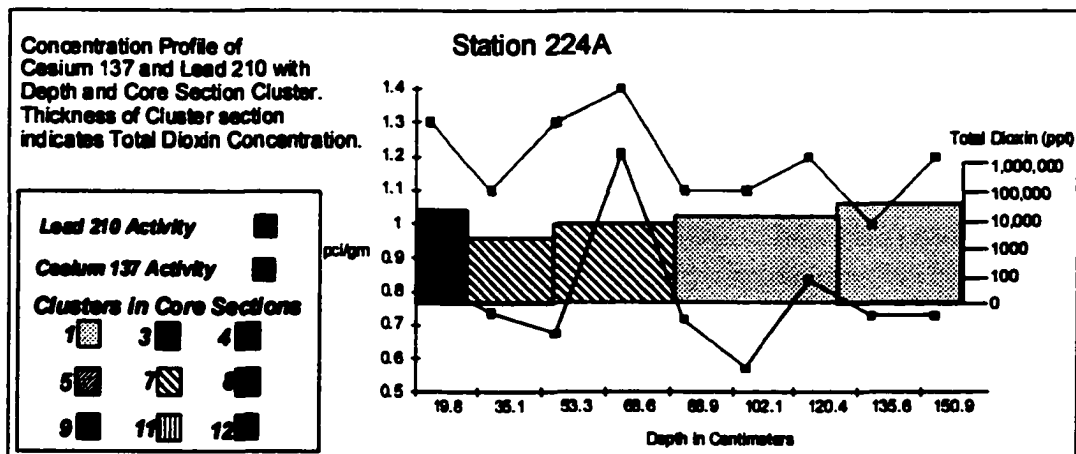


sample contains the 1976 bathymetric surface dating it to the early 1970's. The sample from 15 cm down to 97 cm falls into cluster 5, summed dioxin-furan concentration increases to 28 ppb. This sample contains a very high percentage of octa-chlorinated furan, 79 percent of the summed dioxin-furan furan concentration. The surficial sample falls into cluster 3, summed dioxin-furan concentration is 11 ppb.

#### Station 224A

Station 224A is located in the same transect as station 222A. It is outside the Federal Channel near the north bank of the Lower Passaic. The station is approximately 0.75 kilometers downstream from the Diamond Alkali Site. Water depth as of the 1999 bathymetric survey was just over 3 meters. Figure 4-29 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-39, Core Station 224A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



This station is in an area of active erosion. It is located on the outer bank of the final meander in the Passaic before it empties into Newark Bay. Water depth as of the 1999 survey was 326 cm; the 1986 survey measured a water depth of 289 cm, indicating the removal of 36 cm of

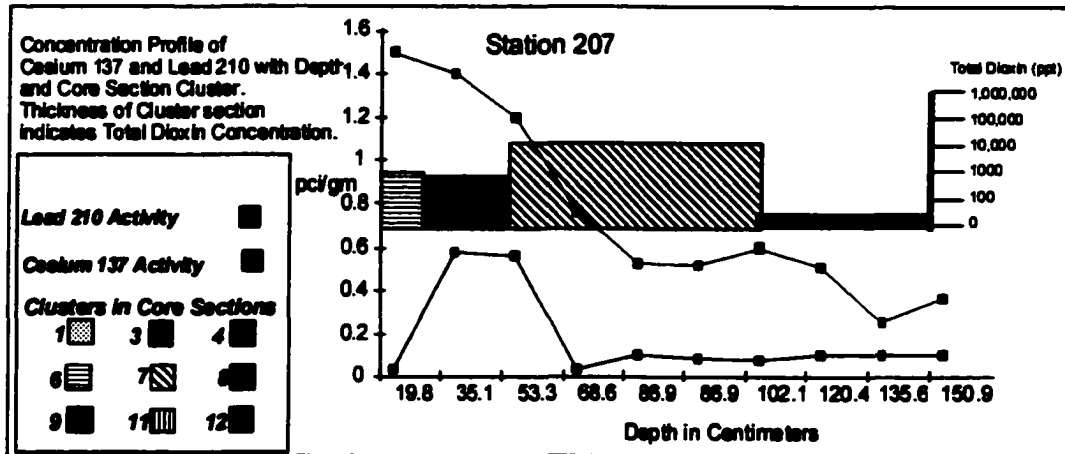
material over this time period. The 1976 Corps of Engineers survey showed a water depth of 231 cm, a removal of 58 cm in the 10-year period 1976-86. The Lead 210 activity was not useful for dating, the surficial activity cannot be determined and the profile shows a decrease and then increase down core. The Cesium 137 profile is not useful either; the maximum sample is also a maximum Lead 210 sample indicating both are likely the result of meteorological or hydrological conditions.

The surficial sample in this core is part of cluster 8, the only location in which cluster 8 is not found in a buried sample. The summed dioxin-furan concentration in this sample is 28 ppb. The presence of this contamination at the sediment surface is a cause for concern due to the high toxicity of cluster 8. The core sample between 15 and 45 cm falls into cluster 7; summed dioxin-furan concentration was 7.5 ppb. The sample below this is also in cluster 7 with a summed dioxin-furan concentration of 11.7 ppb. The bottom two samples are in cluster 1; from 106 to 137 the summed dioxin-furan concentration was 32.9 ppb and from 137 to 167 summed dioxin-furan was measured at 80.5 ppb. This was the second highest summed dioxin-furan concentration in any of the samples in cluster 1.

#### **Station 207A**

Station 207A is located approximately 2.5 kilometers downstream from the Diamond Alkali Site on the west bank of the Passaic River. It is outside the Federal Channel, water depth as of the 1999 bathymetric survey was under 2 meters in depth. Figure 4-28 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-40, Core Station 207A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



This station is located near the bank of the Passaic, about 200 meters upstream from the Getty Oil Doremus Avenue terminal. The immediate area was not surveyed during the 1949, 1976 or 1986 surveys. This area is along the bank of the river, surrounded by the dredged Federal Channel and frequently dredged slips. Water depth varies by hundreds of centimeters over a short distance so no bathymetric information could be assigned. The radioisotope activities show conflicting dates. Only the top three Cesium 137 samples show activity above non-detects, extending down to 53 cm. Lead 210 activity shows a smooth decline down core. The range in dates given below for core section descriptions is based on the uncertainty in determining supported Lead 210 activity.

The surficial sample falls into cluster number 6, summed dioxin-furan concentration was 9 ppb. The core section from 15 cm down to 45 cm was part of cluster 4; summed dioxin-furan concentration was 8.5 ppb. Lead 210 activity yields a date of 1978 – 1980 for the top of the section and 1975 – 1978 for the bottom of the section. The next two core sections are in cluster 7, the top sample extends from 45 to 76 cm, the lower sample from 76 to 106 cm. Summed dioxin-

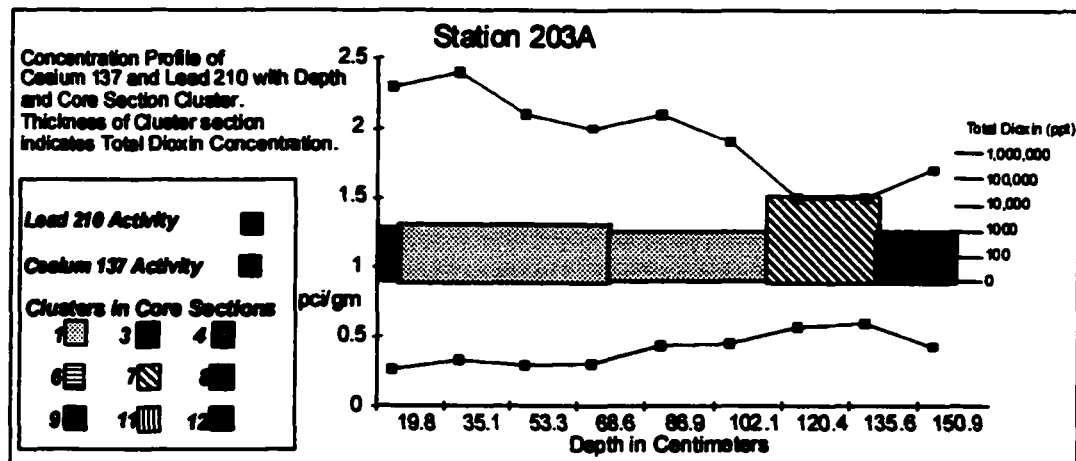
furans concentrations were high in both samples, 18.4 ppb in the upper and 14 ppb in the lower. The date ranges for these samples, from Lead 210 activity, were 1975 – 1978 at the top of the sections and between 1965 and 1956 at the bottom of the section. The uncertainty in date calculation increases as Lead 210 activity decreases approaching the supported level. Summed dioxin-furan concentration drops dramatically in the bottom two core sections, both cluster 4, to 0.4 ppb for the 106 – 137 cm section and 0.1 ppb for the 137 – 167 cm section.

Cluster 8 does not appear in either of the two cores just described, located below the Lincoln Highway. This area was regularly dredged between 1960 and 1995, both channel maintenance dredging and the dredging of bulkhead slips. This resulted in sediment dispersion and mixing, diluting the dioxin-furan contamination from the Diamond Alkali Site. In addition the dominant bottom current is upstream, the downstream transport of dioxin-furan contamination would require a longer transit time and additional mixing resulting in the primary pattern being cluster 7 rather than 8.

#### **Station 203A**

Station 203A is located about 3 kilometers downstream from the Diamond Alkali Site on the east bank of the Passaic near the point where the Passaic empties into Newark Bay. It is outside the Federal Channel, water depth as of the 1999 bathymetric survey was just over 2 meters in depth. Figure 4-27 shows the in core profile of radioisotope activity, dioxin-furan cluster results and the summed dioxin-furan concentration for this core all plotted against depth.

**Figure 4-41, Core Station 203A showing Radioisotope Activity Profiles, Cluster results and Summed dioxin-furan concentrations by depth.**



The 1966 bathymetric surface occurs at a depth of 177 cm in this core. This yields an average sedimentation rate of 6.1 cm per year for the 1966 – 1995 time period. Lead 210 activity shows a continuous decrease and yields some usable dates. The core did not penetrate far enough to determine the supported Lead 210 activity, however nearby station 207A did penetrate deep enough to estimate supported activity in this area. The Cesium 137 activity shows a peak at the 135 cm level

The bottom core section falls into cluster 4, summed dioxin-furan concentration is 15 ppb. The section is dated by Cesium 137 peak at the top of the section. The bottom of the section is undatable, Lead 210 activity exceeds the sample above it and therefore yields a younger date. The next core section falls into cluster 7. The top of the core dates, using Lead 210 activity, to 1975  $\pm$  5 years. The summed dioxin-furan in this section is 21.4 ppb. The next two core sections fall into cluster 1, summed dioxin-furan concentration is 8.4 and 7.8 ppb for the upper and lower cluster 1 sections respectively. The surface sample falls into cluster 3, it contained a summed dioxin-furan concentration of 7.5 ppt.

This is the furthest downstream station at which a sample falls into one of the two clusters, 7 and 8, identified as being derived from the contamination at the Diamond Alkali Site. The lower cluster falls into a cluster not identified with the Diamond Alkali Site. However this sample showed a high 2,3,7,8-TCDD component (0.15) compared with other samples in this cluster. 2,3,7,8-TCDD is the primary congener in the dioxin-furan contamination at the Diamond Alkali Site. The ratio of 2,3,7,8-TCDD to OCDD is 0.88, an indicator that a significant component of the 2,3,7,8-TCDD contamination is derived from the Diamond Alkali Site.

## **Chapter 5 Summary and Conclusions**

Sediment sampling results from a number of studies were examined and evaluated for the spatial, statistical and temporal patterns in dioxin concentration and dioxin congener patterns. Dioxin contamination is ubiquitous in the sediments of the Hudson Estuary. These chemicals are found throughout the Estuary from the oil soaked clays of the Arthur Kill to the sands of the Lower Bay. This is not surprising, as research has shown the presence of dioxin in the discharge of a large number of common human activities. These include a variety of combustion processes, chemical synthesis and the treatment and disposal of human waste.

### **Dioxins and Human Risk**

Dioxins are considered the most toxic human synthesized chemical. They produce a variety of effects in animals; all are based upon the dioxin molecule binding to the Aryl Hydrogen (AH) Receptor site. The effects associated with dioxin uptake include chloracne, liver malfunction, the promotion and possibly initiation of cancer and death. There have been a number of industrial accidents in which humans have been exposed to high levels of dioxins, however most people are exposed to continuous low levels through the ingestion of food. The Food and Drug Administration has issued guidelines for consumption of food containing dioxins. Food containing over 1 part per trillion dioxin TEFs is not considered by the US FDA safe for consumption.

Within an ecosystem such as the Hudson Estuary, dioxins have been shown to bioaccumulate in marine life and become biomagnified up the food chain. Organisms tested for dioxin contamination in the Hudson Estuary, especially the Lower Passaic, have dioxin contamination that significantly exceeds the recommended guideline for consumption. Since the investigation by the New Jersey DEP in 1983 the Lower Passaic has been under fish consumption advisory recommending no consumption of fish caught in the area. The population of the area

surrounding the Lower Passaic is composed of a high percentage of recent immigrants, a group which is generally mistrustful of authority. Considerable anecdotal evidence (Sandiford, 1996) exists that the health warnings on fish consumption are ignored creating a genuine health risk.

In the Hudson Estuary, the highest concentrations of these chemicals are found in the Lower Passaic River. In certain buried sediment samples taken adjacent to the Diamond Alkali site dioxin concentration was measured at over 5 parts per million, an extraordinarily high number for a contaminant usually measured in parts per trillion. These high values are limited to the area immediately adjacent to the site. Away from the vicinity of the site, upstream about 6 kilometers and downstream about 3 kilometers, the dioxin concentrations are merely very high. Clearly this contamination was the result of an industrial accident, which took place at the Diamond Alkali Facility on February 20, 1960.

### **The Analysis**

Statistical tools such as principal components analysis and cluster analysis allow the multitude of sediment samples taken in the Harbor Estuary to be grouped together into a smaller set of variables and groups. The spatial and temporal distribution of these derived datasets can then be more easily examined with respect to industrial activity in the area of interest, environmental regulation, cultural trends and industrial accidents. The use of a Geographic Information System (GIS) allowed the sample points to be analyzed for spatial correlation with sources of dioxin contamination. Time horizons were established using radioisotope activity from samples measured for Cesium 137 activity and Lead 210. Additional temporal data were supplied by historical bathymetric data obtained from the US EPA and the US Army Corps of Engineers. The GIS enabled examination of historical bathymetric data to derive deposition rates and ascertain hydrologic conditions.



The results of this analysis indicate that current deposition of dioxin contamination in the Harbor Estuary is dominated by combustion sources such as automobiles, trucks and to a more limited extent, municipal and industrial incineration. The common dioxin-furan congener signatures from these sources dominate the 339 surficial samples used in this examination. This signature contains primarily the higher chlorinated dioxin furans, especially octa-chlorinated dioxins and furans. In the Lower Passaic River the dioxin-furan signatures show a slight shift toward the lower chlorinated dioxins. In this area chemical facilities are tied into the municipal sewage system, during combined sewage overflow events this effluent is discharged directly into the Passaic. An additional source of lower chlorinated dioxin in the surficial samples is historical dioxin contamination. Until the establishment of regulations on the discharge of industrial waste beginning in the 1970's, industrial facilities routinely discharged toxic material into inland waterways. The contaminant record in the Passaic River attests to this abuse.

The Lower Passaic above the Lincoln Highway has not been dredged since 1949. Sediment accumulation has occurred throughout this area, at a very rapid rate in some spots. Average deposition rates ranged between 0.25 and 8.5 centimeters per year. The temporal analysis of radioisotope activity and historic bathymetry showed that in a number of areas deposition was initially rapid but then leveled off and in some locations sediment erosion took place. When anthropogenic removal of sediment ceased the River returned to its typical configuration, a regime that includes periodic deposition and erosion due to changing hydrologic conditions. In certain places such as station 224A and 285A formerly buried dioxin contamination from the 1960's has been re-exposed in the riverbed.

Subsurface samples show a more complex array of dioxin-furan congener patterns representing spatial and temporal variations in dioxin sources. Two patterns, clusters 1 and 4 are present spatially in all areas of the Harbor Estuary and temporally throughout the core. Cluster 1 occurs in samples above the Dundee Dam, removed from the contamination prevalent in the

harbor Estuary. Calculated time horizons for samples with these patterns date prior to the 1954 Cesium 137 no-detect level and the 1949 bathymetric surface. The principal component plot indicates that these clusters represent a mixing of numerous dioxin sources including combustion sources, chemical discharges and sewage treatment plants. The spatial distribution of these samples suggests that the sources are ubiquitous to the entire watershed as cluster 1 was found in a sample above the Dundee Dam.

Other dioxin patterns are more localized both spatially and temporally. Cluster 9 was found in samples that date to the 1950's. The congener pattern of cluster 9 is unusual, 1,2,3,4,6,7,8-HpCDD dominates it. Such a pattern is not found in the published literature. The samples in this cluster are not evenly dispersed, instead there are four distinct areas of significant concentration levels that may represent point sources or spill locations. Thick accumulations are found around stations 289 and 290 on the inner bend of the Lower Passaic. A single sample adjacent to the Diamond Alkali Site had a 1,2,3,4,6,7,8-HpCDD concentration of 38 ppb and a summed dioxin-furan concentration of 58 ppb. This cluster possibly represents a previously uninvestigated source of dioxin contamination. The Lower Passaic is home to many candidate contamination sources. Much of the wetlands formerly surrounding the Lower Passaic River were filled in using waste material from the local coal gasification plants. DDT was manufactured at the former Diamond Alkali Site prior to and for a time period along with the production of 2,4,5-T.

Cluster 11 is spatially, statistically and temporally related to cluster 9. It represents a mixing of the distinct pattern of cluster 9 with the background general pattern of clusters 1 and 4. This congener pattern needs further investigation and may represent a significant but unknown source of historical dioxin contamination. Its limited distribution within the samples is likely due to the failure of most of the cores to penetrate to the desired time horizon.

The most significant single source of dioxin contamination in the Harbor Estuary is clearly the Diamond Alkali Site. The plant was a significant producer of 2,4,5-T from 1952 until 1969. In addition to this ongoing source there was an industrial accident, which took place in 1960. An explosion and fire destroyed the 1,000-gallon 2,4,5-T reactor vessel, releasing large amounts of material onto the site (US EPA, 1996). As a result of the location of the process building, within 100 meters of the Passaic River, massive amounts of dioxin contamination were dumped into the Lower Passaic River. This contamination, derived from the synthesis of 2,4,5-T, left a distinct pattern of dioxins, primarily 2,3,7,8-tetrachlorinated dibenzo dioxin. This long-term production, as well as the explosion and fire, overlap the limited time period in which cluster 7 and 8 are found in the dated cores. These two clusters mark the presence of contamination from the former Diamond Alkali Site. They occur only in the lower stretch of the Passaic River, all other clusters with over 20 samples in them occur throughout the Newark Bay complex.

Cluster 8 contains the highest percentage of 2,3,7,8-TCDD; it is more limited than cluster 7 in both spatial and temporal extent. It represents a signature from the discharge associated with the 1960 explosion at the Diamond Alkali contamination. This was a one-time event in which the thermal and chemical conditions were unlike those of long-term production. Cluster 7 is representative of dioxin contamination resulting from the long-term activity on the site. It is statistically closest to the soil samples taken from the site and the sump pump sample. The sump collected waste liquid from 2,4,5-T production, it is representative of on-going production rather than the 1960 accident.

Principal Component analysis of the dioxin congeners demonstrated the close statistical relationship between these two clusters, and the statistical relationship with the remaining samples. Clusters 7 and 8 occupy the 2,3,7,8-TCDD region of the component diagram, one of the "arms" of the sample plot. Cluster 8 occupies the tip of the arm, far removed in component space from the remaining samples. Cluster 7 occupies the region of the plot where this arm intersects

the largest grouping of sample points, located in the middle of component space. Cluster 8 represents a unique event, the explosion and discharge of contamination that took place in early 1960. Cluster 7 is a transition between this unique signature and the "typical" dioxin congener patterns found scattered throughout the harbor. The merging between cluster 7 and the remaining sample points is very gradual, with no true gap. This indicates that contamination from the site is a significant component of other clusters. Cluster 1,4 and 11 shows a significant number of members with a relatively high ratio of 2,3,7,8-TCDD to OCDD. Bopp, et al., (1990) has cited a relatively high ratio of these two congeners as indicative of contamination from the former Diamond Alkali Site. Figure 4-21 shows the distribution of points in these clusters displayed by the 2,3,7,8-TCDD to OCDD ratio. All the points with a value over 0.75 occur within 6 kilometers of the former Diamond Alkali Site.

The temporal distributions of the clusters within the cores taken in the lower Passaic show a large influx of dioxin contamination in the late 1950's and early 1960's. Cluster 8 is more narrowly distributed both temporally and spatially than cluster 7. Within the vertical extent of the core sections it was often flanked by cluster 7. Core sections with cluster 8 were found on or below the Cesium 137 peak, dating the section to the early 1960's. Cluster 7 had a wider temporal range, the bottom of some core sections in which it was found dated to the Cesium 137 no detect level, associated with the early 1950's and the 1949 bathymetric surface. Cluster 7 was also found in younger sediments, as recent as core sections dated by the 1976 bathymetric surface. This overlaps the time period of active 2,4,5-T production at the site. Cluster 7 most closely matches soil samples and a sump pump sample taken from the Diamond Alkali Site.

The samples immediately offshore of the plant contain massive amounts of dioxins. Station 285 and 286 contain core sections with dioxin contamination over 1 part per million for a contaminant generally found in parts per trillion. The distribution of contamination reflects the prevailing pattern of bottom currents in the Passaic. As noted in chapter 2 the bottom currents in

the Passaic last longer and are stronger in the upstream direction. Cluster 8, representing a signature from the discharge associated with the 1960 explosion is more narrowly distributed than cluster 7. It is found as far as 1.3 kilometers downstream but extends 6 kilometers upstream. The downstream area between the Lincoln Highway Bridge and Newark Bay has been dredged frequently since 1960. This action has disrupted sediment accumulation; none of the stations in this area show radioisotope activity useful for dating. The dioxin contamination from cluster 8 is either not present due to circulation patterns, or was present and was removed by dredging. In the latter case the contamination would have been transferred out into the New York Bight to the Dredged Material Disposal Site, the Mud Dump Site. Upstream cluster 8 occurs in cores up to the limits of the EPA 1995 Remedial Investigation Sampling Study. The next upstream core station is 1.6 kilometers above this point. This station did not contain cluster 8. No radioisotope data was available for this station and it is outside the areas surveyed for bathymetry.

Samples with the cluster 7 pattern are found downstream from the site as far as top of Newark Bay. Upstream samples with cluster 7 extend to the limits of the EPA 1995 Remedial Investigation Sampling Study, with one sample located 7 kilometers above the limits of the study, 13 kilometers above the site. The contamination in this area is probably not from the Diamond Alkali Site, but results from activity on the Givaudan Roure Corporation site, a former manufacturer of 2,4,5-T. As mentioned previously, dioxin contamination was found on soils at this location. The presence of this contamination supports the conclusion that the dioxin contamination classified as cluster 7 results from long term operation of a 2,4,5-T manufacturing plant. No samples with cluster 8 were found in this area. Between this location and the last transect from the EPA 1995 study only three core samples were taken. The absence of clusters 7 and 8 may be an artifact of the sampling density, not the lack of contamination. Total dioxin concentration at the furthest upstream EPA 1995 station was high at 10 ppb. This concentration indicates that further upstream contamination is likely.

The Diamond Alkali Site represents the largest single source of dioxin contamination in the Harbor Estuary. The two clusters that represent contamination from the site; 7 and 8, account for 74.6 percent of the total dioxins measured in the studies, 94.5% of the 2,3,7,8-TCDD measured in all the studies. No doubt the sampling distribution is skewed toward finding dioxins from the site. However the two clusters identified with the Site were not found at all the stations in the area of densest sampling and always represented less than one quarter the bulk of sediments sampled at the core locations where they were found.

The spatial distribution of clusters 7 and 8 point to a single source. The spatial variation in concentration for cluster 8 points to a spill event, a onetime massive influx of contamination, which decreases in intensity radiating outward from the source, the Diamond Alkali Site. Temporal investigation of the samples containing this contamination dates the event to the early 1960s. This coincides with the explosion and fire that occurred at the Diamond Alkali Site on January 20, 1960. Cluster number 7 represents long-term production and discharge from the site, it is found at one other location, adjacent to an upstream facility that also synthesized 2,4,5-Trichlorophenol.

### **Other Studies**

The results from this study show a sharp contrast with some previous investigations of dioxin contamination in the Estuary. Wenning et al. (1993) and Ehrlich et al. (1994) examined surficial samples of dioxin concentrations. This analysis agrees with their conclusion that surficial dioxin concentration is largely due to incineration sources and is strongly influenced by the presence along the Lower Passaic of numerous Combined Sewer Overflow outlet pipes connected to a sewage system, which contains numerous industrial inputs. This analysis did find a few areas where contamination from the Diamond Alkali Site was present in surficial sediment. This has two implications; contamination was still migrating off site as of 1995 and that formerly buried

sediments have been re-exposed. The Lower Passaic River adjacent to the Site has not been dredged for 50 years. As the River returns to a natural equilibrium in terms of sediment deposition and removal it is highly likely that the River bottom will be restructured, possibly resulting in the exposure of sediments containing high levels of dioxin contamination. One such area was noted on the outer edge of the meander across from the site. Suspension of dredging would temporarily create an area of deposition, which would, under natural conditions, be an area of erosion.

Historical sediments from the area were analyzed by Huntley et al. (1998). They argue that for subsurface points; sewage sludge and PCBs are the major sources of dioxin contamination. This analysis found little evidence for assigning PCBs such an important role. The contamination levels of PCBs were for the most part only one or two orders of magnitude higher than the dioxin concentration. For PCBs to be a major source would require a dioxin contamination level, within the PCB contamination, of parts per thousand. In Wenning et al. (1993) dioxin levels in PCB taken from the literature area given as concentrations ranging from 1 to 5 parts per million. The total PCB to total dioxin ratio, for samples where both were measured ranged from 160,000 to 1. Samples with a PCB to dioxin ratio over 10,000, indicating a potential dioxin concentration in PCBs of 100 parts per million, represented only 33 of the possible. The total dioxin concentration in these samples was very low, from 1 to 94 parts per trillion. This indicates that PCBs are only a minor contributor to dioxin contamination in the Estuary.

The Huntley et al. (1998) investigation groups the samples into time periods for analysis. The samples assigned to the time period 1965 - 1970 are not included in the analysis as there are too few points. The 1965 – 1970 time period is shorter than the other time period groupings in the analysis, which were all 10 years or longer. This study found samples from that time period, in the area of the Diamond Alkali Site, to show strong statistical evidence for contamination derived

from the Site. Ignoring samples from this time period eliminates a large percentage of the dioxin contamination in the samples.

The congener distribution pattern of cluster 8 matches the pattern listed as end member 5065-3 in Huntley et al. (1998). The authors identified this pattern as the major contributor of dioxins at five stations; 5A, 17A, 21A, 75A and 81A. It is classified as an "unidentified end member" adjacent to a "two former 2,4,5-T manufacturing sites" (Huntley et al. 1998). Station 5A is near the Givaudan Chemical plant, the likely source of the contamination. The other former 2,4,5-T manufacturing site is the Diamond Alkali Site, this investigation shows that the contamination at the four other stations is clearly derived from this source.

### **The Future of the Passaic River**

The City of Newark is currently looking to revitalize its Passaic River waterfront, a process that has been successfully carried out in a number of former industrial areas. Plans include creation of a river walk, tax relief to attract restaurants and shops and construction of marinas. The presence of dioxin-contaminated sediment poses a problem for this process. Attracting commercial and private marinas would require dredging of sediments. In the area contaminated by the Diamond Alkali Site, a significant stretch of the Newark Waterfront, dredged sediments would require handling as toxic waste. This dramatically increases costs and has the potential to reintroduce high levels of dioxins to the water column and biologically active surficial zone of the sediments.

The issue bears a strong similarity to the PCB contamination of the Hudson River. Should the River be dredged to remove high levels of contamination or left alone in the hopes that contamination will be locked in place by overlying sediment. The Hudson River dredging issue is scheduled for a final decision in September of 2001. The Passaic River problem is more complex in terms of the causes of contamination. Dioxins represent just one of a large number of contaminants causing toxicity of the sediments. Currently the issue is being handled by the US



EPA's Superfund program, which must by law look for a potentially responsible party to share cleanup costs. Many of the companies known to have discharged contamination are no longer in business. The companies that are still around wish to avoid a disproportional penalty for their role in the contamination. Maxus Energy, successor to Diamond Alkali, has played a very active role in the process, albeit with the goal of avoiding blame and monetary penalties. Maxus, along with a number of other companies, have pushed for the US Army Corps of Engineers to take over the remediation of the Passaic River. The Corps of Engineers, unlike the US EPA, does not seek to recover costs by identifying responsible parties. Currently the US EPA is working with the Corps of Engineers to develop a strategy for dealing with the contaminated sediments until jurisdictional issues are resolved.

### **Future Investigations**

A wealth of information is available for the Hudson estuary, especially the Hudson River and the Upper and Lower Bays of the Estuary. Dennis Suzkowski (1976) did an excellent job of measuring and describing Newark Bay. Information on the Passaic River however is somewhat lacking in the literature, especially in light of the high levels of contamination and the exchange of this contamination with the rest of the Estuary. The Passaic River has been intensely impacted physically and chemically by anthropogenic activity since the last century. The reduction of these impacts offers an opportunity to chart the possible revitalization of a waterway. The cessation of dredging above the Lincoln Highway (see Figure 2-11) provides the chance to chart the restoration of sedimentation patterns in an urban waterway.

The dataset used in this analysis contains a wealth of information for other contaminant investigations. It includes sampling results for metals, PCBs, volatiles and a number of other chemical waste products that humans have seen fit to dump into the Hudson Estuary. The database was compiled by the National Oceanic and Atmospheric Administration's Office of

Response and Restoration (NOAA- ORR) and has been made available on the Web along with a set of tools for viewing the data.

The literature of statistical fingerprinting of dioxins consists of patterns of dioxin sources, patterns found in the ambient environments and attempts to match the two. This analysis indicated that there is a great deal of work to be done in both areas as statistical correlations between sources and ambient measurements were lacking. One reason for this is that dioxin source measurements look at current emissions while source measurement a examining dioxins produced decades ago by processes which no longer occur. A number of patterns were found, cluster 9 for one, for which there were no matches in the source literature. As mentioned in chapter 3, small waste incinerators were present in every apartment building in New York City running on a near constant basis. These devices are significantly different than the huge municipal waste incinerators used today, which, are the sources for waste emission patterns. The dioxins resulting from the older low temperature incinerators are likely to have significantly different patterns. More work is needed in developing congener pattern information and quantifying dioxin releases of the various sources.

## Appendix 1

The data in this section is available in a normalized electronic format at the NOAA Emergency Response Web site at <ftp://ftp.nwn.noaa.gov/pub/hazmat/cpr/qm/nw011213.exe>  
Following is a list of the station id's and coordinates. The second section lists the congener concentrations in parts per trillion.

### Sampling Stations

**Study-** Abbreviated name of the Agency/Consultant and the year of the sampling study. See the text for detail.

**Station ID-** Identifier of the sampling station

**Longitude** - Longitude of the sampling location. See text for coordinate determination method.

**Latitude-** Latitude of the sampling location. See text for coordinate determination method.

**Waterbody-** Area of the Harbor where the sample was taken.

| Study Year   | Station ID | Longitude  | Latitude  | Waterbody       |
|--------------|------------|------------|-----------|-----------------|
| NOAA NS&T 91 | 20         | -73.108333 | 40.709500 | Newark Bay      |
| NOAA NS&T 91 | 21         | -73.118    | 40.708    | Newark Bay      |
| Maxus 91     | 37A        | -73.110    | 40.705278 | Newark Bay      |
| Maxus 3/93   | 85A        | -73.153367 | 40.789    | Newark Bay      |
| REMAP 1994   | UH109      | -73.081    | 40.712167 | Upper Bay       |
| NOAA NS&T 91 | 26         | -73.121500 | 40.693111 | Newark Bay      |
| REMAP 1993   | UH019      | -73.041167 | 40.691    | Upper Bay       |
| Maxus 3/93   | 86A        | -73.160075 | 40.688086 | Newark Bay      |
| Maxus 92     | 63A        | -73.138025 | 40.687778 | Newark Bay      |
| REMAP 1994   | UH101      | -73.043833 | 40.686500 | Upper Bay       |
| NOAA NS&T 91 | 31         | -73.131667 | 40.685333 | Newark Bay      |
| Maxus 92     | 65A        | -73.152744 | 40.683442 | Newark Bay      |
| REMAP 1994   | UH110      | -73.050500 | 40.698    | Upper Bay       |
| Maxus 92     | 64A        | -73.142497 | 40.681669 | Newark Bay      |
| REMAP 1994   | UH111      | -73.040667 | 40.696333 | Upper Bay       |
| Maxus 92     | 66A        | -73.148569 | 40.680478 | Newark Bay      |
| NOAA NS&T 91 | 36         | -73.135667 | 40.677833 | Newark Bay      |
| REMAP 1993   | UH022      | -73.064    | 40.693333 | Upper Bay       |
| REMAP 1994   | UH112      | -73.090833 | 40.673833 | Upper Bay       |
| Maxus 92     | 68A        | -73.139919 | 40.672564 | Newark Bay      |
| Maxus 92     | 69A        | -73.145747 | 40.664214 | Newark Bay      |
| Maxus 92     | 71A        | -73.151736 | 40.659828 | Newark Bay      |
| Maxus 92     | 70A        | -73.149028 | 40.659556 | Newark Bay      |
| Maxus 92     | 72A        | -73.155044 | 40.658400 | Newark Bay      |
| REMAP 1994   | UH113      | -73.093833 | 40.657500 | Upper Bay       |
| Maxus 3/93   | 89A        | -73.063297 | 40.655564 | Upper Bay       |
| REMAP 1994   | NB115      | -73.106167 | 40.666    | Kill Van Kull   |
| NOAA NS&T 91 | 17         | -73.172222 | 40.645278 | Newark Bay      |
| Maxus 91     | 42A        | -73.148958 | 40.645092 | Newark Bay      |
| NOAA NS&T 91 | 57         | -73.154333 | 40.644667 | Newark Bay      |
| Maxus 3/93   | 87A        | -73.140867 | 40.644194 | Kill Van Kull   |
| Maxus 91     | 47A        | -73.188333 | 40.643889 | Arthur Kill     |
| Maxus 91     | 48A        | -73.194722 | 40.643056 | Elizabeth River |
| NOAA NS&T 91 | 56         | -73.148167 | 40.642667 | Newark Bay      |
| Maxus 91     | 49A        | -73.200    | 40.642778 | Elizabeth River |
| Maxus 3/93   | 88A        | -73.125306 | 40.641469 | Kill Van Kull   |

|              |       |            |           |                                   |
|--------------|-------|------------|-----------|-----------------------------------|
| Maxus 91     | 44A   | -73.141111 | 40.640556 | Kill Van Kull                     |
| Maxus 3/93   | 84B   | -73.160453 | 40.637978 | Newark Bay                        |
| REMAP 1993   | UH030 | -73.076667 | 40.620    | Upper Bay                         |
| Maxus 91     | 51A   | -73.205278 | 40.616944 | Arthur Kill                       |
| REMAP 1994   | NB109 | -73.213500 | 40.630833 | Arthur Kill                       |
| Maxus 91     | 56A   | -73.214017 | 40.602986 | Arthur Kill                       |
| Maxus 91     | 55A   | -73.205956 | 40.593836 | Arthur Kill                       |
| REMAP 1993   | RB002 | -73.096500 | 40.570667 | Lower Bay                         |
| Maxus 91     | 59A   | -73.211944 | 40.560278 | Arthur Kill                       |
| REMAP 1994   | NB107 | -73.237    | 40.555333 | Arthur Kill                       |
| REMAP 1993   | RB007 | -73.084500 | 40.563833 | Lower Bay                         |
| REMAP 1994   | RB105 | -73.111    | 40.540667 | Lower Bay                         |
| REMAP 1993   | RB010 | -73.080833 | 40.537667 | Lower Bay                         |
| REMAP 1993   | RB011 | -73.098    | 40.534667 | Lower Bay                         |
| REMAP 1993   | RB012 | -73.117667 | 40.533333 | Lower Bay                         |
| REMAP 1994   | RB106 | -73.118667 | 40.530667 | Lower Bay                         |
| REMAP 1994   | RB108 | -73.06     | 40.529667 | Lower Bay                         |
| REMAP 1994   | RB107 | -73.094333 | 40.530167 | Lower Bay                         |
| REMAP 1993   | RB016 | -73.151167 | 40.507333 | Lower Bay                         |
| REMAP 1993   | RB019 | -73.229    | 40.512167 | Lower Bay                         |
| REMAP 1994   | RB116 | -73.071    | 40.486333 | Lower Bay                         |
| REMAP 1994   | RB110 | -73.271500 | 40.486500 | Raritan River                     |
| REMAP 1993   | RB024 | -73.064167 | 40.474333 | Lower Bay                         |
| REMAP 1994   | RB111 | -73.218    | 40.492    | Lower Bay                         |
| REMAP 1994   | RB112 | -73.160333 | 40.471667 | Lower Bay                         |
| REMAP 1993   | RB027 | -73.068167 | 40.470667 | Lower Bay                         |
| REMAP 1994   | RB114 | -73.127333 | 40.468333 | Lower Bay                         |
| REMAP 1993   | RB029 | -73.254667 | 40.481167 | Lower Bay                         |
| REMAP 1994   | RB117 | -73.118833 | 40.480167 | Lower Bay                         |
| REMAP 1993   | RB030 | -73.120833 | 40.455    | Lower Bay                         |
| REMAP 1993   | RB032 | -73.083    | 40.463333 | Lower Bay                         |
| REMAP 1993   | RB033 | -73.042833 | 40.438167 | Lower Bay                         |
| REMAP 1994   | UH102 | -72.922667 | 40.930833 | Hudson River                      |
| REMAP 1994   | UH103 | -72.933667 | 40.890500 | Hudson River                      |
| REMAP 1993   | UH003 | -72.960167 | 40.867667 | Hudson River                      |
| REMAP 1993   | UH004 | -72.940667 | 40.881833 | Hudson River                      |
| REMAP 1994   | UH105 | -72.996500 | 40.803167 | Hudson River                      |
| REMAP 1993   | UH014 | -73.019833 | 40.756333 | Hudson River                      |
| REMAP 1994   | UH108 | -73.045667 | 40.730500 | Hudson River                      |
| REMAP 1993   | UH018 | -73.022333 | 40.706667 | Hudson River                      |
| Maxus 91     | 01A   | -73.130469 | 40.886144 | Passaic River Above<br>Dundee Dam |
| Maxus 91     | 02A   | -73.120694 | 40.879167 | Passaic River Above<br>Dundee Dam |
| Maxus 92     | 03A   | -73.110136 | 40.855322 | Passaic River Above<br>Dundee Dam |
| Maxus 3/93   | 73B   | -73.133569 | 40.825536 | Third River                       |
| Maxus 91     | 05A   | -73.132119 | 40.821833 | Third River                       |
| Maxus 92     | 05A   | -73.132119 | 40.821833 | Third River                       |
| Maxus 3/93   | 74A   | -73.131122 | 40.821622 | Third River                       |
| Maxus 7/93   | 74A   | -73.131122 | 40.821622 | Third River                       |
| Maxus 91     | 06A   | -73.131156 | 40.819983 | Passaic River                     |
| Maxus 91     | 28A   | -73.053047 | 40.807228 | Hackensack River                  |
| NOAA NS&T 91 | 12    | -73.071667 | 40.797167 | Hackensack River                  |

|              |      |            |           |                  |
|--------------|------|------------|-----------|------------------|
| NOAA NS&T 91 | 14   | -73.079    | 40.791    | Hackensack River |
| Maxus 3/93   | 08A  | -73.142778 | 40.790278 | Passaic River    |
| NOAA NS&T 91 | 01   | -73.146167 | 40.789333 | Passaic River    |
| Maxus 91     | 09A  | -73.149167 | 40.778611 | Passaic River    |
| Maxus 94     | SR6  | -73.151292 | 40.776658 | Passaic River    |
| Maxus 94     | SR5  | -73.151328 | 40.776656 | Passaic River    |
| Maxus 94     | SR1  | -73.151364 | 40.776650 | Passaic River    |
| Maxus 94     | SR2  | -73.151328 | 40.776631 | Passaic River    |
| Maxus 94     | SR7  | -73.151361 | 40.776625 | Passaic River    |
| Maxus 94     | SR3  | -73.151300 | 40.776614 | Passaic River    |
| Maxus 94     | SR8  | -73.151353 | 40.776597 | Passaic River    |
| Maxus 94     | SR4  | -73.151269 | 40.776597 | Passaic River    |
| Maxus 94     | SR9  | -73.151350 | 40.776572 | Passaic River    |
| Maxus 94     | SR10 | -73.151344 | 40.776544 | Passaic River    |
| Maxus 3/93   | 75A  | -73.158936 | 40.765875 | Passaic River    |
| Maxus 92     | 10A  | -73.159394 | 40.765500 | Passaic River    |
| Maxus 94     | HP6  | -73.159636 | 40.765281 | Passaic River    |
| Maxus 94     | HP5  | -73.159672 | 40.765275 | Passaic River    |
| Maxus 94     | HP1  | -73.159706 | 40.765267 | Passaic River    |
| Maxus 94     | HP2  | -73.159672 | 40.765253 | Passaic River    |
| Maxus 94     | HP7  | -73.159697 | 40.765242 | Passaic River    |
| Maxus 94     | HP3  | -73.159644 | 40.765236 | Passaic River    |
| Maxus 94     | HP4  | -73.159614 | 40.765222 | Passaic River    |
| Maxus 94     | HP8  | -73.159694 | 40.765214 | Passaic River    |
| Maxus 94     | HP9  | -73.159686 | 40.765186 | Passaic River    |
| Maxus 94     | HP10 | -73.159681 | 40.765161 | Passaic River    |
| Maxus 3/93   | 76A  | -73.159653 | 40.764969 | Passaic River    |
| EPA RI 95    | 276A | -73.161031 | 40.763428 | Passaic River    |
| EPA RI 95    | 277B | -73.160650 | 40.763242 | Passaic River    |
| EPA RI 95    | 278B | -73.160331 | 40.763019 | Passaic River    |
| EPA RI 95    | 273A | -73.163253 | 40.760553 | Passaic River    |
| EPA RI 95    | 274A | -73.162953 | 40.760433 | Passaic River    |
| EPA RI 95    | 275A | -73.162803 | 40.760375 | Passaic River    |
| Maxus 94     | IS1  | -73.141564 | 40.759431 | Maxus            |
| Maxus 94     | IS2  | -73.141469 | 40.759417 | Maxus            |
| Maxus 94     | IS3  | -73.141356 | 40.759397 | Maxus            |
| Maxus 94     | IS7  | -73.140900 | 40.759394 | Maxus            |
| Maxus 94     | IS4  | -73.141250 | 40.759383 | Maxus            |
| Maxus 94     | IS5  | -73.141097 | 40.759361 | Maxus            |
| Maxus 94     | IS6  | -73.140989 | 40.759344 | Maxus            |
| Maxus 94     | IS8  | -73.140922 | 40.759336 | Maxus            |
| Maxus 94     | IS9  | -73.140872 | 40.759333 | Maxus            |
| Maxus 94     | IS10 | -73.140814 | 40.759214 | Maxus            |
| EPA RI 95 Mx | 296B | -73.163228 | 40.759064 | Passaic River    |
| EPA RI 95    | 270A | -73.164992 | 40.757439 | Passaic River    |
| EPA RI 95    | 271A | -73.164625 | 40.757381 | Passaic River    |
| EPA RI 95    | 272A | -73.164264 | 40.757353 | Passaic River    |
| NOAA NS&T 91 | 03   | -73.165167 | 40.754667 | Passaic River    |
| EPA RI 95    | 269C | -73.164956 | 40.752744 | Passaic River    |
| EPA RI 95    | 267A | -73.165683 | 40.752739 | Passaic River    |
| EPA RI 95    | 268B | -73.165075 | 40.752728 | Passaic River    |
| NOAA NS&T 91 | 17   | -73.085833 | 40.749167 | Hackensack River |
| EPA RI 95    | 264A | -73.166222 | 40.749706 | Passaic River    |
| EPA RI 95    | 265A | -73.166    | 40.749675 | Passaic River    |

|              |      |            |           |                  |
|--------------|------|------------|-----------|------------------|
| EPA RI 95    | 266A | -73.165753 | 40.749658 | Passaic River    |
| Maxus 91     | 32A  | -73.094444 | 40.748889 | Hackensack River |
| Maxus 92     | 33A  | -73.079161 | 40.747958 | Hackensack River |
| EPA RI 95    | 263B | -73.165889 | 40.746503 | Passaic River    |
| EPA RI 95    | 262A | -73.166161 | 40.746500 | Passaic River    |
| EPA RI 95    | 261C | -73.166450 | 40.746433 | Passaic River    |
| EPA RI 95    | 260B | -73.165358 | 40.744175 | Passaic River    |
| EPA RI 95    | 259B | -73.165842 | 40.744081 | Passaic River    |
| EPA RI 95    | 258C | -73.166161 | 40.744    | Passaic River    |
| EPA RI 95    | 224A | -73.127097 | 40.742833 | Passaic River    |
| EPA RI 95    | 221A | -73.124156 | 40.742611 | Passaic River    |
| EPA RI 95    | 227A | -73.131489 | 40.742497 | Passaic River    |
| EPA RI 95    | 223A | -73.127106 | 40.742347 | Passaic River    |
| EPA RI 95    | 220A | -73.124253 | 40.742269 | Passaic River    |
| NOAA NS&T 91 | 8A   | -73.123500 | 40.742    | Passaic River    |
| EPA RI 95    | 222A | -73.127097 | 40.741989 | Passaic River    |
| EPA RI 95 Mx | 294A | -73.136725 | 40.742031 | Passaic River    |
| EPA RI 95    | 230A | -73.135808 | 40.742008 | Passaic River    |
| EPA RI 95    | 219A | -73.124364 | 40.741858 | Passaic River    |
| NOAA NS&T 91 | 8B   | -73.126500 | 40.741833 | Passaic River    |
| NOAA NS&T 91 | 7A   | -73.133167 | 40.741833 | Passaic River    |
| EPA RI 95    | 225A | -73.131394 | 40.741678 | Passaic River    |
| EPA RI 95    | 229A | -73.135736 | 40.741658 | Passaic River    |
| NOAA NS&T 91 | 7B   | -73.135167 | 40.741500 | Passaic River    |
| EPA RI 95    | 228B | -73.135672 | 40.741428 | Passaic River    |
| EPA RI 95    | 218A | -73.118981 | 40.741239 | Passaic River    |
| EPA RI 95 Ns | 284B | -73.127478 | 40.741286 | Passaic River    |
| EPA RI 95    | 257C | -73.164347 | 40.741447 | Passaic River    |
| EPA RI 95    | 256B | -73.164581 | 40.741417 | Passaic River    |
| Maxus 91     | 21A  | -73.134197 | 40.741169 | Passaic River    |
| Maxus 91     | 22A  | -73.122572 | 40.741003 | Passaic River    |
| EPA RI 95    | 255A | -73.165058 | 40.741314 | Passaic River    |
| Maxus 91     | 20A  | -73.134989 | 40.741044 | Passaic River    |
| EPA RI 95    | 217A | -73.119322 | 40.740906 | Passaic River    |
| EPA RI 95    | 233C | -73.140092 | 40.741050 | Passaic River    |
| Maxus 91     | 19A  | -73.135750 | 40.740956 | Passaic River    |
| Maxus 92     | 61A  | -73.134522 | 40.740886 | Passaic River    |
| Maxus 91     | 18A  | -73.136519 | 40.740842 | Passaic River    |
| NOAA NS&T 91 | 7C   | -73.138333 | 40.740833 | Passaic River    |
| EPA RI 95 Ns | 286B | -73.135453 | 40.740814 | Passaic River    |
| EPA RI 95 Ns | 285A | -73.136497 | 40.740669 | Passaic River    |
| Maxus 91     | 17A  | -73.138467 | 40.740425 | Passaic River    |
| EPA RI 95    | 231A | -73.139708 | 40.740417 | Passaic River    |
| EPA RI 95 Ns | 283A | -73.120894 | 40.740175 | Passaic River    |
| Maxus 92     | 60A  | -73.138467 | 40.740297 | Passaic River    |
| EPA RI 95 Mx | 293A | -73.163633 | 40.740397 | Passaic River    |
| EPA RI 95    | 216A | -73.120269 | 40.743    | Passaic River    |
| Maxus 91     | 16A  | -73.140258 | 40.739900 | Passaic River    |
| EPA RI 95 Ns | 282A | -73.119956 | 40.739689 | Passaic River    |
| Maxus 94     | WA1  | -73.144764 | 40.739333 | Passaic River    |
| Maxus 94     | WA2  | -73.144592 | 40.739319 | Passaic River    |
| Maxus 94     | WA4  | -73.144533 | 40.739294 | Passaic River    |
| Maxus 94     | WA3  | -73.144622 | 40.739281 | Passaic River    |
| Maxus 94     | WA5  | -73.144522 | 40.739253 | Passaic River    |

|              |      |            |           |                  |
|--------------|------|------------|-----------|------------------|
| Maxus 94     | WA6  | -73.144547 | 40.739225 | Passaic River    |
| Maxus 94     | WA8  | -73.144461 | 40.739217 | Passaic River    |
| Maxus 94     | WA7  | -73.144275 | 40.739161 | Passaic River    |
| Maxus 94     | WA9  | -73.144503 | 40.738844 | Passaic River    |
| EPA RI 95    | 236A | -73.143406 | 40.738764 | Passaic River    |
| EPA RI 95 Mx | 295B | -73.116928 | 40.738561 | Passaic River    |
| Maxus 91     | 15A  | -73.143881 | 40.738700 | Passaic River    |
| EPA RI 95    | 235A | -73.143039 | 40.738619 | Passaic River    |
| Maxus 94     | WA10 | -73.144456 | 40.738600 | Passaic River    |
| Maxus 91     | 23A  | -73.118525 | 40.738364 | Passaic River    |
| EPA RI 95    | 234B | -73.142719 | 40.738464 | Passaic River    |
| EPA RI 95 Ns | 287B | -73.144228 | 40.738319 | Passaic River    |
| Maxus 92     | 34A  | -73.093739 | 40.737744 | Hackensack River |
| EPA RI 95    | 254A | -73.162964 | 40.738103 | Passaic River    |
| EPA RI 95    | 253A | -73.163283 | 40.738025 | Passaic River    |
| EPA RI 95    | 215B | -73.116617 | 40.737653 | Passaic River    |
| EPA RI 95    | 252C | -73.163622 | 40.737939 | Passaic River    |
| EPA RI 95    | 214A | -73.117161 | 40.737553 | Passaic River    |
| EPA RI 95    | 213A | -73.118506 | 40.737436 | Passaic River    |
| EPA RI 95 Ns | 288B | -73.144628 | 40.737511 | Passaic River    |
| Maxus 91     | 12A  | -73.162533 | 40.737483 | Passaic River    |
| NOAA NS&T 91 | 05   | -73.145    | 40.736333 | Passaic River    |
| EPA RI 95    | 239A | -73.145361 | 40.735825 | Passaic River    |
| EPA RI 95    | 238A | -73.144981 | 40.735653 | Passaic River    |
| EPA RI 95    | 251B | -73.160986 | 40.735381 | Passaic River    |
| EPA RI 95    | 250A | -73.161133 | 40.735181 | Passaic River    |
| EPA RI 95 Ns | 289A | -73.151989 | 40.734572 | Passaic River    |
| EPA RI 95 Ns | 290B | -73.153278 | 40.734461 | Passaic River    |
| EPA RI 95    | 210A | -73.118819 | 40.734136 | Passaic River    |
| Maxus 91     | 14A  | -73.152625 | 40.734347 | Passaic River    |
| EPA RI 95    | 242A | -73.148767 | 40.734242 | Passaic River    |
| EPA RI 95    | 211B | -73.117825 | 40.733983 | Passaic River    |
| EPA RI 95 Ns | 291A | -73.154483 | 40.734203 | Passaic River    |
| EPA RI 95    | 212A | -73.117042 | 40.733906 | Passaic River    |
| EPA RI 95 Mx | 292C | -73.155911 | 40.734089 | Passaic River    |
| EPA RI 95    | 245B | -73.153022 | 40.734069 | Passaic River    |
| EPA RI 95    | 241A | -73.148678 | 40.733989 | Passaic River    |
| EPA RI 95    | 248A | -73.157256 | 40.733847 | Passaic River    |
| EPA RI 95    | 244A | -73.152992 | 40.733683 | Passaic River    |
| EPA RI 95    | 240A | -73.148553 | 40.733553 | Passaic River    |
| EPA RI 95    | 247A | -73.157356 | 40.733567 | Passaic River    |
| Maxus 91     | 13A  | -73.147808 | 40.733397 | Passaic River    |
| EPA RI 95    | 243A | -73.152981 | 40.733431 | Passaic River    |
| EPA RI 95    | 246A | -73.157419 | 40.733400 | Passaic River    |
| EPA RI 95    | 207A | -73.119444 | 40.730886 | Passaic River    |
| EPA RI 95    | 208A | -73.118478 | 40.730736 | Passaic River    |
| EPA RI 95    | 209B | -73.117653 | 40.730597 | Passaic River    |
| EPA RI 95    | 204A | -73.120567 | 40.727769 | Passaic River    |
| EPA RI 95    | 205A | -73.119594 | 40.727539 | Passaic River    |
| EPA RI 95    | 206A | -73.118333 | 40.727294 | Passaic River    |
| Maxus 92     | 62A  | -73.121358 | 40.726119 | Passaic River    |
| NOAA NS&T 91 | 10   | -73.119333 | 40.725333 | Passaic River    |
| EPA RI 95    | 201A | -73.121664 | 40.724600 | Passaic River    |
| EPA RI 95    | 202F | -73.120883 | 40.724397 | Passaic River    |

|              |       |            |           |                   |
|--------------|-------|------------|-----------|-------------------|
| EPA RI 95    | 203A  | -73.119583 | 40.724083 | Passaic River     |
| NOAA NS&T 91 | 11    | -73.120500 | 40.722167 | Passaic River     |
| Maxus 91     | 35A   | -73.105942 | 40.720075 | Hackensack River  |
| Maxus 92     | 35A   | -73.105942 | 40.720075 | Hackensack River  |
| Maxus 3/93   | 83A   | -73.102047 | 40.717642 | Hackensack River  |
| Maxus 3/93   | 82A   | -73.113575 | 40.716692 | Newark Bay        |
| Maxus 91     | 26A   | -73.118056 | 40.713333 | Newark Bay        |
| Maxus 3/93   | 81A   | -73.123500 | 40.713047 | Newark Bay        |
| REMAP 1993   | JB012 | -72.890167 | 40.665167 | Jamaica Bay       |
| REMAP 1993   | JB008 | -72.832667 | 40.641    | Jamaica Bay       |
| REMAP 1994   | JB101 | -72.830333 | 40.639500 | Jamaica Bay       |
| REMAP 1993   | JB002 | -72.814500 | 40.636167 | Jamaica Bay       |
| REMAP 1994   | JB115 | -72.870    | 40.633833 | Jamaica Bay       |
| REMAP 1994   | JB103 | -72.787500 | 40.645667 | Jamaica Bay       |
| REMAP 1993   | JB015 | -72.810667 | 40.642833 | Jamaica Bay       |
| REMAP 1994   | JB117 | -72.781833 | 40.623333 | Jamaica Bay       |
| REMAP 1994   | JB104 | -72.841500 | 40.621833 | Jamaica Bay       |
| REMAP 1994   | JB106 | -72.890333 | 40.620833 | Jamaica Bay       |
| REMAP 1994   | JB108 | -72.857333 | 40.617    | Jamaica Bay       |
| REMAP 1993   | JB033 | -72.887667 | 40.632667 | Jamaica Bay       |
| REMAP 1993   | JB031 | -72.871500 | 40.627833 | Jamaica Bay       |
| REMAP 1993   | JB018 | -72.786    | 40.625333 | Jamaica Bay       |
| REMAP 1993   | JB006 | -72.773167 | 40.625    | Jamaica Bay       |
| REMAP 1994   | JB110 | -72.831167 | 40.606500 | Jamaica Bay       |
| REMAP 1994   | JB111 | -72.790667 | 40.605167 | Jamaica Bay       |
| REMAP 1993   | JB022 | -72.796333 | 40.604    | Jamaica Bay       |
| REMAP 1993   | JB026 | -72.858333 | 40.603333 | Jamaica Bay       |
| REMAP 1994   | JB119 | -72.891833 | 40.603500 | Jamaica Bay       |
| REMAP 1994   | JB112 | -72.881500 | 40.602500 | Jamaica Bay       |
| REMAP 1994   | JB120 | -72.829667 | 40.613    | Jamaica Bay       |
| REMAP 1994   | JB113 | -72.867333 | 40.612500 | Jamaica Bay       |
| REMAP 1994   | JB114 | -72.851333 | 40.591167 | Jamaica Bay       |
| REMAP 1993   | JB039 | -72.862167 | 40.586667 | Jamaica Bay       |
| REMAP 1994   | RB101 | -73.028    | 40.587333 | Lower Bay         |
| REMAP 1993   | JB041 | -72.876833 | 40.585667 | Jamaica Bay       |
| REMAP 1993   | JB042 | -72.864667 | 40.599500 | Jamaica Bay       |
| REMAP 1993   | RB001 | -73.034667 | 40.597333 | Lower Bay         |
| REMAP 1993   | JB043 | -72.873667 | 40.592833 | Jamaica Bay       |
| REMAP 1994   | RB102 | -72.981    | 40.572833 | Lower Bay         |
| REMAP 1994   | RB103 | -73.09     | 40.558    | Lower Bay         |
| REMAP 1994   | RB104 | -73.028500 | 40.566500 | Lower Bay         |
| REMAP 1993   | UH008 | -72.829833 | 40.801833 | Long Island Sound |
| REMAP 1993   | UH010 | -72.913    | 40.790833 | Long Island Sound |
| REMAP 1993   | UH011 | -72.873833 | 40.785500 | Long Island Sound |
| REMAP 1993   | UH020 | -73.04333  | 40.689167 | East River        |
| REMAP 1993   | UH023 | -73.045500 | 40.680167 | Upper Bay         |
| REMAP 1993   | UH026 | -73.059833 | 40.654333 | Upper Bay         |
| REMAP 1994   | UH114 | -73.054667 | 40.665167 | Upper Bay         |
| REMAP 1993   | UH029 | -73.051667 | 40.636167 | Upper Bay         |
| REMAP 1994   | UH104 | -72.830833 | 40.827500 | Long Island Sound |
| REMAP 1994   | UH107 | -72.911167 | 40.813    | Long Island Sound |
| REMAP 1994   | UH106 | -72.892    | 40.812833 | Long Island Sound |



## Sample Results

### Fields

**Station Sample-** Station ID from station table followed by 2digit sample ID

**Upper Depth-** Depth in centimeters of the top of the core sample.

**Lower Depth-** Depth in centimeters of the bottom of the core sample.

**TOC-** Total Organic Carbon in percent

Dioxin congeners are all in parts per trillion

**Summed dioxin-furans** are the total of all the congeners shown here in parts per trillion

**Toxic Equivalence Factor** is the Sum of the congeners used multiplied by their toxic equivalence factor in parts per trillion.

**Cluster-** K-mean Cluster of the sample.

| Station Sample | Upper Depth | Lower Depth | TOC  | Pcdd 1234678 | Pcdd 123478 | Pcdd 123678 | Pcdd 12378 | Pcddf 123789 |
|----------------|-------------|-------------|------|--------------|-------------|-------------|------------|--------------|
| 12A02          | 45.70       | 81.30       | 0.42 | 4.40         | 0.0         | 0.0         | 0.0        | 0.0          |
| 13A02          | 45.70       | 96.50       | 1.29 | 31.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 13A03          | 96.50       | 233.70      | 0.65 | 58.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 13A04          | 233.70      | 370.80      | 0.84 | 24.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 13A05          | 370.80      | 492.80      | 0.33 | 0.0          | 0.0         | 0.0         | 0.0        | 0.0          |
| 14A02          | 45.70       | 96.50       | 1.96 | 28.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 14A03          | 96.50       | 233.70      | 0.67 | 18.0         | 0.0         | 0.0         | 0.0        | 1.70         |
| 14A04          | 233.70      | 370.80      | 0.57 | 6.80         | 0.0         | 0.0         | 0.0        | 0.0          |
| 14A05          | 370.80      | 492.80      | 0.61 | 6.0          | 0.0         | 0.0         | 0.0        | 0.0          |
| 14A06          | 492.80      | 584.20      | 1.04 | 7.60         | 0.0         | 0.0         | 0.0        | 0.0          |
| 14A07          | 584.20      | 0.0         | 0.99 | 8.90         | 0.0         | 0.0         | 0.0        | 0.0          |
| 15A02          | 45.70       | 96.50       | 0.79 | 34.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 15A03          | 96.50       | 233.70      | 1.08 | 31.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 15A04          | 233.70      | 370.80      | 1.24 | 31.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 16A02          | 45.70       | 96.50       | 0.85 | 880.0        | 0.0         | 64.0        | 13.0       | 28.0         |
| 16A03          | 96.50       | 233.70      | 1.60 | 1880.0       | 52.60       | 342.0       | 147.0      | 144.0        |
| 16A04          | 233.70      | 370.80      | 2.48 | 2250.0       | 47.0        | 200.0       | 116.0      | 82.0         |
| 16A05          | 370.80      | 477.50      | 2.02 | 134.0        | 0.0         | 11.0        | 0.0        | 0.0          |
| 16A06          | 477.50      | 569.0       | 0.77 | 0.0          | 0.0         | 0.0         | 0.0        | 0.0          |
| 16A07          | 569.0       | 0.0         | 0.26 | 0.0          | 0.0         | 0.0         | 0.0        | 0.0          |
| 17A02          | 45.70       | 96.50       | 1.28 | 2480.0       | 30.0        | 137.0       | 28.0       | 87.0         |
| 17A03          | 96.50       | 233.70      | 1.74 | 1560.0       | 19.0        | 95.0        | 20.0       | 43.0         |
| 17A04          | 233.70      | 370.80      | 2.29 | 4540.0       | 31.0        | 290.0       | 154.0      | 121.0        |
| 17A05          | 370.80      | 477.50      | 1.64 | 2010.0       | 23.0        | 125.0       | 34.0       | 76.0         |
| 17A06          | 477.50      | 508.0       | 0.52 | 12.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 17A07          | 508.0       | 0.0         | 0.38 | 4.0          | 0.0         | 0.0         | 0.0        | 0.0          |
| 18A02          | 45.70       | 96.50       | 0.11 | 3080.0       | 14.0        | 249.0       | 24.0       | 86.0         |
| 18A03          | 96.50       | 157.50      | 0.09 | 2880.0       | 32.0        | 160.0       | 40.0       | 71.0         |
| 18A04          | 157.50      | 233.70      | 2.15 | 196.0        | 0.0         | 13.0        | 0.0        | 7.60         |
| 18A05          | 233.70      | 309.90      | 0.68 | 47.0         | 0.0         | 0.0         | 0.0        | 0.0          |
| 18A06          | 309.90      | 370.80      | 1.31 | 105.0        | 0.0         | 12.0        | 0.0        | 9.40         |
| 18A07          | 370.80      | 421.60      | 0.88 | 9.70         | 0.0         | 0.0         | 0.0        | 0.0          |
| 19A02          | 45.70       | 96.50       | 1.16 | 1250.0       | 13.90       | 91.90       | 20.70      | 32.30        |
| 19A03          | 96.50       | 233.70      | 2.04 | 1820.0       | 20.30       | 145.0       | 45.50      | 86.0         |
| 19A04          | 233.70      | 370.80      | 0.76 | 31.60        | 0.0         | 0.0         | 0.0        | 0.0          |
| 19A05          | 370.80      | 477.50      | 2.87 | 110.0        | 4.60        | 20.0        | 0.0        | 14.0         |

|       |        |        |      |        |       |       |       |       |
|-------|--------|--------|------|--------|-------|-------|-------|-------|
| 19A07 | 538.50 | 0.0    | 0.21 | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 01A02 | 45.70  | 96.50  | 2.25 | 13.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 01A03 | 96.50  | 0.0    | 4.92 | 13.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 20A02 | 45.70  | 96.50  | 2.01 | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 20A03 | 96.50  | 233.70 | 1.35 | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 20A05 | 370.80 | 477.50 | 1.69 | 4180.0 | 183.0 | 483.0 | 178.0 | 331.0 |
| 20A06 | 477.50 | 584.20 | 1.32 | 49.60  | 0.0   | 0.0   | 0.0   | 0.0   |
| 20A07 | 584.20 | 0.0    | 0.32 | 2.90   | 0.0   | 0.0   | 0.0   | 0.0   |
| 21A02 | 45.70  | 96.50  | 1.59 | 693.0  | 9.20  | 45.0  | 11.0  | 28.0  |
| 21A03 | 96.50  | 233.70 | 1.42 | 1110.0 | 14.0  | 87.0  | 16.0  | 52.0  |
| 21A04 | 233.70 | 370.80 | 2.38 | 865.0  | 0.0   | 70.50 | 0.0   | 0.0   |
| 21A05 | 370.80 | 477.50 | 2.25 | 195.0  | 8.18  | 29.20 | 7.44  | 14.90 |
| 21A06 | 477.50 | 548.60 | 0.23 | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 21A07 | 548.60 | 0.0    | 0.22 | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 22A02 | 45.70  | 96.50  | 1.51 | 1240.0 | 54.0  | 411.0 | 155.0 | 146.0 |
| 22A03 | 96.50  | 233.70 | 1.02 | 1170.0 | 15.0  | 82.0  | 30.0  | 26.0  |
| 22A04 | 233.70 | 370.80 | 0.90 | 60.70  | 0.0   | 8.0   | 0.0   | 6.51  |
| 22A05 | 370.80 | 492.80 | 0.65 | 28.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 23A02 | 45.70  | 96.50  | 1.78 | 778.0  | 8.90  | 41.0  | 16.0  | 20.0  |
| 23A03 | 96.50  | 0.0    | 2.70 | 1660.0 | 17.0  | 161.0 | 22.0  | 67.0  |
| 26A02 | 45.70  | 96.50  | 0.42 | 15.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 26A03 | 96.50  | 0.0    | 0.63 | 129.0  | 0.0   | 19.0  | 5.90  | 8.40  |
| 28A02 | 45.70  | 96.50  | 0.31 | 12.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 28A03 | 96.50  | 0.0    | 0.45 | 7.30   | 0.0   | 0.0   | 0.0   | 0.0   |
| 02A02 | 20.30  | 45.70  | 1.65 | 948.0  | 5.40  | 35.0  | 5.50  | 23.0  |
| 02A03 | 45.70  | 0.0    | 1.52 | 330.0  | 4.10  | 17.0  | 2.50  | 9.40  |
| 32A02 | 45.70  | 96.50  | 0.83 | 25.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 32A03 | 96.50  | 0.0    | 0.86 | 34.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 35A02 | 45.70  | 96.50  | 1.46 | 703.0  | 8.70  | 41.0  | 0.0   | 21.0  |
| 35A03 | 96.50  | 0.0    | 2.09 | 649.0  | 8.10  | 40.0  | 0.0   | 16.0  |
| 37A02 | 45.70  | 96.50  | 0.79 | 13.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 37A03 | 96.50  | 0.0    | 0.69 | 1.80   | 0.0   | 0.0   | 0.0   | 0.0   |
| 42A02 | 45.70  | 96.50  | 0.77 | 8.70   | 0.0   | 0.0   | 0.0   | 0.0   |
| 42A03 | 96.50  | 0.0    | 0.15 | 4.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 44A02 | 20.30  | 45.70  | 0.02 | 378.0  | 0.0   | 35.0  | 4.60  | 17.0  |
| 44A03 | 45.70  | 0.0    | 0.02 | 665.0  | 3.60  | 38.0  | 5.10  | 20.0  |
| 48A02 | 20.30  | 45.70  | 1.55 | 1380.0 | 11.0  | 60.0  | 8.80  | 36.0  |
| 48A03 | 45.70  | 0.0    | 1.35 | 1560.0 | 29.0  | 119.0 | 19.0  | 46.0  |
| 49A02 | 45.70  | 96.50  | 0.09 | 4.30   | 0.0   | 0.0   | 0.0   | 0.0   |
| 49A03 | 96.50  | 0.0    | 1.07 | 22.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 51A02 | 45.70  | 96.50  | 1.08 | 75.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 51A03 | 96.50  | 0.0    | 0.89 | 70.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 55A02 | 45.70  | 96.50  | 1.11 | 100.0  | 0.0   | 0.0   | 0.0   | 0.0   |
| 55A03 | 96.50  | 0.0    | 2.13 | 57.0   | 0.0   | 0.0   | 0.0   | 4.40  |
| 56A02 | 45.70  | 96.50  | 1.96 | 404.0  | 0.0   | 33.0  | 0.0   | 23.0  |
| 56A03 | 96.50  | 0.0    | 1.82 | 531.0  | 0.0   | 53.0  | 0.0   | 38.0  |
| 59A02 | 45.70  | 96.50  | 1.06 | 952.0  | 29.0  | 95.0  | 30.0  | 49.0  |
| 59A03 | 96.50  | 0.0    | 1.22 | 421.0  | 0.0   | 39.0  | 0.0   | 0.0   |
| 05A02 | 20.30  | 45.70  | 0.98 | 420.0  | 7.20  | 21.0  | 6.30  | 12.0  |
| 05A03 | 45.70  | 0.0    | 0.48 | 262.0  | 4.70  | 22.0  | 19.0  | 7.50  |
| 06A02 | 45.70  | 96.50  | 1.32 | 116.0  | 0.0   | 0.0   | 0.0   | 0.0   |
| 06A03 | 96.50  | 0.0    | 0.41 | 14.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 09A02 | 20.30  | 45.70  | 2.0  | 78.50  | 0.0   | 5.93  | 0.0   | 4.37  |
| 09A03 | 45.70  | 0.0    | 0.67 | 197.0  | 0.0   | 0.0   | 0.0   | 0.0   |

|        |        |        |      |        |       |        |       |       |
|--------|--------|--------|------|--------|-------|--------|-------|-------|
| 21EPA0 | 0.0    | 152.40 | 0.22 | 1030.0 | 11.0  | 70.0   | 20.0  | 28.0  |
| 60AG2  | 61.0   | 121.90 | 1.05 | 1400.0 | 0.0   | 130.0  | 36.0  | 49.0  |
| 60AG3  | 121.90 | 0.0    | 0.56 | 38.0   | 43.0  | 2.0    | 73.0  | 620.0 |
| 61AH2  | 55.90  | 116.80 | 2.78 | 1500.0 | 44.0  | 210.0  | 190.0 | 99.0  |
| 61AH3  | 116.80 | 0.0    | 2.96 | 200.0  | 190.0 | 6800.0 | 180.0 | 240.0 |
| 62AJ2  | 55.90  | 116.80 | 0.54 | 470.0  | 0.0   | 36.0   | 12.0  | 15.0  |
| 62AJ3  | 116.80 | 0.0    | 0.61 | 750.0  | 0.0   | 43.0   | 15.0  | 58.0  |
| 63AK2  | 61.0   | 121.90 | 0.64 | 430.0  | 7.20  | 17.0   | 5.40  | 15.0  |
| 63AK3  | 121.90 | 0.0    | 0.67 | 380.0  | 6.40  | 26.0   | 4.20  | 15.0  |
| 64AL2  | 61.0   | 121.90 | 0.26 | 350.0  | 3.70  | 23.0   | 0.0   | 13.0  |
| 64AL3  | 121.90 | 0.0    | 0.43 | 250.0  | 2.90  | 17.0   | 0.0   | 8.0   |
| 65AM2  | 61.0   | 121.90 | 0.08 | 5.80   | 0.0   | 0.0    | 0.0   | 0.0   |
| 65AM3  | 121.90 | 0.0    | 0.15 | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   |
| 66AN2  | 61.0   | 121.90 | 0.02 | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   |
| 66AN3  | 121.90 | 0.0    | 0.06 | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   |
| 68AP2  | 61.0   | 121.90 | 0.47 | 330.0  | 5.20  | 18.0   | 0.0   | 12.0  |
| 68AP3  | 121.90 | 0.0    | 0.63 | 190.0  | 0.0   | 14.0   | 0.0   | 0.0   |
| 69AQ2  | 61.0   | 121.90 | 0.94 | 330.0  | 4.90  | 21.0   | 0.0   | 12.0  |
| 69AQ3  | 121.90 | 0.0    | 0.39 | 170.0  | 3.40  | 12.0   | 0.0   | 5.70  |
| 70AR2  | 61.0   | 121.90 | 1.38 | 340.0  | 0.0   | 23.0   | 0.0   | 10.0  |
| 70AR3  | 121.90 | 0.0    | 0.40 | 260.0  | 3.40  | 14.0   | 0.0   | 8.50  |
| 71AS2  | 61.0   | 121.90 | 0.25 | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   |
| 71AS3  | 121.90 | 0.0    | 0.21 | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   |
| 72AT2  | 61.0   | 121.90 | 1.87 | 550.0  | 13.0  | 32.0   | 0.0   | 17.0  |
| 72AT3  | 121.90 | 0.0    | 0.53 | 88.0   | 0.0   | 5.90   | 0.0   | 2.90  |
| 03AA2  | 55.90  | 116.80 | 1.30 | 720.0  | 6.90  | 32.0   | 0.0   | 12.0  |
| 03AA3  | 116.80 | 0.0    | 2.55 | 1500.0 | 15.0  | 62.0   | 0.0   | 26.0  |
| 05AB1  | 50.80  | 0.0    | 0.32 | 390.0  | 0.0   | 0.0    | 0.0   | 0.0   |
| 10AC2  | 55.90  | 116.80 | 1.36 | 560.0  | 8.50  | 48.0   | 24.0  | 21.0  |
| 10AC3  | 116.80 | 0.0    | 0.64 | 23.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 33AD2  | 55.90  | 116.80 | 1.0  | 35.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 33AD3  | 116.80 | 0.0    | 1.0  | 37.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 34AE2  | 55.90  | 116.80 | 1.27 | 31.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 34AE3  | 116.80 | 0.0    | 2.04 | 42.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 35AF1  | 248.90 | 0.0    | 1.38 | 860.0  | 0.0   | 62.0   | 12.0  | 21.0  |
| 08A02  | 56.36  | 117.96 | 3.36 | 120.0  | 6.20  | 19.0   | 4.80  | 14.0  |
| 08A03  | 117.96 | 0.0    | 0.50 | 6.30   | 0.0   | 0.0    | 0.0   | 0.0   |
| 74A02  | 56.36  | 117.96 | 5.38 | 35.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 74A03  | 117.96 | 0.0    | 2.14 | 7.80   | 0.0   | 0.0    | 0.0   | 0.0   |
| 75A02  | 56.36  | 117.96 | 3.34 | 1300.0 | 27.0  | 93.0   | 25.0  | 38.0  |
| 75A03  | 117.96 | 0.0    | 4.17 | 1900.0 | 40.0  | 140.0  | 95.0  | 46.0  |
| 76A02  | 56.36  | 117.96 | 0.58 | 3.40   | 0.0   | 0.0    | 0.0   | 0.0   |
| 76A03  | 117.96 | 0.0    | 0.67 | 13.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 77A02  | 56.36  | 117.96 | 7.10 | 1900.0 | 68.0  | 240.0  | 80.0  | 140.0 |
| 77A03  | 117.96 | 0.0    | 5.35 | 2.0    | 31.0  | 130.0  | 15.0  | 46.0  |
| 81A02  | 56.36  | 117.96 | 2.10 | 810.0  | 20.0  | 56.0   | 11.0  | 23.0  |
| 81A03  | 117.96 | 0.0    | 3.74 | 360.0  | 28.0  | 76.0   | 6.90  | 33.0  |
| 82A02  | 56.36  | 117.96 | 1.95 | 23.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 82A03  | 117.96 | 0.0    | 2.0  | 28.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 83A02  | 56.36  | 117.96 | 6.74 | 160.0  | 11.0  | 23.0   | 18.0  | 13.0  |
| 83A03  | 117.96 | 0.0    | 0.95 | 6.60   | 0.0   | 0.0    | 0.0   | 0.0   |
| 84B02  | 56.36  | 117.96 | 0.69 | 100.0  | 0.0   | 2.30   | 0.0   | 1.10  |
| 84B03  | 117.96 | 0.0    | 1.38 | 170.0  | 0.0   | 9.20   | 0.0   | 4.60  |
| 85A02  | 56.36  | 117.96 | 4.63 | 2700.0 | 54.0  | 190.0  | 37.0  | 63.0  |

|        |        |        |       |         |        |        |       |        |
|--------|--------|--------|-------|---------|--------|--------|-------|--------|
| 85A03  | 117.96 | 0.0    | 3.79  | 2300.0  | 26.0   | 120.0  | 26.0  | 42.0   |
| 86A02  | 56.36  | 117.96 | 6.16  | 600.0   | 11.0   | 28.0   | 5.80  | 12.0   |
| 86A03  | 117.96 | 0.0    | 4.01  | 650.0   | 10.0   | 32.0   | 5.30  | 15.0   |
| 87A02  | 56.36  | 117.96 | 2.03  | 9.80    | 0.0    | 0.0    | 0.0   | 0.0    |
| 87A03  | 117.96 | 0.0    | 1.88  | 1100.0  | 21.0   | 76.0   | 15.0  | 23.0   |
| 201A02 | 15.24  | 45.72  | 11.40 | 683.0   | 10.60  | 37.10  | 16.0  | 20.20  |
| 201A03 | 45.72  | 76.20  | 6.73  | 543.0   | 8.90   | 33.60  | 8.10  | 17.10  |
| 201A04 | 76.20  | 106.68 | 6.11  | 539.0   | 8.58   | 35.0   | 14.10 | 17.70  |
| 201A05 | 106.68 | 137.16 | 5.86  | 794.0   | 10.80  | 55.30  | 9.68  | 25.80  |
| 201A06 | 137.16 | 167.64 | 6.90  | 787.0   | 10.50  | 58.50  | 15.70 | 25.50  |
| 202E03 | 15.24  | 234.70 | 8.36  | 782.0   | 12.20  | 51.10  | 8.86  | 25.30  |
| 202E05 | 234.70 | 295.66 | 7.06  | 1660.0  | 18.50  | 136.0  | 20.40 | 52.40  |
| 202E06 | 295.66 | 312.42 | 4.43  | 1680.0  | 19.50  | 136.0  | 23.70 | 55.90  |
| 203A02 | 15.24  | 45.72  | 9.29  | 577.0   | 11.50  | 41.70  | 9.47  | 20.50  |
| 203A04 | 45.72  | 76.20  | 8.24  | 543.0   | 11.60  | 42.10  | 12.10 | 21.10  |
| 203A06 | 76.20  | 106.68 | 6.40  | 1110.0  | 14.10  | 100.0  | 15.0  | 41.90  |
| 203A08 | 106.68 | 137.16 | 8.15  | 2720.0  | 38.0   | 287.0  | 56.40 | 112.0  |
| 203A10 | 137.16 | 167.64 | 4.68  | 3070.0  | 29.30  | 315.0  | 44.50 | 115.0  |
| 204A02 | 15.24  | 45.72  | 13.80 | 1490.0  | 64.0   | 71.40  | 11.10 | 44.40  |
| 204A03 | 45.72  | 76.20  | 12.70 | 718.0   | 12.40  | 40.70  | 6.34  | 17.90  |
| 204A04 | 76.20  | 106.68 | 15.0  | 906.0   | 11.80  | 46.50  | 8.50  | 26.60  |
| 204A05 | 106.68 | 137.16 | 13.70 | 1290.0  | 16.90  | 98.60  | 15.60 | 41.50  |
| 204A06 | 137.16 | 167.64 | 33.70 | 37200.0 | 3150.0 | 2330.0 | 515.0 | 1250.0 |
| 205A02 | 15.24  | 381.0  | 11.10 | 914.0   | 15.80  | 66.50  | 16.90 | 38.70  |
| 205A03 | 381.0  | 441.96 | 4.47  | 355.0   | 4.80   | 27.80  | 6.62  | 12.20  |
| 206A02 | 15.24  | 45.72  | 23.0  | 1630.0  | 13.60  | 175.0  | 16.60 | 76.0   |
| 206A03 | 45.72  | 76.20  | 18.80 | 1640.0  | 24.40  | 151.0  | 41.60 | 68.90  |
| 206A04 | 76.20  | 106.68 | 13.0  | 1450.0  | 18.20  | 121.0  | 17.90 | 51.0   |
| 206A05 | 106.68 | 137.16 | 14.60 | 1800.0  | 40.0   | 172.0  | 57.70 | 70.0   |
| 206A06 | 137.16 | 167.64 | 23.30 | 1230.0  | 22.80  | 101.0  | 27.90 | 42.40  |
| 207A02 | 15.24  | 45.72  | 11.50 | 1550.0  | 28.0   | 210.0  | 52.70 | 99.90  |
| 207A03 | 45.72  | 76.20  | 12.80 | 1260.0  | 19.70  | 123.0  | 27.20 | 52.60  |
| 207A04 | 76.20  | 106.68 | 8.13  | 1950.0  | 111.0  | 678.0  | 161.0 | 295.0  |
| 207A05 | 106.68 | 137.16 | 6.26  | 56.70   | 1.80   | 5.78   | 1.82  | 3.36   |
| 207A06 | 137.16 | 167.64 | 2.35  | 20.70   | 0.83   | 1.82   | 0.77  | 1.49   |
| 208A02 | 15.24  | 417.58 | 11.30 | 1470.0  | 17.80  | 120.0  | 20.70 | 49.70  |
| 208A03 | 417.58 | 478.54 | 1.75  | 2.86    | 0.0    | 0.0    | 0.0   | 0.0    |
| 209B02 | 15.24  | 45.72  | 7.01  | 1180.0  | 12.50  | 76.40  | 11.50 | 34.50  |
| 209B03 | 45.72  | 76.20  | 12.60 | 2040.0  | 30.90  | 164.0  | 36.0  | 75.10  |
| 209B04 | 76.20  | 106.68 | 13.80 | 1540.0  | 17.0   | 125.0  | 17.70 | 47.80  |
| 209B05 | 106.68 | 137.16 | 13.90 | 2120.0  | 31.80  | 171.0  | 50.30 | 62.30  |
| 209B06 | 137.16 | 167.64 | 19.20 | 1750.0  | 32.60  | 175.0  | 62.40 | 67.20  |
| 210A02 | 15.24  | 45.72  | 2.62  | 118.0   | 2.70   | 10.70  | 3.34  | 6.34   |
| 210A03 | 45.72  | 76.20  | 1.56  | 40.20   | 0.98   | 1.53   | 0.49  | 1.84   |
| 210A04 | 76.20  | 106.68 | 1.31  | 44.10   | 1.07   | 1.61   | 0.56  | 2.02   |
| 210A05 | 106.68 | 137.16 | 1.20  | 36.80   | 0.84   | 1.52   | 0.49  | 1.67   |
| 210A06 | 137.16 | 167.64 | 4.50  | 28.60   | 0.90   | 1.24   | 0.58  | 1.56   |
| 211B02 | 15.24  | 408.43 | 13.90 | 1420.0  | 20.30  | 122.0  | 33.20 | 48.20  |
| 211B04 | 408.43 | 469.39 | 8.92  | 220.0   | 3.64   | 18.40  | 3.72  | 7.59   |
| 211B05 | 469.39 | 530.35 | 3.40  | 29.40   | 1.19   | 2.94   | 1.16  | 1.93   |
| 212A02 | 15.24  | 45.72  | 7.93  | 1740.0  | 16.50  | 159.0  | 20.60 | 66.80  |
| 212A04 | 45.72  | 76.20  | 7.49  | 1840.0  | 33.10  | 160.0  | 41.90 | 89.20  |
| 212A05 | 76.20  | 106.68 | 7.80  | 2430.0  | 71.30  | 191.0  | 59.20 | 125.0  |
| 212A06 | 106.68 | 137.16 | 4.92  | 1070.0  | 9.06   | 58.20  | 8.06  | 21.60  |

|        |        |        |       |        |       |       |       |       |
|--------|--------|--------|-------|--------|-------|-------|-------|-------|
| 212A07 | 137.16 | 167.64 | 11.70 | 1920.0 | 24.30 | 154.0 | 36.0  | 67.10 |
| 213A02 | 15.24  | 45.72  | 17.40 | 1380.0 | 17.10 | 116.0 | 27.0  | 49.90 |
| 213A03 | 45.72  | 76.20  | 12.0  | 361.0  | 5.67  | 36.60 | 10.20 | 15.10 |
| 213A04 | 76.20  | 106.68 | 5.70  | 40.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 213A05 | 106.68 | 137.16 | 5.70  | 41.30  | 0.89  | 1.34  | 0.0   | 2.07  |
| 213A06 | 137.16 | 167.64 | 5.76  | 41.50  | 0.86  | 0.93  | 0.0   | 1.33  |
| 214A02 | 15.24  | 256.03 | 12.20 | 1240.0 | 16.60 | 80.30 | 38.60 | 34.20 |
| 214A03 | 256.03 | 316.99 | 14.60 | 986.0  | 14.60 | 65.50 | 11.80 | 27.60 |
| 214A04 | 316.99 | 377.95 | 16.20 | 887.0  | 9.90  | 54.70 | 0.0   | 21.30 |
| 215B02 | 15.24  | 45.72  | 12.10 | 528.0  | 12.40 | 36.0  | 7.54  | 18.80 |
| 215B03 | 45.72  | 76.20  | 8.45  | 563.0  | 9.67  | 36.80 | 7.78  | 21.40 |
| 215B04 | 76.20  | 106.68 | 10.50 | 590.0  | 8.26  | 47.60 | 8.34  | 19.0  |
| 215B05 | 106.68 | 137.16 | 13.20 | 772.0  | 16.70 | 56.30 | 10.70 | 29.90 |
| 215B06 | 137.16 | 167.64 | 11.10 | 1030.0 | 13.50 | 82.80 | 12.80 | 39.80 |
| 216A02 | 15.24  | 45.72  | 12.40 | 693.0  | 11.30 | 42.70 | 8.22  | 24.0  |
| 216A03 | 45.72  | 76.20  | 11.50 | 711.0  | 10.30 | 45.50 | 7.83  | 20.50 |
| 216A04 | 76.20  | 106.68 | 10.70 | 873.0  | 12.20 | 57.30 | 9.07  | 25.0  |
| 216A05 | 106.68 | 137.16 | 15.30 | 1050.0 | 14.30 | 71.50 | 12.40 | 35.40 |
| 216A06 | 137.16 | 167.64 | 18.50 | 1700.0 | 14.0  | 103.0 | 14.10 | 48.40 |
| 217A02 | 15.24  | 274.32 | 7.19  | 789.0  | 12.40 | 70.10 | 13.80 | 27.90 |
| 217A03 | 274.32 | 335.28 | 6.28  | 42.50  | 2.40  | 3.80  | 0.0   | 3.20  |
| 217A04 | 335.28 | 396.24 | 0.87  | 7.59   | 0.0   | 0.0   | 0.0   | 0.0   |
| 218A02 | 15.24  | 45.72  | 5.11  | 919.0  | 18.70 | 59.60 | 18.20 | 25.80 |
| 218A03 | 45.72  | 76.20  | 2.26  | 1010.0 | 14.70 | 66.20 | 17.90 | 29.50 |
| 218A04 | 76.20  | 106.68 | 10.10 | 1380.0 | 14.10 | 105.0 | 22.80 | 49.60 |
| 218A05 | 106.68 | 137.16 | 10.80 | 1530.0 | 13.50 | 115.0 | 19.0  | 56.50 |
| 218A06 | 137.16 | 167.64 | 10.10 | 1840.0 | 14.80 | 137.0 | 28.60 | 68.30 |
| 222A02 | 15.24  | 97.54  | 6.21  | 1090.0 | 22.0  | 73.20 | 25.10 | 40.60 |
| 222A03 | 97.54  | 158.50 | 6.01  | 1220.0 | 11.60 | 71.50 | 12.50 | 28.30 |
| 222A04 | 158.50 | 268.22 | 6.82  | 2010.0 | 24.80 | 151.0 | 38.90 | 64.20 |
| 222A05 | 268.22 | 335.28 | 11.20 | 2240.0 | 46.10 | 196.0 | 215.0 | 79.80 |
| 222A06 | 335.28 | 411.48 | 8.85  | 2240.0 | 28.40 | 174.0 | 57.10 | 73.10 |
| 222A07 | 213.36 | 301.75 | 11.30 | 1630.0 | 23.30 | 126.0 | 41.20 | 47.50 |
| 223A02 | 15.24  | 94.49  | 8.43  | 1230.0 | 29.50 | 81.90 | 20.0  | 36.50 |
| 223A04 | 94.49  | 167.64 | 8.77  | 1760.0 | 33.90 | 150.0 | 15.0  | 42.30 |
| 223A05 | 167.64 | 204.22 | 11.20 | 1830.0 | 27.30 | 133.0 | 76.50 | 55.90 |
| 223A06 | 131.06 | 185.93 | 9.25  | 2160.0 | 36.10 | 118.0 | 26.0  | 41.80 |
| 223A07 | 204.22 | 262.13 | 7.82  | 462.0  | 9.16  | 37.80 | 8.40  | 19.80 |
| 224A02 | 15.24  | 45.72  | 12.90 | 1310.0 | 12.90 | 75.80 | 12.20 | 33.0  |
| 224A03 | 45.72  | 76.20  | 15.90 | 1550.0 | 19.10 | 125.0 | 26.50 | 54.70 |
| 224A04 | 76.20  | 106.68 | 15.90 | 1730.0 | 23.70 | 131.0 | 32.70 | 52.30 |
| 224A05 | 106.68 | 137.16 | 14.10 | 1520.0 | 30.30 | 137.0 | 45.80 | 56.50 |
| 224A06 | 137.16 | 167.64 | 11.50 | 2180.0 | 49.70 | 176.0 | 67.40 | 75.0  |
| 225A02 | 15.24  | 64.01  | 11.30 | 993.0  | 17.60 | 81.60 | 18.20 | 37.70 |
| 225A03 | 64.01  | 140.21 | 9.16  | 1860.0 | 18.70 | 225.0 | 27.20 | 79.50 |
| 225A04 | 140.21 | 268.22 | 11.50 | 1930.0 | 33.20 | 153.0 | 67.60 | 68.70 |
| 225A05 | 204.22 | 304.80 | 14.40 | 2070.0 | 37.80 | 196.0 | 75.90 | 70.40 |
| 225A06 | 268.22 | 338.33 | 11.70 | 1520.0 | 38.60 | 193.0 | 59.30 | 63.70 |
| 225A07 | 338.33 | 426.72 | 10.0  | 521.0  | 17.80 | 53.90 | 10.70 | 21.20 |
| 226A04 | 131.06 | 195.07 | 11.40 | 1890.0 | 27.10 | 120.0 | 49.20 | 47.90 |
| 226A05 | 161.54 | 207.26 | 1.09  | 1740.0 | 28.50 | 122.0 | 61.30 | 45.80 |
| 226A06 | 195.07 | 219.46 | 8.46  | 978.0  | 14.50 | 70.30 | 27.60 | 34.40 |
| 227A02 | 15.24  | 45.72  | 10.60 | 1420.0 | 19.10 | 92.50 | 22.50 | 30.40 |
| 227A03 | 45.72  | 76.20  | 13.0  | 1370.0 | 14.40 | 96.20 | 32.70 | 46.80 |

|        |        |        |       |        |       |       |       |       |
|--------|--------|--------|-------|--------|-------|-------|-------|-------|
| 227A04 | 76.20  | 106.68 | 11.50 | 2030.0 | 48.60 | 173.0 | 35.90 | 70.60 |
| 227A05 | 106.68 | 137.16 | 15.30 | 2540.0 | 80.90 | 230.0 | 73.10 | 89.50 |
| 227A06 | 137.16 | 167.64 | 13.30 | 2170.0 | 45.80 | 187.0 | 255.0 | 55.20 |
| 228B02 | 15.24  | 57.91  | 15.50 | 1590.0 | 15.10 | 139.0 | 0.0   | 78.70 |
| 228B03 | 57.91  | 134.11 | 14.20 | 1580.0 | 15.20 | 99.0  | 18.10 | 50.20 |
| 228B04 | 134.11 | 225.55 | 12.60 | 2130.0 | 36.30 | 154.0 | 114.0 | 67.80 |
| 228B05 | 179.83 | 243.84 | 9.68  | 1800.0 | 28.20 | 128.0 | 55.20 | 54.70 |
| 228B06 | 225.55 | 265.18 | 10.50 | 883.0  | 10.40 | 92.40 | 12.90 | 29.90 |
| 228B07 | 265.18 | 332.23 | 9.91  | 233.0  | 6.21  | 24.60 | 6.43  | 11.70 |
| 229A02 | 15.24  | 42.67  | 7.24  | 754.0  | 24.30 | 45.70 | 7.58  | 25.70 |
| 229A03 | 42.67  | 70.10  | 7.31  | 1410.0 | 18.40 | 89.60 | 15.50 | 39.40 |
| 229A04 | 70.10  | 97.54  | 7.19  | 1280.0 | 19.50 | 84.50 | 15.40 | 36.10 |
| 229A05 | 97.54  | 124.97 | 5.87  | 1760.0 | 29.60 | 119.0 | 25.0  | 51.50 |
| 229A06 | 124.97 | 149.35 | 7.91  | 2190.0 | 32.50 | 165.0 | 45.70 | 80.40 |
| 230A02 | 15.24  | 42.67  | 4.88  | 653.0  | 99.0  | 43.10 | 8.82  | 16.60 |
| 230A04 | 48.77  | 121.92 | 8.62  | 1090.0 | 13.50 | 69.70 | 15.60 | 35.10 |
| 230A05 | 85.34  | 146.30 | 10.30 | 1510.0 | 19.30 | 94.40 | 29.30 | 47.40 |
| 230A06 | 121.92 | 170.69 | 9.13  | 2210.0 | 27.0  | 141.0 | 51.80 | 73.30 |
| 230A07 | 170.69 | 219.46 | 11.40 | 1550.0 | 30.60 | 108.0 | 139.0 | 54.70 |
| 231A02 | 15.24  | 82.30  | 12.50 | 1210.0 | 16.20 | 98.60 | 17.0  | 42.30 |
| 231A03 | 82.30  | 152.40 | 15.10 | 2.0    | 25.40 | 166.0 | 38.0  | 59.50 |
| 231A04 | 152.40 | 277.37 | 13.0  | 2210.0 | 37.80 | 179.0 | 57.20 | 67.50 |
| 231A05 | 216.41 | 307.85 | 11.20 | 2600.0 | 53.90 | 250.0 | 115.0 | 93.60 |
| 231A06 | 277.37 | 335.28 | 13.50 | 1680.0 | 25.70 | 156.0 | 123.0 | 51.40 |
| 231A07 | 335.28 | 396.24 | 8.94  | 133.0  | 0.0   | 12.20 | 0.0   | 8.77  |
| 232A02 | 15.24  | 48.77  | 13.30 | 984.0  | 13.20 | 56.40 | 10.0  | 8.79  |
| 232A03 | 48.77  | 82.30  | 12.40 | 1410.0 | 15.70 | 114.0 | 12.80 | 53.10 |
| 232A04 | 82.30  | 115.82 | 13.60 | 3380.0 | 29.30 | 442.0 | 26.0  | 167.0 |
| 232A05 | 115.82 | 149.35 | 9.61  | 923.0  | 15.90 | 71.0  | 17.90 | 34.70 |
| 232A06 | 149.35 | 182.88 | 8.55  | 62.30  | 0.0   | 5.85  | 0.0   | 0.0   |
| 233C04 | 76.20  | 106.68 | 1.12  | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 234B02 | 15.24  | 88.39  | 10.30 | 676.0  | 8.99  | 43.20 | 8.91  | 21.50 |
| 234B03 | 88.39  | 137.16 | 14.70 | 1330.0 | 11.60 | 101.0 | 13.40 | 44.30 |
| 234B04 | 137.16 | 246.89 | 10.60 | 2230.0 | 38.30 | 187.0 | 30.0  | 72.80 |
| 234B05 | 192.02 | 274.32 | 15.60 | 2010.0 | 35.30 | 159.0 | 33.90 | 56.50 |
| 234B06 | 246.89 | 298.70 | 17.80 | 3400.0 | 42.40 | 230.0 | 69.60 | 90.10 |
| 234B07 | 298.70 | 368.81 | 14.70 | 921.0  | 10.60 | 64.70 | 28.10 | 26.10 |
| 235A02 | 15.24  | 67.06  | 10.70 | 1150.0 | 15.20 | 74.70 | 14.60 | 40.0  |
| 235A03 | 67.06  | 100.58 | 8.96  | 985.0  | 9.22  | 79.80 | 13.20 | 43.30 |
| 235A04 | 100.58 | 149.35 | 15.90 | 2940.0 | 32.90 | 156.0 | 34.30 | 75.70 |
| 235A05 | 124.97 | 161.54 | 16.20 | 2380.0 | 31.60 | 161.0 | 56.0  | 79.50 |
| 235A06 | 149.35 | 173.74 | 12.90 | 1610.0 | 26.0  | 123.0 | 50.0  | 54.30 |
| 235A07 | 173.74 | 219.46 | 10.70 | 302.0  | 6.96  | 29.60 | 6.09  | 12.70 |
| 236A02 | 15.24  | 48.77  | 11.90 | 1500.0 | 16.70 | 78.10 | 0.0   | 33.50 |
| 236A03 | 48.77  | 82.30  | 12.0  | 1480.0 | 25.30 | 114.0 | 68.20 | 53.50 |
| 236A04 | 82.30  | 115.82 | 10.60 | 1450.0 | 24.20 | 89.50 | 22.70 | 25.60 |
| 236A05 | 115.82 | 149.35 | 9.66  | 737.0  | 13.20 | 80.10 | 17.30 | 30.70 |
| 236A06 | 149.35 | 185.93 | 10.60 | 857.0  | 11.30 | 85.10 | 13.80 | 19.20 |
| 238A02 | 15.24  | 45.72  | 7.15  | 726.0  | 8.37  | 31.90 | 0.0   | 18.70 |
| 238A05 | 106.68 | 137.16 | 5.05  | 21.30  | 0.0   | 2.69  | 0.0   | 2.34  |
| 238A06 | 137.16 | 167.64 | 0.65  | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 239A02 | 15.24  | 70.10  | 6.05  | 837.0  | 11.40 | 58.70 | 9.76  | 60.50 |
| 239A03 | 70.10  | 121.92 | 11.30 | 800.0  | 8.21  | 49.0  | 0.0   | 22.0  |
| 240A02 | 15.24  | 36.58  | 13.50 | 2360.0 | 36.0  | 144.0 | 42.20 | 66.40 |

|        |        |        |       |        |       |       |       |       |
|--------|--------|--------|-------|--------|-------|-------|-------|-------|
| 240A03 | 36.58  | 57.91  | 16.20 | 2440.0 | 34.30 | 183.0 | 33.70 | 79.30 |
| 240A04 | 57.91  | 76.20  | 16.30 | 2270.0 | 34.0  | 158.0 | 93.60 | 62.40 |
| 240A05 | 76.20  | 97.54  | 14.60 | 1400.0 | 22.10 | 137.0 | 66.50 | 53.60 |
| 240A06 | 97.54  | 118.87 | 14.80 | 1290.0 | 31.70 | 118.0 | 24.60 | 47.90 |
| 241A02 | 15.24  | 106.68 | 9.90  | 703.0  | 10.70 | 51.20 | 9.30  | 26.50 |
| 241A03 | 106.68 | 164.59 | 13.80 | 933.0  | 11.20 | 55.80 | 10.90 | 29.20 |
| 241A04 | 164.59 | 256.03 | 17.0  | 4610.0 | 42.40 | 228.0 | 56.10 | 104.0 |
| 241A05 | 210.31 | 280.42 | 11.80 | 1650.0 | 17.50 | 143.0 | 55.70 | 54.10 |
| 241A06 | 256.03 | 304.80 | 14.50 | 1060.0 | 23.30 | 111.0 | 0.0   | 47.30 |
| 241A07 | 304.80 | 362.71 | 16.40 | 5080.0 | 21.10 | 137.0 | 12.40 | 66.30 |
| 242A02 | 15.24  | 76.20  | 15.10 | 959.0  | 7.80  | 41.70 | 10.20 | 26.0  |
| 242A03 | 76.20  | 137.16 | 14.80 | 3820.0 | 21.40 | 422.0 | 0.0   | 188.0 |
| 242A04 | 137.16 | 316.99 | 16.20 | 2530.0 | 40.30 | 153.0 | 77.30 | 71.20 |
| 242A05 | 225.55 | 368.81 | 12.10 | 2340.0 | 39.80 | 142.0 | 46.10 | 62.80 |
| 242A06 | 316.99 | 423.67 | 16.20 | 1410.0 | 31.50 | 120.0 | 23.60 | 43.30 |
| 242A07 | 423.67 | 524.26 | 14.50 | 798.0  | 12.0  | 53.20 | 15.10 | 26.60 |
| 243A02 | 15.24  | 45.72  | 11.10 | 946.0  | 10.0  | 71.70 | 12.70 | 32.10 |
| 243A03 | 45.72  | 79.25  | 13.70 | 2150.0 | 35.20 | 185.0 | 51.30 | 72.70 |
| 243A04 | 79.25  | 109.73 | 10.30 | 2610.0 | 57.90 | 241.0 | 139.0 | 108.0 |
| 243A05 | 109.73 | 140.21 | 12.60 | 2290.0 | 38.60 | 222.0 | 822.0 | 99.60 |
| 243A06 | 140.21 | 170.69 | 14.10 | 2150.0 | 26.10 | 141.0 | 62.80 | 60.20 |
| 244A02 | 15.24  | 45.72  | 8.40  | 1780.0 | 17.0  | 246.0 | 20.60 | 129.0 |
| 244A03 | 45.72  | 76.20  | 3.31  | 374.0  | 3.72  | 24.50 | 5.77  | 12.0  |
| 244A04 | 76.20  | 106.68 | 8.32  | 2840.0 | 40.20 | 187.0 | 81.50 | 88.20 |
| 244A05 | 106.68 | 137.16 | 10.70 | 1260.0 | 23.50 | 74.70 | 41.0  | 37.80 |
| 244A06 | 137.16 | 167.64 | 6.21  | 73.20  | 2.64  | 6.34  | 1.90  | 4.25  |
| 245B02 | 15.24  | 45.72  | 8.46  | 1140.0 | 12.10 | 50.10 | 8.95  | 23.20 |
| 245B03 | 45.72  | 112.78 | 8.26  | 1510.0 | 21.40 | 96.40 | 24.0  | 47.90 |
| 245B04 | 112.78 | 222.50 | 9.90  | 2410.0 | 34.70 | 155.0 | 55.40 | 64.30 |
| 245B05 | 167.64 | 256.03 | 10.10 | 2190.0 | 33.20 | 145.0 | 114.0 | 70.40 |
| 245B06 | 222.50 | 286.51 | 8.03  | 2140.0 | 23.60 | 140.0 | 47.60 | 62.60 |
| 245B07 | 286.51 | 347.47 | 12.50 | 832.0  | 13.50 | 64.60 | 13.70 | 35.50 |
| 246A02 | 15.24  | 45.72  | 0.06  | 2.01   | 0.0   | 0.0   | 0.0   | 0.0   |
| 246A03 | 45.72  | 76.20  | 0.10  | 1.56   | 0.0   | 0.0   | 0.0   | 0.0   |
| 246A04 | 76.20  | 106.68 | 0.10  | 1.73   | 0.0   | 0.0   | 0.0   | 0.0   |
| 246A05 | 106.68 | 137.16 | 0.15  | 1.61   | 0.0   | 0.0   | 0.0   | 0.0   |
| 246A06 | 137.16 | 167.64 | 0.03  | 1.05   | 0.0   | 0.0   | 0.0   | 0.0   |
| 247A02 | 15.24  | 45.72  | 2.53  | 4.07   | 0.0   | 0.0   | 0.0   | 0.0   |
| 247A03 | 45.72  | 76.20  | 0.07  | 8.68   | 0.0   | 0.0   | 0.0   | 0.0   |
| 248A02 | 15.24  | 128.02 | 9.83  | 912.0  | 17.0  | 56.90 | 15.60 | 26.0  |
| 248A03 | 128.02 | 185.93 | 17.50 | 2120.0 | 34.60 | 137.0 | 48.60 | 54.70 |
| 248A04 | 185.93 | 307.85 | 16.10 | 1140.0 | 0.0   | 161.0 | 0.0   | 51.10 |
| 248A05 | 246.89 | 341.38 | 10.60 | 301.0  | 0.0   | 0.0   | 16.0  | 0.0   |
| 248A06 | 307.85 | 374.90 | 2.59  | 17.80  | 0.0   | 0.0   | 0.0   | 0.0   |
| 249B02 | 15.24  | 39.62  | 5.92  | 768.0  | 15.0  | 48.90 | 12.80 | 28.70 |
| 249B03 | 39.62  | 85.34  | 10.30 | 1220.0 | 19.0  | 74.30 | 16.10 | 33.70 |
| 249B04 | 60.96  | 97.54  | 4.30  | 707.0  | 28.60 | 53.50 | 7.98  | 26.40 |
| 249B05 | 85.34  | 109.73 | 5.61  | 921.0  | 19.0  | 112.0 | 25.90 | 51.30 |
| 249B06 | 109.73 | 146.30 | 1.60  | 157.0  | 3.73  | 11.80 | 6.20  | 5.76  |
| 250A02 | 15.24  | 45.72  | 0.43  | 3.51   | 0.0   | 0.0   | 0.0   | 0.0   |
| 250A03 | 45.72  | 76.20  | 0.39  | 1.35   | 0.0   | 0.0   | 0.0   | 0.0   |
| 250A04 | 76.20  | 106.68 | 0.31  | 0.61   | 0.0   | 0.0   | 0.0   | 0.0   |
| 250A05 | 106.68 | 137.16 | 0.56  | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 250A06 | 137.16 | 167.64 | 0.67  | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |

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|--------|--------|--------|-------|--------|-------|-------|-------|-------|
| 251B02 | 15.24  | 128.02 | 11.20 | 854.0  | 9.11  | 54.20 | 7.19  | 26.10 |
| 251B03 | 128.02 | 152.40 | 9.98  | 1510.0 | 14.40 | 88.40 | 15.0  | 37.10 |
| 251B04 | 152.40 | 198.12 | 14.0  | 2070.0 | 25.0  | 140.0 | 46.40 | 68.80 |
| 251B05 | 173.74 | 210.31 | 16.80 | 1800.0 | 24.10 | 128.0 | 36.40 | 51.50 |
| 251B06 | 198.12 | 222.50 | 8.43  | 432.0  | 3.73  | 46.20 | 11.0  | 15.50 |
| 251B07 | 222.50 | 259.08 | 2.52  | 39.40  | 0.0   | 5.10  | 0.0   | 0.0   |
| 252C02 | 15.24  | 67.06  | 9.66  | 533.0  | 5.56  | 27.20 | 0.0   | 15.0  |
| 252C03 | 67.06  | 88.39  | 9.59  | 942.0  | 8.99  | 48.30 | 7.35  | 25.80 |
| 252C04 | 88.39  | 173.74 | 12.20 | 1950.0 | 21.20 | 141.0 | 25.20 | 63.70 |
| 252C05 | 131.06 | 201.17 | 12.70 | 2200.0 | 28.60 | 158.0 | 95.60 | 68.60 |
| 252C06 | 173.74 | 228.60 | 13.50 | 2060.0 | 26.90 | 128.0 | 190.0 | 57.60 |
| 252C07 | 228.60 | 286.51 | 5.84  | 842.0  | 10.90 | 65.20 | 23.10 | 22.10 |
| 253A02 | 15.24  | 88.39  | 19.10 | 888.0  | 16.50 | 56.70 | 11.10 | 28.60 |
| 253A03 | 88.39  | 100.58 | 12.30 | 909.0  | 16.10 | 62.70 | 13.0  | 28.60 |
| 253A04 | 100.58 | 118.87 | 10.20 | 753.0  | 12.10 | 59.10 | 17.90 | 24.30 |
| 253A07 | 128.02 | 167.64 | 6.48  | 72.20  | 1.59  | 7.51  | 2.05  | 3.56  |
| 254A02 | 15.24  | 51.82  | 15.50 | 737.0  | 34.80 | 10.0  | 0.0   | 20.10 |
| 254A03 | 51.82  | 88.39  | 15.40 | 704.0  | 7.76  | 36.10 | 6.20  | 18.60 |
| 254A04 | 88.39  | 128.02 | 9.58  | 917.0  | 9.38  | 60.50 | 8.61  | 29.50 |
| 254A05 | 128.02 | 164.59 | 14.40 | 1170.0 | 12.0  | 69.50 | 16.80 | 34.50 |
| 254A06 | 164.59 | 204.22 | 8.28  | 46.40  | 0.0   | 3.13  | 0.0   | 2.86  |
| 255A02 | 15.24  | 76.20  | 11.50 | 712.0  | 7.84  | 35.30 | 8.41  | 22.10 |
| 255A03 | 76.20  | 137.16 | 13.0  | 895.0  | 9.56  | 42.70 | 9.66  | 24.40 |
| 255A04 | 137.16 | 201.17 | 12.90 | 1010.0 | 12.10 | 48.70 | 9.60  | 29.20 |
| 255A05 | 201.17 | 262.13 | 3.98  | 334.0  | 3.59  | 20.30 | 0.0   | 12.0  |
| 255A06 | 262.13 | 326.14 | 1.73  | 2.73   | 0.0   | 0.0   | 0.0   | 0.0   |
| 256B02 | 15.24  | 103.63 | 18.0  | 590.0  | 8.04  | 32.80 | 5.60  | 17.0  |
| 256B04 | 103.63 | 149.35 | 12.0  | 708.0  | 9.06  | 46.80 | 10.0  | 22.60 |
| 256B07 | 149.35 | 176.78 | 1.0   | 6.25   | 0.0   | 0.0   | 0.0   | 0.0   |
| 257C02 | 15.24  | 121.92 | 8.95  | 1180.0 | 12.20 | 64.40 | 10.60 | 29.70 |
| 257C03 | 121.92 | 192.02 | 9.72  | 882.0  | 11.30 | 51.70 | 10.60 | 23.90 |
| 257C05 | 192.02 | 210.31 | 3.45  | 81.40  | 2.68  | 10.60 | 2.34  | 5.12  |
| 257C06 | 210.31 | 259.08 | 0.98  | 16.40  | 0.0   | 3.07  | 0.0   | 1.42  |
| 258C02 | 15.24  | 42.67  | 22.60 | 832.0  | 12.40 | 46.80 | 6.78  | 26.90 |
| 258C03 | 42.67  | 70.10  | 18.20 | 1010.0 | 14.40 | 57.20 | 9.03  | 31.20 |
| 258C04 | 70.10  | 97.54  | 12.20 | 642.0  | 7.73  | 44.0  | 10.10 | 20.10 |
| 258C05 | 97.54  | 128.02 | 1.27  | 3.91   | 0.0   | 0.0   | 0.0   | 0.0   |
| 259B02 | 15.24  | 51.82  | 15.50 | 1940.0 | 25.90 | 135.0 | 44.60 | 65.70 |
| 259B04 | 51.82  | 76.20  | 4.29  | 578.0  | 8.15  | 36.60 | 10.70 | 16.50 |
| 260B02 | 15.24  | 64.01  | 7.68  | 727.0  | 13.50 | 49.30 | 11.90 | 28.90 |
| 260B03 | 64.01  | 112.78 | 10.30 | 1160.0 | 21.0  | 82.30 | 26.0  | 40.80 |
| 260B04 | 112.78 | 161.54 | 13.30 | 2120.0 | 31.60 | 159.0 | 43.60 | 70.10 |
| 260B05 | 161.54 | 210.31 | 15.10 | 2420.0 | 48.10 | 233.0 | 67.60 | 94.80 |
| 260B06 | 210.31 | 259.08 | 15.60 | 2200.0 | 38.20 | 198.0 | 131.0 | 77.0  |
| 261C02 | 15.24  | 45.72  | 0.72  | 1.46   | 0.0   | 0.0   | 0.0   | 0.0   |
| 261C06 | 137.16 | 167.64 | 0.84  | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 262A02 | 15.24  | 45.72  | 0.62  | 17.50  | 0.0   | 2.64  | 0.0   | 1.51  |
| 262A03 | 45.72  | 76.20  | 0.23  | 5.71   | 0.0   | 0.0   | 0.0   | 0.0   |
| 262A04 | 76.20  | 106.68 | 0.33  | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 262A05 | 106.68 | 137.16 | 0.18  | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 263B02 | 18.29  | 48.77  | 10.50 | 730.0  | 8.17  | 33.50 | 4.59  | 17.20 |
| 263B03 | 48.77  | 79.25  | 4.24  | 396.0  | 3.58  | 32.20 | 3.51  | 13.80 |
| 263B04 | 79.25  | 109.73 | 2.02  | 197.0  | 2.35  | 13.40 | 2.11  | 6.02  |
| 263B05 | 109.73 | 140.21 | 1.53  | 101.0  | 1.17  | 7.07  | 1.60  | 3.19  |



|        |        |        |       |        |       |       |       |       |
|--------|--------|--------|-------|--------|-------|-------|-------|-------|
| 263B06 | 140.21 | 170.69 | 3.04  | 425.0  | 6.05  | 30.70 | 7.91  | 13.0  |
| 264A02 | 15.24  | 45.72  | 2.68  | 13.20  | 0.0   | 0.0   | 0.0   | 0.0   |
| 264A03 | 45.72  | 76.20  | 1.90  | 3.97   | 0.0   | 0.0   | 0.0   | 0.0   |
| 264A06 | 137.16 | 167.64 | 0.71  | 3.97   | 0.0   | 0.0   | 0.0   | 0.0   |
| 265A04 | 76.20  | 106.68 | 1.29  | 2.42   | 0.0   | 1.67  | 0.0   | 0.75  |
| 265A05 | 106.68 | 137.16 | 1.08  | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 265A06 | 137.16 | 167.64 | 1.19  | 0.0    | 0.0   | 0.83  | 0.0   | 0.0   |
| 266A02 | 15.24  | 45.72  | 15.80 | 205.0  | 3.36  | 20.0  | 4.27  | 8.57  |
| 266A03 | 45.72  | 76.20  | 2.98  | 4650.0 | 0.0   | 161.0 | 2.88  | 13.10 |
| 266A04 | 76.20  | 106.68 | 0.98  | 20.20  | 0.0   | 3.71  | 0.0   | 1.72  |
| 266A05 | 106.68 | 137.16 | 4.45  | 15.80  | 0.0   | 1.70  | 0.0   | 0.88  |
| 266A06 | 137.16 | 167.64 | 4.32  | 17.30  | 0.0   | 0.0   | 0.0   | 0.0   |
| 267A02 | 15.24  | 45.72  | 2.69  | 113.0  | 0.0   | 10.40 | 0.0   | 5.44  |
| 267A03 | 45.72  | 76.20  | 1.17  | 39.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 268B02 | 15.24  | 45.72  | 6.75  | 793.0  | 9.47  | 39.90 | 8.85  | 20.0  |
| 268B03 | 45.72  | 76.20  | 5.15  | 702.0  | 8.31  | 46.0  | 8.78  | 19.20 |
| 268B04 | 76.20  | 106.68 | 4.51  | 212.0  | 3.66  | 16.80 | 7.44  | 8.28  |
| 268B05 | 106.68 | 137.16 | 0.96  | 3.22   | 0.0   | 0.0   | 0.0   | 0.0   |
| 269C02 | 15.24  | 54.86  | 4.15  | 775.0  | 10.10 | 48.30 | 7.89  | 23.50 |
| 269C04 | 54.86  | 121.92 | 5.06  | 863.0  | 6.76  | 39.0  | 4.80  | 15.10 |
| 269C06 | 121.92 | 149.35 | 6.26  | 1430.0 | 15.40 | 67.40 | 13.0  | 33.40 |
| 269C07 | 149.35 | 182.88 | 7.95  | 1910.0 | 17.50 | 93.50 | 14.70 | 47.0  |
| 270A02 | 15.24  | 30.48  | 11.30 | 1930.0 | 21.60 | 111.0 | 21.0  | 53.40 |
| 270A03 | 30.48  | 54.86  | 13.10 | 1320.0 | 17.80 | 92.30 | 18.20 | 42.60 |
| 270A04 | 54.86  | 79.25  | 18.60 | 2210.0 | 33.90 | 163.0 | 29.70 | 75.10 |
| 270A06 | 79.25  | 97.54  | 22.70 | 3190.0 | 48.50 | 221.0 | 50.70 | 103.0 |
| 270A07 | 97.54  | 131.06 | 4.95  | 542.0  | 9.77  | 36.80 | 13.70 | 15.20 |
| 271A02 | 15.24  | 27.43  | 7.36  | 222.0  | 0.0   | 18.0  | 0.0   | 8.95  |
| 271A03 | 27.43  | 94.49  | 6.32  | 856.0  | 9.81  | 53.50 | 11.40 | 22.10 |
| 271A04 | 94.49  | 143.26 | 15.30 | 1600.0 | 18.60 | 89.80 | 33.0  | 38.50 |
| 271A07 | 143.26 | 179.83 | 3.98  | 283.0  | 3.43  | 22.30 | 8.91  | 9.60  |
| 272A02 | 15.24  | 73.15  | 6.46  | 331.0  | 5.03  | 18.0  | 0.0   | 11.70 |
| 272A03 | 73.15  | 140.21 | 7.68  | 846.0  | 12.60 | 70.0  | 16.80 | 35.0  |
| 272A04 | 140.21 | 222.50 | 11.80 | 1690.0 | 22.50 | 116.0 | 39.90 | 44.40 |
| 272A05 | 182.88 | 237.74 | 13.30 | 1030.0 | 105.0 | 32.90 | 0.0   | 35.20 |
| 272A06 | 222.50 | 256.03 | 11.0  | 580.0  | 40.90 | 120.0 | 0.0   | 0.0   |
| 272A07 | 256.03 | 316.99 | 1.44  | 693.0  | 9.06  | 59.30 | 8.27  | 25.0  |
| 273A02 | 15.24  | 45.72  | 8.83  | 666.0  | 10.80 | 45.40 | 28.10 | 22.0  |
| 273A03 | 45.72  | 73.15  | 13.80 | 1050.0 | 11.30 | 77.80 | 34.20 | 31.20 |
| 273A04 | 73.15  | 103.63 | 12.10 | 751.0  | 14.40 | 72.50 | 15.40 | 21.80 |
| 273A05 | 103.63 | 131.06 | 10.60 | 601.0  | 11.70 | 44.90 | 10.20 | 19.40 |
| 273A06 | 131.06 | 161.54 | 9.86  | 356.0  | 6.18  | 29.10 | 0.0   | 13.50 |
| 274A02 | 15.24  | 27.43  | 12.70 | 1120.0 | 12.10 | 60.50 | 15.30 | 22.10 |
| 274A03 | 27.43  | 85.34  | 9.93  | 1730.0 | 25.50 | 123.0 | 37.40 | 44.40 |
| 274A04 | 54.86  | 103.63 | 8.10  | 966.0  | 15.0  | 86.70 | 17.20 | 29.40 |
| 274A05 | 85.34  | 121.92 | 6.74  | 236.0  | 4.86  | 21.0  | 0.0   | 11.50 |
| 274A06 | 121.92 | 155.45 | 9.10  | 390.0  | 7.16  | 31.40 | 0.0   | 15.80 |
| 275A02 | 15.24  | 54.86  | 10.60 | 1.0    | 17.70 | 49.30 | 0.0   | 23.20 |
| 275A03 | 54.86  | 94.49  | 6.83  | 688.0  | 9.81  | 50.50 | 0.0   | 16.20 |
| 275A04 | 94.49  | 134.11 | 8.58  | 1850.0 | 30.20 | 122.0 | 0.0   | 53.40 |
| 275A05 | 134.11 | 173.74 | 6.93  | 688.0  | 12.60 | 71.40 | 14.20 | 23.80 |
| 275A06 | 173.74 | 213.36 | 8.32  | 374.0  | 9.43  | 31.60 | 7.57  | 15.50 |
| 276A02 | 15.24  | 109.73 | 8.57  | 727.0  | 17.50 | 55.40 | 15.0  | 31.0  |
| 276A03 | 109.73 | 204.22 | 10.70 | 1020.0 | 16.20 | 85.60 | 18.70 | 43.0  |

|        |        |        |       |        |       |       |       |       |
|--------|--------|--------|-------|--------|-------|-------|-------|-------|
| 276A04 | 204.22 | 298.70 | 15.60 | 1310.0 | 19.10 | 82.60 | 20.10 | 37.30 |
| 276A05 | 298.70 | 393.19 | 17.50 | 1640.0 | 18.70 | 124.0 | 24.70 | 53.10 |
| 276A06 | 393.19 | 487.68 | 4.13  | 189.0  | 0.0   | 14.40 | 0.0   | 7.73  |
| 277B02 | 15.24  | 45.72  | 5.92  | 360.0  | 0.0   | 20.30 | 4.19  | 12.0  |
| 277B03 | 45.72  | 76.20  | 8.38  | 1020.0 | 11.90 | 54.10 | 8.96  | 29.30 |
| 277B04 | 76.20  | 106.68 | 11.0  | 949.0  | 11.60 | 68.80 | 11.60 | 34.30 |
| 277B05 | 106.68 | 137.16 | 11.0  | 236.0  | 4.20  | 22.90 | 0.0   | 10.50 |
| 277B06 | 137.16 | 167.64 | 2.31  | 53.60  | 0.0   | 5.23  | 0.0   | 0.0   |
| 278B02 | 15.24  | 36.58  | 4.50  | 928.0  | 17.70 | 82.90 | 23.60 | 35.10 |
| 278B03 | 36.58  | 57.91  | 22.60 | 3040.0 | 73.60 | 258.0 | 54.60 | 96.50 |
| 278B04 | 57.91  | 76.20  | 12.70 | 2800.0 | 55.90 | 232.0 | 78.50 | 84.90 |
| 278B05 | 76.20  | 97.54  | 14.40 | 2230.0 | 45.40 | 162.0 | 51.80 | 58.50 |
| 278B06 | 97.54  | 118.87 | 13.10 | 1390.0 | 36.70 | 145.0 | 41.60 | 49.10 |
| 282A02 | 15.24  | 45.72  | 8.53  | 815.0  | 13.0  | 42.60 | 10.80 | 24.50 |
| 282A03 | 45.72  | 76.20  | 10.70 | 789.0  | 12.10 | 48.40 | 12.60 | 22.60 |
| 282A04 | 76.20  | 106.68 | 10.90 | 938.0  | 16.20 | 64.30 | 15.70 | 33.80 |
| 282A05 | 106.68 | 137.16 | 6.73  | 1370.0 | 12.10 | 148.0 | 15.20 | 69.30 |
| 282A06 | 137.16 | 167.64 | 9.90  | 1550.0 | 19.0  | 136.0 | 23.50 | 58.80 |
| 283A02 | 15.24  | 45.72  | 7.81  | 610.0  | 12.40 | 40.20 | 9.99  | 20.40 |
| 283A03 | 45.72  | 76.20  | 7.20  | 718.0  | 11.30 | 47.30 | 7.68  | 24.40 |
| 283A04 | 76.20  | 106.68 | 8.36  | 899.0  | 16.30 | 62.30 | 11.90 | 31.30 |
| 283A05 | 106.68 | 137.16 | 6.19  | 1120.0 | 15.30 | 77.70 | 7.04  | 39.40 |
| 283A06 | 137.16 | 167.64 | 9.84  | 1490.0 | 16.0  | 102.0 | 17.80 | 46.40 |
| 284B02 | 15.24  | 45.72  | 11.40 | 1780.0 | 25.20 | 164.0 | 36.20 | 79.0  |
| 284B03 | 45.72  | 76.20  | 7.78  | 1490.0 | 26.40 | 185.0 | 77.0  | 94.20 |
| 284B04 | 76.20  | 106.68 | 4.36  | 49.30  | 0.0   | 0.0   | 0.0   | 0.0   |
| 284B05 | 106.68 | 137.16 | 6.20  | 38.30  | 0.0   | 0.0   | 0.0   | 2.17  |
| 284B06 | 137.16 | 167.64 | 5.15  | 28.40  | 0.0   | 0.0   | 0.0   | 0.0   |
| 285A02 | 15.24  | 45.72  | 6.76  | 1360.0 | 30.70 | 116.0 | 43.10 | 51.40 |
| 285A03 | 45.72  | 76.20  | 14.70 | 3960.0 | 139.0 | 548.0 | 875.0 | 212.0 |
| 285A04 | 76.20  | 106.68 | 10.70 | 4610.0 | 230.0 | 946.0 | 334.0 | 323.0 |
| 285A05 | 106.68 | 137.16 | 19.20 | 1710.0 | 26.20 | 135.0 | 61.50 | 55.70 |
| 286B02 | 15.24  | 45.72  | 7.84  | 1280.0 | 23.20 | 108.0 | 25.80 | 47.80 |
| 286B03 | 45.72  | 76.20  | 9.40  | 3410.0 | 85.0  | 637.0 | 288.0 | 280.0 |
| 286B04 | 76.20  | 106.68 | 6.42  | 1790.0 | 50.10 | 409.0 | 209.0 | 182.0 |
| 287B02 | 15.24  | 45.72  | 17.30 | 34.30  | 1.55  | 1.12  | 0.0   | 2.55  |
| 287B03 | 45.72  | 76.20  | 5.90  | 28.60  | 0.0   | 0.0   | 0.0   | 0.0   |
| 287B04 | 76.20  | 106.68 | 4.80  | 29.90  | 0.0   | 0.0   | 0.0   | 0.0   |
| 287B05 | 106.68 | 137.16 | 4.43  | 28.20  | 1.21  | 1.30  | 0.97  | 2.09  |
| 287B06 | 137.16 | 167.64 | 4.08  | 23.60  | 0.0   | 0.0   | 0.0   | 0.0   |
| 288B02 | 15.24  | 45.72  | 5.42  | 33.10  | 2.20  | 5.24  | 1.30  | 3.42  |
| 288B03 | 45.72  | 76.20  | 5.17  | 28.50  | 0.69  | 1.29  | 0.0   | 1.52  |
| 288B04 | 76.20  | 106.68 | 4.66  | 22.90  | 0.0   | 0.0   | 0.0   | 0.0   |
| 288B05 | 106.68 | 137.16 | 5.66  | 23.60  | 0.0   | 0.0   | 0.0   | 0.0   |
| 288B06 | 137.16 | 167.64 | 5.47  | 24.20  | 0.0   | 0.0   | 0.0   | 0.0   |
| 289A02 | 15.24  | 45.72  | 9.30  | 1410.0 | 19.90 | 96.60 | 25.0  | 46.60 |
| 289A03 | 45.72  | 76.20  | 9.54  | 402.0  | 16.0  | 43.40 | 7.42  | 18.30 |
| 289A04 | 76.20  | 106.68 | 5.06  | 25.90  | 0.0   | 0.0   | 0.0   | 0.0   |
| 289A05 | 106.68 | 137.16 | 4.26  | 38.10  | 1.30  | 1.66  | 0.0   | 2.59  |
| 289A06 | 137.16 | 167.64 | 3.63  | 27.50  | 0.87  | 1.38  | 0.0   | 1.66  |
| 290B02 | 15.24  | 45.72  | 9.84  | 1260.0 | 19.80 | 101.0 | 9.21  | 38.60 |
| 290B03 | 45.72  | 76.20  | 3.73  | 25.70  | 0.0   | 0.0   | 0.0   | 0.0   |
| 290B04 | 76.20  | 106.68 | 4.42  | 28.40  | 0.0   | 0.0   | 0.0   | 0.0   |
| 290B05 | 106.68 | 137.16 | 4.38  | 35.90  | 0.0   | 0.0   | 0.0   | 0.0   |

|        |        |        |       |        |       |       |       |       |
|--------|--------|--------|-------|--------|-------|-------|-------|-------|
| 290B06 | 137.16 | 167.64 | 3.55  | 20.20  | 0.0   | 0.0   | 0.0   | 0.0   |
| 291A02 | 15.24  | 45.72  | 13.80 | 828.0  | 9.60  | 62.90 | 11.50 | 23.50 |
| 291A03 | 45.72  | 76.20  | 13.90 | 535.0  | 9.62  | 46.0  | 9.17  | 18.0  |
| 291A04 | 76.20  | 106.68 | 9.01  | 786.0  | 11.40 | 55.90 | 10.0  | 22.20 |
| 291A05 | 106.68 | 137.16 | 4.45  | 154.0  | 3.95  | 11.60 | 3.27  | 6.26  |
| 291A06 | 137.16 | 167.64 | 2.97  | 15.10  | 0.0   | 0.0   | 0.0   | 0.0   |
| 295B02 | 15.24  | 45.72  | 6.21  | 570.0  | 8.97  | 37.40 | 8.32  | 20.50 |
| 295B03 | 45.72  | 76.20  | 6.48  | 685.0  | 14.30 | 45.90 | 11.80 | 20.10 |
| 295B04 | 76.20  | 106.68 | 7.10  | 957.0  | 15.70 | 55.20 | 10.20 | 24.60 |
| 295B05 | 106.68 | 137.16 | 5.79  | 924.0  | 22.0  | 75.60 | 17.0  | 28.10 |
| 295B06 | 137.16 | 167.64 | 6.60  | 856.0  | 21.10 | 60.50 | 14.20 | 25.40 |
| 294A02 | 15.24  | 45.72  | 8.91  | 145.0  | 8.0   | 11.40 | 5.35  | 5.30  |
| 294A03 | 45.72  | 76.20  | 2.41  | 18.60  | 0.0   | 0.0   | 0.0   | 0.0   |
| 294A04 | 76.20  | 106.68 | 4.12  | 39.30  | 0.0   | 0.0   | 0.0   | 0.0   |
| 294A05 | 106.68 | 137.16 | 4.79  | 47.30  | 0.0   | 0.0   | 0.0   | 0.0   |
| 294A06 | 137.16 | 167.64 | 2.10  | 20.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 292C02 | 15.24  | 45.72  | 15.80 | 1470.0 | 16.10 | 111.0 | 16.0  | 52.90 |
| 292C03 | 45.72  | 76.20  | 14.10 | 1490.0 | 15.80 | 139.0 | 12.20 | 57.70 |
| 292C04 | 76.20  | 106.68 | 18.50 | 1970.0 | 17.50 | 189.0 | 15.70 | 78.10 |
| 292C05 | 106.68 | 137.16 | 13.50 | 1730.0 | 23.40 | 93.40 | 15.20 | 50.30 |
| 292C06 | 137.16 | 167.64 | 11.40 | 1960.0 | 23.70 | 103.0 | 19.80 | 48.70 |
| 293A02 | 15.24  | 45.72  | 8.67  | 171.0  | 0.0   | 22.60 | 0.0   | 11.0  |
| 293A03 | 45.72  | 76.20  | 1.78  | 13.40  | 0.0   | 0.0   | 0.0   | 0.0   |
| 293A04 | 76.20  | 106.68 | 1.44  | 10.20  | 0.0   | 0.0   | 0.0   | 0.0   |
| 293A06 | 137.16 | 167.64 | 0.49  | 2.94   | 0.0   | 0.0   | 0.0   | 0.0   |
| 296B02 | 15.24  | 45.72  | 8.84  | 744.0  | 11.20 | 42.70 | 8.81  | 22.60 |
| 296B03 | 45.72  | 76.20  | 9.35  | 664.0  | 11.70 | 44.30 | 8.72  | 21.10 |
| 296B04 | 76.20  | 106.68 | 6.49  | 640.0  | 10.40 | 50.20 | 7.62  | 24.0  |
| 296B05 | 106.68 | 137.16 | 7.53  | 1540.0 | 21.50 | 98.20 | 11.0  | 46.70 |
| 296B06 | 137.16 | 167.64 | 11.10 | 2750.0 | 28.10 | 157.0 | 34.80 | 64.0  |
| UH1090 | 0.0    | 0.0    | 5.15  | 386.05 | 5.83  | 18.81 | 0.99  | 19.09 |
| UH0190 | 0.0    | 0.0    | 1.06  | 138.35 | 2.39  | 9.78  | 0.35  | 9.74  |
| UH1010 | 0.0    | 0.0    | 4.96  | 28.04  | 0.46  | 1.72  | 0.27  | 1.95  |
| UH1100 | 0.0    | 0.0    | 2.03  | 53.68  | 0.79  | 3.23  | 0.87  | 2.07  |
| UH1110 | 0.0    | 0.0    | 4.37  | 293.25 | 3.81  | 18.03 | 0.72  | 17.27 |
| UH0220 | 0.0    | 0.0    | 0.79  | 184.87 | 2.60  | 12.21 | 0.31  | 11.03 |
| UH1120 | 0.0    | 0.0    | 3.55  | 372.74 | 4.14  | 21.39 | 0.75  | 18.11 |
| UH1130 | 0.0    | 0.0    | 2.97  | 382.82 | 5.14  | 24.01 | 0.97  | 19.01 |
| NB1150 | 0.0    | 0.0    | 2.02  | 414.81 | 3.55  | 23.41 | 0.48  | 19.49 |
| UH0300 | 0.0    | 0.0    | 0.21  | 17.44  | 0.42  | 0.37  | 1.63  | 0.41  |
| NB1090 | 0.0    | 0.0    | 3.24  | 895.62 | 8.71  | 43.40 | 4.62  | 37.56 |
| RBC020 | 0.0    | 0.0    |       | 17.39  | 0.23  | 0.28  | 0.47  | 0.57  |
| NB1070 | 0.0    | 0.0    | 2.22  | 496.44 | 6.83  | 37.26 | 2.96  | 32.77 |
| RB0070 | 0.0    | 0.0    |       | 22.83  | 0.36  | 0.26  | 0.44  | 0.89  |
| RB1050 | 0.0    | 0.0    | 2.44  | 26.74  | 0.44  | 1.52  | 0.47  | 1.69  |
| RB0100 | 0.0    | 0.0    | 0.30  | 17.21  | 0.51  | 1.15  | 0.44  | 0.55  |
| RB0110 | 0.0    | 0.0    | 0.17  | 15.75  | 0.39  | 0.94  | 0.45  | 0.96  |
| RB0120 | 0.0    | 0.0    | 0.08  | 11.53  | 0.24  | 0.28  | 0.41  | 0.57  |
| RB1060 | 0.0    | 0.0    | 2.68  | 27.29  | 0.33  | 1.22  | 1.08  | 2.18  |
| RB1080 | 0.0    | 0.0    | 0.42  | 3.22   | 0.12  | 0.24  | 0.14  | 0.40  |
| RB1070 | 0.0    | 0.0    | 2.60  | 14.77  | 0.11  | 0.78  | 0.34  | 0.10  |
| RB0160 | 0.0    | 0.0    | 0.42  | 126.92 | 1.65  | 9.18  | 0.31  | 7.94  |
| RB0190 | 0.0    | 0.0    | 2.29  | 456.52 | 5.84  | 41.13 | 1.17  | 33.57 |
| RB1160 | 0.0    | 0.0    | 3.91  | 169.24 | 1.99  | 12.38 | 0.28  | 10.43 |

|        |     |     |      |         |       |        |       |        |
|--------|-----|-----|------|---------|-------|--------|-------|--------|
| RB1100 | 0.0 | 0.0 | 2.63 | 243.59  | 3.50  | 22.80  | 0.28  | 16.19  |
| RB0240 | 0.0 | 0.0 | 0.88 | 385.35  | 4.80  | 29.72  | 0.52  | 24.63  |
| RB1110 | 0.0 | 0.0 | 2.08 | 423.35  | 2.98  | 46.26  | 0.32  | 27.78  |
| RB1120 | 0.0 | 0.0 | 3.03 | 286.76  | 3.33  | 27.16  | 0.22  | 18.02  |
| RB0270 | 0.0 | 0.0 | 0.97 | 502.81  | 5.75  | 37.95  | 0.64  | 32.04  |
| RB1140 | 0.0 | 0.0 | 5.30 | 484.92  | 4.53  | 38.77  | 0.32  | 27.09  |
| RB0290 | 0.0 | 0.0 | 0.53 | 8.34    | 0.23  | 0.17   | 0.29  | 0.58   |
| RB1170 | 0.0 | 0.0 | 1.03 | 10.20   | 0.03  | 0.16   | 0.19  | 0.12   |
| RB0300 | 0.0 | 0.0 | 0.12 | 5.53    | 0.26  | 0.31   | 0.48  | 0.64   |
| RB0320 | 0.0 | 0.0 | 0.52 | 13.14   | 0.40  | 0.29   | 0.49  | 0.98   |
| RB0330 | 0.0 | 0.0 | 1.17 | 570.07  | 8.84  | 44.51  | 0.73  | 38.84  |
| UH1020 | 0.0 | 0.0 | 2.56 | 211.85  | 3.65  | 13.25  | 1.17  | 11.31  |
| UH1030 | 0.0 | 0.0 | 3.06 | 419.51  | 4.91  | 27.86  | 0.87  | 21.92  |
| UH0030 | 0.0 | 0.0 |      | 674.84  | 5.41  | 34.99  | 8.04  | 27.0   |
| UH0040 | 0.0 | 0.0 |      | 58.91   | 1.25  | 3.97   | 0.32  | 4.56   |
| UH1050 | 0.0 | 0.0 | 2.71 | 132.66  | 1.86  | 7.82   | 0.80  | 7.03   |
| UH0140 | 0.0 | 0.0 | 1.21 | 472.85  | 3.97  | 28.08  | 0.43  | 24.19  |
| UH1080 | 0.0 | 0.0 | 2.66 | 322.05  | 6.26  | 18.32  | 0.51  | 15.89  |
| UH0180 | 0.0 | 0.0 | 1.03 | 328.06  | 3.80  | 17.01  | 5.75  | 17.07  |
| JB0120 | 0.0 | 0.0 | 1.52 | 3094.60 | 54.73 | 176.81 | 2.26  | 185.53 |
| JB0080 | 0.0 | 0.0 |      | 259.24  | 4.40  | 12.42  | 0.48  | 16.48  |
| JB1010 | 0.0 | 0.0 | 6.55 | 441.14  | 8.13  | 23.37  | 6.07  | 23.96  |
| JB0020 | 0.0 | 0.0 |      | 12.0    | 0.16  | 0.19   | 0.25  | 0.19   |
| JB1150 | 0.0 | 0.0 | 0.75 | 3.85    | 0.20  | 0.52   | 0.47  | 0.26   |
| JB1030 | 0.0 | 0.0 | 8.45 | 299.25  | 5.63  | 16.99  | 1.92  | 18.37  |
| JP0150 | 0.0 | 0.0 | 0.83 | 353.16  | 20.03 | 22.45  | 1.66  | 28.07  |
| JB1170 | 0.0 | 0.0 | 3.86 | 126.85  | 2.44  | 5.75   | 2.24  | 8.03   |
| JB1040 | 0.0 | 0.0 | 4.11 | 43.19   | 7.18  | 2.93   | 0.59  | 3.93   |
| JB1060 | 0.0 | 0.0 | 5.47 | 299.93  | 4.92  | 5.31   | 9.34  | 5.68   |
| JB1080 | 0.0 | 0.0 | 0.74 | 5.0     | 0.16  | 0.38   | 0.40  | 0.20   |
| JB0330 | 0.0 | 0.0 | 0.54 | 115.06  | 0.97  | 7.76   | 0.76  | 8.34   |
| JB0310 | 0.0 | 0.0 | 0.27 | 6.89    | 0.80  | 0.41   | 0.61  | 0.34   |
| JB0180 | 0.0 | 0.0 | 0.97 | 451.65  | 6.54  | 19.91  | 0.60  | 29.02  |
| JB0060 | 0.0 | 0.0 |      | 9.54    | 0.74  | 1.05   | 0.41  | 0.32   |
| JB1100 | 0.0 | 0.0 | 1.40 | 4.54    | 0.17  | 0.41   | 0.40  | 0.22   |
| JB1110 | 0.0 | 0.0 | 7.70 | 383.27  | 3.54  | 27.10  | 1.51  | 21.96  |
| JB0220 | 0.0 | 0.0 | 0.26 | 13.43   | 1.04  | 0.52   | 0.62  | 0.43   |
| JB0260 | 0.0 | 0.0 | 0.35 | 10.51   | 0.53  | 0.37   | 0.59  | 1.27   |
| JB1190 | 0.0 | 0.0 | 0.58 | 4.15    | 0.08  | 0.15   | 0.29  | 0.23   |
| JB1120 | 0.0 | 0.0 | 0.20 | 7.49    | 0.25  | 0.40   | 0.38  | 0.93   |
| JB1200 | 0.0 | 0.0 | 0.69 | 6.09    | 2.32  | 0.27   | 0.61  | 0.51   |
| JB1130 | 0.0 | 0.0 | 1.20 | 9.53    | 0.42  | 0.65   | 0.44  | 0.40   |
| JB1140 | 0.0 | 0.0 | 1.30 | 20.48   | 0.51  | 1.54   | 0.19  | 1.22   |
| JB0390 | 0.0 | 0.0 | 1.12 | 90.84   | 1.52  | 5.64   | 0.19  | 7.0    |
| RB1010 | 0.0 | 0.0 | 3.21 | 139.73  | 1.74  | 8.59   | 2.57  | 7.72   |
| JB0410 | 0.0 | 0.0 | 1.14 | 203.44  | 3.16  | 13.13  | 3.06  | 13.78  |
| JB0420 | 0.0 | 0.0 | 0.21 | 2.73    | 0.14  | 0.12   | 0.26  | 0.43   |
| RB0010 | 0.0 | 0.0 |      | 17.85   | 0.31  | 0.35   | 0.53  | 0.72   |
| JB0430 | 0.0 | 0.0 | 1.58 | 73.30   | 1.68  | 5.43   | 0.33  | 6.27   |
| RB1020 | 0.0 | 0.0 | 3.54 | 12.40   | 0.32  | 0.96   | 1.28  | 1.53   |
| RB1030 | 0.0 | 0.0 | 2.52 | 3.14    | 0.09  | 0.08   | 0.31  | 0.53   |
| RB1040 | 0.0 | 0.0 | 2.39 | 88.70   | 1.28  | 6.08   | 2.28  | 5.51   |
| UH0080 | 0.0 | 0.0 |      | 50.28   | 0.95  | 4.65   | 0.37  | 2.45   |
| UH0100 | 0.0 | 0.0 | 2.33 | 231.62  | 2.83  | 14.11  | 18.65 | 13.10  |

|        |     |     |      |        |       |       |       |       |
|--------|-----|-----|------|--------|-------|-------|-------|-------|
| UH0110 | 0.0 | 0.0 | 0.91 | 40.26  | 1.07  | 3.13  | 0.55  | 4.28  |
| UH0200 | 0.0 | 0.0 | 1.39 | 622.97 | 7.37  | 33.38 | 0.53  | 35.02 |
| UH0230 | 0.0 | 0.0 | 1.06 | 155.60 | 2.50  | 10.84 | 4.58  | 10.35 |
| UH0260 | 0.0 | 0.0 | 0.43 | 47.37  | 0.75  | 3.89  | 0.36  | 4.41  |
| UH1140 | 0.0 | 0.0 | 3.32 | 44.68  | 0.25  | 2.60  | 0.46  | 2.57  |
| UH0290 | 0.0 | 0.0 | 0.13 | 6.28   | 0.44  | 0.33  | 0.33  | 0.20  |
| UH1040 | 0.0 | 0.0 | 2.58 | 44.94  | 1.11  | 1.98  | 0.47  | 3.81  |
| UH1070 | 0.0 | 0.0 | 4.78 | 450.09 | 4.95  | 27.65 | 1.48  | 23.27 |
| UH1060 | 0.0 | 0.0 | 3.89 | 65.44  | 0.70  | 2.06  | 0.30  | 2.59  |
| 2800   | 0.0 | 0.0 |      | 398.0  | 5.0   | 20.50 | 5.0   | 12.10 |
| 2      | 0.0 | 0.0 | 1.70 | 110.0  | 1.20  | 6.20  | 1.20  | 4.0   |
| 2100   | 0.0 | 0.0 | 1.50 | 140.0  | 2.30  | 8.0   | 1.90  | 5.90  |
| 1600   | 0.0 | 0.0 |      | 14.0   | 5.0   | 5.0   | 5.0   | 5.0   |
| 2300   | 0.0 | 0.0 |      | 5.0    | 5.0   | 5.0   | 5.0   | 5.0   |
| 2200   | 0.0 | 0.0 |      | 89.0   | 5.0   | 5.0   | 5.0   | 5.0   |
| 2400   | 0.0 | 0.0 |      | 5.40   | 5.0   | 5.0   | 5.0   | 5.0   |
| 2500   | 0.0 | 0.0 |      | 320.0  | 4.60  | 19.30 | 4.60  | 12.10 |
| 85A00  | 0.0 | 0.0 | 0.02 | 1500.0 | 24.0  | 94.0  | 18.0  | 38.0  |
| 2900   | 0.0 | 0.0 |      | 445.0  | 20.0  | 27.0  | 20.0  | 20.0  |
| 3      | 0.0 | 0.0 |      | 543.0  | 5.0   | 30.50 | 8.10  | 20.20 |
| 2600   | 0.0 | 0.0 | 2.20 | 620.0  | 5.50  | 32.0  | 6.50  | 21.0  |
| 2700   | 0.0 | 0.0 |      | 377.0  | 5.10  | 25.60 | 6.20  | 13.50 |
| 3300   | 0.0 | 0.0 |      | 498.0  | 4.90  | 27.40 | 4.90  | 17.80 |
| 86A00  | 0.0 | 0.0 | 0.02 | 570.0  | 11.0  | 37.0  | 8.20  | 18.0  |
| 63A00  | 0.0 | 0.0 | 0.68 | 430.0  | 7.10  | 28.0  | 5.30  | 16.0  |
| 3200   | 0.0 | 0.0 |      | 481.0  | 23.80 | 23.80 | 23.80 | 23.80 |
| 3100   | 0.0 | 0.0 | 2.10 | 310.0  | 3.20  | 15.0  | 3.0   | 11.0  |
| 3400   | 0.0 | 0.0 |      | 393.0  | 5.0   | 22.20 | 5.10  | 12.20 |
| 3700   | 0.0 | 0.0 |      | 493.0  | 4.60  | 28.40 | 6.41  | 16.40 |
| 65A00  | 0.0 | 0.0 | 0.23 | 380.0  | 7.50  | 25.0  | 0.0   | 13.0  |
| 3500   | 0.0 | 0.0 |      | 110.0  | 5.0   | 6.68  | 5.0   | 5.0   |
| 64A00  | 0.0 | 0.0 | 1.07 | 420.0  | 6.20  | 24.0  | 0.0   | 14.0  |
| 3600   | 0.0 | 0.0 | 2.40 | 350.0  | 4.10  | 17.0  | 4.0   | 13.0  |
| 3800   | 0.0 | 0.0 |      | 285.0  | 5.0   | 16.10 | 5.0   | 8.96  |
| 3900   | 0.0 | 0.0 |      | 260.0  | 4.40  | 14.20 | 4.40  | 10.0  |
| 4      | 0.0 | 0.0 |      | 280.0  | 5.0   | 16.70 | 5.0   | 10.0  |
| 68A00  | 0.0 | 0.0 | 0.51 | 360.0  | 5.60  | 24.0  | 0.0   | 12.0  |
| 4100   | 0.0 | 0.0 |      | 76.10  | 5.0   | 5.0   | 5.0   | 5.0   |
| 69A00  | 0.0 | 0.0 | 0.85 | 220.0  | 0.0   | 14.0  | 0.0   | 8.70  |
| 71A00  | 0.0 | 0.0 | 0.33 | 14.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 70A00  | 0.0 | 0.0 | 0.51 | 64.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 4400   | 0.0 | 0.0 |      | 615.0  | 5.0   | 33.0  | 7.25  | 20.60 |
| 72A00  | 0.0 | 0.0 | 0.70 | 440.0  | 6.40  | 24.0  | 6.40  | 14.0  |
| 89A00  | 0.0 | 0.0 | 0.01 | 36.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 5100   | 0.0 | 0.0 |      | 288.0  | 4.40  | 16.80 | 4.40  | 10.20 |
| 1700   | 0.0 | 0.0 | 2.40 | 71.0   | 1.20  | 4.10  | 1.0   | 2.80  |
| 42A00  | 0.0 | 0.0 | 0.84 | 77.0   | 0.0   | 4.80  | 0.0   | 3.60  |
| 5700   | 0.0 | 0.0 | 0.47 | 42.0   | 0.70  | 2.40  | 0.70  | 1.40  |
| 4900   | 0.0 | 0.0 |      | 377.0  | 5.0   | 22.20 | 5.58  | 12.40 |
| 87A00  | 0.0 | 0.0 | 0.01 | 200.0  | 7.10  | 13.0  | 0.0   | 8.90  |
| 5400   | 0.0 | 0.0 |      | 467.0  | 6.24  | 27.30 | 7.71  | 16.40 |
| 47A00  | 0.0 | 0.0 | 2.42 | 212.0  | 0.0   | 17.0  | 0.0   | 0.0   |
| 48A00  | 0.0 | 0.0 | 0.85 | 82.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 5600   | 0.0 | 0.0 | 2.50 | 410.0  | 3.20  | 16.0  | 3.0   | 12.0  |

|        |     |     |       |       |       |       |       |       |
|--------|-----|-----|-------|-------|-------|-------|-------|-------|
| 5500   | 0.0 | 0.0 |       | 292.0 | 5.0   | 16.70 | 5.0   | 10.40 |
| 49A00  | 0.0 | 0.0 | 0.81  | 95.0  | 0.0   | 5.30  | 0.0   | 3.20  |
| 88A00  | 0.0 | 0.0 | 0.01  | 82.0  | 0.0   | 5.20  | 0.0   | 2.70  |
| 44A00  | 0.0 | 0.0 | 0.02  | 240.0 | 0.0   | 20.0  | 0.0   | 11.0  |
| 4800   | 0.0 | 0.0 |       | 642.0 | 5.0   | 35.0  | 5.0   | 21.60 |
| 84B00  | 0.0 | 0.0 | 0.0   | 500.0 | 3.20  | 12.0  | 0.0   | 4.20  |
| 4600   | 0.0 | 0.0 |       | 103.0 | 5.0   | 6.32  | 5.0   | 5.0   |
| 51A00  | 0.0 | 0.0 | 1.87  | 49.0  | 0.0   | 0.0   | 0.0   | 0.0   |
| 56A00  | 0.0 | 0.0 | 1.20  | 288.0 | 3.0   | 18.0  | 0.0   | 13.0  |
| 55A00  | 0.0 | 0.0 | 1.11  | 446.0 | 12.0  | 43.0  | 9.40  | 20.0  |
| 59A00  | 0.0 | 0.0 | 1.32  | 712.0 | 14.0  | 61.0  | 0.0   | 31.0  |
| 01A00  | 0.0 | 0.0 | 1.38  | 520.0 | 4.90  | 24.0  | 4.20  | 16.0  |
| 02A00  | 0.0 | 0.0 | 4.61  | 167.0 | 0.0   | 6.10  | 0.0   | 0.0   |
| 03A00  | 0.0 | 0.0 | 1.58  | 290.0 | 3.10  | 12.0  | 0.0   | 4.50  |
| 73B00  | 0.0 | 0.0 | 0.0   | 17.0  | 0.0   | 1.30  | 0.0   | 0.0   |
| 05A00  | 0.0 | 0.0 | 1.02  | 468.0 | 0.0   | 22.0  | 0.0   | 12.0  |
| 05A00  | 0.0 | 0.0 | 1.02  | 468.0 | 0.0   | 22.0  | 0.0   | 12.0  |
| 74A00  | 0.0 | 0.0 | 0.01  | 440.0 | 7.10  | 28.0  | 0.0   | 16.0  |
| 74A00  | 0.0 | 0.0 | 0.01  | 440.0 | 7.10  | 28.0  | 0.0   | 16.0  |
| 06A00  | 0.0 | 0.0 | 0.31  | 29.0  | 0.0   | 0.0   | 0.0   | 0.0   |
| 28A00  | 0.0 | 0.0 | 0.75  | 291.0 | 0.0   | 20.0  | 5.30  | 10.0  |
| 1200   | 0.0 | 0.0 | 1.70  | 63.0  | 0.70  | 2.90  | 0.50  | 2.0   |
| 1300   | 0.0 | 0.0 |       | 31.0  | 5.0   | 5.0   | 5.0   | 5.0   |
| 1400   | 0.0 | 0.0 | 4.30  | 400.0 | 3.50  | 17.0  | 3.30  | 12.0  |
| 08A00  | 0.0 | 0.0 | 0.02  | 83.0  | 1.50  | 5.10  | 0.0   | 1.20  |
| 0100   | 0.0 | 0.0 | 2.0   | 180.0 | 1.60  | 7.50  | 2.20  | 4.30  |
| 1500   | 0.0 | 0.0 |       | 5.30  | 5.0   | 5.0   | 5.0   | 5.0   |
| 09A00  | 0.0 | 0.0 | 0.63  | 309.0 | 6.52  | 18.0  | 4.97  | 10.0  |
| SR600  | 0.0 | 0.0 | 13.60 | 1.0   | 13.0  | 53.0  | 17.0  | 29.0  |
| SR500  | 0.0 | 0.0 | 6.49  | 830.0 | 12.0  | 42.0  | 10.0  | 20.0  |
| SR100  | 0.0 | 0.0 | 22.0  | 780.0 | 13.0  | 42.0  | 11.0  | 21.0  |
| SR200  | 0.0 | 0.0 | 13.20 | 770.0 | 11.0  | 48.0  | 12.0  | 24.0  |
| SR700  | 0.0 | 0.0 | 16.30 | 900.0 | 12.0  | 49.0  | 13.0  | 25.0  |
| SR300  | 0.0 | 0.0 | 13.50 | 710.0 | 11.0  | 37.0  | 10.0  | 20.0  |
| SR800  | 0.0 | 0.0 | 17.60 | 870.0 | 14.0  | 46.0  | 14.0  | 25.0  |
| SR400  | 0.0 | 0.0 | 18.70 | 710.0 | 11.0  | 38.0  | 13.0  | 20.0  |
| SR900  | 0.0 | 0.0 | 13.40 | 710.0 | 11.0  | 38.0  | 9.40  | 20.0  |
| SR1    | 0.0 | 0.0 | 12.60 | 750.0 | 12.0  | 41.0  | 13.0  | 23.0  |
| 0200   | 0.0 | 0.0 |       | 51.0  | 5.0   | 5.0   | 5.0   | 5.0   |
| 75A00  | 0.0 | 0.0 | 0.01  | 790.0 | 14.0  | 48.0  | 12.0  | 30.0  |
| 10A00  | 0.0 | 0.0 | 1.07  | 520.0 | 15.0  | 49.0  | 0.0   | 29.0  |
| HP600  | 0.0 | 0.0 | 5.90  | 720.0 | 11.0  | 32.0  | 8.20  | 16.0  |
| HP500  | 0.0 | 0.0 | 10.30 | 820.0 | 15.0  | 46.0  | 10.0  | 24.0  |
| HP100  | 0.0 | 0.0 | 23.30 | 880.0 | 11.0  | 52.0  | 15.0  | 27.0  |
| HP200  | 0.0 | 0.0 | 10.30 | 840.0 | 16.0  | 47.0  | 13.0  | 24.0  |
| HP700  | 0.0 | 0.0 | 14.10 | 920.0 | 15.0  | 49.0  | 12.0  | 26.0  |
| HP300  | 0.0 | 0.0 | 16.30 | 720.0 | 13.0  | 44.0  | 9.70  | 21.0  |
| HP400  | 0.0 | 0.0 | 5.01  | 190.0 | 2.80  | 11.0  | 2.30  | 5.50  |
| HP800  | 0.0 | 0.0 | 6.38  | 560.0 | 8.30  | 29.0  | 7.90  | 14.0  |
| HP900  | 0.0 | 0.0 | 10.40 | 420.0 | 6.90  | 25.0  | 6.0   | 13.0  |
| HP1    | 0.0 | 0.0 | 5.80  | 300.0 | 3.80  | 16.0  | 4.40  | 8.20  |
| 76A00  | 0.0 | 0.0 | 0.0   | 40.0  | 0.99  | 2.90  | 0.0   | 1.50  |
| 276A00 | 0.0 | 0.0 | 15.60 | 749.0 | 11.70 | 47.10 | 12.10 | 22.50 |
| 277B00 | 0.0 | 0.0 | 7.70  | 551.0 | 6.59  | 27.10 | 7.70  | 15.20 |

|        |     |     |       |        |       |       |       |       |
|--------|-----|-----|-------|--------|-------|-------|-------|-------|
| 278B00 | 0.0 | 0.0 | 9.35  | 399.0  | 5.89  | 25.70 | 5.0   | 12.90 |
| 273A00 | 0.0 | 0.0 | 10.80 | 1060.0 | 22.70 | 86.70 | 27.80 | 37.20 |
| 274A00 | 0.0 | 0.0 | 7.11  | 839.0  | 11.70 | 47.40 | 7.40  | 25.0  |
| 275A00 | 0.0 | 0.0 | 18.50 | 648.0  | 9.62  | 33.30 | 7.53  | 21.10 |
| IS100  | 0.0 | 0.0 | 1.23  | 230.0  | 3.20  | 9.10  | 1.50  | 7.70  |
| IS200  | 0.0 | 0.0 | 0.85  | 59.0   | 1.40  | 2.30  | 0.0   | 2.10  |
| IS300  | 0.0 | 0.0 | 4.24  | 200.0  | 4.40  | 9.70  | 3.0   | 6.0   |
| IS700  | 0.0 | 0.0 | 2.06  | 95.0   | 1.40  | 3.90  | 0.0   | 2.60  |
| IS400  | 0.0 | 0.0 | 2.46  | 160.0  | 2.40  | 7.20  | 1.50  | 4.30  |
| IS500  | 0.0 | 0.0 | 2.60  | 190.0  | 3.50  | 8.30  | 2.0   | 6.0   |
| IS600  | 0.0 | 0.0 | 0.72  | 130.0  | 2.20  | 5.90  | 1.30  | 3.80  |
| IS800  | 0.0 | 0.0 | 3.74  | 400.0  | 6.20  | 18.0  | 4.20  | 11.0  |
| IS900  | 0.0 | 0.0 | 11.50 | 730.0  | 5.50  | 28.0  | 3.20  | 14.0  |
| IS1    | 0.0 | 0.0 | 7.26  | 400.0  | 5.90  | 18.0  | 3.60  | 11.0  |
| 296B00 | 0.0 | 0.0 | 11.80 | 567.0  | 10.10 | 32.60 | 5.92  | 17.60 |
| 270A00 | 0.0 | 0.0 | 11.10 | 382.0  | 6.17  | 29.60 | 5.59  | 14.80 |
| 271A00 | 0.0 | 0.0 | 2.01  | 95.30  | 2.0   | 7.96  | 0.0   | 3.92  |
| 272A00 | 0.0 | 0.0 | 6.70  | 291.0  | 5.90  | 15.30 | 0.0   | 8.76  |
| 0300   | 0.0 | 0.0 | 5.0   | 450.0  | 4.10  | 33.0  | 4.40  | 4.50  |
| 269C00 | 0.0 | 0.0 | 3.11  | 559.0  | 7.35  | 38.40 | 10.50 | 18.0  |
| 267A00 | 0.0 | 0.0 | 9.31  | 200.0  | 0.0   | 17.90 | 0.0   | 10.90 |
| 268B00 | 0.0 | 0.0 | 2.97  | 546.0  | 6.24  | 26.50 | 0.0   | 11.70 |
| 264A00 | 0.0 | 0.0 | 5.01  | 176.0  | 0.0   | 9.86  | 0.0   | 5.57  |
| 266A00 | 0.0 | 0.0 | 24.80 | 510.0  | 8.69  | 26.90 | 6.68  | 9.36  |
| 33A00  | 0.0 | 0.0 | 1.25  | 77.0   | 1.90  | 4.50  | 0.0   | 3.40  |
| 263B00 | 0.0 | 0.0 | 16.90 | 576.0  | 7.13  | 42.10 | 6.68  | 19.80 |
| 262A00 | 0.0 | 0.0 | 0.26  | 66.40  | 1.22  | 7.04  | 1.44  | 2.99  |
| 261C00 | 0.0 | 0.0 | 1.21  | 24.90  | 0.0   | 0.0   | 0.0   | 0.0   |
| 260B00 | 0.0 | 0.0 | 9.39  | 656.0  | 10.20 | 79.10 | 5.45  | 37.20 |
| 259B00 | 0.0 | 0.0 | 13.20 | 818.0  | 12.80 | 53.90 | 14.80 | 25.0  |
| 258C00 | 0.0 | 0.0 | 20.30 | 642.0  | 9.94  | 40.10 | 6.19  | 23.80 |
| 224A00 | 0.0 | 0.0 | 8.64  | 1150.0 | 14.30 | 67.20 | 17.90 | 31.10 |
| 221A00 | 0.0 | 0.0 | 6.94  | 232.0  | 5.63  | 18.20 | 0.0   | 9.88  |
| 227A00 | 0.0 | 0.0 | 8.95  | 1050.0 | 15.70 | 64.10 | 11.80 | 24.60 |
| 223A00 | 0.0 | 0.0 | 9.37  | 576.0  | 7.92  | 34.60 | 6.30  | 18.50 |
| 220A00 | 0.0 | 0.0 | 9.36  | 578.0  | 9.23  | 30.30 | 7.35  | 17.60 |
| 95A00  | 0.0 | 0.0 |       | 200.0  | 0.0   | 18.0  | 0.0   | 7.70  |
| 8A00   | 0.0 | 0.0 | 2.40  | 870.0  | 9.70  | 38.0  | 10.0  | 29.0  |
| 222A00 | 0.0 | 0.0 | 10.90 | 675.0  | 9.90  | 32.60 | 6.10  | 19.80 |
| 294A00 | 0.0 | 0.0 | 4.98  | 588.0  | 16.40 | 48.80 | 31.0  | 21.80 |
| 230A00 | 0.0 | 0.0 | 9.02  | 454.0  | 9.07  | 30.40 | 0.0   | 15.60 |
| 219A00 | 0.0 | 0.0 | 4.87  | 362.0  | 4.94  | 22.0  | 6.16  | 11.30 |
| 8B00   | 0.0 | 0.0 | 2.40  | 780.0  | 8.20  | 32.0  | 7.0   | 22.0  |
| 7A00   | 0.0 | 0.0 | 5.80  | 590.0  | 7.70  | 29.0  | 8.10  | 20.0  |
| 225A00 | 0.0 | 0.0 | 13.60 | 604.0  | 9.21  | 39.20 | 11.50 | 20.40 |
| 229A00 | 0.0 | 0.0 | 6.31  | 717.0  | 11.70 | 40.30 | 7.66  | 22.0  |
| 7B00   | 0.0 | 0.0 | 2.40  | 660.0  | 8.40  | 31.0  | 8.20  | 25.0  |
| 228B00 | 0.0 | 0.0 | 9.95  | 525.0  | 7.10  | 38.40 | 0.0   | 23.80 |
| 218A00 | 0.0 | 0.0 | 6.30  | 645.0  | 14.40 | 46.80 | 14.60 | 23.40 |
| 284B00 | 0.0 | 0.0 | 17.80 | 724.0  | 12.60 | 43.60 | 10.80 | 26.20 |
| 257C00 | 0.0 | 0.0 | 10.30 | 826.0  | 11.20 | 50.80 | 7.86  | 27.40 |
| 256B00 | 0.0 | 0.0 | 24.30 | 901.0  | 6.88  | 37.70 | 0.0   | 18.90 |
| 21A00  | 0.0 | 0.0 | 0.75  | 381.0  | 0.0   | 24.90 | 0.0   | 0.0   |
| 93A00  | 0.0 | 0.0 |       | 980.0  | 18.0  | 44.0  | 12.0  | 23.0  |

|        |     |     |       |         |       |        |       |       |
|--------|-----|-----|-------|---------|-------|--------|-------|-------|
| 22A00  | 0.0 | 0.0 | 0.77  | 434.0   | 10.0  | 22.0   | 8.10  | 17.0  |
| 255A00 | 0.0 | 0.0 | 12.80 | 548.0   | 7.04  | 28.40  | 6.61  | 17.90 |
| 94A00  | 0.0 | 0.0 |       | 700.0   | 15.0  | 48.0   | 6.80  | 21.0  |
| 217A00 | 0.0 | 0.0 | 8.70  | 14200.0 | 119.0 | 1730.0 | 14.90 | 547.0 |
| 233C00 | 0.0 | 0.0 | 2.92  | 80.10   | 1.99  | 5.43   | 0.94  | 2.63  |
| 19A00  | 0.0 | 0.0 | 0.47  | 760.0   | 0.0   | 46.0   | 13.0  | 19.0  |
| 61A00  | 0.0 | 0.0 | 1.41  | 640.0   | 0.0   | 46.0   | 19.0  | 22.0  |
| 18A00  | 0.0 | 0.0 | 0.08  | 1700.0  | 19.0  | 120.0  | 21.0  | 53.0  |
| 7C00   | 0.0 | 0.0 | 2.30  | 790.0   | 9.70  | 39.0   | 12.0  | 29.0  |
| 286B00 | 0.0 | 0.0 | 9.42  | 757.0   | 15.50 | 51.80  | 19.0  | 28.70 |
| 232A00 | 0.0 | 0.0 |       | 670.0   | 8.49  | 34.70  | 5.60  | 19.70 |
| 285A00 | 0.0 | 0.0 | 5.41  | 971.0   | 98.70 | 100.0  | 760.0 | 47.30 |
| 77A00  | 0.0 | 0.0 |       | 1.0     | 93.0  | 110.0  | 47.0  | 39.0  |
| 17A00  | 0.0 | 0.0 | 0.60  | 766.0   | 13.0  | 56.0   | 13.0  | 30.0  |
| 231A00 | 0.0 | 0.0 | 9.86  | 463.0   | 7.0   | 37.80  | 7.70  | 19.80 |
| 283A00 | 0.0 | 0.0 | 7.34  | 580.0   | 11.40 | 37.20  | 9.03  | 21.90 |
| 60A00  | 0.0 | 0.0 | 2.89  | 660.0   | 13.0  | 44.0   | 0.0   | 23.0  |
| 293A00 | 0.0 | 0.0 | 21.20 | 112.0   | 3.43  | 10.40  | 0.0   | 5.97  |
| 216A00 | 0.0 | 0.0 | 14.30 | 628.0   | 11.90 | 37.60  | 7.83  | 21.0  |
| 16A00  | 0.0 | 0.0 | 1.32  | 209.0   | 0.0   | 15.0   | 0.0   | 8.80  |
| 282A00 | 0.0 | 0.0 | 9.61  | 612.0   | 11.10 | 38.90  | 11.0  | 22.60 |
| 0600   | 0.0 | 0.0 |       | 81.0    | 5.0   | 5.0    | 5.0   | 5.0   |
| WA100  | 0.0 | 0.0 | 8.66  | 440.0   | 7.30  | 23.0   | 5.40  | 13.0  |
| WA200  | 0.0 | 0.0 | 7.01  | 650.0   | 10.0  | 44.0   | 13.0  | 24.0  |
| WA400  | 0.0 | 0.0 | 9.16  | 570.0   | 7.90  | 35.0   | 9.30  | 18.0  |
| WA300  | 0.0 | 0.0 | 3.34  | 560.0   | 8.30  | 49.0   | 7.40  | 23.0  |
| WA500  | 0.0 | 0.0 | 2.54  | 40.0    | 0.92  | 2.70   | 0.0   | 1.70  |
| WA600  | 0.0 | 0.0 | 5.07  | 310.0   | 5.0   | 18.0   | 3.90  | 9.80  |
| WA800  | 0.0 | 0.0 | 11.30 | 550.0   | 9.60  | 31.0   | 10.0  | 19.0  |
| WA700  | 0.0 | 0.0 | 4.44  | 210.0   | 3.10  | 16.0   | 2.90  | 8.50  |
| WA900  | 0.0 | 0.0 | 3.20  | 160.0   | 2.50  | 11.0   | 2.90  | 5.60  |
| 236A00 | 0.0 | 0.0 | 10.90 | 927.0   | 120.0 | 53.40  | 12.90 | 26.20 |
| 295B00 | 0.0 | 0.0 | 6.77  | 458.0   | 8.65  | 30.0   | 6.05  | 15.10 |
| 15A00  | 0.0 | 0.0 | 1.33  | 306.0   | 5.40  | 23.0   | 8.60  | 8.60  |
| 235A00 | 0.0 | 0.0 | 13.20 | 786.0   | 11.60 | 51.0   | 8.30  | 29.70 |
| WA1    | 0.0 | 0.0 | 9.03  | 610.0   | 9.60  | 34.0   | 9.0   | 19.0  |
| 23A00  | 0.0 | 0.0 | 1.45  | 1470.0  | 12.0  | 49.0   | 14.0  | 22.0  |
| 234B00 | 0.0 | 0.0 | 12.10 | 447.0   | 7.36  | 26.30  | 4.29  | 15.20 |
| 287B00 | 0.0 | 0.0 | 10.30 | 76.60   | 1.89  | 5.17   | 2.23  | 3.57  |
| 0900   | 0.0 | 0.0 |       | 50.0    | 5.0   | 5.0    | 5.0   | 5.0   |
| 34A00  | 0.0 | 0.0 | 0.96  | 340.0   | 6.0   | 24.0   | 0.0   | 12.0  |
| 254A00 | 0.0 | 0.0 | 9.22  | 407.0   | 4.76  | 18.60  | 0.0   | 9.75  |
| 253A00 | 0.0 | 0.0 | 22.60 | 588.0   | 13.20 | 37.10  | 6.63  | 20.90 |
| 215B00 | 0.0 | 0.0 | 9.81  | 534.0   | 10.40 | 37.70  | 7.26  | 20.20 |
| 252C00 | 0.0 | 0.0 | 13.40 | 457.0   | 6.25  | 22.10  | 4.68  | 12.30 |
| 214A00 | 0.0 | 0.0 | 40.90 | 644.0   | 6.30  | 50.0   | 0.0   | 20.60 |
| 213A00 | 0.0 | 0.0 | 13.40 | 1340.0  | 13.50 | 62.10  | 11.60 | 28.30 |
| 288B00 | 0.0 | 0.0 | 6.38  | 36.50   | 0.0   | 5.17   | 1.77  | 3.61  |
| 12A00  | 0.0 | 0.0 | 1.73  | 695.0   | 11.0  | 51.0   | 13.0  | 20.0  |
| 91A00  | 0.0 | 0.0 |       | 360.0   | 0.0   | 70.0   | 25.0  | 0.0   |
| 0500   | 0.0 | 0.0 | 6.10  | 720.0   | 8.0   | 44.0   | 7.80  | 26.0  |
| 239A00 | 0.0 | 0.0 | 11.30 | 699.0   | 9.46  | 39.30  | 7.19  | 23.70 |
| 238A00 | 0.0 | 0.0 | 12.20 | 708.0   | 8.84  | 28.60  | 5.30  | 18.60 |
| 251B00 | 0.0 | 0.0 | 14.10 | 556.0   | 6.75  | 34.30  | 5.30  | 20.20 |



|        |     |     |       |        |       |       |       |       |
|--------|-----|-----|-------|--------|-------|-------|-------|-------|
| 250A00 | 0.0 | 0.0 | 0.09  | 6.33   | 0.0   | 0.0   | 0.0   | 0.0   |
| 289A00 | 0.0 | 0.0 | 10.80 | 1510.0 | 11.80 | 105.0 | 20.90 | 62.10 |
| 0400   | 0.0 | 0.0 |       | 29.0   | 5.0   | 5.0   | 5.0   | 5.0   |
| 290B00 | 0.0 | 0.0 | 7.69  | 1570.0 | 25.10 | 120.0 | 28.60 | 51.60 |
| 210A00 | 0.0 | 0.0 | 2.81  | 230.0  | 4.54  | 17.90 | 4.33  | 8.73  |
| 14A00  | 0.0 | 0.0 | 1.06  | 662.0  | 4.0   | 71.0  | 17.0  | 28.0  |
| 242A00 | 0.0 | 0.0 | 11.30 | 469.0  | 9.10  | 25.90 | 0.0   | 18.90 |
| 211B00 | 0.0 | 0.0 | 14.10 | 1090.0 | 14.70 | 91.50 | 17.50 | 43.40 |
| 291A00 | 0.0 | 0.0 | 8.21  | 815.0  | 10.80 | 58.50 | 12.80 | 23.70 |
| 212A00 | 0.0 | 0.0 | 6.75  | 709.0  | 9.44  | 58.0  | 9.74  | 27.70 |
| 292C00 | 0.0 | 0.0 | 10.20 | 781.0  | 11.80 | 44.40 | 12.80 | 25.30 |
| 245B00 | 0.0 | 0.0 | 7.31  | 517.0  | 9.75  | 30.20 | 7.79  | 15.60 |
| 241A00 | 0.0 | 0.0 | 8.77  | 379.0  | 7.02  | 26.30 | 0.0   | 13.70 |
| 248A00 | 0.0 | 0.0 | 11.40 | 609.0  | 10.80 | 36.70 | 7.70  | 20.80 |
| 244A00 | 0.0 | 0.0 | 8.68  | 628.0  | 8.02  | 27.0  | 7.10  | 14.60 |
| 92A00  | 0.0 | 0.0 |       | 670.0  | 12.0  | 38.0  | 8.30  | 19.0  |
| 240A00 | 0.0 | 0.0 | 10.90 | 1790.0 | 19.10 | 104.0 | 24.60 | 51.60 |
| 247A00 | 0.0 | 0.0 | 1.56  | 29.70  | 0.0   | 2.39  | 0.0   | 0.0   |
| 13A00  | 0.0 | 0.0 | 1.97  | 2070.0 | 0.0   | 115.0 | 13.0  | 38.0  |
| 243A00 | 0.0 | 0.0 | 14.50 | 889.0  | 10.60 | 57.80 | 11.40 | 27.20 |
| 246A00 | 0.0 | 0.0 | 17.90 | 76.50  | 1.71  | 6.81  | 3.57  | 3.08  |
| 97B00  | 0.0 | 0.0 |       | 480.0  | 7.50  | 34.0  | 13.0  | 16.0  |
| 207A00 | 0.0 | 0.0 | 9.85  | 642.0  | 8.61  | 44.10 | 8.53  | 22.30 |
| 208A00 | 0.0 | 0.0 | 9.24  | 603.0  | 9.08  | 37.0  | 6.46  | 19.0  |
| 209B00 | 0.0 | 0.0 | 12.0  | 500.0  | 8.45  | 33.40 | 6.69  | 17.40 |
| 204A00 | 0.0 | 0.0 | 12.0  | 508.0  | 7.66  | 30.80 | 5.61  | 14.70 |
| 205A00 | 0.0 | 0.0 | 19.0  | 606.0  | 7.26  | 45.70 | 8.65  | 22.40 |
| 206A00 | 0.0 | 0.0 | 14.10 | 605.0  | 12.10 | 52.90 | 11.60 | 30.30 |
| 100A00 | 0.0 | 0.0 |       | 540.0  | 8.50  | 30.0  | 6.70  | 16.0  |
| 1800   | 0.0 | 0.0 |       | 5.30   | 5.0   | 5.0   | 5.0   | 5.0   |
| 62A00  | 0.0 | 0.0 | 0.53  | 470.0  | 0.0   | 31.0  | 10.0  | 0.0   |
| 1      | 0.0 | 0.0 | 4.20  | 610.0  | 7.30  | 33.0  | 7.50  | 24.0  |
| 96A00  | 0.0 | 0.0 |       | 720.0  | 34.0  | 60.0  | 9.50  | 48.0  |
| 201A00 | 0.0 | 0.0 | 10.80 | 580.0  | 9.33  | 33.0  | 6.71  | 18.20 |
| 202F00 | 0.0 | 0.0 | 11.30 | 635.0  | 12.20 | 31.30 | 6.61  | 15.50 |
| 202B00 | 0.0 | 0.0 |       | 666.0  | 10.20 | 37.10 | 7.14  | 20.50 |
| 203A00 | 0.0 | 0.0 | 9.17  | 488.0  | 9.89  | 36.0  | 7.95  | 18.30 |
| 1100   | 0.0 | 0.0 | 5.10  | 660.0  | 8.30  | 31.0  | 9.10  | 24.0  |
| 35A00  | 0.0 | 0.0 | 0.48  | 432.0  | 8.10  | 30.0  | 0.0   | 12.0  |
| 35A00  | 0.0 | 0.0 | 0.48  | 432.0  | 8.10  | 30.0  | 0.0   | 12.0  |
| 99A00  | 0.0 | 0.0 |       | 260.0  | 3.30  | 15.0  | 0.0   | 7.90  |
| 98A00  | 0.0 | 0.0 |       | 81.0   | 1.90  | 5.40  | 1.70  | 2.20  |
| 83A00  | 0.0 | 0.0 | 0.01  | 250.0  | 3.30  | 12.0  | 4.0   | 6.60  |
| 1900   | 0.0 | 0.0 |       | 5.0    | 5.0   | 5.0   | 5.0   | 5.0   |
| 82A00  | 0.0 | 0.0 | 0.01  | 200.0  | 3.50  | 15.0  | 0.0   | 7.80  |
| 26A00  | 0.0 | 0.0 | 0.92  | 203.0  | 0.0   | 18.90 | 0.0   | 10.10 |
| 81A00  | 0.0 | 0.0 | 0.01  | 260.0  | 3.60  | 21.0  | 4.20  | 9.50  |

| Station Sample | P c d d<br>2 3 7 8 | P c d 8 | P c d f<br>1234678 | P c d f<br>123478 | P c d f<br>1234789 | P c d f<br>123678 | P c d f<br>12378 | P c d f<br>123789 |
|----------------|--------------------|---------|--------------------|-------------------|--------------------|-------------------|------------------|-------------------|
| 12A02          | 3.30               | 0.0     | 0.0                | 0.0               | 0.0                | 0.0               | 0.0              | 0.0               |
| 13A02          | 4.60               | 11.0    | 3.20               | 0.0               | 0.0                | 0.0               | 0.0              | 0.0               |
| 13A03          | 0.0                | 0.0     | 0.0                | 0.0               | 0.0                | 0.0               | 0.0              | 0.0               |
| 13A04          | 0.0                | 0.0     | 0.0                | 0.0               | 0.0                | 0.0               | 0.0              | 0.0               |

|       |         |         |        |       |       |        |       |       |
|-------|---------|---------|--------|-------|-------|--------|-------|-------|
| 13A05 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 14A02 | 2.50    | 5.70    | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 14A03 | 0.77    | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 14A04 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 14A05 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 14A06 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 14A07 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 15A02 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 15A03 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 15A04 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 16A02 | 488.0   | 629.0   | 144.0  | 27.0  | 36.0  | 17.0   | 8.60  | 49.0  |
| 16A03 | 356.0   | 1720.0  | 391.0  | 59.20 | 85.90 | 33.70  | 26.80 | 90.10 |
| 16A04 | 3260.0  | 15900.0 | 6400.0 | 665.0 | 912.0 | 1910.0 | 152.0 | 437.0 |
| 16A05 | 181.0   | 153.0   | 68.10  | 11.70 | 16.30 | 15.90  | 7.30  | 15.70 |
| 16A06 | 3.30    | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 16A07 | 2.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 17A02 | 697.0   | 1530.0  | 328.0  | 68.0  | 78.0  | 34.0   | 6.40  | 40.0  |
| 17A03 | 1810.0  | 2590.0  | 709.0  | 92.0  | 155.0 | 48.0   | 0.0   | 63.0  |
| 17A04 | 66900.0 | 5420.0  | 1090.0 | 179.0 | 244.0 | 85.0   | 40.0  | 153.0 |
| 17A05 | 8200.0  | 1530.0  | 412.0  | 93.0  | 120.0 | 94.0   | 8.90  | 67.0  |
| 17A06 | 34.0    | 23.0    | 5.70   | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 17A07 | 51.0    | 9.90    | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 18A02 | 1920.0  | 1610.0  | 226.0  | 42.0  | 52.0  | 33.0   | 19.0  | 81.0  |
| 18A03 | 6270.0  | 2180.0  | 547.0  | 89.0  | 118.0 | 71.0   | 30.0  | 172.0 |
| 18A04 | 0.0     | 668.0   | 107.0  | 35.0  | 68.0  | 24.0   | 14.0  | 58.0  |
| 18A05 | 88.0    | 169.0   | 68.0   | 11.0  | 13.0  | 10.0   | 3.90  | 13.0  |
| 18A06 | 22.0    | 88.0    | 40.0   | 8.60  | 11.0  | 13.0   | 0.0   | 8.80  |
| 18A07 | 8.60    | 13.0    | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 19A02 | 1670.0  | 1220.0  | 320.0  | 49.0  | 68.70 | 29.30  | 21.20 | 58.30 |
| 19A03 | 12.0    | 1940.0  | 487.0  | 74.40 | 101.0 | 68.80  | 32.60 | 97.20 |
| 19A04 | 36.90   | 28.90   | 11.60  | 0.0   | 0.0   | 5.40   | 0.0   | 0.0   |
| 19A05 | 0.0     | 53.0    | 27.0   | 9.80  | 8.80  | 13.0   | 0.0   | 7.40  |
| 19A07 | 2.50    | 3.20    | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 01A02 | 1.90    | 48.0    | 14.0   | 5.40  | 13.0  | 6.10   | 0.0   | 0.0   |
| 01A03 | 0.0     | 20.0    | 10.0   | 3.80  | 0.0   | 3.70   | 0.0   | 0.0   |
| 20A02 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 20A03 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 20A05 | 1920.0  | 2460.0  | 511.0  | 157.0 | 215.0 | 63.90  | 67.90 | 301.0 |
| 20A06 | 151.0   | 155.0   | 31.50  | 0.0   | 24.30 | 0.0    | 0.0   | 0.0   |
| 20A07 | 4.80    | 5.20    | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 21A02 | 847.0   | 794.0   | 219.0  | 37.0  | 47.0  | 22.0   | 0.0   | 22.0  |
| 21A03 | 1960.0  | 931.0   | 225.0  | 47.0  | 56.0  | 30.0   | 0.0   | 29.0  |
| 21A04 | 15500.0 | 2670.0  | 1010.0 | 91.10 | 125.0 | 79.60  | 57.70 | 117.0 |
| 21A05 | 29.60   | 63.70   | 24.0   | 8.04  | 9.20  | 18.60  | 0.0   | 6.86  |
| 21A06 | 9.90    | 7.70    | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 21A07 | 2.40    | 5.70    | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 22A02 | 1360.0  | 1380.0  | 213.0  | 0.0   | 46.0  | 26.0   | 36.0  | 69.0  |
| 22A03 | 3020.0  | 1350.0  | 383.0  | 55.0  | 80.0  | 49.0   | 21.0  | 56.0  |
| 22A04 | 18.80   | 47.40   | 18.90  | 10.30 | 6.56  | 0.0    | 6.22  | 6.17  |
| 22A05 | 17.0    | 12.0    | 4.20   | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 23A02 | 504.0   | 1420.0  | 373.0  | 41.0  | 80.0  | 26.0   | 13.0  | 50.0  |
| 23A03 | 497.0   | 1350.0  | 314.0  | 42.0  | 66.0  | 34.0   | 30.0  | 52.0  |
| 26A02 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0    | 0.0   | 0.0   |
| 26A03 | 185.0   | 480.0   | 152.0  | 15.0  | 31.0  | 14.0   | 5.50  | 24.0  |

|        |        |        |        |       |       |       |       |       |
|--------|--------|--------|--------|-------|-------|-------|-------|-------|
| 28A02  | 0.0    | 12.0   | 3.50   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 28A03  | 1.80   | 7.0    | 2.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 02A02  | 16.0   | 210.0  | 24.0   | 12.0  | 12.0  | 6.60  | 4.40  | 9.10  |
| 02A03  | 4.50   | 249.0  | 9.20   | 7.60  | 9.90  | 3.50  | 3.70  | 18.0  |
| 32A02  | 0.0    | 9.50   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 32A03  | 0.0    | 16.0   | 7.50   | 2.50  | 2.80  | 4.20  | 0.0   | 2.90  |
| 35A02  | 240.0  | 2360.0 | 547.0  | 54.0  | 100.0 | 44.0  | 15.0  | 45.0  |
| 35A03  | 243.0  | 1480.0 | 416.0  | 39.0  | 74.0  | 34.0  | 14.0  | 40.0  |
| 37A02  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 37A03  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 42A02  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 42A03  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 44A02  | 38.0   | 144.0  | 33.0   | 7.80  | 10.0  | 9.50  | 4.60  | 12.0  |
| 44A03  | 42.0   | 178.0  | 40.0   | 9.50  | 12.0  | 13.0  | 4.90  | 13.0  |
| 48A02  | 39.0   | 431.0  | 97.0   | 34.0  | 33.0  | 21.0  | 0.0   | 28.0  |
| 48A03  | 80.0   | 717.0  | 149.0  | 54.0  | 242.0 | 33.0  | 0.0   | 41.0  |
| 49A02  | 0.0    | 2.60   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 49A03  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 51A02  | 0.0    | 20.0   | 11.0   | 4.10  | 4.80  | 13.0  | 0.0   | 5.30  |
| 51A03  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 55A02  | 3.80   | 52.0   | 15.0   | 7.80  | 8.80  | 9.40  | 0.0   | 10.0  |
| 55A03  | 0.0    | 30.0   | 18.0   | 9.0   | 7.60  | 11.0  | 5.80  | 8.50  |
| 56A02  | 27.0   | 243.0  | 77.0   | 24.0  | 22.0  | 19.0  | 12.0  | 28.0  |
| 56A03  | 34.0   | 349.0  | 106.0  | 33.0  | 33.0  | 29.0  | 18.0  | 38.0  |
| 59A02  | 67.0   | 737.0  | 215.0  | 123.0 | 116.0 | 98.0  | 84.0  | 172.0 |
| 59A03  | 63.0   | 318.0  | 83.0   | 38.0  | 39.0  | 34.0  | 19.0  | 47.0  |
| 05A02  | 71.0   | 235.0  | 35.0   | 13.0  | 16.0  | 7.50  | 5.30  | 29.0  |
| 05A03  | 720.0  | 228.0  | 42.0   | 12.0  | 18.0  | 6.0   | 6.40  | 40.0  |
| 06A02  | 15.0   | 59.0   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 06A03  | 4.30   | 9.20   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 09A02  | 32.0   | 32.70  | 8.19   | 7.10  | 0.0   | 0.0   | 0.0   | 4.25  |
| 09A03  | 24.0   | 22.0   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 21EPA0 | 4810.0 | 1270.0 | 291.0  | 53.0  | 89.0  | 35.0  | 23.0  | 46.0  |
| 60AG2  | 750.0  | 2500.0 | 690.0  | 79.0  | 160.0 | 16.0  | 27.0  | 80.0  |
| 60AG3  | 1500.0 | 9.0    | 3100.0 | 100.0 | 1.0   | 190.0 | 51.0  | 480.0 |
| 61AH2  | 3700.0 | 2600.0 | 530.0  | 92.0  | 160.0 | 50.0  | 28.0  | 76.0  |
| 61AH3  | 62.0   | 77.0   | 3.0    | 920.0 | 680.0 | 170.0 | 830.0 | 940.0 |
| 62AJ2  | 160.0  | 1200.0 | 520.0  | 33.0  | 64.0  | 21.0  | 11.0  | 35.0  |
| 62AJ3  | 350.0  | 970.0  | 220.0  | 33.0  | 60.0  | 21.0  | 9.60  | 37.0  |
| 63AK2  | 110.0  | 320.0  | 60.0   | 12.0  | 20.0  | 13.0  | 4.90  | 16.0  |
| 63AK3  | 94.0   | 340.0  | 64.0   | 12.0  | 21.0  | 13.0  | 4.80  | 16.0  |
| 64AL2  | 81.0   | 270.0  | 59.0   | 11.0  | 17.0  | 12.0  | 4.50  | 14.0  |
| 64AL3  | 58.0   | 180.0  | 44.0   | 7.70  | 13.0  | 9.60  | 3.60  | 12.0  |
| 65AM2  | 0.0    | 3.60   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 65AM3  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 66AN2  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 66AN3  | 0.49   | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 68AP2  | 40.0   | 250.0  | 54.0   | 11.0  | 52.0  | 11.0  | 4.70  | 17.0  |
| 68AP3  | 28.0   | 120.0  | 24.0   | 5.90  | 8.30  | 4.80  | 0.0   | 6.90  |
| 69AQ2  | 46.0   | 220.0  | 42.0   | 9.0   | 21.0  | 12.0  | 5.0   | 15.0  |
| 69AQ3  | 28.0   | 98.0   | 20.0   | 3.60  | 11.0  | 4.90  | 2.0   | 7.0   |
| 70AR2  | 41.0   | 230.0  | 44.0   | 9.20  | 25.0  | 12.0  | 0.0   | 14.0  |
| 70AR3  | 33.0   | 170.0  | 33.0   | 6.40  | 17.0  | 8.40  | 3.90  | 9.90  |
| 71AS2  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |

|        |        |        |        |       |       |       |       |       |
|--------|--------|--------|--------|-------|-------|-------|-------|-------|
| 71AS3  | 0.39   | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 72AT2  | 50.0   | 290.0  | 55.0   | 13.0  | 27.0  | 14.0  | 6.20  | 17.0  |
| 72AT3  | 7.40   | 49.0   | 8.80   | 2.80  | 4.30  | 2.80  | 0.0   | 3.50  |
| 03AA2  | 5.60   | 200.0  | 19.0   | 13.0  | 20.0  | 8.40  | 4.50  | 18.0  |
| 03AA3  | 130.0  | 420.0  | 42.0   | 24.0  | 40.0  | 13.0  | 8.30  | 38.0  |
| 05AB1  | 42.0   | 220.0  | 48.0   | 0.0   | 21.0  | 0.0   | 0.0   | 27.0  |
| 10AC2  | 32.0   | 610.0  | 160.0  | 23.0  | 33.0  | 13.0  | 10.0  | 30.0  |
| 10AC3  | 31.0   | 14.0   | 5.10   | 0.0   | 4.0   | 2.40  | 2.40  | 3.90  |
| 33AD2  | 0.0    | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 33AD3  | 0.89   | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 34AE2  | 0.0    | 12.0   | 4.20   | 0.0   | 0.0   | 1.70  | 0.0   | 0.0   |
| 34AE3  | 0.83   | 6.50   | 2.40   | 0.0   | 1.80  | 1.40  | 0.0   | 1.80  |
| 35AF1  | 250.0  | 4500.0 | 400.0  | 30.0  | 100.0 | 57.0  | 0.0   | 54.0  |
| 08A02  | 0.93   | 27.0   | 53.0   | 11.0  | 9.60  | 30.0  | 9.50  | 5.50  |
| 08A03  | 0.0    | 1.40   | 0.84   | 0.53  | 0.42  | 1.30  | 0.45  | 0.91  |
| 74A02  | 3.60   | 11.0   | 1.90   | 0.0   | 0.0   | 0.0   | 0.0   | 1.40  |
| 74A03  | 0.68   | 2.50   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 75A02  | 4400.0 | 1200.0 | 300.0  | 50.0  | 62.0  | 27.0  | 17.0  | 62.0  |
| 75A03  | 4500.0 | 1900.0 | 390.0  | 66.0  | 82.0  | 32.0  | 20.0  | 90.0  |
| 76A02  | 0.44   | 1.50   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.74  |
| 76A03  | 0.56   | 10.0   | 1.70   | 0.0   | 1.10  | 1.40  | 0.0   | 1.60  |
| 77A02  | 1100.0 | 18.0   | 4800.0 | 330.0 | 620.0 | 150.0 | 50.0  | 320.0 |
| 77A03  | 830.0  | 5700.0 | 1300.0 | 130.0 | 200.0 | 62.0  | 20.0  | 120.0 |
| 81A02  | 160.0  | 1.0    | 260.0  | 26.0  | 52.0  | 25.0  | 10.0  | 35.0  |
| 81A03  | 630.0  | 250.0  | 58.0   | 12.0  | 17.0  | 33.0  | 5.20  | 12.0  |
| 82A02  | 0.84   | 4.60   | 1.50   | 0.0   | 0.65  | 0.57  | 0.0   | 1.02  |
| 82A03  | 0.0    | 4.30   | 1.10   | 0.0   | 0.65  | 0.0   | 0.0   | 1.0   |
| 83A02  | 6.20   | 110.0  | 36.0   | 6.50  | 25.0  | 34.0  | 8.60  | 36.0  |
| 83A03  | 0.54   | 5.80   | 2.30   | 0.69  | 1.20  | 1.60  | 0.0   | 1.90  |
| 84B02  | 1.0    | 10.0   | 2.30   | 0.0   | 1.10  | 0.78  | 0.0   | 1.70  |
| 84B03  | 4.40   | 58.0   | 13.0   | 5.20  | 4.80  | 3.90  | 2.40  | 5.10  |
| 85A02  | 310.0  | 1800.0 | 290.0  | 80.0  | 150.0 | 98.0  | 39.0  | 120.0 |
| 85A03  | 550.0  | 1700.0 | 310.0  | 48.0  | 88.0  | 41.0  | 18.0  | 62.0  |
| 86A02  | 26.0   | 220.0  | 38.0   | 9.90  | 13.0  | 8.20  | 4.10  | 15.0  |
| 86A03  | 21.0   | 240.0  | 37.0   | 11.0  | 15.0  | 8.70  | 5.30  | 19.0  |
| 87A02  | 0.55   | 3.70   | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 1.0   |
| 87A03  | 130.0  | 480.0  | 92.0   | 24.0  | 25.0  | 18.0  | 3.70  | 28.0  |
| 201A02 | 442.0  | 1010.0 | 221.0  | 28.70 | 51.50 | 17.70 | 8.80  | 32.60 |
| 201A03 | 272.0  | 1240.0 | 276.0  | 30.10 | 63.90 | 21.10 | 9.15  | 33.50 |
| 201A04 | 1.0    | 1370.0 | 266.0  | 29.30 | 68.10 | 18.90 | 9.19  | 33.60 |
| 201A05 | 378.0  | 1130.0 | 262.0  | 33.30 | 64.30 | 27.30 | 11.10 | 40.90 |
| 201A06 | 356.0  | 1020.0 | 222.0  | 31.50 | 56.40 | 29.90 | 11.20 | 38.80 |
| 202E03 | 433.0  | 1100.0 | 230.0  | 31.30 | 57.50 | 18.80 | 9.90  | 35.70 |
| 202E05 | 883.0  | 1410.0 | 289.0  | 45.10 | 73.20 | 29.60 | 15.80 | 55.60 |
| 202E06 | 947.0  | 1410.0 | 300.0  | 48.10 | 71.40 | 26.80 | 15.50 | 56.40 |
| 203A02 | 288.0  | 1860.0 | 486.0  | 42.80 | 106.0 | 30.40 | 14.90 | 49.20 |
| 203A04 | 520.0  | 3030.0 | 787.0  | 59.60 | 183.0 | 45.20 | 17.40 | 63.40 |
| 203A06 | 403.0  | 2170.0 | 472.0  | 48.80 | 115.0 | 36.10 | 16.70 | 60.10 |
| 203A08 | 4650.0 | 4.0    | 977.0  | 111.0 | 202.0 | 58.60 | 39.50 | 123.0 |
| 203A10 | 2350.0 | 2650.0 | 577.0  | 68.0  | 136.0 | 51.50 | 27.0  | 91.80 |
| 204A02 | 236.0  | 959.0  | 170.0  | 37.20 | 51.10 | 16.20 | 11.10 | 34.10 |
| 204A03 | 255.0  | 1580.0 | 325.0  | 35.80 | 81.50 | 24.70 | 12.60 | 41.50 |
| 204A04 | 277.0  | 1260.0 | 276.0  | 27.90 | 66.50 | 20.0  | 10.80 | 35.30 |
| 204A05 | 2080.0 | 1870.0 | 357.0  | 43.20 | 84.30 | 28.50 | 16.90 | 54.40 |

|        |         |         |        |       |       |       |       |       |
|--------|---------|---------|--------|-------|-------|-------|-------|-------|
| 204A06 | 7580.0  | 5170.0  | 942.0  | 260.0 | 220.0 | 83.70 | 65.80 | 181.0 |
| 205A02 | 456.0   | 1030.0  | 215.0  | 31.60 | 58.70 | 21.0  | 11.80 | 41.60 |
| 205A03 | 516.0   | 1260.0  | 175.0  | 19.90 | 44.70 | 10.20 | 6.86  | 22.20 |
| 206A02 | 886.0   | 1530.0  | 310.0  | 50.70 | 82.20 | 32.70 | 18.20 | 53.90 |
| 206A03 | 842.0   | 2310.0  | 492.0  | 71.40 | 124.0 | 38.20 | 26.80 | 85.80 |
| 206A04 | 3170.0  | 1880.0  | 423.0  | 58.50 | 104.0 | 42.40 | 21.30 | 73.50 |
| 206A05 | 11900.0 | 6680.0  | 1410.0 | 152.0 | 294.0 | 105.0 | 50.10 | 161.0 |
| 206A06 | 6240.0  | 7260.0  | 1240.0 | 124.0 | 299.0 | 85.70 | 47.0  | 174.0 |
| 207A02 | 776.0   | 1940.0  | 378.0  | 51.10 | 96.70 | 48.10 | 21.40 | 78.0  |
| 207A03 | 8450.0  | 2730.0  | 755.0  | 74.90 | 173.0 | 130.0 | 40.70 | 149.0 |
| 207A04 | 3010.0  | 1890.0  | 566.0  | 140.0 | 361.0 | 75.10 | 218.0 | 821.0 |
| 207A05 | 4.25    | 103.0   | 18.70  | 12.40 | 17.50 | 7.15  | 4.70  | 15.40 |
| 207A06 | 2.39    | 25.0    | 6.0    | 2.44  | 5.54  | 2.77  | 1.44  | 4.23  |
| 208A02 | 1910.0  | 1360.0  | 308.0  | 49.0  | 70.60 | 29.60 | 16.40 | 54.20 |
| 208A03 | 0.07    | 2.01    | 0.85   | 0.37  | 0.37  | 0.42  | 0.0   | 0.64  |
| 209B02 | 2840.0  | 1840.0  | 377.0  | 47.0  | 94.10 | 30.90 | 16.30 | 53.0  |
| 209B03 | 757.0   | 2400.0  | 424.0  | 80.70 | 119.0 | 45.30 | 27.10 | 102.0 |
| 209B04 | 2440.0  | 2090.0  | 460.0  | 66.0  | 108.0 | 50.50 | 21.0  | 73.70 |
| 209B05 | 9140.0  | 6.0     | 1370.0 | 173.0 | 288.0 | 177.0 | 48.60 | 163.0 |
| 209B06 | 17400.0 | 10600.0 | 2780.0 | 235.0 | 496.0 | 137.0 | 79.60 | 243.0 |
| 210A02 | 67.80   | 146.0   | 48.90  | 4.87  | 10.10 | 8.31  | 3.35  | 9.99  |
| 210A03 | 0.43    | 3.69    | 1.04   | 0.43  | 0.63  | 0.52  | 0.27  | 1.03  |
| 210A04 | 0.46    | 3.76    | 1.06   | 0.47  | 0.83  | 0.49  | 0.32  | 1.10  |
| 210A05 | 0.91    | 3.68    | 1.20   | 0.64  | 0.65  | 0.49  | 0.0   | 0.89  |
| 210A06 | 0.59    | 2.55    | 0.88   | 0.44  | 0.63  | 0.51  | 3.17  | 0.97  |
| 211B02 | 9760.0  | 3430.0  | 884.0  | 98.40 | 170.0 | 55.10 | 31.70 | 103.0 |
| 211B04 | 14.40   | 1010.0  | 140.0  | 31.40 | 58.10 | 15.0  | 10.70 | 43.20 |
| 211B05 | 11.80   | 73.10   | 17.10  | 6.87  | 13.10 | 6.23  | 3.24  | 8.20  |
| 212A02 | 594.0   | 1150.0  | 236.0  | 41.40 | 65.50 | 27.30 | 19.80 | 56.20 |
| 212A04 | 1210.0  | 1790.0  | 369.0  | 79.0  | 108.0 | 47.60 | 40.80 | 121.0 |
| 212A05 | 1100.0  | 1970.0  | 451.0  | 71.90 | 139.0 | 61.50 | 26.50 | 103.0 |
| 212A06 | 581.0   | 1370.0  | 349.0  | 39.0  | 77.90 | 25.30 | 12.40 | 41.0  |
| 212A07 | 5390.0  | 2070.0  | 469.0  | 72.0  | 111.0 | 49.90 | 23.80 | 77.0  |
| 213A02 | 3150.0  | 1820.0  | 454.0  | 64.60 | 104.0 | 78.70 | 24.0  | 74.40 |
| 213A03 | 3800.0  | 2270.0  | 426.0  | 46.10 | 85.30 | 22.10 | 14.40 | 41.70 |
| 213A04 | 11.30   | 11.30   | 2.68   | 1.79  | 0.87  | 0.0   | 0.0   | 2.24  |
| 213A05 | 14.0    | 7.50    | 2.95   | 0.0   | 1.21  | 0.85  | 0.0   | 1.56  |
| 213A06 | 4.83    | 4.39    | 1.51   | 0.0   | 0.47  | 0.54  | 0.0   | 0.96  |
| 214A02 | 11600.0 | 4610.0  | 1040.0 | 92.60 | 195.0 | 53.50 | 24.0  | 85.40 |
| 214A03 | 20.0    | 7080.0  | 1300.0 | 105.0 | 237.0 | 57.50 | 32.90 | 136.0 |
| 214A04 | 12.0    | 3570.0  | 422.0  | 55.70 | 127.0 | 33.20 | 23.10 | 121.0 |
| 215B02 | 217.0   | 3130.0  | 771.0  | 60.60 | 185.0 | 40.20 | 19.40 | 64.50 |
| 215B03 | 743.0   | 2750.0  | 676.0  | 58.0  | 174.0 | 39.50 | 16.40 | 57.30 |
| 215B04 | 231.0   | 3010.0  | 761.0  | 62.40 | 187.0 | 43.60 | 20.60 | 61.10 |
| 215B05 | 307.0   | 4150.0  | 1080.0 | 87.80 | 253.0 | 57.90 | 28.10 | 80.20 |
| 215B06 | 313.0   | 1730.0  | 424.0  | 52.20 | 99.80 | 34.90 | 17.20 | 52.90 |
| 216A02 | 339.0   | 1720.0  | 369.0  | 35.20 | 84.90 | 27.80 | 11.60 | 44.40 |
| 216A03 | 478.0   | 1900.0  | 417.0  | 41.60 | 101.0 | 24.90 | 13.30 | 45.50 |
| 216A04 | 392.0   | 2090.0  | 472.0  | 45.40 | 108.0 | 30.80 | 15.70 | 54.40 |
| 216A05 | 512.0   | 1800.0  | 379.0  | 46.90 | 96.80 | 34.70 | 14.30 | 53.40 |
| 216A06 | 415.0   | 1290.0  | 266.0  | 39.70 | 69.0  | 30.20 | 13.80 | 51.0  |
| 217A02 | 4400.0  | 3550.0  | 679.0  | 77.30 | 150.0 | 43.40 | 28.0  | 89.70 |
| 217A03 | 29.60   | 115.0   | 28.0   | 10.70 | 21.10 | 10.60 | 6.65  | 13.30 |
| 217A04 | 8.93    | 29.60   | 4.88   | 1.58  | 1.55  | 0.0   | 0.0   | 2.56  |

|        |         |         |        |       |        |       |       |       |
|--------|---------|---------|--------|-------|--------|-------|-------|-------|
| 218A02 | 479.0   | 8730.0  | 1970.0 | 136.0 | 433.0  | 80.90 | 36.10 | 126.0 |
| 218A03 | 522.0   | 5610.0  | 1330.0 | 96.80 | 261.0  | 61.0  | 30.70 | 95.50 |
| 218A04 | 954.0   | 2180.0  | 427.0  | 52.50 | 92.50  | 75.40 | 19.20 | 61.10 |
| 218A05 | 402.0   | 3380.0  | 747.0  | 82.50 | 149.0  | 40.50 | 23.40 | 81.20 |
| 218A06 | 795.0   | 5980.0  | 1060.0 | 122.0 | 209.0  | 43.0  | 30.90 | 91.10 |
| 222A02 | 1530.0  | 2260.0  | 377.0  | 57.20 | 99.80  | 44.70 | 19.80 | 63.70 |
| 222A03 | 1510.0  | 1410.0  | 280.0  | 43.30 | 65.90  | 27.20 | 16.10 | 53.70 |
| 222A04 | 59600.0 | 2530.0  | 547.0  | 75.60 | 120.0  | 50.80 | 27.10 | 93.70 |
| 222A05 | 97600.0 | 8700.0  | 1910.0 | 236.0 | 417.0  | 492.0 | 71.30 | 225.0 |
| 222A06 | 25600.0 | 10300.0 | 2240.0 | 290.0 | 483.0  | 432.0 | 71.40 | 219.0 |
| 222A07 | 19100.0 | 5600.0  | 1180.0 | 123.0 | 238.0  | 80.90 | 65.50 | 174.0 |
| 223A02 | 3850.0  | 33500.0 | 9940.0 | 656.0 | 1090.0 | 186.0 | 116.0 | 230.0 |
| 223A04 | 2750.0  | 1610.0  | 239.0  | 52.0  | 75.50  | 28.70 | 19.10 | 75.20 |
| 223A05 | 7530.0  | 4620.0  | 1210.0 | 138.0 | 235.0  | 88.0  | 39.80 | 143.0 |
| 223A06 | 4890.0  | 3450.0  | 622.0  | 87.50 | 149.0  | 46.90 | 33.60 | 107.0 |
| 223A07 | 1.0     | 950.0   | 166.0  | 28.90 | 46.90  | 18.10 | 15.50 | 58.90 |
| 224A02 | 1750.0  | 1320.0  | 303.0  | 49.80 | 72.0   | 31.30 | 16.10 | 56.60 |
| 224A03 | 4030.0  | 1740.0  | 373.0  | 63.90 | 87.80  | 43.30 | 22.90 | 71.80 |
| 224A04 | 11300.0 | 3280.0  | 817.0  | 92.90 | 165.0  | 63.70 | 29.80 | 100.0 |
| 224A05 | 6480.0  | 7360.0  | 1710.0 | 159.0 | 301.0  | 146.0 | 45.90 | 127.0 |
| 224A06 | 7400.0  | 20800.0 | 5300.0 | 517.0 | 861.0  | 735.0 | 114.0 | 360.0 |
| 225A02 | 493.0   | 1020.0  | 231.0  | 38.50 | 56.10  | 24.0  | 11.40 | 43.80 |
| 225A03 | 1730.0  | 1330.0  | 295.0  | 47.80 | 69.70  | 31.90 | 15.60 | 60.50 |
| 225A04 | 19.0    | 4870.0  | 1220.0 | 167.0 | 272.0  | 321.0 | 49.50 | 159.0 |
| 225A05 | 54100.0 | 4020.0  | 933.0  | 119.0 | 200.0  | 71.80 | 43.60 | 147.0 |
| 225A06 | 51800.0 | 4820.0  | 1120.0 | 122.0 | 207.0  | 62.30 | 41.20 | 152.0 |
| 225A07 | 1690.0  | 1770.0  | 367.0  | 54.70 | 104.0  | 35.30 | 33.10 | 89.50 |
| 226A04 | 5.0     | 4420.0  | 1180.0 | 136.0 | 225.0  | 133.0 | 40.70 | 144.0 |
| 226A05 | 14800.0 | 5870.0  | 1650.0 | 182.0 | 287.0  | 112.0 | 55.70 | 189.0 |
| 226A06 | 15200.0 | 2600.0  | 451.0  | 69.50 | 104.0  | 31.90 | 30.70 | 103.0 |
| 227A02 | 5100.0  | 2160.0  | 353.0  | 83.40 | 138.0  | 44.90 | 23.0  | 75.80 |
| 227A03 | 8740.0  | 1580.0  | 438.0  | 56.40 | 67.0   | 41.20 | 24.0  | 73.10 |
| 227A04 | 9920.0  | 5300.0  | 1230.0 | 127.0 | 246.0  | 77.0  | 44.40 | 130.0 |
| 227A05 | 9870.0  | 12200.0 | 4310.0 | 465.0 | 843.0  | 692.0 | 122.0 | 390.0 |
| 227A06 | 15700.0 | 6850.0  | 1710.0 | 163.0 | 284.0  | 77.50 | 42.70 | 145.0 |
| 228B02 | 590.0   | 1940.0  | 327.0  | 47.80 | 83.90  | 32.70 | 16.90 | 63.0  |
| 228B03 | 5330.0  | 1350.0  | 288.0  | 57.40 | 74.0   | 51.80 | 20.90 | 72.60 |
| 228B04 | 15700.0 | 8770.0  | 2460.0 | 302.0 | 512.0  | 197.0 | 66.30 | 239.0 |
| 228B05 | 13800.0 | 2360.0  | 435.0  | 83.50 | 108.0  | 34.30 | 25.70 | 118.0 |
| 228B06 | 1630.0  | 2050.0  | 321.0  | 50.10 | 85.80  | 28.0  | 28.0  | 102.0 |
| 228B07 | 8.31    | 792.0   | 128.0  | 28.40 | 39.60  | 17.0  | 16.90 | 44.0  |
| 229A02 | 291.0   | 993.0   | 221.0  | 24.30 | 55.90  | 17.90 | 11.10 | 38.90 |
| 229A03 | 563.0   | 788.0   | 137.0  | 31.90 | 44.80  | 17.30 | 14.10 | 40.40 |
| 229A04 | 2110.0  | 985.0   | 186.0  | 42.10 | 54.70  | 24.40 | 17.40 | 60.60 |
| 229A05 | 5170.0  | 1550.0  | 262.0  | 58.90 | 81.70  | 37.0  | 24.70 | 76.70 |
| 229A06 | 6280.0  | 4460.0  | 1040.0 | 104.0 | 223.0  | 72.20 | 46.20 | 137.0 |
| 230A02 | 967.0   | 620.0   | 112.0  | 23.60 | 31.20  | 12.50 | 7.66  | 27.10 |
| 230A04 | 4330.0  | 871.0   | 201.0  | 35.20 | 49.50  | 21.60 | 13.10 | 44.40 |
| 230A05 | 9180.0  | 1440.0  | 316.0  | 55.50 | 86.70  | 34.20 | 21.90 | 68.90 |
| 230A06 | 7390.0  | 4660.0  | 1400.0 | 141.0 | 277.0  | 73.80 | 41.80 | 139.0 |
| 230A07 | 14800.0 | 7260.0  | 1650.0 | 201.0 | 405.0  | 267.0 | 62.70 | 197.0 |
| 231A02 | 774.0   | 966.0   | 208.0  | 35.20 | 54.60  | 24.0  | 13.10 | 49.80 |
| 231A03 | 7460.0  | 2240.0  | 490.0  | 86.50 | 136.0  | 56.60 | 25.30 | 94.60 |
| 231A04 | 9590.0  | 6640.0  | 1720.0 | 247.0 | 292.0  | 81.80 | 53.0  | 178.0 |

|        |         |         |        |       |       |       |       |       |
|--------|---------|---------|--------|-------|-------|-------|-------|-------|
| 231A05 | 29600.0 | 9340.0  | 2570.0 | 340.0 | 462.0 | 160.0 | 81.10 | 271.0 |
| 231A06 | 23200.0 | 2980.0  | 511.0  | 93.60 | 144.0 | 51.0  | 36.30 | 161.0 |
| 231A07 | 5.46    | 243.0   | 38.40  | 19.60 | 26.90 | 11.40 | 11.20 | 31.30 |
| 232A02 | 405.0   | 1220.0  | 248.0  | 35.30 | 63.10 | 20.30 | 11.0  | 43.50 |
| 232A03 | 431.0   | 872.0   | 168.0  | 37.40 | 48.10 | 22.60 | 12.0  | 46.50 |
| 232A04 | 1600.0  | 1270.0  | 211.0  | 60.0  | 61.10 | 23.50 | 17.20 | 58.60 |
| 232A05 | 4010.0  | 1500.0  | 324.0  | 42.10 | 71.90 | 29.40 | 19.10 | 50.50 |
| 232A06 | 5.36    | 55.0    | 17.90  | 9.15  | 11.20 | 11.0  | 5.93  | 12.20 |
| 233C04 | 4.58    | 0.0     | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 234B02 | 335.0   | 1480.0  | 286.0  | 34.70 | 68.50 | 18.10 | 11.40 | 39.0  |
| 234B03 | 554.0   | 1360.0  | 241.0  | 40.80 | 57.80 | 22.80 | 12.90 | 44.0  |
| 234B04 | 2490.0  | 2300.0  | 405.0  | 65.0  | 104.0 | 41.70 | 25.0  | 81.60 |
| 234B05 | 8430.0  | 3080.0  | 674.0  | 92.90 | 145.0 | 50.90 | 34.20 | 103.0 |
| 234B06 | 16500.0 | 7870.0  | 2060.0 | 234.0 | 333.0 | 107.0 | 61.10 | 192.0 |
| 234B07 | 28600.0 | 1590.0  | 315.0  | 53.20 | 80.30 | 31.70 | 19.40 | 59.70 |
| 235A02 | 545.0   | 1530.0  | 300.0  | 39.80 | 77.40 | 22.80 | 13.80 | 48.80 |
| 235A03 | 337.0   | 727.0   | 138.0  | 26.70 | 34.20 | 16.0  | 10.90 | 33.60 |
| 235A04 | 4570.0  | 3380.0  | 800.0  | 121.0 | 160.0 | 49.30 | 41.40 | 123.0 |
| 235A05 | 11400.0 | 4810.0  | 1720.0 | 150.0 | 240.0 | 83.80 | 50.80 | 173.0 |
| 235A06 | 22200.0 | 2730.0  | 570.0  | 83.0  | 134.0 | 32.70 | 31.30 | 129.0 |
| 235A07 | 5510.0  | 682.0   | 139.0  | 30.70 | 41.90 | 12.90 | 14.0  | 43.0  |
| 236A02 | 2.0     | 1910.0  | 575.0  | 74.0  | 119.0 | 74.30 | 23.70 | 88.30 |
| 236A03 | 14900.0 | 2370.0  | 451.0  | 70.30 | 103.0 | 29.90 | 26.60 | 104.0 |
| 236A04 | 8920.0  | 1240.0  | 203.0  | 38.10 | 54.0  | 14.90 | 16.60 | 70.70 |
| 236A05 | 4160.0  | 1770.0  | 424.0  | 49.0  | 85.30 | 24.0  | 23.70 | 91.90 |
| 236A06 | 979.0   | 2270.0  | 356.0  | 61.90 | 104.0 | 27.10 | 22.90 | 93.30 |
| 238A02 | 1220.0  | 785.0   | 157.0  | 23.50 | 42.60 | 14.70 | 7.49  | 30.70 |
| 238A05 | 3.46    | 29.60   | 9.60   | 3.33  | 6.05  | 5.49  | 3.51  | 9.42  |
| 238A06 | 3.18    | 4.05    | 2.87   | 0.0   | 0.0   | 0.0   | 0.0   | 1.48  |
| 239A02 | 308.0   | 826.0   | 172.0  | 24.50 | 43.80 | 16.70 | 9.58  | 34.90 |
| 239A03 | 528.0   | 414.0   | 70.60  | 13.50 | 24.0  | 11.80 | 6.21  | 25.80 |
| 240A02 | 8970.0  | 2710.0  | 541.0  | 99.50 | 146.0 | 55.0  | 34.50 | 116.0 |
| 240A03 | 12100.0 | 3340.0  | 766.0  | 119.0 | 175.0 | 63.30 | 37.90 | 141.0 |
| 240A04 | 13100.0 | 4.0     | 782.0  | 114.0 | 222.0 | 62.0  | 36.80 | 130.0 |
| 240A05 | 40900.0 | 2840.0  | 657.0  | 100.0 | 139.0 | 44.40 | 33.70 | 118.0 |
| 240A06 | 13.0    | 4420.0  | 1250.0 | 97.30 | 202.0 | 50.60 | 45.50 | 135.0 |
| 241A02 | 341.0   | 909.0   | 197.0  | 27.80 | 49.50 | 17.70 | 9.81  | 35.50 |
| 241A03 | 2660.0  | 873.0   | 176.0  | 30.70 | 41.10 | 18.10 | 12.80 | 41.20 |
| 241A04 | 20100.0 | 6420.0  | 2430.0 | 253.0 | 370.0 | 105.0 | 52.30 | 232.0 |
| 241A05 | 26300.0 | 3680.0  | 693.0  | 107.0 | 147.0 | 46.70 | 34.0  | 132.0 |
| 241A06 | 8350.0  | 4360.0  | 1270.0 | 113.0 | 207.0 | 49.0  | 44.50 | 132.0 |
| 241A07 | 33.10   | 856.0   | 139.0  | 46.0  | 55.60 | 19.40 | 23.80 | 81.60 |
| 242A02 | 384.0   | 1030.0  | 180.0  | 22.0  | 50.30 | 16.80 | 7.64  | 33.40 |
| 242A03 | 1040.0  | 1300.0  | 217.0  | 36.50 | 53.70 | 22.10 | 11.0  | 49.90 |
| 242A04 | 33900.0 | 6750.0  | 1420.0 | 140.0 | 304.0 | 68.60 | 40.40 | 154.0 |
| 242A05 | 34.0    | 9180.0  | 1520.0 | 128.0 | 319.0 | 62.90 | 37.80 | 150.0 |
| 242A06 | 11300.0 | 6870.0  | 1700.0 | 150.0 | 295.0 | 65.80 | 56.10 | 144.0 |
| 242A07 | 21.0    | 1960.0  | 332.0  | 82.40 | 123.0 | 37.70 | 36.40 | 107.0 |
| 243A02 | 1370.0  | 813.0   | 177.0  | 35.90 | 49.20 | 29.60 | 11.70 | 43.60 |
| 243A03 | 19300.0 | 4360.0  | 1050.0 | 154.0 | 246.0 | 127.0 | 48.90 | 146.0 |
| 243A04 | 16800.0 | 11900.0 | 3770.0 | 458.0 | 615.0 | 190.0 | 112.0 | 330.0 |
| 243A05 | 36.0    | 3480.0  | 766.0  | 122.0 | 177.0 | 54.40 | 33.40 | 143.0 |
| 243A06 | 28500.0 | 5330.0  | 987.0  | 99.80 | 198.0 | 53.90 | 33.0  | 140.0 |
| 244A02 | 454.0   | 688.0   | 158.0  | 29.70 | 33.80 | 9.88  | 14.50 | 37.90 |

|        |         |         |        |       |       |       |       |       |
|--------|---------|---------|--------|-------|-------|-------|-------|-------|
| 244A03 | 724.0   | 220.0   | 48.20  | 8.89  | 10.30 | 4.19  | 3.11  | 12.0  |
| 244A04 | 4090.0  | 12500.0 | 3840.0 | 401.0 | 497.0 | 143.0 | 84.20 | 273.0 |
| 244A05 | 3710.0  | 2440.0  | 436.0  | 59.90 | 100.0 | 42.80 | 29.0  | 113.0 |
| 244A06 | 5.70    | 235.0   | 43.50  | 30.0  | 44.20 | 14.10 | 12.10 | 32.20 |
| 245B02 | 1420.0  | 990.0   | 195.0  | 36.80 | 52.30 | 20.80 | 13.40 | 46.80 |
| 245B03 | 5740.0  | 1410.0  | 312.0  | 50.40 | 72.0  | 32.60 | 22.70 | 71.50 |
| 245B04 | 7880.0  | 9400.0  | 2230.0 | 303.0 | 409.0 | 136.0 | 61.0  | 216.0 |
| 245B05 | 14200.0 | 8200.0  | 2250.0 | 252.0 | 370.0 | 106.0 | 63.60 | 214.0 |
| 245B06 | 13500.0 | 2300.0  | 428.0  | 79.80 | 110.0 | 31.70 | 32.70 | 123.0 |
| 245B07 | 1940.0  | 2100.0  | 483.0  | 55.0  | 137.0 | 39.10 | 34.90 | 117.0 |
| 246A02 | 0.0     | 1.64    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 246A03 | 0.76    | 1.06    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 246A04 | 0.0     | 1.33    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 246A05 | 0.0     | 0.93    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 246A06 | 0.0     | 1.22    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 247A02 | 1.80    | 1.44    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 247A03 | 9.11    | 8.26    | 23.50  | 0.0   | 0.0   | 0.0   | 0.0   | 2.23  |
| 248A02 | 326.0   | 662.0   | 102.0  | 28.20 | 33.80 | 0.0   | 10.90 | 33.20 |
| 248A03 | 5110.0  | 1980.0  | 370.0  | 80.0  | 96.10 | 58.20 | 27.10 | 91.60 |
| 248A04 | 3460.0  | 1450.0  | 410.0  | 63.30 | 93.20 | 0.0   | 28.60 | 88.60 |
| 248A05 | 361.0   | 422.0   | 86.90  | 0.0   | 31.40 | 11.80 | 0.0   | 40.80 |
| 248A06 | 0.0     | 29.70   | 4.72   | 0.0   | 3.42  | 3.38  | 0.0   | 6.73  |
| 249B02 | 364.0   | 1410.0  | 261.0  | 40.80 | 63.90 | 22.60 | 11.80 | 43.70 |
| 249B03 | 496.0   | 991.0   | 197.0  | 34.60 | 54.60 | 21.90 | 13.80 | 53.70 |
| 249B04 | 299.0   | 659.0   | 126.0  | 25.20 | 32.10 | 12.90 | 8.26  | 30.10 |
| 249B05 | 696.0   | 664.0   | 122.0  | 28.20 | 35.10 | 13.60 | 10.50 | 38.50 |
| 249B06 | 81.90   | 346.0   | 56.40  | 21.50 | 22.80 | 8.80  | 7.04  | 22.0  |
| 250A02 | 4.06    | 2.76    | 0.66   | 0.0   | 0.0   | 0.0   | 0.0   | 1.61  |
| 250A03 | 0.0     | 1.30    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 1.80  |
| 250A04 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 1.59  |
| 250A05 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 1.48  |
| 250A06 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 1.57  |
| 251B02 | 474.0   | 686.0   | 152.0  | 26.40 | 38.50 | 12.90 | 9.35  | 35.80 |
| 251B03 | 3660.0  | 1260.0  | 282.0  | 46.30 | 76.70 | 25.20 | 19.20 | 68.50 |
| 251B04 | 18100.0 | 3960.0  | 1190.0 | 124.0 | 219.0 | 48.90 | 40.10 | 141.0 |
| 251B05 | 43300.0 | 3460.0  | 1050.0 | 118.0 | 195.0 | 41.20 | 38.80 | 123.0 |
| 251B06 | 3620.0  | 872.0   | 199.0  | 26.60 | 44.20 | 16.50 | 11.80 | 44.40 |
| 251B07 | 37.0    | 96.90   | 21.10  | 5.14  | 7.30  | 2.91  | 0.0   | 9.41  |
| 252C02 | 282.0   | 932.0   | 193.0  | 20.80 | 45.60 | 12.90 | 7.09  | 29.30 |
| 252C03 | 442.0   | 1740.0  | 324.0  | 30.40 | 64.50 | 16.80 | 10.0  | 36.30 |
| 252C04 | 12700.0 | 2310.0  | 504.0  | 63.0  | 101.0 | 33.30 | 21.80 | 76.50 |
| 252C05 | 23.0    | 5620.0  | 1520.0 | 145.0 | 253.0 | 69.20 | 43.60 | 153.0 |
| 252C06 | 20900.0 | 4560.0  | 1200.0 | 125.0 | 198.0 | 63.30 | 38.60 | 129.0 |
| 252C07 | 15200.0 | 1730.0  | 312.0  | 40.30 | 69.50 | 22.0  | 15.30 | 61.80 |
| 253A02 | 515.0   | 1140.0  | 264.0  | 34.40 | 66.70 | 18.30 | 10.80 | 44.20 |
| 253A03 | 1.0     | 956.0   | 212.0  | 36.30 | 61.0  | 19.50 | 12.50 | 44.10 |
| 253A04 | 3430.0  | 801.0   | 203.0  | 30.70 | 48.50 | 18.40 | 13.60 | 42.60 |
| 253A07 | 83.30   | 112.0   | 24.80  | 6.0   | 10.0  | 6.34  | 3.45  | 12.60 |
| 254A02 | 608.0   | 1210.0  | 239.0  | 25.80 | 59.30 | 16.80 | 9.79  | 34.80 |
| 254A03 | 355.0   | 806.0   | 158.0  | 23.90 | 39.20 | 13.70 | 7.92  | 29.30 |
| 254A04 | 429.0   | 726.0   | 128.0  | 22.90 | 34.50 | 39.60 | 8.57  | 29.70 |
| 254A05 | 4810.0  | 1130.0  | 208.0  | 32.30 | 46.90 | 23.80 | 12.70 | 43.80 |
| 254A06 | 12.0    | 64.80   | 12.20  | 4.57  | 7.04  | 7.35  | 3.12  | 8.04  |
| 255A02 | 618.0   | 1120.0  | 206.0  | 28.30 | 53.20 | 14.40 | 9.14  | 34.40 |



|        |         |        |        |       |        |       |       |       |
|--------|---------|--------|--------|-------|--------|-------|-------|-------|
| 255A03 | 461.0   | 1600.0 | 330.0  | 37.50 | 74.80  | 19.40 | 11.20 | 44.80 |
| 255A04 | 598.0   | 1470.0 | 316.0  | 35.80 | 72.20  | 22.70 | 12.70 | 51.50 |
| 255A05 | 382.0   | 394.0  | 74.30  | 14.60 | 18.60  | 6.66  | 4.23  | 17.90 |
| 255A06 | 3.44    | 2.23   | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 0.0   |
| 256B02 | 317.0   | 561.0  | 113.0  | 18.0  | 33.10  | 14.10 | 7.48  | 28.50 |
| 256B04 | 324.0   | 602.0  | 118.0  | 21.80 | 33.80  | 14.70 | 8.37  | 31.20 |
| 256B07 | 5.05    | 5.23   | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 2.02  |
| 257C02 | 1450.0  | 827.0  | 148.0  | 33.40 | 44.80  | 22.80 | 12.20 | 49.20 |
| 257C03 | 2440.0  | 957.0  | 196.0  | 32.50 | 47.70  | 20.30 | 12.20 | 44.70 |
| 257C05 | 14.80   | 22.80  | 6.36   | 2.72  | 2.43   | 4.02  | 1.95  | 4.38  |
| 257C06 | 11.90   | 7.52   | 1.94   | 0.0   | 0.68   | 0.0   | 0.0   | 2.11  |
| 258C02 | 414.0   | 4880.0 | 761.0  | 104.0 | 141.0  | 23.20 | 17.40 | 63.70 |
| 258C03 | 668.0   | 1240.0 | 266.0  | 34.70 | 35.50  | 20.20 | 11.30 | 47.40 |
| 258C04 | 343.0   | 783.0  | 133.0  | 27.0  | 54.50  | 10.80 | 8.29  | 29.30 |
| 258C05 | 2.84    | 2.88   | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 0.0   |
| 259B02 | 10.0    | 2300.0 | 527.0  | 76.90 | 117.0  | 44.50 | 24.30 | 86.90 |
| 259B04 | 2350.0  | 726.0  | 187.0  | 25.30 | 38.60  | 20.10 | 9.20  | 26.30 |
| 260B02 | 408.0   | 994.0  | 198.0  | 27.30 | 53.10  | 17.70 | 9.31  | 29.0  |
| 260B03 | 2570.0  | 1290.0 | 234.0  | 38.80 | 559.50 | 23.70 | 11.80 | 42.80 |
| 260B04 | 10900.0 | 2520.0 | 483.0  | 77.40 | 109.0  | 52.0  | 29.10 | 94.40 |
| 260B05 | 57500.0 | 4720.0 | 1020.0 | 125.0 | 211.0  | 62.10 | 48.60 | 127.0 |
| 260B06 | 18500.0 | 2810.0 | 513.0  | 84.50 | 121.0  | 34.10 | 30.10 | 113.0 |
| 261C02 | 3.24    | 1.57   | 0.0    | 0.96  | 0.0    | 0.0   | 0.0   | 1.06  |
| 261C06 | 31.10   | 0.0    | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 0.0   |
| 262A02 | 14.80   | 15.20  | 4.67   | 0.99  | 1.41   | 0.96  | 0.67  | 2.95  |
| 262A03 | 6.42    | 3.60   | 1.17   | 0.0   | 0.0    | 0.0   | 0.0   | 1.67  |
| 262A04 | 2.10    | 0.0    | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 0.0   |
| 262A05 | 0.0     | 0.0    | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 1.60  |
| 263B02 | 233.0   | 929.0  | 174.0  | 23.50 | 48.10  | 14.70 | 7.14  | 40.50 |
| 263B03 | 295.0   | 279.0  | 56.70  | 11.60 | 15.80  | 7.65  | 4.25  | 17.80 |
| 263B04 | 378.0   | 162.0  | 30.90  | 6.37  | 8.69   | 4.25  | 2.65  | 10.50 |
| 263B05 | 452.0   | 113.0  | 23.20  | 3.97  | 5.55   | 2.47  | 1.51  | 5.90  |
| 263B06 | 2170.0  | 638.0  | 140.0  | 17.70 | 29.0   | 9.01  | 7.64  | 23.10 |
| 264A02 | 12.10   | 7.28   | 3.64   | 0.0   | 0.0    | 0.0   | 0.0   | 0.0   |
| 264A03 | 0.0     | 1.54   | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 0.0   |
| 264A06 | 0.0     | 3.21   | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 0.0   |
| 265A04 | 0.0     | 1.38   | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 1.60  |
| 265A05 | 0.0     | 0.0    | 0.0    | 1.28  | 0.0    | 0.0   | 0.0   | 1.39  |
| 265A06 | 1.05    | 0.87   | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 1.57  |
| 266A02 | 183.0   | 201.0  | 46.40  | 9.11  | 14.90  | 3.73  | 3.55  | 16.40 |
| 266A03 | 112.0   | 2400.0 | 36.20  | 69.90 | 13.40  | 4.30  | 4.41  | 24.50 |
| 266A04 | 15.60   | 21.0   | 5.35   | 1.86  | 1.59   | 0.62  | 0.71  | 2.68  |
| 266A05 | 14.60   | 19.10  | 4.92   | 1.91  | 1.46   | 0.63  | 0.0   | 3.16  |
| 266A06 | 12.20   | 14.20  | 3.69   | 2.29  | 1.54   | 0.0   | 0.0   | 2.35  |
| 267A02 | 456.0   | 128.0  | 31.20  | 9.42  | 10.80  | 4.97  | 5.73  | 16.0  |
| 267A03 | 164.0   | 40.0   | 10.30  | 3.48  | 3.67   | 0.0   | 2.34  | 6.15  |
| 268B02 | 1090.0  | 1900.0 | 241.0  | 53.10 | 55.30  | 12.0  | 10.20 | 40.50 |
| 268B03 | 1510.0  | 705.0  | 114.0  | 26.90 | 31.20  | 14.20 | 9.20  | 33.30 |
| 268B04 | 1260.0  | 321.0  | 55.30  | 12.0  | 14.60  | 7.37  | 4.70  | 18.50 |
| 268B05 | 2.13    | 0.0    | 0.0    | 0.0   | 0.0    | 0.0   | 0.0   | 0.0   |
| 269C02 | 629.0   | 535.0  | 101.0  | 28.60 | 28.90  | 12.30 | 9.32  | 31.0  |
| 269C04 | 848.0   | 521.0  | 95.90  | 20.50 | 25.70  | 10.50 | 7.57  | 27.30 |
| 269C06 | 1890.0  | 784.0  | 138.0  | 28.30 | 36.80  | 17.70 | 10.70 | 40.20 |
| 269C07 | 4670.0  | 1990.0 | 401.0  | 55.90 | 78.0   | 28.30 | 21.50 | 64.80 |

|        |         |        |        |       |       |       |       |       |
|--------|---------|--------|--------|-------|-------|-------|-------|-------|
| 270A02 | 628.0   | 807.0  | 169.0  | 35.10 | 51.90 | 19.40 | 19.10 | 51.30 |
| 270A03 | 2350.0  | 771.0  | 176.0  | 35.20 | 51.0  | 21.40 | 16.10 | 51.20 |
| 270A04 | 12.0    | 2210.0 | 534.0  | 69.50 | 125.0 | 51.10 | 31.90 | 106.0 |
| 270A06 | 9590.0  | 3330.0 | 859.0  | 102.0 | 191.0 | 63.90 | 42.90 | 146.0 |
| 270A07 | 3190.0  | 614.0  | 134.0  | 21.30 | 33.10 | 12.70 | 7.62  | 28.50 |
| 271A02 | 163.0   | 161.0  | 31.70  | 10.70 | 12.30 | 0.0   | 0.0   | 16.20 |
| 271A03 | 1630.0  | 881.0  | 144.0  | 33.60 | 40.70 | 18.50 | 11.10 | 41.80 |
| 271A04 | 8850.0  | 1400.0 | 258.0  | 49.0  | 66.0  | 24.0  | 14.50 | 66.60 |
| 271A07 | 4540.0  | 334.0  | 60.90  | 16.10 | 17.10 | 6.68  | 7.54  | 21.60 |
| 272A02 | 179.0   | 363.0  | 65.40  | 13.50 | 21.0  | 7.33  | 0.0   | 16.0  |
| 272A03 | 543.0   | 1.0    | 91.0   | 28.0  | 28.60 | 0.0   | 0.0   | 31.30 |
| 272A04 | 17100.0 | 1400.0 | 294.0  | 61.20 | 66.20 | 40.40 | 24.60 | 89.50 |
| 272A05 | 3780.0  | 769.0  | 119.0  | 36.30 | 44.20 | 23.90 | 18.0  | 76.10 |
| 272A06 | 587.0   | 139.0  | 54.30  | 29.50 | 31.80 | 0.0   | 0.0   | 63.90 |
| 272A07 | 17.40   | 975.0  | 80.80  | 28.50 | 45.40 | 11.70 | 15.50 | 83.30 |
| 273A02 | 3510.0  | 1240.0 | 262.0  | 38.0  | 52.10 | 17.20 | 9.61  | 50.90 |
| 273A03 | 7690.0  | 1120.0 | 166.0  | 35.10 | 47.80 | 21.0  | 19.80 | 62.50 |
| 273A04 | 4690.0  | 842.0  | 140.0  | 32.60 | 47.0  | 15.40 | 14.10 | 71.70 |
| 273A05 | 35.80   | 586.0  | 79.80  | 23.0  | 38.50 | 13.40 | 16.90 | 72.60 |
| 273A06 | 4.56    | 498.0  | 81.10  | 23.90 | 32.0  | 16.50 | 17.60 | 48.90 |
| 274A02 | 3740.0  | 703.0  | 115.0  | 26.90 | 34.30 | 13.0  | 10.80 | 38.0  |
| 274A03 | 26500.0 | 2670.0 | 448.0  | 71.80 | 103.0 | 32.30 | 26.50 | 106.0 |
| 274A04 | 8070.0  | 1520.0 | 262.0  | 42.10 | 69.70 | 21.0  | 18.80 | 79.50 |
| 274A05 | 185.0   | 335.0  | 37.10  | 17.20 | 21.0  | 9.83  | 10.80 | 41.60 |
| 274A06 | 6.88    | 593.0  | 77.60  | 26.30 | 32.80 | 15.70 | 13.10 | 49.40 |
| 275A02 | 747.0   | 814.0  | 192.0  | 31.40 | 39.60 | 17.0  | 11.10 | 36.10 |
| 275A03 | 1720.0  | 532.0  | 146.0  | 27.0  | 40.10 | 0.0   | 8.0   | 35.40 |
| 275A04 | 13400.0 | 2620.0 | 484.0  | 68.80 | 128.0 | 0.0   | 31.30 | 121.0 |
| 275A05 | 640.0   | 647.0  | 117.0  | 32.20 | 46.30 | 17.80 | 17.60 | 74.60 |
| 275A06 | 4.62    | 550.0  | 80.20  | 23.60 | 32.10 | 15.0  | 15.30 | 50.60 |
| 276A02 | 506.0   | 1040.0 | 241.0  | 33.10 | 60.60 | 18.70 | 11.20 | 40.90 |
| 276A03 | 699.0   | 1320.0 | 297.0  | 43.20 | 69.50 | 21.20 | 14.60 | 51.80 |
| 276A04 | 876.0   | 1170.0 | 183.0  | 38.60 | 36.10 | 20.20 | 11.20 | 38.10 |
| 276A05 | 1860.0  | 1480.0 | 199.0  | 47.60 | 49.0  | 25.30 | 18.60 | 62.30 |
| 276A06 | 0.0     | 257.0  | 34.90  | 11.0  | 14.10 | 6.18  | 0.0   | 21.10 |
| 277B02 | 245.0   | 434.0  | 85.0   | 14.90 | 22.50 | 8.39  | 5.38  | 18.90 |
| 277B03 | 799.0   | 892.0  | 165.0  | 28.40 | 42.80 | 16.10 | 10.40 | 34.20 |
| 277B04 | 381.0   | 847.0  | 145.0  | 27.30 | 45.10 | 19.20 | 15.40 | 58.30 |
| 277B05 | 0.0     | 528.0  | 81.40  | 19.30 | 28.80 | 8.94  | 10.90 | 42.10 |
| 277B06 | 0.0     | 65.70  | 10.30  | 5.07  | 4.78  | 3.45  | 0.0   | 8.78  |
| 278B02 | 4990.0  | 1080.0 | 229.0  | 41.10 | 52.20 | 19.10 | 17.40 | 47.60 |
| 278B03 | 27.0    | 6330.0 | 1080.0 | 166.0 | 208.0 | 64.20 | 54.10 | 145.0 |
| 278B04 | 24500.0 | 4920.0 | 1070.0 | 150.0 | 207.0 | 66.70 | 50.80 | 150.0 |
| 278B05 | 12500.0 | 2230.0 | 522.0  | 102.0 | 126.0 | 42.30 | 35.20 | 112.0 |
| 278B06 | 12300.0 | 2030.0 | 389.0  | 61.20 | 103.0 | 32.30 | 29.90 | 102.0 |
| 282A02 | 437.0   | 2430.0 | 523.0  | 52.0  | 117.0 | 33.60 | 15.60 | 57.80 |
| 282A03 | 343.0   | 1900.0 | 404.0  | 42.70 | 97.10 | 30.50 | 13.80 | 49.20 |
| 282A04 | 425.0   | 3600.0 | 823.0  | 72.10 | 183.0 | 46.10 | 22.60 | 72.30 |
| 282A05 | 638.0   | 2080.0 | 289.0  | 54.20 | 80.0  | 31.20 | 16.50 | 54.40 |
| 282A06 | 648.0   | 1820.0 | 347.0  | 53.50 | 81.50 | 36.10 | 18.80 | 58.0  |
| 283A02 | 318.0   | 1800.0 | 391.0  | 39.0  | 89.90 | 24.70 | 11.0  | 46.40 |
| 283A03 | 7610.0  | 1700.0 | 358.0  | 37.70 | 84.30 | 26.0  | 12.30 | 45.60 |
| 283A04 | 467.0   | 2680.0 | 881.0  | 74.40 | 196.0 | 45.20 | 21.50 | 79.0  |
| 283A05 | 553.0   | 1340.0 | 266.0  | 37.90 | 66.80 | 28.30 | 12.80 | 46.60 |

|        |         |         |        |       |       |       |       |       |
|--------|---------|---------|--------|-------|-------|-------|-------|-------|
| 283A06 | 733.0   | 1230.0  | 239.0  | 39.30 | 60.70 | 26.70 | 14.80 | 47.60 |
| 284B02 | 574.0   | 2410.0  | 482.0  | 63.40 | 122.0 | 42.80 | 23.10 | 76.80 |
| 284B03 | 77900.0 | 2490.0  | 609.0  | 85.70 | 142.0 | 52.50 | 29.50 | 81.10 |
| 284B04 | 167.0   | 101.0   | 23.50  | 6.21  | 9.31  | 4.69  | 2.86  | 6.81  |
| 284B05 | 18.50   | 7.53    | 2.79   | 0.0   | 1.18  | 0.0   | 0.0   | 3.16  |
| 284B06 | 0.0     | 2.31    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 2.36  |
| 285A02 | 5040.0  | 3450.0  | 731.0  | 92.30 | 172.0 | 37.10 | 26.50 | 74.30 |
| 285A03 | 65200.0 | 5160.0  | 2410.0 | 284.0 | 453.0 | 78.80 | 68.90 | 207.0 |
| 285A04 | 932.0   | 26300.0 | 1590.0 | 245.0 | 328.0 | 106.0 | 211.0 | 398.0 |
| 285A05 | 28.0    | 3710.0  | 976.0  | 138.0 | 8.33  | 66.90 | 39.70 | 111.0 |
| 286B02 | 2200.0  | 3360.0  | 646.0  | 78.30 | 153.0 | 39.0  | 21.20 | 70.60 |
| 286B03 | 4950.0  | 3420.0  | 736.0  | 102.0 | 194.0 | 55.50 | 35.20 | 116.0 |
| 286B04 | 62100.0 | 4560.0  | 1010.0 | 142.0 | 240.0 | 66.40 | 48.10 | 153.0 |
| 287B02 | 4.67    | 5.16    | 1.57   | 1.90  | 0.68  | 0.0   | 0.36  | 1.75  |
| 287B03 | 0.0     | 1.40    | 0.0    | 1.12  | 0.0   | 0.0   | 0.0   | 1.60  |
| 287B04 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 287B05 | 65.30   | 51.40   | 9.69   | 2.75  | 4.33  | 0.0   | 0.87  | 2.26  |
| 287B06 | 4.60    | 5.41    | 1.19   | 0.0   | 0.0   | 0.0   | 0.0   | 1.38  |
| 288B02 | 3.66    | 11.40   | 5.17   | 2.99  | 1.97  | 5.02  | 1.56  | 3.42  |
| 288B03 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 1.84  |
| 288B04 | 2.07    | 1.13    | 0.0    | 1.30  | 0.0   | 0.0   | 0.0   | 0.0   |
| 288B05 | 3.03    | 0.0     | 0.0    | 1.21  | 0.0   | 0.0   | 0.0   | 1.30  |
| 288B06 | 2.28    | 1.10    | 0.0    | 1.21  | 0.0   | 0.0   | 0.0   | 0.0   |
| 289A02 | 2440.0  | 1460.0  | 315.0  | 49.10 | 75.0  | 28.90 | 18.10 | 63.80 |
| 289A03 | 13.50   | 97.70   | 21.30  | 13.50 | 15.80 | 11.0  | 8.35  | 16.30 |
| 289A04 | 2.91    | 1.49    | 0.0    | 1.34  | 0.0   | 0.0   | 0.0   | 1.62  |
| 289A05 | 1.77    | 1.42    | 0.0    | 1.67  | 0.0   | 0.0   | 0.0   | 1.79  |
| 289A06 | 0.0     | 0.0     | 0.0    | 1.14  | 0.0   | 0.0   | 0.0   | 1.30  |
| 290B02 | 2800.0  | 1410.0  | 188.0  | 51.40 | 68.40 | 28.80 | 19.90 | 77.20 |
| 290B03 | 4.27    | 16.10   | 4.64   | 3.24  | 3.25  | 3.16  | 0.0   | 3.37  |
| 290B04 | 4.39    | 3.91    | 0.0    | 1.68  | 0.0   | 0.0   | 0.0   | 0.0   |
| 290B05 | 6.61    | 3.25    | 1.40   | 0.0   | 0.0   | 0.0   | 0.0   | 1.64  |
| 290B06 | 0.0     | 0.0     | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 291A02 | 12.50   | 2220.0  | 126.0  | 44.20 | 91.60 | 19.60 | 27.30 | 154.0 |
| 291A03 | 7.57    | 1070.0  | 82.10  | 38.70 | 59.80 | 14.80 | 19.70 | 89.0  |
| 291A04 | 7.54    | 871.0   | 86.80  | 72.50 | 84.40 | 23.0  | 27.20 | 129.0 |
| 291A05 | 35.40   | 250.0   | 33.40  | 28.20 | 29.30 | 8.49  | 9.99  | 34.70 |
| 291A06 | 2.37    | 3.49    | 1.39   | 1.69  | 0.0   | 0.0   | 0.0   | 2.04  |
| 295B02 | 173.0   | 2340.0  | 508.0  | 43.70 | 108.0 | 25.60 | 14.10 | 47.60 |
| 295B03 | 218.0   | 3780.0  | 1030.0 | 68.70 | 199.0 | 42.60 | 22.40 | 75.30 |
| 295B04 | 287.0   | 3990.0  | 22.0   | 71.90 | 135.0 | 46.90 | 24.40 | 84.40 |
| 295B05 | 291.0   | 5640.0  | 1450.0 | 88.0  | 295.0 | 68.60 | 31.0  | 115.0 |
| 295B06 | 300.0   | 5760.0  | 1560.0 | 98.50 | 315.0 | 61.60 | 33.50 | 112.0 |
| 294A02 | 31.60   | 383.0   | 66.50  | 34.0  | 31.10 | 9.68  | 9.74  | 24.60 |
| 294A03 | 26.70   | 40.40   | 7.97   | 14.30 | 4.09  | 0.0   | 0.0   | 4.57  |
| 294A04 | 17.30   | 30.50   | 10.90  | 9.49  | 3.86  | 6.84  | 0.0   | 6.69  |
| 294A05 | 6.37    | 31.60   | 11.10  | 5.44  | 5.59  | 7.87  | 3.36  | 6.95  |
| 294A06 | 7.19    | 16.30   | 5.73   | 0.0   | 3.56  | 4.17  | 0.0   | 4.02  |
| 292C02 | 371.0   | 827.0   | 128.0  | 37.60 | 43.0  | 18.20 | 13.10 | 40.30 |
| 292C03 | 427.0   | 601.0   | 103.0  | 29.10 | 32.30 | 14.40 | 8.56  | 31.80 |
| 292C04 | 469.0   | 903.0   | 158.0  | 32.50 | 41.90 | 21.50 | 12.60 | 38.10 |
| 292C05 | 1650.0  | 1300.0  | 217.0  | 51.30 | 65.80 | 30.40 | 18.10 | 66.50 |
| 292C06 | 19800.0 | 1520.0  | 271.0  | 56.90 | 69.90 | 32.80 | 20.40 | 71.20 |
| 293A02 | 6.03    | 33.20   | 10.80  | 0.0   | 5.08  | 9.24  | 0.0   | 6.89  |

|        |        |         |        |        |       |       |       |       |
|--------|--------|---------|--------|--------|-------|-------|-------|-------|
| 293A03 | 3.85   | 4.39    | 0.0    | 1.68   | 0.0   | 0.0   | 0.0   | 0.0   |
| 293A04 | 0.0    | 0.0     | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 0.0   |
| 293A06 | 0.0    | 0.0     | 0.0    | 0.0    | 0.0   | 0.0   | 0.0   | 1.59  |
| 296B02 | 456.0  | 1130.0  | 232.0  | 30.60  | 56.50 | 17.50 | 9.56  | 35.70 |
| 296B03 | 412.0  | 808.0   | 160.0  | 25.70  | 44.40 | 14.70 | 8.33  | 32.20 |
| 296B04 | 1450.0 | 596.0   | 119.0  | 29.60  | 34.80 | 15.50 | 10.70 | 35.90 |
| 296B05 | 7460.0 | 1520.0  | 319.0  | 49.0   | 79.70 | 30.40 | 19.20 | 71.90 |
| 296B06 | 12.0   | 2770.0  | 639.0  | 86.20  | 131.0 | 36.90 | 32.60 | 101.0 |
| UH1090 | 8.58   | 3098.56 | 142.09 | 33.23  | 7.78  | 7.05  | 9.37  | 0.57  |
| UH0190 | 4.78   | 1053.46 | 44.91  | 18.0   | 2.97  | 4.35  | 0.53  | 0.35  |
| UH1010 | 1.01   | 223.90  | 16.43  | 2.57   | 0.75  | 2.14  | 1.10  | 0.14  |
| UH1100 | 1.71   | 538.76  | 13.52  | 2.57   | 0.90  | 1.21  | 0.39  | 0.66  |
| UH1110 | 8.67   | 2314.52 | 97.50  | 26.51  | 5.55  | 5.30  | 0.96  | 0.40  |
| UH0220 | 6.50   | 1443.88 | 64.01  | 20.83  | 4.03  | 5.24  | 0.47  | 0.30  |
| UH1120 | 23.16  | 3033.30 | 109.68 | 34.66  | 7.03  | 3.28  | 1.04  | 0.43  |
| UH1130 | 14.74  | 3156.55 | 131.88 | 25.53  | 7.31  | 6.83  | 0.42  | 0.75  |
| NB1150 | 17.98  | 3615.95 | 173.79 | 33.12  | 10.11 | 0.39  | 0.67  | 0.76  |
| UH0300 | 0.25   | 182.64  | 21.89  | 0.62   | 0.29  | 0.56  | 0.35  | 0.76  |
| NB1090 | 42.15  | 10508.3 | 429.52 | 137.39 | 37.42 | 1.92  | 7.03  | 4.43  |
| RB0020 | 0.55   | 183.10  | 20.52  | 2.15   | 0.38  | 0.52  | 0.27  | 0.21  |
| NB1070 | 24.46  | 6714.0  | 301.98 | 86.59  | 28.28 | 1.08  | 1.10  | 2.29  |
| RB0070 | 0.68   | 245.74  | 7.23   | 1.95   | 0.90  | 0.70  | 0.36  | 0.44  |
| RB1050 | 1.53   | 278.02  | 16.0   | 1.70   | 0.11  | 0.58  | 0.14  | 0.04  |
| RB0100 | 0.92   | 213.92  | 10.59  | 2.45   | 0.38  | 0.96  | 1.0   | 0.20  |
| RB0110 | 0.75   | 197.09  | 4.68   | 1.95   | 1.03  | 0.35  | 0.36  | 0.45  |
| RB0120 | 0.20   | 241.77  | 1.36   | 0.41   | 0.41  | 0.19  | 0.25  | 0.22  |
| RB1060 | 0.73   | 423.22  | 12.81  | 2.19   | 0.54  | 0.59  | 0.15  | 0.97  |
| RB1080 | 0.14   | 37.62   | 20.36  | 0.92   | 0.34  | 0.05  | 0.38  | 0.06  |
| RB1070 | 0.45   | 309.29  | 3.86   | 1.15   | 0.30  | 0.45  | 0.09  | 0.07  |
| RB0160 | 5.84   | 1471.05 | 39.41  | 12.43  | 2.80  | 3.02  | 3.02  | 0.28  |
| RB0190 | 27.95  | 6405.55 | 144.64 | 42.38  | 11.52 | 12.84 | 8.0   | 0.84  |
| RB1160 | 7.13   | 1734.31 | 59.33  | 16.42  | 3.46  | 3.65  | 0.38  | 0.51  |
| RB1100 | 7.71   | 4274.69 | 83.51  | 27.70  | 6.20  | 5.51  | 0.73  | 0.11  |
| RB0240 | 16.09  | 3957.36 | 120.93 | 36.44  | 9.04  | 8.34  | 6.69  | 1.32  |
| RB1110 | 10.17  | 6445.34 | 158.24 | 46.35  | 13.45 | 9.89  | 0.80  | 0.14  |
| RB1120 | 8.48   | 3992.48 | 92.06  | 26.44  | 7.15  | 5.88  | 0.55  | 1.39  |
| RB0270 | 20.49  | 5746.30 | 158.79 | 47.96  | 11.15 | 11.71 | 7.72  | 0.31  |
| RB1140 | 14.12  | 6075.21 | 181.73 | 47.16  | 12.89 | 11.06 | 16.76 | 0.14  |
| RB0290 | 0.20   | 160.03  | 5.36   | 1.38   | 0.69  | 0.24  | 0.24  | 0.28  |
| RB1170 | 0.18   | 157.93  | 4.39   | 1.36   | 0.12  | 0.31  | 0.49  | 0.07  |
| RB0300 | 0.25   | 84.08   | 10.85  | 0.45   | 0.49  | 0.20  | 0.29  | 0.21  |
| RB0320 | 0.31   | 167.21  | 4.94   | 0.39   | 0.98  | 0.36  | 0.38  | 0.47  |
| RB0330 | 21.71  | 6904.26 | 168.15 | 53.98  | 10.37 | 12.09 | 7.14  | 0.34  |
| UH1020 | 3.53   | 1507.69 | 47.03  | 9.08   | 4.0   | 6.98  | 4.07  | 0.25  |
| UH1030 | 8.96   | 3054.86 | 101.03 | 28.35  | 5.75  | 4.54  | 0.40  | 0.81  |
| UH0030 | 10.57  | 4538.50 | 124.26 | 35.34  | 7.41  | 6.23  | 3.02  | 0.79  |
| UH0040 | 2.03   | 495.93  | 16.71  | 6.75   | 1.24  | 1.80  | 0.87  | 0.39  |
| UH1050 | 1.50   | 1094.90 | 57.53  | 7.28   | 2.68  | 8.17  | 2.88  | 0.15  |
| UH0140 | 9.28   | 3300.37 | 112.53 | 35.26  | 7.53  | 8.37  | 4.26  | 0.50  |
| UH1080 | 2.89   | 2240.57 | 72.24  | 19.0   | 3.34  | 3.60  | 1.18  | 0.42  |
| UH0180 | 9.47   | 2879.70 | 83.17  | 26.89  | 5.08  | 5.87  | 3.42  | 0.98  |
| JB0120 | 16.81  | 23303.4 | 825.26 | 2.43   | 52.41 | 1.48  | 1.0   | 4.49  |
| JB0080 | 4.29   | 2076.96 | 64.02  | 18.18  | 1.06  | 5.50  | 5.26  | 0.70  |
| JB1010 | 5.25   | 3819.03 | 146.84 | 27.62  | 7.37  | 10.15 | 14.57 | 0.67  |

|        |       |         |        |       |       |       |       |      |
|--------|-------|---------|--------|-------|-------|-------|-------|------|
| JB0020 | 0.26  | 121.65  | 3.40   | 1.09  | 0.36  | 0.22  | 0.37  | 0.25 |
| JB1150 | 0.16  | 39.47   | 1.85   | 0.66  | 0.27  | 0.14  | 0.15  | 0.33 |
| JB1030 | 1.11  | 2672.33 | 97.02  | 11.79 | 5.35  | 3.67  | 1.16  | 0.89 |
| JB0150 | 17.73 | 3294.37 | 95.76  | 36.45 | 8.55  | 13.44 | 2.09  | 3.48 |
| JB1170 | 0.66  | 1021.47 | 33.27  | 3.45  | 1.76  | 3.49  | 4.58  | 1.86 |
| JB1040 | 0.85  | 357.43  | 18.75  | 3.07  | 1.06  | 1.71  | 1.94  | 0.15 |
| JB1060 | 5.0   | 2453.05 | 86.19  | 20.48 | 2.64  | 11.17 | 4.97  | 4.35 |
| JB1080 | 0.11  | 51.48   | 21.48  | 1.15  | 0.24  | 0.38  | 0.12  | 0.25 |
| JB0330 | 2.71  | 1043.19 | 36.14  | 10.66 | 2.70  | 3.32  | 3.60  | 0.47 |
| JB0310 | 0.13  | 66.34   | 2.15   | 0.93  | 0.14  | 0.26  | 0.18  | 0.37 |
| JB0180 | 7.85  | 3414.46 | 92.89  | 27.65 | 5.46  | 0.56  | 0.87  | 0.62 |
| JB0060 | 0.30  | 86.21   | 3.88   | 2.30  | 0.68  | 0.18  | 0.51  | 0.50 |
| JB1100 | 0.12  | 42.59   | 5.84   | 0.13  | 0.18  | 0.10  | 0.13  | 0.17 |
| JB1110 | 38.94 | 2956.19 | 93.69  | 20.73 | 0.42  | 9.94  | 16.84 | 0.70 |
| JB0220 | 0.32  | 115.38  | 4.04   | 1.0   | 0.20  | 0.33  | 0.20  | 0.52 |
| JB0260 | 0.35  | 85.49   | 4.01   | 0.54  | 1.21  | 0.50  | 0.49  | 0.67 |
| JB1190 | 0.10  | 49.52   | 1.81   | 0.70  | 0.38  | 0.11  | 0.13  | 0.23 |
| JB1120 | 0.12  | 63.50   | 2.84   | 0.94  | 0.16  | 0.48  | 0.12  | 0.15 |
| JB1200 | 0.73  | 43.85   | 4.88   | 1.50  | 1.0   | 1.01  | 0.57  | 0.38 |
| JB1130 | 1.85  | 80.22   | 4.46   | 1.85  | 0.80  | 0.81  | 0.58  | 0.30 |
| JB1140 | 0.38  | 187.94  | 8.20   | 2.13  | 0.61  | 1.19  | 1.04  | 0.20 |
| JB0390 | 2.55  | 802.56  | 28.33  | 8.09  | 0.17  | 1.84  | 0.08  | 0.22 |
| RB1010 | 4.75  | 1145.10 | 44.28  | 8.05  | 2.98  | 2.99  | 2.97  | 0.18 |
| JB0410 | 5.84  | 1764.85 | 61.49  | 18.45 | 4.92  | 4.73  | 0.59  | 0.77 |
| JB0420 | 0.11  | 17.54   | 1.41   | 0.07  | 0.26  | 0.11  | 0.08  | 0.32 |
| RB0010 | 0.79  | 169.57  | 9.34   | 2.22  | 0.58  | 0.22  | 0.31  | 0.27 |
| JB0430 | 2.35  | 636.33  | 26.14  | 9.43  | 2.09  | 3.68  | 0.49  | 0.32 |
| RB1020 | 0.10  | 107.61  | 7.05   | 1.42  | 0.52  | 0.10  | 0.14  | 0.13 |
| RB1030 | 0.07  | 24.10   | 2.01   | 0.55  | 0.10  | 0.04  | 0.08  | 0.05 |
| RB1040 | 3.12  | 745.26  | 29.88  | 5.93  | 2.15  | 2.13  | 2.09  | 0.10 |
| UH0080 | 2.0   | 378.83  | 20.78  | 11.41 | 1.31  | 4.18  | 0.18  | 0.32 |
| UH0100 | 10.80 | 1699.67 | 76.26  | 32.35 | 3.99  | 6.63  | 0.47  | 0.55 |
| UH0110 | 0.84  | 780.72  | 17.43  | 8.91  | 0.87  | 2.69  | 0.23  | 0.72 |
| UH0200 | 13.29 | 5033.22 | 180.96 | 61.82 | 12.08 | 17.07 | 0.76  | 0.50 |
| UH0230 | 3.44  | 1287.09 | 55.66  | 20.54 | 3.65  | 6.25  | 5.24  | 0.40 |
| UH0260 | 2.41  | 370.73  | 21.70  | 10.08 | 1.36  | 2.14  | 0.15  | 0.48 |
| UH1140 | 0.99  | 380.91  | 14.65  | 2.73  | 0.91  | 1.13  | 1.07  | 0.54 |
| UH0290 | 0.43  | 54.20   | 2.62   | 0.38  | 0.21  | 0.25  | 0.21  | 0.39 |
| UH1040 | 0.47  | 739.67  | 10.53  | 2.09  | 0.58  | 1.56  | 1.05  | 0.21 |
| UH1070 | 4.72  | 3941.15 | 164.89 | 36.76 | 9.45  | 8.72  | 8.70  | 0.95 |
| UH1060 | 0.62  | 441.96  | 11.85  | 2.75  | 0.77  | 8.14  | 0.16  | 0.14 |
| 2800   | 87.80 | 3910.0  | 328.0  | 61.0  | 10.60 | 18.0  | 9.81  | 5.0  |
| 2      | 38.0  | 1400.0  | 320.0  | 75.0  | 8.70  | 14.0  | 5.40  | 0.0  |
| 2100   | 140.0 | 1800.0  | 280.0  | 69.0  | 6.60  | 12.0  | 5.20  | 0.70 |
| 1600   | 4.10  | 300.0   | 210.0  | 71.0  | 5.0   | 42.0  | 5.0   | 5.0  |
| 2300   | 3.60  | 36.0    | 14.0   | 5.70  | 5.0   | 5.0   | 5.0   | 5.0  |
| 2200   | 38.0  | 960.0   | 240.0  | 81.0  | 5.0   | 41.0  | 5.0   | 5.90 |
| 2400   | 3.30  | 55.0    | 21.0   | 5.0   | 5.0   | 5.0   | 5.0   | 5.0  |
| 2500   | 96.80 | 3660.0  | 526.0  | 110.0 | 15.90 | 26.90 | 11.30 | 4.60 |
| 85A00  | 180.0 | 13.0    | 1.0    | 180.0 | 44.0  | 71.0  | 42.0  | 17.0 |
| 2900   | 97.20 | 5830.0  | 532.0  | 85.60 | 20.0  | 20.0  | 20.0  | 20.0 |
| 3      | 155.0 | 5350.0  | 502.0  | 91.20 | 16.50 | 25.80 | 14.70 | 5.0  |
| 2600   | 470.0 | 5900.0  | 750.0  | 200.0 | 21.0  | 35.0  | 15.0  | 1.20 |
| 2700   | 134.0 | 3670.0  | 1160.0 | 164.0 | 29.30 | 44.10 | 23.0  | 5.10 |

|       |       |        |       |       |       |       |       |       |
|-------|-------|--------|-------|-------|-------|-------|-------|-------|
| 3300  | 132.0 | 5460.0 | 496.0 | 94.10 | 17.40 | 26.20 | 14.40 | 4.90  |
| 86A00 | 32.0  | 5100.0 | 390.0 | 80.0  | 21.0  | 28.0  | 15.0  | 14.0  |
| 63A00 | 63.0  | 3800.0 | 350.0 | 76.0  | 13.0  | 20.0  | 12.0  | 4.90  |
| 3200  | 57.30 | 4380.0 | 299.0 | 50.50 | 23.80 | 23.80 | 23.80 | 23.80 |
| 3100  | 62.0  | 3100.0 | 510.0 | 95.0  | 18.0  | 21.0  | 10.0  | 1.50  |
| 3400  | 50.70 | 4030.0 | 207.0 | 32.90 | 9.29  | 12.50 | 8.85  | 5.0   |
| 3700  | 96.40 | 5180.0 | 385.0 | 67.10 | 13.30 | 19.20 | 12.0  | 4.60  |
| 65A00 | 60.0  | 3300.0 | 280.0 | 55.0  | 14.0  | 19.0  | 13.0  | 5.50  |
| 3500  | 42.60 | 1140.0 | 179.0 | 32.80 | 5.0   | 7.92  | 5.0   | 5.0   |
| 64A00 | 50.0  | 4.0    | 380.0 | 88.0  | 12.0  | 22.0  | 14.0  | 6.0   |
| 3600  | 55.0  | 3600.0 | 380.0 | 90.0  | 12.0  | 17.0  | 7.50  | 0.70  |
| 3800  | 59.60 | 3020.0 | 206.0 | 39.60 | 8.37  | 12.20 | 7.80  | 5.0   |
| 3900  | 268.0 | 2570.0 | 222.0 | 41.50 | 8.26  | 12.10 | 7.61  | 4.40  |
| 4     | 56.70 | 2960.0 | 252.0 | 41.50 | 8.81  | 13.0  | 8.20  | 5.0   |
| 68A00 | 45.0  | 3300.0 | 270.0 | 49.0  | 9.30  | 16.0  | 10.0  | 3.70  |
| 4100  | 10.60 | 784.0  | 46.70 | 8.40  | 5.0   | 5.0   | 5.0   | 5.0   |
| 69A00 | 25.0  | 2100.0 | 180.0 | 28.0  | 5.70  | 23.0  | 8.50  | 0.0   |
| 71A00 | 0.0   | 130.0  | 10.0  | 2.30  | 0.0   | 0.0   | 0.0   | 0.0   |
| 70A00 | 88.0  | 720.0  | 67.0  | 11.0  | 2.70  | 12.0  | 2.10  | 1.40  |
| 4400  | 91.80 | 5970.0 | 328.0 | 55.80 | 15.80 | 20.20 | 14.50 | 5.0   |
| 72A00 | 49.0  | 4500.0 | 250.0 | 50.0  | 13.0  | 23.0  | 13.0  | 4.70  |
| 89A00 | 1.80  | 800.0  | 17.0  | 3.20  | 0.0   | 1.90  | 1.90  | 0.0   |
| 5100  | 47.60 | 3300.0 | 160.0 | 27.0  | 7.90  | 10.30 | 7.99  | 4.40  |
| 1700  | 29.0  | 1100.0 | 190.0 | 45.0  | 4.80  | 7.60  | 2.70  | 0.0   |
| 42A00 | 19.0  | 824.0  | 53.0  | 13.0  | 0.0   | 3.70  | 0.0   | 0.0   |
| 5700  | 3.60  | 510.0  | 23.0  | 4.30  | 1.0   | 1.20  | 1.10  | 0.0   |
| 4900  | 48.40 | 4570.0 | 203.0 | 36.90 | 19.10 | 17.30 | 14.80 | 8.03  |
| 87A00 | 1.80  | 2300.0 | 650.0 | 110.0 | 18.0  | 39.0  | 9.90  | 9.40  |
| 5400  | 59.60 | 4850.0 | 294.0 | 47.90 | 12.90 | 17.30 | 12.10 | 5.0   |
| 47A00 | 28.0  | 2540.0 | 259.0 | 36.0  | 12.0  | 18.0  | 9.90  | 0.0   |
| 48A00 | 0.0   | 2400.0 | 12.0  | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 5600  | 30.0  | 4800.0 | 190.0 | 32.0  | 6.70  | 8.90  | 6.40  | 0.0   |
| 5500  | 65.0  | 3300.0 | 350.0 | 70.60 | 11.40 | 19.0  | 9.14  | 5.0   |
| 49A00 | 4.40  | 1610.0 | 39.0  | 6.80  | 0.0   | 3.20  | 0.0   | 0.0   |
| 88A00 | 5.50  | 710.0  | 34.0  | 5.70  | 0.0   | 2.40  | 1.90  | 0.0   |
| 44A00 | 25.0  | 2290.0 | 106.0 | 20.0  | 0.0   | 7.0   | 7.0   | 0.0   |
| 4800  | 55.80 | 7950.0 | 341.0 | 59.30 | 24.70 | 25.90 | 20.80 | 5.0   |
| 84B00 | 4.30  | 4800.0 | 67.0  | 11.0  | 4.0   | 4.20  | 3.40  | 1.60  |
| 4600  | 13.70 | 1700.0 | 78.30 | 12.80 | 9.84  | 5.0   | 5.0   | 5.0   |
| 51A00 | 7.30  | 662.0  | 51.0  | 13.0  | 9.60  | 6.10  | 6.0   | 0.0   |
| 56A00 | 19.0  | 3910.0 | 158.0 | 44.0  | 13.0  | 13.0  | 11.0  | 5.30  |
| 55A00 | 52.0  | 4890.0 | 397.0 | 93.0  | 45.0  | 41.0  | 34.0  | 23.0  |
| 59A00 | 36.0  | 7060.0 | 365.0 | 102.0 | 39.0  | 43.0  | 32.0  | 24.0  |
| 01A00 | 27.0  | 7340.0 | 135.0 | 14.0  | 11.0  | 8.90  | 4.40  | 0.0   |
| 02A00 | 2.40  | 1860.0 | 37.0  | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 03A00 | 4.0   | 2300.0 | 99.0  | 6.70  | 6.0   | 7.60  | 2.80  | 0.0   |
| 73B00 | 0.0   | 170.0  | 8.80  | 1.60  | 0.0   | 0.0   | 0.0   | 0.0   |
| 05A00 | 77.0  | 5730.0 | 250.0 | 42.0  | 12.0  | 17.0  | 0.0   | 0.0   |
| 05A00 | 77.0  | 5730.0 | 250.0 | 42.0  | 12.0  | 17.0  | 0.0   | 0.0   |
| 74A00 | 86.0  | 4800.0 | 310.0 | 65.0  | 12.0  | 17.0  | 7.70  | 4.90  |
| 74A00 | 86.0  | 4800.0 | 310.0 | 65.0  | 12.0  | 17.0  | 7.70  | 4.90  |
| 06A00 | 12.0  | 351.0  | 26.0  | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 28A00 | 55.0  | 2920.0 | 365.0 | 96.0  | 12.0  | 22.0  | 9.40  | 4.40  |
| 1200  | 7.40  | 1200.0 | 95.0  | 16.0  | 2.40  | 3.10  | 1.30  | 0.0   |

|        |        |        |        |       |       |       |       |       |
|--------|--------|--------|--------|-------|-------|-------|-------|-------|
| 1300   | 3.80   | 460.0  | 30.0   | 8.80  | 5.0   | 5.30  | 5.0   | 5.0   |
| 1400   | 62.0   | 5.0    | 950.0  | 230.0 | 24.0  | 36.0  | 9.0   | 0.80  |
| 08A00  | 16.0   | 2700.0 | 71.0   | 14.0  | 4.30  | 5.80  | 5.0   | 3.0   |
| 0100   | 99.0   | 1900.0 | 82.0   | 19.0  | 5.30  | 5.50  | 2.80  | 0.0   |
| 1500   | 2.90   | 61.0   | 30.0   | 11.0  | 5.0   | 6.20  | 5.0   | 5.0   |
| 09A00  | 111.0  | 2750.0 | 209.0  | 36.40 | 9.68  | 13.70 | 7.54  | 3.71  |
| SR600  | 590.0  | 11.0   | 1400.0 | 290.0 | 37.0  | 69.0  | 22.0  | 10.0  |
| SR500  | 580.0  | 9100.0 | 1200.0 | 230.0 | 35.0  | 60.0  | 21.0  | 10.0  |
| SR100  | 580.0  | 8800.0 | 12.0   | 190.0 | 32.0  | 51.0  | 16.0  | 7.30  |
| SR200  | 480.0  | 8700.0 | 910.0  | 170.0 | 27.0  | 46.0  | 15.0  | 7.0   |
| SR700  | 600.0  | 9900.0 | 1100.0 | 210.0 | 34.0  | 55.0  | 18.0  | 9.0   |
| SR300  | 390.0  | 7600.0 | 940.0  | 180.0 | 27.0  | 47.0  | 15.0  | 7.0   |
| SR800  | 600.0  | 9500.0 | 1200.0 | 230.0 | 29.0  | 57.0  | 18.0  | 9.30  |
| SR400  | 970.0  | 7800.0 | 960.0  | 180.0 | 27.0  | 46.0  | 16.0  | 6.90  |
| SR900  | 680.0  | 7800.0 | 970.0  | 180.0 | 28.0  | 46.0  | 15.0  | 7.60  |
| SR1    | 400.0  | 8500.0 | 1100.0 | 200.0 | 30.0  | 52.0  | 17.0  | 8.40  |
| 0200   | 32.0   | 550.0  | 45.0   | 13.0  | 5.0   | 8.60  | 5.0   | 5.0   |
| 75A00  | 370.0  | 9300.0 | 1.0    | 270.0 | 15.0  | 44.0  | 19.0  | 11.0  |
| 10A00  | 630.0  | 5300.0 | 460.0  | 110.0 | 37.0  | 54.0  | 15.0  | 13.0  |
| HP600  | 300.0  | 9600.0 | 870.0  | 160.0 | 21.0  | 40.0  | 13.0  | 6.30  |
| HP500  | 550.0  | 9.0    | 1400.0 | 270.0 | 38.0  | 64.0  | 17.0  | 11.0  |
| HP100  | 680.0  | 10.0   | 1400.0 | 290.0 | 39.0  | 71.0  | 21.0  | 10.0  |
| HP200  | 640.0  | 9600.0 | 1300.0 | 290.0 | 35.0  | 60.0  | 22.0  | 11.0  |
| HP700  | 590.0  | 11.0   | 1300.0 | 270.0 | 34.0  | 68.0  | 23.0  | 10.0  |
| HP300  | 1600.0 | 8400.0 | 1700.0 | 280.0 | 35.0  | 57.0  | 17.0  | 9.50  |
| HP400  | 110.0  | 2300.0 | 240.0  | 49.0  | 7.0   | 12.0  | 4.60  | 2.30  |
| HP800  | 430.0  | 6200.0 | 800.0  | 160.0 | 18.0  | 37.0  | 13.0  | 5.90  |
| HP900  | 320.0  | 4700.0 | 580.0  | 130.0 | 16.0  | 30.0  | 11.0  | 5.50  |
| HP1    | 150.0  | 4200.0 | 310.0  | 64.0  | 9.0   | 16.0  | 6.40  | 3.20  |
| 76A00  | 21.0   | 340.0  | 34.0   | 8.60  | 1.10  | 2.60  | 1.50  | 1.0   |
| 276A00 | 337.0  | 7370.0 | 777.0  | 185.0 | 28.90 | 45.50 | 13.60 | 8.37  |
| 277B00 | 255.0  | 5970.0 | 770.0  | 148.0 | 19.80 | 36.60 | 13.10 | 6.80  |
| 278B00 | 1580.0 | 4470.0 | 430.0  | 91.0  | 15.10 | 23.60 | 9.27  | 6.34  |
| 273A00 | 6660.0 | 13.0   | 1690.0 | 337.0 | 45.10 | 69.0  | 21.0  | 15.80 |
| 274A00 | 434.0  | 9520.0 | 801.0  | 142.0 | 26.40 | 39.70 | 15.30 | 10.20 |
| 275A00 | 297.0  | 7370.0 | 870.0  | 168.0 | 27.10 | 40.80 | 14.80 | 9.25  |
| IS100  | 1.30   | 1300.0 | 100.0  | 11.0  | 3.40  | 4.40  | 1.30  | 0.90  |
| IS200  | 1.20   | 570.0  | 59.0   | 9.90  | 2.20  | 3.30  | 1.20  | 0.86  |
| IS300  | 3.80   | 2100.0 | 170.0  | 25.0  | 5.50  | 9.20  | 3.20  | 1.50  |
| IS700  | 1.10   | 1200.0 | 92.0   | 15.0  | 2.90  | 4.70  | 1.80  | 1.0   |
| IS400  | 1.40   | 1700.0 | 120.0  | 19.0  | 4.30  | 6.0   | 2.0   | 1.40  |
| IS500  | 2.0    | 1700.0 | 220.0  | 31.0  | 8.70  | 9.60  | 3.10  | 1.80  |
| IS600  | 1.50   | 1400.0 | 140.0  | 23.0  | 4.60  | 7.10  | 2.30  | 1.40  |
| IS800  | 8.10   | 3900.0 | 320.0  | 46.0  | 10.0  | 15.0  | 5.0   | 3.30  |
| IS900  | 8.50   | 5600.0 | 280.0  | 41.0  | 8.20  | 13.0  | 4.80  | 2.80  |
| IS1    | 4.40   | 3500.0 | 350.0  | 55.0  | 10.0  | 17.0  | 5.20  | 2.90  |
| 296B00 | 336.0  | 5830.0 | 3150.0 | 855.0 | 62.0  | 122.0 | 21.80 | 14.30 |
| 270A00 | 382.0  | 4360.0 | 359.0  | 89.40 | 15.20 | 25.20 | 8.91  | 5.61  |
| 271A00 | 80.30  | 1030.0 | 60.10  | 13.10 | 0.0   | 1.59  | 2.97  | 0.0   |
| 272A00 | 152.0  | 3240.0 | 336.0  | 62.80 | 12.80 | 19.40 | 6.42  | 0.0   |
| 0300   | 270.0  | 4800.0 | 480.0  | 120.0 | 19.0  | 29.0  | 8.70  | 0.0   |
| 269C00 | 392.0  | 5470.0 | 408.0  | 57.80 | 14.90 | 17.60 | 7.64  | 5.13  |
| 267A00 | 595.0  | 2310.0 | 195.0  | 53.0  | 12.90 | 18.20 | 8.29  | 7.86  |
| 268B00 | 734.0  | 6120.0 | 406.0  | 72.0  | 15.70 | 22.20 | 7.63  | 6.36  |

|        |         |         |        |        |        |        |       |       |
|--------|---------|---------|--------|--------|--------|--------|-------|-------|
| 264A00 | 65.20   | 1740.0  | 87.70  | 26.30  | 5.63   | 7.29   | 3.94  | 3.01  |
| 266A00 | 208.0   | 5020.0  | 334.0  | 59.80  | 12.10  | 20.20  | 4.18  | 4.87  |
| 33A00  | 0.0     | 1400.0  | 94.0   | 23.0   | 3.30   | 6.40   | 2.50  | 1.40  |
| 263B00 | 404.0   | 5240.0  | 526.0  | 113.0  | 20.70  | 30.90  | 11.80 | 6.72  |
| 262A00 | 56.30   | 689.0   | 37.50  | 9.70   | 2.09   | 3.55   | 1.82  | 0.91  |
| 261C00 | 25.0    | 250.0   | 21.70  | 4.60   | 2.07   | 1.75   | 0.0   | 0.0   |
| 260B00 | 239.0   | 5290.0  | 588.0  | 105.0  | 15.90  | 28.10  | 10.30 | 5.87  |
| 259B00 | 5560.0  | 10700.0 | 780.0  | 172.0  | 30.40  | 46.80  | 16.20 | 9.88  |
| 258C00 | 269.0   | 6300.0  | 925.0  | 188.0  | 23.60  | 44.90  | 14.0  | 7.28  |
| 224A00 | 13500.0 | 12300.0 | 1060.0 | 211.0  | 37.0   | 59.30  | 24.10 | 13.50 |
| 221A00 | 202.0   | 2420.0  | 519.0  | 128.0  | 14.30  | 32.20  | 11.40 | 6.04  |
| 227A00 | 1280.0  | 12300.0 | 1160.0 | 215.0  | 51.20  | 52.20  | 28.80 | 15.20 |
| 223A00 | 376.0   | 6020.0  | 1010.0 | 214.0  | 24.40  | 53.0   | 16.0  | 7.75  |
| 220A00 | 240.0   | 6620.0  | 787.0  | 150.0  | 25.0   | 40.0   | 12.10 | 7.35  |
| 95A00  | 200.0   | 1900.0  | 960.0  | 250.0  | 21.0   | 69.0   | 15.0  | 5.40  |
| 8A00   | 440.0   | 8700.0  | 1500.0 | 350.0  | 36.0   | 68.0   | 16.0  | 1.40  |
| 222A00 | 266.0   | 7230.0  | 2220.0 | 381.0  | 41.0   | 83.60  | 21.20 | 11.50 |
| 294A00 | 1790.0  | 6660.0  | 3050.0 | 861.0  | 118.0  | 145.0  | 50.50 | 31.0  |
| 230A00 | 360.0   | 4770.0  | 1070.0 | 212.0  | 24.60  | 52.60  | 14.30 | 8.82  |
| 219A00 | 312.0   | 3550.0  | 655.0  | 132.0  | 17.30  | 32.0   | 10.60 | 6.42  |
| 8B00   | 300.0   | 7700.0  | 800.0  | 170.0  | 24.0   | 38.0   | 11.0  | 1.20  |
| 7A00   | 390.0   | 6400.0  | 830.0  | 170.0  | 21.0   | 40.0   | 12.0  | 1.50  |
| 225A00 | 292.0   | 6220.0  | 1140.0 | 287.0  | 32.60  | 63.0   | 18.70 | 11.10 |
| 229A00 | 283.0   | 7500.0  | 991.0  | 207.0  | 26.0   | 53.30  | 16.80 | 9.69  |
| 7B00   | 360.0   | 6700.0  | 910.0  | 210.0  | 26.0   | 45.0   | 13.0  | 1.10  |
| 228B00 | 233.0   | 5600.0  | 858.0  | 172.0  | 26.60  | 44.70  | 14.0  | 7.56  |
| 218A00 | 244.0   | 6400.0  | 5600.0 | 1300.0 | 100.0  | 267.0  | 61.70 | 27.30 |
| 284B00 | 329.0   | 7630.0  | 1980.0 | 404.0  | 40.0   | 96.50  | 28.40 | 15.0  |
| 257C00 | 431.0   | 8040.0  | 1050.0 | 198.0  | 30.50  | 52.10  | 18.10 | 9.83  |
| 256B00 | 377.0   | 9730.0  | 757.0  | 122.0  | 22.20  | 37.0   | 35.0  | 6.95  |
| 21A00  | 259.0   | 4260.0  | 1080.0 | 262.0  | 44.40  | 351.0  | 31.10 | 5.72  |
| 93A00  | 310.0   | 15.0    | 2100.0 | 540.0  | 62.0   | 150.0  | 30.0  | 18.0  |
| 22A00  | 219.0   | 4020.0  | 944.0  | 260.0  | 23.0   | 56.0   | 21.0  | 8.0   |
| 255A00 | 318.0   | 5950.0  | 862.0  | 177.0  | 20.0   | 43.20  | 13.0  | 6.75  |
| 94A00  | 270.0   | 7400.0  | 1600.0 | 440.0  | 45.0   | 100.0  | 28.0  | 15.0  |
| 217A00 | 311.0   | 14600.0 | 1270.0 | 290.0  | 39.70  | 62.90  | 18.10 | 11.90 |
| 233C00 | 24.50   | 724.0   | 159.0  | 27.10  | 2.68   | 10.60  | 3.24  | 2.44  |
| 19A00  | 396.0   | 8790.0  | 918.0  | 231.0  | 31.0   | 53.0   | 19.0  | 0.0   |
| 61A00  | 590.0   | 6800.0  | 2740.0 | 1300.0 | 84.0   | 210.0  | 42.0  | 18.0  |
| 18A00  | 749.0   | 16900.0 | 1060.0 | 230.0  | 42.0   | 60.0   | 33.0  | 15.0  |
| 7C00   | 620.0   | 8100.0  | 1600.0 | 370.0  | 41.0   | 74.0   | 19.0  | 1.20  |
| 286B00 | 722.0   | 8120.0  | 2410.0 | 507.0  | 57.70  | 117.0  | 29.60 | 15.70 |
| 232A00 | 260.0   | 9060.0  | 803.0  | 155.0  | 22.40  | 41.40  | 12.80 | 8.13  |
| 285A00 | 5220.0  | 8340.0  | 21300  | 6800.0 | 666.0  | 1200.0 | 139.0 | 123.0 |
| 77A00  | 270.0   | 81.0    | 64.0   | 20.0   | 1400.0 | 2900.0 | 580.0 | 300.0 |
| 17A00  | 422.0   | 7900.0  | 1610.0 | 706.0  | 68.0   | 92.0   | 49.0  | 0.0   |
| 231A00 | 322.0   | 4690.0  | 809.0  | 181.0  | 22.60  | 47.0   | 16.20 | 8.12  |
| 283A00 | 285.0   | 5730.0  | 1350.0 | 295.0  | 34.50  | 67.0   | 20.0  | 9.83  |
| 60A00  | 360.0   | 6500.0  | 1700.0 | 30.0   | 68.0   | 112.0  | 32.0  | 13.0  |
| 293A00 | 38.70   | 1570.0  | 116.0  | 26.10  | 9.45   | 8.77   | 5.25  | 4.36  |
| 216A00 | 331.0   | 6120.0  | 1370.0 | 275.0  | 30.60  | 67.50  | 49.10 | 9.66  |
| 16A00  | 135.0   | 2390.0  | 441.0  | 120.0  | 12.0   | 22.0   | 7.60  | 0.0   |
| 282A00 | 413.0   | 7480.0  | 1320.0 | 294.0  | 30.60  | 65.10  | 21.40 | 10.80 |
| 0600   | 44.0    | 1100.0  | 130.0  | 37.0   | 5.0    | 28.0   | 5.0   | 5.80  |



|        |        |         |        |       |       |       |       |       |
|--------|--------|---------|--------|-------|-------|-------|-------|-------|
| WA100  | 120.0  | 4400.0  | 990.0  | 200.0 | 20.0  | 55.0  | 16.0  | 6.40  |
| WA200  | 1100.0 | 5200.0  | 740.0  | 160.0 | 22.0  | 40.0  | 14.0  | 6.90  |
| WA400  | 170.0  | 5400.0  | 560.0  | 96.0  | 19.0  | 32.0  | 13.0  | 6.20  |
| WA300  | 210.0  | 4500.0  | 410.0  | 74.0  | 13.0  | 24.0  | 11.0  | 4.80  |
| WA500  | 12.0   | 400.0   | 60.0   | 12.0  | 1.60  | 4.20  | 1.60  | 0.54  |
| WA600  | 200.0  | 3200.0  | 490.0  | 97.0  | 12.0  | 27.0  | 9.50  | 4.0   |
| WA800  | 350.0  | 5500.0  | 860.0  | 170.0 | 23.0  | 49.0  | 18.0  | 7.60  |
| WA700  | 72.0   | 2100.0  | 230.0  | 50.0  | 6.50  | 14.0  | 5.30  | 2.40  |
| WA900  | 120.0  | 1600.0  | 280.0  | 52.0  | 7.20  | 13.0  | 4.80  | 2.50  |
| 236A00 | 980.0  | 10500.0 | 843.0  | 164.0 | 29.90 | 46.30 | 19.60 | 12.0  |
| 295B00 | 145.0  | 4720.0  | 1900.0 | 465.0 | 41.0  | 95.70 | 24.40 | 12.0  |
| 15A00  | 85.0   | 3590.0  | 202.0  | 36.0  | 10.0  | 14.0  | 7.20  | 5.10  |
| 235A00 | 616.0  | 8850.0  | 958.0  | 195.0 | 34.40 | 50.90 | 16.80 | 10.30 |
| WA1    | 350.0  | 6500.0  | 1200.0 | 250.0 | 29.0  | 62.0  | 18.0  | 8.30  |
| 23A00  | 778.0  | 16200.0 | 1020.0 | 282.0 | 33.0  | 59.0  | 22.0  | 11.0  |
| 234B00 | 327.0  | 4690.0  | 677.0  | 153.0 | 19.10 | 38.10 | 12.10 | 7.26  |
| 287B00 | 37.40  | 1010.0  | 106.0  | 29.60 | 4.26  | 5.62  | 4.33  | 1.42  |
| 0900   | 82.0   | 690.0   | 81.0   | 24.0  | 5.0   | 14.0  | 5.0   | 5.0   |
| 34A00  | 120.0  | 3100.0  | 1200.0 | 280.0 | 29.0  | 83.0  | 27.0  | 13.0  |
| 254A00 | 216.0  | 4620.0  | 450.0  | 83.80 | 12.30 | 22.30 | 7.75  | 4.31  |
| 253A00 | 258.0  | 6050.0  | 817.0  | 212.0 | 23.40 | 49.20 | 15.40 | 8.34  |
| 215B00 | 188.0  | 5720.0  | 1900.0 | 474.0 | 40.60 | 115.0 | 28.40 | 12.80 |
| 252C00 | 187.0  | 5340.0  | 793.0  | 161.0 | 19.50 | 35.20 | 10.20 | 6.43  |
| 214A00 | 149.0  | 4960.0  | 1450.0 | 291.0 | 33.0  | 56.20 | 14.50 | 9.81  |
| 213A00 | 1020.0 | 14.0    | 1360.0 | 304.0 | 37.90 | 73.30 | 26.90 | 15.20 |
| 288B00 | 11.50  | 524.0   | 31.20  | 9.46  | 3.49  | 3.57  | 4.13  | 2.0   |
| 12A00  | 534.0  | 6090.0  | 1230.0 | 264.0 | 44.0  | 58.0  | 19.0  | 15.0  |
| 91A00  | 130.0  | 3.0     | 600.0  | 160.0 | 0.0   | 72.0  | 39.0  | 0.0   |
| 0500   | 450.0  | 7100.0  | 940.0  | 220.0 | 26.0  | 47.0  | 14.0  | 0.90  |
| 239A00 | 289.0  | 6980.0  | 835.0  | 167.0 | 27.0  | 45.90 | 16.10 | 7.57  |
| 238A00 | 386.0  | 8840.0  | 1500.0 | 330.0 | 27.30 | 85.60 | 19.90 | 9.36  |
| 251B00 | 285.0  | 5790.0  | 530.0  | 122.0 | 17.70 | 35.10 | 9.69  | 6.64  |
| 250A00 | 3.53   | 46.70   | 4.0    | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| 289A00 | 469.0  | 14400.0 | 1190.0 | 286.0 | 43.90 | 56.60 | 25.60 | 13.80 |
| 0400   | 24.0   | 260.0   | 51.0   | 15.0  | 5.0   | 9.30  | 5.0   | 5.0   |
| 290B00 | 769.0  | 16200.0 | 1160.0 | 172.0 | 34.0  | 48.40 | 20.90 | 13.50 |
| 210A00 | 85.60  | 3130.0  | 487.0  | 134.0 | 11.70 | 30.60 | 17.50 | 6.29  |
| 14A00  | 764.0  | 6720.0  | 583.0  | 134.0 | 22.0  | 30.0  | 18.0  | 7.60  |
| 242A00 | 256.0  | 5370.0  | 1570.0 | 305.0 | 27.70 | 64.80 | 13.70 | 11.70 |
| 211B00 | 519.0  | 11600.0 | 664.0  | 126.0 | 27.10 | 38.60 | 16.20 | 8.91  |
| 291A00 | 199.0  | 10600.0 | 1740.0 | 139.0 | 38.20 | 94.0  | 20.30 | 30.20 |
| 212A00 | 260.0  | 6460.0  | 1690.0 | 371.0 | 40.40 | 86.90 | 25.80 | 12.40 |
| 292C00 | 291.0  | 8570.0  | 1240.0 | 223.0 | 36.40 | 59.10 | 17.50 | 10.40 |
| 245B00 | 314.0  | 5940.0  | 903.0  | 196.0 | 28.0  | 51.30 | 18.0  | 10.70 |
| 241A00 | 242.0  | 4030.0  | 625.0  | 138.0 | 18.40 | 36.30 | 12.10 | 3.77  |
| 248A00 | 230.0  | 8930.0  | 788.0  | 131.0 | 25.20 | 42.0  | 14.60 | 7.85  |
| 244A00 | 354.0  | 6040.0  | 767.0  | 158.0 | 22.50 | 47.0  | 15.10 | 7.33  |
| 92A00  | 280.0  | 6700.0  | 990.0  | 260.0 | 22.0  | 53.0  | 18.0  | 8.70  |
| 240A00 | 9730.0 | 25200.0 | 1700.0 | 351.0 | 64.40 | 85.40 | 37.50 | 22.10 |
| 247A00 | 37.30  | 321.0   | 43.10  | 10.10 | 1.63  | 3.19  | 1.20  | 0.0   |
| 13A00  | 425.0  | 24400.0 | 550.0  | 100.0 | 0.0   | 23.0  | 11.0  | 6.70  |
| 243A00 | 599.0  | 11300.0 | 1430.0 | 272.0 | 43.20 | 70.30 | 21.80 | 11.90 |
| 246A00 | 11.20  | 893.0   | 114.0  | 18.90 | 5.09  | 12.20 | 8.16  | 3.74  |
| 97B00  | 180.0  | 4800.0  | 1800.0 | 450.0 | 33.0  | 92.0  | 28.0  | 14.0  |

|        |        |        |        |       |       |       |       |       |
|--------|--------|--------|--------|-------|-------|-------|-------|-------|
| 207A00 | 275.0  | 6650.0 | 951.0  | 209.0 | 24.80 | 51.60 | 24.40 | 9.32  |
| 208A00 | 204.0  | 6600.0 | 934.0  | 185.0 | 24.10 | 50.20 | 14.80 | 7.06  |
| 209B00 | 208.0  | 5030.0 | 1420.0 | 341.0 | 36.10 | 76.60 | 23.40 | 11.30 |
| 204A00 | 169.0  | 5530.0 | 916.0  | 195.0 | 26.50 | 48.80 | 16.50 | 8.41  |
| 205A00 | 195.0  | 6740.0 | 830.0  | 169.0 | 25.10 | 44.30 | 13.0  | 9.11  |
| 206A00 | 235.0  | 6380.0 | 1270.0 | 309.0 | 38.60 | 76.60 | 27.10 | 12.60 |
| 100A00 | 130.0  | 5600.0 | 810.0  | 220.0 | 24.0  | 50.0  | 28.0  | 9.30  |
| 1800   | 2.40   | 72.0   | 47.0   | 11.0  | 5.0   | 5.90  | 5.0   | 5.0   |
| 62A00  | 380.0  | 4300.0 | 1200.0 | 650.0 | 41.0  | 76.0  | 25.0  | 15.0  |
| 1      | 430.0  | 5900.0 | 1600.0 | 360.0 | 35.0  | 71.0  | 22.0  | 1.40  |
| 96A00  | 1909.0 | 6900.0 | 1400.0 | 370.0 | 29.0  | 110.0 | 45.0  | 30.0  |
| 201A00 | 169.0  | 6960.0 | 927.0  | 201.0 | 23.40 | 46.0  | 16.70 | 7.69  |
| 202F00 | 220.0  | 6520.0 | 730.0  | 150.0 | 21.80 | 42.50 | 14.10 | 7.34  |
| 202B00 | 248.0  | 7880.0 | 829.0  | 166.0 | 23.40 | 41.40 | 14.30 | 7.52  |
| 203A00 | 228.0  | 4930.0 | 1240.0 | 340.0 | 31.60 | 71.70 | 21.40 | 11.50 |
| 1100   | 280.0  | 7400.0 | 1600.0 | 380.0 | 37.0  | 72.0  | 18.0  | 1.50  |
| 35A00  | 188.0  | 4740.0 | 1530.0 | 441.0 | 38.0  | 88.0  | 32.0  | 15.0  |
| 35A00  | 188.0  | 4740.0 | 1530.0 | 441.0 | 38.0  | 88.0  | 32.0  | 15.0  |
| 99A00  | 94.0   | 2700.0 | 670.0  | 160.0 | 19.0  | 44.0  | 13.0  | 4.50  |
| 98A00  | 19.0   | 730.0  | 490.0  | 110.0 | 11.0  | 26.0  | 8.50  | 2.30  |
| 83A00  | 12.0   | 2.0    | 150.0  | 31.0  | 5.50  | 11.0  | 8.0   | 3.20  |
| 1900   | 2.90   | 37.0   | 120.0  | 47.0  | 5.0   | 15.0  | 5.0   | 5.0   |
| 82A00  | 79.0   | 2.0    | 500.0  | 130.0 | 13.0  | 29.0  | 12.0  | 4.80  |
| 26A00  | 110.0  | 1760.0 | 701.0  | 162.0 | 18.40 | 28.0  | 29.30 | 0.0   |
| 81A00  | 120.0  | 2400.0 | 280.0  | 69.0  | 10.0  | 16.0  | 8.40  | 3.50  |

| Station sample | Pcdf 234678 | Pcdf 2378 | Pcdf8    | Summed Dioxin furans | Toxic Equivalence Factor | Cluster |
|----------------|-------------|-----------|----------|----------------------|--------------------------|---------|
| 12A02          | 0.00        | 0.00      | 3.90     | 11.6                 | 107.6                    | 1       |
| 13A02          | 0.00        | 7.40      | 13.00    | 70.2                 | 714.8                    | 1       |
| 13A03          | 0.00        | 0.00      | 3.00     | 61.0                 | 3043.2                   | 9       |
| 13A04          | 0.00        | 0.00      | 2.00     | 26.0                 | 781.2                    | 9       |
| 13A05          | 0.00        | 0.00      | 2.50     | 2.5                  | 55.0                     | 5       |
| 14A02          | 0.00        | 8.80      | 11.00    | 56.0                 | 1545.6                   | 1       |
| 14A03          | 0.00        | 0.00      | 0.67     | 21.1                 | 369.4                    | 9       |
| 14A04          | 0.00        | 0.00      | 0.73     | 7.5                  | 190.1                    | 9       |
| 14A05          | 0.00        | 0.00      | 0.85     | 6.8                  | 260.1                    | 9       |
| 14A06          | 0.00        | 0.00      | 0.38     | 8.0                  | 267.1                    | 9       |
| 14A07          | 0.00        | 0.00      | 0.52     | 9.4                  | 470.1                    | 9       |
| 15A02          | 0.00        | 0.00      | 2.00     | 36.0                 | 667.3                    | 9       |
| 15A03          | 0.00        | 0.00      | 4.90     | 35.9                 | 666.3                    | 9       |
| 15A04          | 0.00        | 0.00      | 7.00     | 38.0                 | 608.3                    | 9       |
| 16A02          | 97.00       | 126.00    | 1140.00  | 3746.6               | 9368.0                   | 1       |
| 16A03          | 144.00      | 60.80     | 4500.00  | 10033.1              | 16995.6                  | 4       |
| 16A04          | 1050.00     | 642.00    | 35200.00 | 69223.0              | 25248.6                  | 4       |
| 16A05          | 23.20       | 15.00     | 234.00   | 886.2                | 2879.3                   | 7       |
| 16A06          | 0.00        | 0.48      | 8.70     | 12.5                 | 14.1                     | 5       |
| 16A07          | 0.00        | 0.00      | 4.80     | 6.8                  | 7.6                      | 5       |
| 17A02          | 63.00       | 60.00     | 3570.00  | 9236.4               | 26639.6                  | 1       |
| 17A03          | 95.00       | 90.00     | 6860.00  | 14249.0              | 16544.7                  | 4       |
| 17A04          | 227.00      | 1130.00   | 12600.00 | 93204.0              | 52103.1                  | 8       |
| 17A05          | 78.00       | 55.00     | 2240.00  | 15165.9              | 14521.3                  | 8       |
| 17A06          | 0.00        | 3.70      | 24.00    | 102.4                | 243.4                    | 7       |

|       |        |        |         |         |         |   |
|-------|--------|--------|---------|---------|---------|---|
| 17A07 | 0.00   | 1.20   | 28.00   | 94.1    | 43.2    | 8 |
| 18A02 | 117.00 | 64.00  | 2400.00 | 10017.0 | 22859.5 | 1 |
| 18A03 | 92.00  | 143.00 | 4370.00 | 17265.0 | 36132.1 | 7 |
| 18A04 | 20.00  | 17.00  | 307.00  | 1534.6  | 3880.5  | 3 |
| 18A05 | 7.60   | 9.20   | 254.00  | 693.7   | 1591.2  | 4 |
| 18A06 | 13.00  | 42.00  | 87.00   | 459.8   | 3333.3  | 1 |
| 18A07 | 0.00   | 0.00   | 17.00   | 48.3    | 301.1   | 4 |
| 19A02 | 151.00 | 97.20  | 3040.00 | 8133.5  | 13739.5 | 7 |
| 19A03 | 232.00 | 144.00 | 8060.00 | 25353.8 | 21731.0 | 7 |
| 19A04 | 5.83   | 12.80  | 104.00  | 237.0   | 1039.2  | 4 |
| 19A05 | 16.00  | 37.00  | 68.00   | 388.6   | 1772.2  | 1 |
| 19A07 | 0.00   | 0.00   | 27.00   | 32.7    | 16.0    | 5 |
| 01A02 | 3.50   | 5.50   | 39.00   | 149.4   | 735.2   | 4 |
| 01A03 | 0.00   | 5.80   | 38.00   | 94.3    | 800.5   | 4 |
| 20A02 | 0.00   | 0.00   | 28.70   | 28.7    | 593.7   | 5 |
| 20A03 | 0.00   | 0.00   | 20.60   | 20.6    | 122.0   | 5 |
| 20A05 | 192.00 | 62.60  | 3720.00 | 15025.4 | 17039.7 | 1 |
| 20A06 | 0.00   | 9.30   | 918.00  | 1338.7  | 2326.7  | 5 |
| 20A07 | 0.00   | 0.00   | 6.00    | 18.9    | 39.0    | 7 |
| 21A02 | 40.00  | 44.00  | 1480.00 | 4338.2  | 7337.5  | 4 |
| 21A03 | 47.00  | 76.00  | 1900.00 | 6580.0  | 12706.4 | 7 |
| 21A04 | 229.00 | 55.10  | 3720.00 | 24590.0 | 8215.3  | 8 |
| 21A05 | 16.70  | 55.70  | 107.00  | 594.1   | 2663.4  | 1 |
| 21A06 | 0.00   | 0.00   | 18.00   | 35.6    | 28.0    | 7 |
| 21A07 | 0.00   | 0.00   | 8.20    | 16.3    | 12.0    | 4 |
| 22A02 | 108.00 | 40.00  | 4260.00 | 9544.0  | 9997.8  | 4 |
| 22A03 | 96.00  | 53.00  | 4010.00 | 10496.0 | 12117.6 | 7 |
| 22A04 | 7.74   | 13.40  | 99.10   | 309.8   | 1633.1  | 4 |
| 22A05 | 0.00   | 3.10   | 25.00   | 89.3    | 760.2   | 1 |
| 23A02 | 75.00  | 53.00  | 1500.00 | 4998.9  | 8767.2  | 4 |
| 23A03 | 205.00 | 124.00 | 3200.00 | 7841.0  | 16076.6 | 4 |
| 26A02 | 0.00   | 0.00   | 1.10    | 16.1    | 453.2   | 9 |
| 26A03 | 19.00  | 25.00  | 739.00  | 1851.8  | 1184.4  | 4 |
| 28A02 | 0.00   | 0.00   | 16.00   | 43.5    | 186.2   | 4 |
| 28A03 | 0.00   | 0.00   | 8.50    | 26.6    | 126.1   | 1 |
| 02A02 | 13.00  | 257.00 | 366.00  | 1947.0  | 9980.2  | 1 |
| 02A03 | 26.00  | 38.00  | 198.00  | 930.4   | 4177.6  | 1 |
| 32A02 | 0.00   | 8.70   | 19.00   | 62.2    | 1535.5  | 1 |
| 32A03 | 5.60   | 19.00  | 26.00   | 120.5   | 1553.4  | 1 |
| 35A02 | 29.00  | 53.00  | 4370.00 | 8630.7  | 7101.0  | 4 |
| 35A03 | 71.00  | 47.00  | 2180.00 | 5351.1  | 7155.5  | 4 |
| 37A02 | 0.00   | 0.00   | 0.62    | 13.6    | 218.1   | 9 |
| 37A03 | 0.00   | 0.00   | 0.86    | 2.7     | 25.0    | 9 |
| 42A02 | 0.00   | 0.00   | 1.20    | 9.9     | 235.1   | 9 |
| 42A03 | 0.00   | 0.00   | 3.70    | 7.7     | 93.0    | 1 |
| 44A02 | 19.00  | 25.00  | 265.00  | 1002.5  | 3384.1  | 1 |
| 44A03 | 33.00  | 33.00  | 430.00  | 1540.1  | 6205.4  | 1 |
| 48A02 | 31.00  | 43.00  | 1150.00 | 3402.8  | 15672.0 | 1 |
| 48A03 | 48.00  | 55.00  | 1810.00 | 5002.0  | 42708.8 | 1 |
| 49A02 | 0.00   | 0.00   | 2.60    | 9.5     | 818.0   | 1 |
| 49A03 | 0.00   | 0.00   | 0.96    | 23.0    | 552.2   | 9 |
| 51A02 | 9.40   | 21.00  | 104.00  | 267.6   | 3876.7  | 1 |
| 51A03 | 0.00   | 0.00   | 3.50    | 73.5    | 2980.7  | 9 |
| 55A02 | 10.00  | 12.00  | 258.00  | 486.8   | 4552.2  | 4 |

|        |        |        |          |          |          |   |
|--------|--------|--------|----------|----------|----------|---|
| 55A03  | 9.10   | 20.00  | 208.00   | 388.4    | 2417.3   | 4 |
| 56A02  | 34.00  | 34.00  | 467.00   | 1447.0   | 4672.2   | 1 |
| 56A03  | 55.00  | 48.00  | 710.00   | 2075.0   | 6151.1   | 1 |
| 59A02  | 201.00 | 146.00 | 1300.00  | 4414.0   | 18711.5  | 1 |
| 59A03  | 52.00  | 51.00  | 620.00   | 1824.0   | 5328.1   | 1 |
| 05A02  | 39.00  | 17.00  | 453.00   | 1387.3   | 5444.4   | 1 |
| 05A03  | 12.00  | 29.00  | 408.00   | 1836.6   | 2940.4   | 7 |
| 06A02  | 0.00   | 5.20   | 99.00    | 294.2    | 1694.3   | 1 |
| 06A03  | 0.00   | 0.00   | 17.00    | 44.5     | 157.1    | 1 |
| 09A02  | 10.10  | 2.83   | 233.00   | 419.0    | 494.8    | 4 |
| 09A03  | 0.00   | 2.90   | 40.00    | 285.9    | 1703.7   | 9 |
| 21EPA0 | 48.00  | 43.00  | 1940.00  |          |          |   |
| 60AG2  | 38.00  | 70.00  | 3400.00  | 9425.0   | 13141.6  | 4 |
| 60AG3  | 490.00 | 70.00  | 1800.00  | 58517.0  | 170931.9 | 9 |
| 61AH2  | 160.00 | 73.00  | 3200.00  | 12712.0  | 12330.8  | 7 |
| 61AH3  | 510.00 | 180.00 | 43000.00 | 396640.0 | 293355.3 | 1 |
| 62AJ2  | 55.00  | 31.00  | 1800.00  | 4463.0   | 4561.5   | 4 |
| 62AJ3  | 61.00  | 29.00  | 1400.00  | 4056.6   | 8168.7   | 4 |
| 63AK2  | 25.00  | 23.00  | 540.00   | 1618.5   | 4035.2   | 1 |
| 63AK3  | 24.00  | 24.00  | 500.00   | 1544.4   | 3534.8   | 1 |
| 64AL2  | 23.00  | 23.00  | 410.00   | 1314.2   | 3228.3   | 1 |
| 64AL3  | 18.00  | 16.00  | 210.00   | 849.8    | 2020.4   | 1 |
| 65AM2  | 0.00   | 0.00   | 7.50     | 16.9     | 48.1     | 1 |
| 65AM3  | 0.00   | 0.00   | 5.40     | 5.4      | 13.0     | 5 |
| 66AN2  | 0.00   | 0.00   | 0.91     | 0.9      | 6.2      | 5 |
| 66AN3  | 0.00   | 0.00   | 1.60     | 2.1      | 9.3      | 5 |
| 68AP2  | 22.00  | 25.00  | 390.00   | 1241.9   | 2929.3   | 1 |
| 68AP3  | 9.60   | 11.00  | 250.00   | 672.5    | 1413.0   | 1 |
| 69AQ2  | 20.00  | 23.00  | 330.00   | 1110.9   | 3127.4   | 1 |
| 69AQ3  | 9.70   | 11.00  | 190.00   | 576.3    | 1413.4   | 1 |
| 70AR2  | 22.00  | 21.00  | 450.00   | 1241.2   | 3225.8   | 1 |
| 70AR3  | 15.00  | 15.00  | 280.00   | 877.5    | 2518.9   | 1 |
| 71AS2  | 0.00   | 0.00   | 2.80     | 2.8      | 13.0     | 5 |
| 71AS3  | 0.00   | 0.00   | 2.40     | 2.8      | 9.9      | 5 |
| 72AT2  | 26.00  | 29.00  | 400.00   | 1539.2   | 4837.3   | 1 |
| 72AT3  | 4.80   | 5.00   | 80.00    | 265.2    | 776.3    | 1 |
| 03AA2  | 26.00  | 19.00  | 410.00   | 1514.4   | 7330.9   | 1 |
| 03AA3  | 73.00  | 82.00  | 880.00   | 3353.3   | 19090.7  | 1 |
| 05AB1  | 25.00  | 26.00  | 360.00   | 1159.0   | 3225.4   | 1 |
| 10AC2  | 65.00  | 38.00  | 1200.00  | 34843.5  | 6775.9   | 8 |
| 10AC3  | 3.80   | 2.80   | 29.00    | 121.4    | 843.1    | 7 |
| 33AD2  | 0.00   | 0.00   | 1.20     | 36.2     | 1100.4   | 9 |
| 33AD3  | 0.00   | 0.00   | 3.60     | 41.5     | 1300.4   | 9 |
| 34AE2  | 1.60   | 2.40   | 13.00    | 65.9     | 1102.1   | 1 |
| 34AE3  | 1.20   | 2.30   | 7.70     | 67.9     | 1602.3   | 9 |
| 35AF1  | 130.00 | 74.00  | 2200.00  | 8750.0   | 7506.1   | 3 |
| 08A02  | 19.00  | 24.00  | 13.00    | 366.5    | 1232.0   | 1 |
| 08A03  | 0.77   | 1.20   | 2.40     | 16.5     | 181.2    | 1 |
| 74A02  | 0.00   | 0.57   | 26.00    | 79.5     | 630.9    | 1 |
| 74A03  | 0.00   | 0.00   | 4.80     | 15.8     | 110.1    | 1 |
| 75A02  | 120.00 | 61.00  | 2400.00  | 10182.0  | 16121.1  | 7 |
| 75A03  | 160.00 | 180.00 | 16000.00 | 25641.0  | 25286.9  | 5 |
| 76A02  | 0.00   | 0.66   | 2.00     | 8.7      | 160.5    | 1 |
| 76A03  | 1.60   | 1.90   | 36.00    | 68.9     | 541.8    | 4 |

|        |         |        |          |         |         |   |
|--------|---------|--------|----------|---------|---------|---|
| 77A02  | 470.00  | 83.00  | 22000.00 | 50351.0 | 17381.3 | 4 |
| 77A03  | 190.00  | 48.00  | 12000.00 | 22822.0 | 20152.5 | 4 |
| 81A02  | 95.00   | 50.00  | 1800.00  | 4433.0  | 7181.0  | 4 |
| 81A03  | 51.00   | 140.00 | 550.00   | 2262.1  | 3320.1  | 7 |
| 82A02  | 0.71    | 0.65   | 5.20     | 38.7    | 730.9   | 9 |
| 82A03  | 0.00    | 0.00   | 5.00     | 40.0    | 990.4   | 9 |
| 83A02  | 82.00   | 57.00  | 100.00   | 726.3   | 945.4   | 1 |
| 83A03  | 2.60    | 2.90   | 7.60     | 33.7    | 132.5   | 1 |
| 84B02  | 1.30    | 0.84   | 48.00    | 170.4   | 932.3   | 9 |
| 84B03  | 6.80    | 4.80   | 180.00   | 472.2   | 1908.4  | 1 |
| 85A02  | 230.00  | 420.00 | 2900.00  | 9481.0  | 23406.3 | 1 |
| 85A03  | 100.00  | 66.00  | 2400.00  | 7897.0  | 21137.8 | 1 |
| 86A02  | 24.00   | 14.00  | 340.00   | 1369.0  | 5131.8  | 1 |
| 86A03  | 26.00   | 14.00  | 420.00   | 1529.3  | 5733.2  | 1 |
| 87A02  | 0.00    | 0.69   | 4.30     | 20.0    | 270.6   | 1 |
| 87A03  | 49.00   | 39.00  | 1100.00  | 3223.7  | 9574.8  | 1 |
| 201A02 | 57.80   | 37.70  | 1420.00  | 4094.7  | 7749.3  | 4 |
| 201A03 | 54.90   | 37.00  | 1490.00  | 4138.4  | 5449.8  | 4 |
| 201A04 | 51.60   | 34.80  | 1770.00  | 5265.9  | 5804.0  | 4 |
| 201A05 | 78.50   | 64.20  | 1540.00  | 4525.2  | 8107.4  | 4 |
| 201A06 | 86.90   | 74.90  | 1460.00  | 4284.8  | 7580.3  | 4 |
| 202E03 | 64.30   | 40.30  | 1400.00  | 4300.3  | 8948.4  | 4 |
| 202E05 | 111.00  | 66.60  | 24.80    | 4891.0  | 14426.3 | 1 |
| 202E06 | 112.00  | 64.10  | 2530.00  | 7496.4  | 16029.3 | 1 |
| 203A02 | 80.70   | 45.40  | 2230.00  | 5893.6  | 5957.2  | 4 |
| 203A04 | 103.00  | 41.80  | 2950.00  | 8430.3  | 5208.4  | 4 |
| 203A06 | 202.00  | 138.00 | 2950.00  | 7892.7  | 10566.4 | 4 |
| 203A08 | 238.00  | 181.00 | 7650.00  | 21443.5 | 25703.9 | 7 |
| 203A10 | 291.00  | 214.00 | 5170.00  | 15200.1 | 3079.0  | 4 |
| 204A02 | 44.90   | 52.10  | 1170.00  | 4462.6  | 9211.5  | 1 |
| 204A03 | 67.70   | 64.80  | 2610.00  | 5893.9  | 8341.6  | 4 |
| 204A04 | 56.70   | 53.50  | 1480.00  | 4563.1  | 10476.4 | 4 |
| 204A05 | 98.20   | 81.70  | 3330.00  | 9506.8  | 15021.4 | 7 |
| 204A06 | 304.00  | 345.00 | 5350.00  | 64946.5 | 18765.8 | 9 |
| 205A02 | 89.70   | 62.00  | 1620.00  | 4689.3  | 9257.3  | 4 |
| 205A03 | 31.30   | 18.80  | 2370.00  | 4881.4  | 3687.2  | 4 |
| 206A02 | 245.00  | 166.00 | 3660.00  | 8945.9  | 15402.5 | 4 |
| 206A03 | 133.00  | 69.90  | 3600.00  | 9719.0  | 15165.3 | 4 |
| 206A04 | 148.00  | 95.70  | 2870.00  | 10544.5 | 16847.9 | 7 |
| 206A05 | 307.00  | 233.00 | 12100.00 | 35531.8 | 19437.6 | 7 |
| 206A06 | 287.00  | 84.80  | 10400.00 | 27665.6 | 11494.3 | 4 |
| 207A02 | 201.00  | 148.00 | 2830.00  | 8508.9  | 14334.9 | 4 |
| 207A03 | 466.00  | 444.00 | 3520.00  | 18415.1 | 16519.7 | 7 |
| 207A04 | 2150.00 | 131.00 | 1570.00  | 14127.1 | 9356.6  | 7 |
| 207A05 | 19.30   | 14.80  | 108.00   | 394.7   | 1158.4  | 4 |
| 207A06 | 5.53    | 2.71   | 17.20    | 100.9   | 614.7   | 1 |
| 208A02 | 104.00  | 81.30  | 2150.00  | 7811.3  | 18631.6 | 7 |
| 208A03 | 0.42    | 0.76   | 3.75     | 12.5    | 85.8    | 1 |
| 209B02 | 97.40   | 49.50  | 2230.00  | 8990.1  | 13494.1 | 7 |
| 209B03 | 175.00  | 68.80  | 3780.00  | 10324.9 | 23972.4 | 4 |
| 209B04 | 139.00  | 105.00 | 3060.00  | 10360.7 | 19555.2 | 7 |
| 209B05 | 284.00  | 248.00 | 11800.00 | 32127.0 | 27347.3 | 7 |
| 209B06 | 441.00  | 206.00 | 22600.00 | 57304.8 | 18676.6 | 7 |
| 210A02 | 28.40   | 22.10  | 167.00   | 657.9   | 2205.7  | 4 |

|        |        |        |          |          |         |   |
|--------|--------|--------|----------|----------|---------|---|
| 210A03 | 0.73   | 0.85   | 2.65     | 57.3     | 1412.1  | 9 |
| 210A04 | 0.55   | 0.82   | 2.76     | 62.0     | 1542.3  | 9 |
| 210A05 | 0.71   | 0.84   | 3.76     | 55.1     | 1172.1  | 9 |
| 210A06 | 0.55   | 0.51   | 2.40     | 46.1     | 869.0   | 9 |
| 211B02 | 183.00 | 120.00 | 5520.00  | 21998.9  | 17895.4 | 7 |
| 211B04 | 51.10  | 18.60  | 697.00   | 2342.8   | 2956.8  | 4 |
| 211B05 | 8.27   | 8.86   | 65.60    | 259.0    | 883.8   | 4 |
| 212A02 | 158.00 | 88.20  | 1950.00  | 6389.3   | 14647.8 | 1 |
| 212A04 | 237.00 | 70.90  | 3470.00  | 9707.5   | 18986.9 | 4 |
| 212A05 | 133.00 | 66.20  | 3040.00  | 10038.6  | 23006.6 | 1 |
| 212A06 | 71.30  | 39.90  | 1920.00  | 5693.7   | 9174.5  | 4 |
| 212A07 | 133.00 | 143.00 | 3700.00  | 14440.1  | 25706.3 | 7 |
| 213A02 | 134.00 | 120.00 | 3070.00  | 10683.7  | 13973.5 | 7 |
| 213A03 | 70.00  | 58.00  | 3470.00  | 10732.2  | 3998.7  | 7 |
| 213A04 | 0.00   | 1.88   | 25.90    | 98.0     | 1282.0  | 1 |
| 213A05 | 1.69   | 1.60   | 10.60    | 87.6     | 1442.3  | 1 |
| 213A06 | 0.64   | 0.52   | 6.25     | 64.7     | 1541.3  | 9 |
| 214A02 | 152.00 | 117.00 | 6800.00  | 26179.2  | 14087.4 | 7 |
| 214A03 | 244.00 | 63.20  | 8670.00  | 19051.1  | 10943.2 | 4 |
| 214A04 | 202.00 | 51.50  | 2450.00  | 8040.4   | 9506.8  | 4 |
| 215B02 | 101.00 | 68.50  | 3690.00  | 8949.9   | 5558.5  | 4 |
| 215B03 | 103.00 | 61.30  | 3020.00  | 8337.1   | 5902.7  | 4 |
| 215B04 | 105.00 | 61.50  | 3130.00  | 8346.4   | 6327.0  | 4 |
| 215B05 | 149.00 | 65.20  | 3670.00  | 10813.8  | 7910.8  | 4 |
| 215B06 | 135.00 | 105.00 | 2710.00  | 6852.9   | 10133.8 | 4 |
| 216A02 | 79.10  | 55.50  | 1880.00  | 5425.7   | 7520.4  | 4 |
| 216A03 | 80.70  | 65.50  | 4630.00  | 8592.6   | 7027.6  | 4 |
| 216A04 | 104.00 | 66.80  | 2330.00  | 6685.7   | 8677.8  | 4 |
| 216A05 | 107.00 | 77.60  | 2330.00  | 6635.3   | 11411.7 | 4 |
| 216A06 | 145.00 | 108.00 | 2280.00  | 6587.2   | 14143.4 | 1 |
| 217A02 | 134.00 | 69.70  | 5780.00  | 15914.3  | 7459.6  | 7 |
| 217A03 | 12.30  | 12.00  | 110.00   | 421.1    | 1444.1  | 4 |
| 217A04 | 0.00   | 1.71   | 66.00    | 124.4    | 170.6   | 4 |
| 218A02 | 194.00 | 50.90  | 7690.00  | 20967.2  | 7159.5  | 4 |
| 218A03 | 169.00 | 65.80  | 5540.00  | 14920.1  | 10009.3 | 4 |
| 218A04 | 221.00 | 139.00 | 3820.00  | 9613.2   | 12884.6 | 4 |
| 218A05 | 165.00 | 101.00 | 5330.00  | 12235.6  | 14861.3 | 4 |
| 218A06 | 285.00 | 157.00 | 10800.00 | 21661.7  | 17533.2 | 4 |
| 222A02 | 102.00 | 61.60  | 23000.00 | 28866.7  | 17221.6 | 5 |
| 222A03 | 86.00  | 71.70  | 3100.00  | 8007.8   | 12504.6 | 4 |
| 222A04 | 163.00 | 137.00 | 4780.00  | 70413.1  | 22212.3 | 8 |
| 222A05 | 395.00 | 561.00 | 29600.00 | 142984.2 | 22671.7 | 8 |
| 222A06 | 341.00 | 316.00 | 21000.00 | 63865.0  | 25158.8 | 7 |
| 222A07 | 327.00 | 97.50  | 8050.00  | 36903.9  | 23925.0 | 8 |
| 223A02 | 488.00 | 85.80  | 64200.00 | 115739.7 | 12180.4 | 4 |
| 223A04 | 110.00 | 88.00  | 4390.00  | 11438.7  | 19139.3 | 7 |
| 223A05 | 271.00 | 224.00 | 10700.00 | 27321.5  | 19132.8 | 7 |
| 223A06 | 176.00 | 117.00 | 6580.00  | 18640.9  | 18589.5 | 7 |
| 223A07 | 97.80  | 38.10  | 1230.00  | 4187.4   | 5056.0  | 7 |
| 224A02 | 99.50  | 79.60  | 2330.00  | 7551.8   | 16213.9 | 7 |
| 224A03 | 134.00 | 129.00 | 3310.00  | 11781.0  | 18076.8 | 7 |
| 224A04 | 178.00 | 137.00 | 5520.00  | 23653.1  | 20608.5 | 7 |
| 224A05 | 223.00 | 177.00 | 14400.00 | 32918.5  | 18879.7 | 4 |
| 224A06 | 641.00 | 463.00 | 40800.00 | 80539.1  | 27595.8 | 4 |

|        |        |        |           |          |         |   |
|--------|--------|--------|-----------|----------|---------|---|
| 225A02 | 143.00 | 97.70  | 1630.00   | 4936.6   | 9339.1  | 4 |
| 225A03 | 108.00 | 79.60  | 2490.00   | 8468.5   | 14855.5 | 7 |
| 225A04 | 266.00 | 232.00 | 14300.00  | 43109.0  | 22962.2 | 7 |
| 225A05 | 266.00 | 303.00 | 10900.00  | 73553.5  | 23984.2 | 8 |
| 225A06 | 282.00 | 281.00 | 12500.00  | 73262.1  | 15151.5 | 8 |
| 225A07 | 165.00 | 40.20  | 1990.00   | 6963.4   | 5550.5  | 7 |
| 226A04 | 253.00 | 163.00 | 8660.00   | 22488.9  | 20469.4 | 7 |
| 226A05 | 351.00 | 227.00 | 12300.00  | 38021.3  | 18741.9 | 7 |
| 226A06 | 196.00 | 109.00 | 4330.00   | 24349.9  | 9352.5  | 8 |
| 227A02 | 105.00 | 108.00 | 3320.00   | 13095.6  | 16853.2 | 7 |
| 227A03 | 135.00 | 130.00 | 3440.00   | 16284.8  | 17177.5 | 8 |
| 227A04 | 227.00 | 155.00 | 8620.00   | 28434.5  | 23052.9 | 7 |
| 227A05 | 745.00 | 406.00 | 26800.00  | 59856.5  | 29672.9 | 4 |
| 227A06 | 250.00 | 301.00 | 11000.00  | 39236.2  | 19873.5 | 7 |
| 228B02 | 202.00 | 12.80  | 5980.00   | 11118.9  | 16787.2 | 4 |
| 228B03 | 127.00 | 108.00 | 3010.00   | 12252.2  | 19251.1 | 7 |
| 228B04 | 480.00 | 237.00 | 14900.00  | 46365.4  | 22160.5 | 7 |
| 228B05 | 215.00 | 231.00 | 7270.00   | 26746.6  | 18485.6 | 8 |
| 228B06 | 174.00 | 54.40  | 2660.00   | 8211.9   | 9219.0  | 4 |
| 228B07 | 62.90  | 29.50  | 790.00    | 2238.6   | 3558.6  | 4 |
| 229A02 | 63.90  | 35.90  | 1330.00   | 3940.2   | 7644.3  | 4 |
| 229A03 | 64.70  | 51.30  | 1460.00   | 4785.4   | 13693.3 | 1 |
| 229A04 | 98.80  | 75.10  | 1820.00   | 6909.6   | 13613.4 | 7 |
| 229A05 | 134.00 | 103.00 | 2950.00   | 12433.1  | 21160.2 | 7 |
| 229A06 | 220.00 | 144.00 | 10000.00  | 25240.0  | 24151.5 | 7 |
| 230A02 | 41.30  | 36.20  | 1050.00   | 3749.1   | 8295.4  | 7 |
| 230A04 | 78.70  | 66.90  | 1460.00   | 8395.3   | 16999.9 | 8 |
| 230A05 | 114.00 | 93.00  | 2720.00   | 15830.6  | 20949.1 | 8 |
| 230A06 | 225.00 | 166.00 | 8230.00   | 25246.7  | 22575.7 | 7 |
| 230A07 | 306.00 | 206.00 | 183000.00 | 210237.0 | 86737.2 | 5 |
| 231A02 | 106.00 | 82.90  | 1590.00   | 5287.7   | 11919.6 | 1 |
| 231A03 | 151.00 | 128.00 | 3870.00   | 17026.9  | 22206.9 | 7 |
| 231A04 | 277.00 | 226.00 | 12300.00  | 34156.3  | 24446.4 | 7 |
| 231A05 | 532.00 | 418.00 | 25500.00  | 72386.6  | 33099.7 | 7 |
| 231A06 | 317.00 | 318.00 | 6540.00   | 36388.0  | 16325.5 | 8 |
| 231A07 | 46.10  | 21.10  | 245.00    | 853.4    | 2628.2  | 4 |
| 232A02 | 73.30  | 47.80  | 1590.00   | 4829.7   | 10177.5 | 4 |
| 232A03 | 190.00 | 126.00 | 1670.00   | 5229.2   | 13253.4 | 1 |
| 232A04 | 111.00 | 85.30  | 2500.00   | 10042.0  | 14904.1 | 1 |
| 232A05 | 79.80  | 57.60  | 2820.00   | 10066.9  | 10599.4 | 7 |
| 232A06 | 11.90  | 26.70  | 119.00    | 353.5    | 2072.3  | 4 |
| 233C04 | 0.00   | 0.00   | 0.00      | 4.6      | 2.7     | 8 |
| 234B02 | 59.90  | 46.70  | 1920.00   | 5057.9   | 7060.7  | 4 |
| 234B03 | 128.00 | 104.00 | 2470.00   | 6535.6   | 12732.4 | 4 |
| 234B04 | 287.00 | 154.00 | 4310.00   | 12821.4  | 23529.0 | 4 |
| 234B05 | 191.00 | 125.00 | 6920.00   | 22140.7  | 20508.8 | 7 |
| 234B06 | 336.00 | 294.00 | 16300.00  | 48119.2  | 45532.6 | 7 |
| 234B07 | 95.40  | 127.00 | 3230.00   | 35252.2  | 1903.1  | 8 |
| 235A02 | 78.00  | 52.40  | 1940.00   | 5942.5   | 12394.3 | 4 |
| 235A03 | 104.00 | 84.90  | 1400.00   | 4042.8   | 9087.7  | 1 |
| 235A04 | 202.00 | 136.00 | 5390.00   | 18211.6  | 39533.8 | 7 |
| 235A05 | 273.00 | 263.00 | 8360.00   | 30231.7  | 25956.2 | 7 |
| 235A06 | 195.00 | 284.00 | 6840.00   | 35092.3  | 16410.4 | 8 |
| 235A07 | 57.50  | 61.30  | 1320.00   | 8269.6   | 4307.9  | 8 |

|        |        |        |          |         |         |   |
|--------|--------|--------|----------|---------|---------|---|
| 236A02 | 156.00 | 151.00 | 4030.00  | 10829.6 | 23166.4 | 4 |
| 236A03 | 181.00 | 521.00 | 4840.00  | 25337.8 | 15861.0 | 8 |
| 236A04 | 123.00 | 92.00  | 3010.00  | 15394.3 | 32834.8 | 8 |
| 236A05 | 165.00 | 55.20  | 2420.00  | 10146.4 | 7679.9  | 7 |
| 236A06 | 175.00 | 52.20  | 4140.00  | 9267.8  | 8297.4  | 4 |
| 238A02 | 51.50  | 49.10  | 1280.00  | 4446.6  | 8697.2  | 7 |
| 238A05 | 5.84   | 14.00  | 34.80    | 151.4   | 598.9   | 4 |
| 238A06 | 0.00   | 0.00   | 7.21     | 18.8    | 20.3    | 4 |
| 239A02 | 80.60  | 73.50  | 1180.00  | 3746.9  | 8153.8  | 4 |
| 239A03 | 41.40  | 31.40  | 1100.00  | 3145.9  | 8175.4  | 1 |
| 240A02 | 181.00 | 142.00 | 4660.00  | 20303.6 | 29630.1 | 7 |
| 240A03 | 229.00 | 159.00 | 5750.00  | 25650.5 | 29750.6 | 7 |
| 240A04 | 199.00 | 266.00 | 6930.00  | 28459.8 | 25064.8 | 7 |
| 240A05 | 208.00 | 287.00 | 5760.00  | 52766.3 | 13331.5 | 8 |
| 240A06 | 233.00 | 57.80  | 7260.00  | 28263.4 | 11461.5 | 7 |
| 241A02 | 67.20  | 51.30  | 1090.00  | 3596.5  | 8183.9  | 4 |
| 241A03 | 62.40  | 51.40  | 1440.00  | 6446.8  | 11679.0 | 7 |
| 241A04 | 469.00 | 268.00 | 12600.00 | 48339.8 | 65538.9 | 7 |
| 241A05 | 261.00 | 222.00 | 1450.00  | 34993.0 | 17692.1 | 8 |
| 241A06 | 264.00 | 67.60  | 8530.00  | 24628.7 | 9943.4  | 7 |
| 241A07 | 160.00 | 46.90  | 304.00   | 7082.2  | 26847.7 | 9 |
| 242A02 | 130.00 | 85.00  | 1600.00  | 4583.8  | 11001.5 | 4 |
| 242A03 | 142.00 | 116.00 | 2670.00  | 10109.6 | 21599.6 | 1 |
| 242A04 | 307.00 | 379.00 | 17100.00 | 63434.8 | 25845.1 | 8 |
| 242A05 | 283.00 | 281.00 | 19600.00 | 68192.4 | 23648.1 | 7 |
| 242A06 | 271.00 | 70.20  | 10300.00 | 32850.5 | 15086.9 | 7 |
| 242A07 | 173.00 | 49.00  | 1620.00  | 5446.4  | 9328.4  | 4 |
| 243A02 | 87.60  | 59.20  | 1600.00  | 5349.3  | 11491.8 | 7 |
| 243A03 | 196.00 | 213.00 | 7510.00  | 35845.1 | 22808.8 | 8 |
| 243A04 | 516.00 | 399.00 | 27800.00 | 66045.9 | 28748.0 | 7 |
| 243A05 | 223.00 | 397.00 | 6780.00  | 51648.0 | 25285.5 | 8 |
| 243A06 | 251.00 | 545.00 | 9440.00  | 48017.8 | 18903.5 | 8 |
| 244A02 | 139.00 | 48.50  | 1210.00  | 5015.9  | 9531.2  | 1 |
| 244A03 | 21.80  | 19.10  | 443.00   | 1934.6  | 2950.5  | 7 |
| 244A04 | 562.00 | 356.00 | 26600.00 | 52583.1 | 33444.4 | 4 |
| 244A05 | 221.00 | 185.00 | 4170.00  | 12943.7 | 13329.3 | 7 |
| 244A06 | 33.40  | 17.60  | 221.00   | 777.1   | 2287.0  | 4 |
| 245B02 | 75.00  | 70.10  | 1820.00  | 5974.6  | 12992.3 | 7 |
| 245B03 | 117.00 | 105.00 | 3090.00  | 12722.9 | 16551.2 | 7 |
| 245B04 | 328.00 | 246.00 | 19100.00 | 43028.4 | 2783.1  | 4 |
| 245B05 | 370.00 | 403.00 | 14800.00 | 43781.2 | 18528.4 | 7 |
| 245B06 | 197.00 | 247.00 | 6530.00  | 25993.0 | 17790.9 | 8 |
| 245B07 | 204.00 | 38.90  | 3100.00  | 9208.2  | 8516.7  | 4 |
| 246A02 | 0.00   | 0.00   | 1.88     | 5.5     | 16.6    | 1 |
| 246A03 | 0.00   | 0.00   | 1.34     | 4.7     | 12.3    | 1 |
| 246A04 | 0.00   | 0.00   | 1.30     | 4.4     | 14.5    | 1 |
| 246A05 | 0.00   | 0.00   | 1.01     | 3.5     | 15.3    | 1 |
| 246A06 | 0.00   | 0.00   | 0.98     | 3.3     | 10.8    | 1 |
| 247A02 | 0.00   | 0.49   | 0.00     | 7.8     | 144.1   | 1 |
| 247A03 | 0.00   | 1.90   | 9.10     | 62.8    | 84.5    | 4 |
| 248A02 | 68.40  | 55.50  | 1030.00  | 3377.5  | 9603.1  | 1 |
| 248A03 | 150.00 | 156.00 | 3790.00  | 14303.9 | 24130.6 | 7 |
| 248A04 | 158.00 | 118.00 | 2730.00  | 9951.8  | 11441.3 | 7 |
| 248A05 | 66.30  | 22.80  | 419.00   | 1779.0  | 3105.8  | 7 |



|        |        |        |          |         |         |   |
|--------|--------|--------|----------|---------|---------|---|
| 248A06 | 7.57   | 7.11   | 24.90    | 105.3   | 331.3   | 4 |
| 249B02 | 72.50  | 46.80  | 2590.00  | 5800.5  | 7550.0  | 4 |
| 249B03 | 97.90  | 62.90  | 1670.00  | 5056.5  | 12203.0 | 1 |
| 249B04 | 66.70  | 44.50  | 1290.00  | 3417.2  | 6408.3  | 4 |
| 249B05 | 66.10  | 38.10  | 1870.00  | 4711.3  | 8003.2  | 4 |
| 249B06 | 41.40  | 13.50  | 335.00   | 1140.8  | 1958.6  | 4 |
| 250A02 | 0.00   | 0.00   | 4.09     | 16.7    | 28.5    | 7 |
| 250A03 | 0.00   | 0.00   | 1.87     | 6.3     | 9.8     | 1 |
| 250A04 | 0.00   | 0.00   | 0.00     | 2.2     | 4.3     | 2 |
| 250A05 | 0.00   | 0.00   | 0.00     | 1.5     | 3.1     | 2 |
| 250A06 | 0.00   | 0.00   | 0.00     | 1.6     | 3.0     | 2 |
| 251B02 | 56.40  | 51.40  | 1230.00  | 3723.3  | 9311.2  | 1 |
| 251B03 | 95.80  | 71.60  | 2350.00  | 9620.2  | 16815.5 | 7 |
| 251B04 | 210.00 | 207.00 | 7910.00  | 34500.2 | 22084.4 | 8 |
| 251B05 | 197.00 | 357.00 | 7160.00  | 58080.0 | 18152.3 | 8 |
| 251B06 | 78.50  | 39.20  | 1680.00  | 7140.6  | 4385.3  | 8 |
| 251B07 | 12.80  | 7.34   | 109.00   | 353.4   | 405.6   | 4 |
| 252C02 | 46.00  | 38.10  | 1040.00  | 3227.6  | 5866.8  | 4 |
| 252C03 | 66.00  | 56.50  | 2490.00  | 6308.9  | 9968.7  | 4 |
| 252C04 | 165.00 | 147.00 | 3650.00  | 21972.7 | 19697.0 | 8 |
| 252C05 | 297.00 | 333.00 | 16000.00 | 49984.6 | 27431.4 | 7 |
| 252C06 | 252.00 | 430.00 | 33300.00 | 63658.4 | 34566.5 | 7 |
| 252C07 | 112.00 | 198.00 | 3970.00  | 22694.2 | 8788.9  | 8 |
| 253A02 | 68.10  | 50.10  | 1450.00  | 4662.5  | 9670.8  | 4 |
| 253A03 | 75.50  | 58.20  | 1400.00  | 4904.5  | 9878.9  | 7 |
| 253A04 | 76.80  | 61.50  | 1380.00  | 6972.5  | 7542.1  | 8 |
| 253A07 | 20.40  | 15.30  | 111.00   | 492.1   | 1098.3  | 4 |
| 254A02 | 53.10  | 39.00  | 1340.00  | 4437.5  | 8854.0  | 4 |
| 254A03 | 48.80  | 43.20  | 999.00   | 3296.7  | 8599.5  | 4 |
| 254A04 | 139.00 | 114.00 | 1140.00  | 3836.3  | 9191.5  | 1 |
| 254A05 | 74.40  | 85.50  | 1970.00  | 9740.2  | 14312.3 | 8 |
| 254A06 | 10.30  | 30.40  | 63.60    | 275.8   | 1542.7  | 4 |
| 255A02 | 49.80  | 40.40  | 1940.00  | 4899.3  | 8752.3  | 4 |
| 255A03 | 69.00  | 61.00  | 1990.00  | 5680.0  | 10284.9 | 4 |
| 255A04 | 72.20  | 70.80  | 1710.00  | 5541.5  | 10994.2 | 4 |
| 255A05 | 30.10  | 30.30  | 684.00   | 2026.6  | 3773.3  | 4 |
| 255A06 | 0.00   | 0.00   | 0.00     | 8.4     | 16.2    | 7 |
| 256B02 | 47.70  | 41.80  | 784.00   | 2619.1  | 5955.2  | 1 |
| 256B04 | 70.40  | 54.30  | 855.00   | 2930.0  | 6833.4  | 1 |
| 256B07 | 0.00   | 0.00   | 7.62     | 26.2    | 44.3    | 1 |
| 257C02 | 82.00  | 82.20  | 1560.00  | 5608.5  | 11403.9 | 7 |
| 257C03 | 75.80  | 56.80  | 1820.00  | 6682.5  | 10682.8 | 7 |
| 257C05 | 5.98   | 16.80  | 66.50    | 250.9   | 681.0   | 1 |
| 257C06 | 1.14   | 4.36   | 12.70    | 63.2    | 135.6   | 1 |
| 258C02 | 68.00  | 46.20  | 8540.00  | 15983.4 | 8298.6  | 4 |
| 258C03 | 74.70  | 60.20  | 1650.00  | 5229.8  | 10027.1 | 4 |
| 258C04 | 44.30  | 40.40  | 1350.00  | 3547.5  | 7351.6  | 4 |
| 258C05 | 0.00   | 0.00   | 0.00     | 9.6     | 35.7    | 1 |
| 259B02 | 153.00 | 115.00 | 6570.00  | 22225.8 | 28100.3 | 7 |
| 259B04 | 51.30  | 42.50  | 1030.00  | 5156.3  | 7773.3  | 7 |
| 260B02 | 61.80  | 36.80  | 947.00   | 3612.6  | 8127.2  | 4 |
| 260B03 | 86.10  | 61.90  | 1440.00  | 7688.7  | 13017.1 | 7 |
| 260B04 | 185.00 | 127.00 | 3460.00  | 20461.2 | 26615.9 | 8 |
| 260B05 | 265.00 | 209.00 | 9750.00  | 76901.2 | 30628.9 | 8 |

|        |        |        |         |         |         |   |
|--------|--------|--------|---------|---------|---------|---|
| 260B06 | 177.00 | 321.00 | 5330.00 | 30677.9 | 28726.4 | 8 |
| 261C02 | 0.00   | 0.00   | 2.04    | 10.3    | 14.2    | 7 |
| 261C06 | 0.00   | 1.00   | 11.30   | 43.4    | 9.9     | 8 |
| 262A02 | 4.54   | 3.47   | 20.20   | 91.5    | 167.7   | 1 |
| 262A03 | 1.27   | 0.94   | 5.09    | 25.9    | 47.8    | 7 |
| 262A04 | 0.00   | 0.00   | 0.00    | 2.1     | 14.2    | 8 |
| 262A05 | 0.00   | 0.00   | 0.00    | 1.6     | 5.6     | 2 |
| 263B02 | 47.00  | 30.40  | 1080.00 | 3420.8  | 6441.4  | 4 |
| 263B03 | 52.90  | 38.20  | 460.00  | 1688.0  | 3695.4  | 1 |
| 263B04 | 19.10  | 18.80  | 301.00  | 1163.1  | 2062.1  | 7 |
| 263B05 | 8.27   | 10.50  | 192.00  | 932.4   | 1162.5  | 8 |
| 263B06 | 39.10  | 35.30  | 1250.00 | 4841.5  | 4239.5  | 7 |
| 264A02 | 4.06   | 3.99   | 10.80   | 55.1    | 123.0   | 1 |
| 264A03 | 0.00   | 1.21   | 0.00    | 6.7     | 29.1    | 9 |
| 264A06 | 0.00   | 0.00   | 2.74    | 9.9     | 12.7    | 1 |
| 265A04 | 0.00   | 0.00   | 0.00    | 7.8     | 4.2     | 1 |
| 265A05 | 0.00   | 0.00   | 0.00    | 2.7     | 3.2     | 2 |
| 265A06 | 0.00   | 0.00   | 0.87    | 5.2     | 3.9     | 7 |
| 266A02 | 16.20  | 28.00  | 231.00  | 994.5   | 1691.7  | 1 |
| 266A03 | 20.30  | 12.50  | 7040.00 | 14564.5 | 27787.9 | 1 |
| 266A04 | 2.55   | 3.09   | 18.80   | 99.5    | 149.5   | 1 |
| 266A05 | 2.22   | 3.38   | 16.90   | 86.7    | 138.3   | 1 |
| 266A06 | 2.29   | 2.73   | 16.20   | 74.8    | 209.6   | 1 |
| 267A02 | 34.50  | 25.20  | 159.00  | 1009.7  | 1155.1  | 7 |
| 267A03 | 11.40  | 10.80  | 50.60   | 341.7   | 430.2   | 8 |
| 268B02 | 56.40  | 45.20  | 3150.00 | 7524.9  | 8971.0  | 4 |
| 268B03 | 55.10  | 46.40  | 1090.00 | 4419.6  | 8336.0  | 7 |
| 268B04 | 30.50  | 22.10  | 396.00  | 2390.3  | 2683.5  | 8 |
| 268B05 | 0.00   | 0.00   | 0.00    | 5.3     | 22.7    | 9 |
| 269C02 | 47.90  | 35.80  | 747.00  | 3070.6  | 7899.2  | 1 |
| 269C04 | 45.20  | 36.40  | 775.00  | 3341.7  | 8903.4  | 7 |
| 269C06 | 71.40  | 52.40  | 1270.00 | 5898.7  | 11588.6 | 7 |
| 269C07 | 125.00 | 87.30  | 2910.00 | 12514.5 | 23335.7 | 7 |
| 270A02 | 94.60  | 66.70  | 1250.00 | 5329.1  | 20622.3 | 1 |
| 270A03 | 86.50  | 73.40  | 1410.00 | 6532.7  | 14513.4 | 7 |
| 270A04 | 168.00 | 134.00 | 3430.00 | 21371.2 | 23007.6 | 8 |
| 270A06 | 244.00 | 169.00 | 4530.00 | 22881.0 | 32690.3 | 7 |
| 270A07 | 46.50  | 33.80  | 928.00  | 5667.0  | 5828.7  | 8 |
| 271A02 | 28.70  | 24.40  | 228.00  | 925.0   | 2115.6  | 1 |
| 271A03 | 69.50  | 49.60  | 1120.00 | 4992.6  | 9637.2  | 7 |
| 271A04 | 155.00 | 85.50  | 1990.00 | 14738.5 | 16348.8 | 8 |
| 271A07 | 35.60  | 39.10  | 664.00  | 6069.9  | 2988.0  | 8 |
| 272A02 | 24.20  | 20.50  | 388.00  | 1463.7  | 3666.1  | 1 |
| 272A03 | 60.90  | 35.20  | 980.00  | 3778.4  | 8721.6  | 1 |
| 272A04 | 201.00 | 147.00 | 2360.00 | 23696.7 | 22507.7 | 8 |
| 272A05 | 155.00 | 143.00 | 1310.00 | 7677.6  | 11545.3 | 8 |
| 272A06 | 114.00 | 50.20  | 365.00  | 2175.6  | 5923.7  | 7 |
| 272A07 | 133.00 | 31.10  | 789.00  | 3005.3  | 7141.1  | 4 |
| 273A02 | 100.00 | 113.00 | 1990.00 | 8155.1  | 6234.9  | 7 |
| 273A03 | 119.00 | 471.00 | 2070.00 | 13026.7 | 10666.5 | 8 |
| 273A04 | 125.00 | 45.60  | 1030.00 | 7928.5  | 8538.4  | 8 |
| 273A05 | 125.00 | 34.70  | 451.00  | 2163.9  | 5860.2  | 1 |
| 273A06 | 83.70  | 32.50  | 365.00  | 1608.5  | 3687.3  | 4 |
| 274A02 | 77.20  | 68.30  | 1120.00 | 7176.5  | 9694.7  | 8 |

|        |        |        |           |           |          |   |
|--------|--------|--------|-----------|-----------|----------|---|
| 274A03 | 206.00 | 158.00 | 4280.00   | 36561.9   | 18317.9  | 8 |
| 274A04 | 130.00 | 53.20  | 1910.00   | 13290.6   | 4403.8   | 8 |
| 274A05 | 76.00  | 26.90  | 282.00    | 1315.8    | 2397.9   | 4 |
| 274A06 | 89.40  | 43.10  | 418.00    | 1809.6    | 4485.1   | 4 |
| 275A02 | 61.60  | 47.30  | 1090.00   | 4177.3    | 11765.1  | 1 |
| 275A03 | 66.70  | 42.80  | 846.00    | 4228.5    | 8575.5   | 7 |
| 275A04 | 229.00 | 96.00  | 3570.00   | 22803.7   | 19146.8  | 8 |
| 275A05 | 145.00 | 36.90  | 674.00    | 3258.4    | 7263.6   | 1 |
| 275A06 | 79.80  | 40.20  | 478.00    | 1807.5    | 4710.0   | 4 |
| 276A02 | 56.50  | 45.30  | 1200.00   | 4099.2    | 7748.6   | 4 |
| 276A03 | 79.10  | 63.70  | 1610.00   | 5452.6    | 11005.8  | 4 |
| 276A04 | 129.00 | 92.00  | 1650.00   | 5713.3    | 13627.9  | 1 |
| 276A05 | 193.00 | 102.00 | 2040.00   | 7937.3    | 15358.5  | 7 |
| 276A06 | 37.20  | 15.80  | 179.00    | 787.4     | 2001.7   | 1 |
| 277B02 | 31.20  | 23.20  | 439.00    | 1724.0    | 4113.7   | 4 |
| 277B03 | 60.50  | 47.80  | 981.00    | 4201.5    | 10774.1  | 1 |
| 277B04 | 145.00 | 62.50  | 947.00    | 3768.1    | 9707.9   | 1 |
| 277B05 | 80.30  | 30.40  | 362.00    | 1465.7    | 2741.2   | 4 |
| 277B06 | 13.70  | 7.44   | 70.60     | 248.7     | 654.8    | 4 |
| 278B02 | 79.80  | 56.50  | 1370.00   | 9070.0    | 12603.0  | 8 |
| 278B03 | 279.00 | 176.00 | 6820.00   | 45845.0   | 37415.7  | 8 |
| 278B04 | 227.00 | 178.00 | 9140.00   | 43910.8   | 43026.7  | 8 |
| 278B05 | 181.00 | 201.00 | 3460.00   | 22059.2   | 21673.8  | 8 |
| 278B06 | 158.00 | 69.70  | 3710.00   | 20647.5   | 14762.7  | 8 |
| 282A02 | 93.90  | 45.20  | 1960.00   | 6671.0    | 9405.4   | 4 |
| 282A03 | 91.00  | 52.00  | 1600.00   | 5508.0    | 8637.4   | 4 |
| 282A04 | 140.00 | 71.60  | 2570.00   | 9093.7    | 9544.3   | 4 |
| 282A05 | 140.00 | 104.00 | 2690.00   | 7791.9    | 12847.2  | 4 |
| 282A06 | 156.00 | 111.00 | 2070.00   | 7187.2    | 14963.0  | 4 |
| 283A02 | 69.60  | 26.80  | 1530.00   | 5039.4    | 6433.1   | 4 |
| 283A03 | 72.00  | 28.90  | 1290.00   | 12073.5   | 7114.0   | 8 |
| 283A04 | 141.00 | 37.00  | 3010.00   | 8652.9    | 9250.5   | 4 |
| 283A05 | 110.00 | 44.20  | 1940.00   | 5705.0    | 10184.6  | 4 |
| 283A06 | 143.00 | 59.20  | 1580.00   | 5845.5    | 14114.3  | 1 |
| 284B02 | 189.00 | 158.00 | 2250.00   | 8475.5    | 15720.5  | 4 |
| 284B03 | 228.00 | 132.00 | 3540.00   | 87162.4   | 15656.0  | 8 |
| 284B04 | 8.56   | 11.10  | 86.50     | 476.8     | 519.3    | 7 |
| 284B05 | 0.00   | 6.56   | 8.05      | 88.2      | 1794.9   | 1 |
| 284B06 | 0.00   | 1.16   | 0.00      | 34.2      | 737.2    | 9 |
| 285A02 | 162.00 | 85.90  | 5410.00   | 16882.3   | 12475.9  | 7 |
| 285A03 | 508.00 | 200.00 | 13900.00  | 94203.7   | 25266.3  | 8 |
| 285A04 | 420.00 | 190.00 | 113000.00 | 1081231.0 | 802804.6 | 8 |
| 285A05 | 212.00 | 129.00 | 7960.00   | 43339.3   | 20343.5  | 8 |
| 286B02 | 158.00 | 80.40  | 4150.00   | 12441.3   | 12449.1  | 4 |
| 286B03 | 216.00 | 111.00 | 4730.00   | 19365.7   | 25449.7  | 7 |
| 286B04 | 324.00 | 183.00 | 14800.00  | 86266.6   | 25586.2  | 8 |
| 287B02 | 0.00   | 0.28   | 15.10     | 71.0      | 686.4    | 1 |
| 287B03 | 0.00   | 0.49   | 3.44      | 36.6      | 561.6    | 9 |
| 287B04 | 0.00   | 0.55   | 4.78      | 35.2      | 626.4    | 9 |
| 287B05 | 1.43   | 0.85   | 539.00    | 711.6     | 974.1    | 5 |
| 287B06 | 0.00   | 0.00   | 31.40     | 67.6      | 613.4    | 1 |
| 288B02 | 5.13   | 19.10  | 26.70     | 131.4     | 670.0    | 1 |
| 288B03 | 0.00   | 0.47   | 0.00      | 34.3      | 650.9    | 9 |
| 288B04 | 0.00   | 0.00   | 4.13      | 31.5      | 558.4    | 9 |

|        |        |        |         |         |         |   |
|--------|--------|--------|---------|---------|---------|---|
| 288B05 | 0.00   | 0.00   | 4.04    | 33.2    | 689.5   | 9 |
| 288B06 | 0.00   | 0.00   | 4.70    | 33.5    | 654.4   | 9 |
| 289A02 | 110.00 | 95.00  | 1900.00 | 8153.0  | 17742.7 | 7 |
| 289A03 | 14.80  | 21.20  | 184.00  | 904.6   | 2208.3  | 1 |
| 289A04 | 0.00   | 0.00   | 6.18    | 39.4    | 548.6   | 9 |
| 289A05 | 0.00   | 0.56   | 2.87    | 53.7    | 825.3   | 9 |
| 289A06 | 0.00   | 0.25   | 0.00    | 34.1    | 516.9   | 9 |
| 290B02 | 152.00 | 103.00 | 1520.00 | 7847.3  | 15334.3 | 7 |
| 290B03 | 3.74   | 8.03   | 22.30   | 97.8    | 1166.5  | 1 |
| 290B04 | 0.00   | 0.00   | 12.40   | 50.8    | 691.5   | 1 |
| 290B05 | 0.00   | 0.00   | 12.10   | 60.9    | 921.5   | 9 |
| 290B06 | 0.00   | 0.00   | 5.50    | 25.7    | 505.2   | 9 |
| 291A02 | 253.00 | 69.30  | 969.00  | 4922.0  | 10071.9 | 3 |
| 291A03 | 131.00 | 26.50  | 688.00  | 2845.0  | 6967.7  | 4 |
| 291A04 | 173.00 | 36.70  | 869.00  | 3265.6  | 11691.8 | 1 |
| 291A05 | 36.90  | 12.00  | 273.00  | 930.5   | 2486.2  | 4 |
| 291A06 | 0.00   | 3.77   | 8.56    | 38.4    | 569.8   | 1 |
| 295B02 | 67.00  | 22.80  | 2100.00 | 6095.0  | 5660.1  | 4 |
| 295B03 | 108.00 | 25.80  | 3380.00 | 9726.9  | 6195.7  | 4 |
| 295B04 | 123.00 | 32.30  | 3490.00 | 9369.6  | 7244.9  | 4 |
| 295B05 | 184.00 | 39.30  | 4480.00 | 13748.6 | 8338.0  | 4 |
| 295B06 | 159.00 | 41.10  | 4790.00 | 14207.9 | 8782.7  | 4 |
| 294A02 | 31.50  | 12.20  | 556.00  | 1365.0  | 2188.1  | 4 |
| 294A03 | 3.57   | 6.08   | 131.00  | 257.3   | 351.2   | 4 |
| 294A04 | 6.43   | 23.10  | 76.20   | 230.6   | 1407.4  | 4 |
| 294A05 | 8.65   | 14.10  | 51.90   | 200.2   | 1902.2  | 1 |
| 294A06 | 4.07   | 7.19   | 24.50   | 96.7    | 821.8   | 1 |
| 292C02 | 211.00 | 154.00 | 1720.00 | 5229.2  | 13974.4 | 1 |
| 292C03 | 118.00 | 113.00 | 852.00  | 4044.9  | 12737.4 | 1 |
| 292C04 | 197.00 | 176.00 | 1160.00 | 5479.9  | 14901.2 | 1 |
| 292C05 | 104.00 | 46.10  | 1840.00 | 7301.5  | 19306.1 | 7 |
| 292C06 | 118.00 | 45.30  | 2190.00 | 26350.7 | 32616.8 | 8 |
| 293A02 | 10.60  | 25.30  | 55.60   | 367.3   | 1763.1  | 1 |
| 293A03 | 0.00   | 1.75   | 11.90   | 37.0    | 287.4   | 1 |
| 293A04 | 0.00   | 0.00   | 0.00    | 10.2    | 203.1   | 9 |
| 293A06 | 0.00   | 0.00   | 1.78    | 6.3     | 66.9    | 1 |
| 296B02 | 57.10  | 38.80  | 1080.00 | 3973.1  | 7714.9  | 4 |
| 296B03 | 49.20  | 40.60  | 821.00  | 3165.9  | 6942.2  | 4 |
| 296B04 | 61.80  | 56.40  | 888.00  | 4029.9  | 6722.8  | 7 |
| 296B05 | 130.00 | 110.00 | 2060.00 | 13566.6 | 20442.5 | 8 |
| 296B06 | 183.00 | 142.00 | 4230.00 | 23385.6 | 36823.2 | 8 |
| UH1090 | 9.89   | 56.54  | 343.66  | 4148.1  | 36.5    | 6 |
| UH0190 | 3.56   | 28.05  | 63.44   | 1385.0  | 15.1    | 6 |
| UH1010 | 1.09   | 7.05   | 35.06   | 323.7   | 3.7     | 6 |
| UH1100 | 0.92   | 9.27   | 18.98   | 649.5   | 6.2     | 6 |
| UH1110 | 4.61   | 47.56  | 130.66  | 2975.3  | 31.1    | 6 |
| UH0220 | 4.20   | 29.29  | 93.38   | 1883.1  | 20.9    | 6 |
| UH1120 | 3.79   | 69.21  | 164.38  | 3867.1  | 49.2    | 6 |
| UH1130 | 6.33   | 62.38  | 178.10  | 4022.8  | 42.5    | 6 |
| NB1150 | 7.99   | 70.41  | 273.55  | 4666.4  | 44.9    | 6 |
| UH0300 | 0.59   | 3.41   | 111.82  | 343.4   | 3.2     | 3 |
| NB1090 | 13.32  | 126.93 | 769.62  | 13068.0 | 107.0   | 6 |
| RB0020 | 0.72   | 2.98   | 72.21   | 302.5   | 2.5     | 3 |
| NB1070 | 21.69  | 97.09  | 459.83  | 8314.6  | 71.5    | 6 |

|        |       |       |         |         |       |   |
|--------|-------|-------|---------|---------|-------|---|
| RB0070 | 0.82  | 3.84  | 13.76   | 301.2   | 2.6   | 6 |
| RB1050 | 0.82  | 4.92  | 41.07   | 375.8   | 4.2   | 6 |
| RB0100 | 0.87  | 3.56  | 33.94   | 288.6   | 2.8   | 6 |
| RB0110 | 0.80  | 3.16  | 9.87    | 239.0   | 2.5   | 6 |
| RB0120 | 0.46  | 1.11  | 3.31    | 262.7   | 1.2   | 6 |
| RB1060 | 0.03  | 3.57  | 19.50   | 496.4   | 3.8   | 6 |
| RB1080 | 0.52  | 1.03  | 64.37   | 129.9   | 0.9   | 4 |
| RB1070 | 0.60  | 2.62  | 6.38    | 341.3   | 1.9   | 6 |
| RB0160 | 3.16  | 22.90 | 62.27   | 1772.2  | 14.3  | 6 |
| RB0190 | 9.83  | 60.04 | 263.61  | 7525.4  | 64.8  | 6 |
| RB1160 | 3.19  | 28.36 | 86.44   | 2137.5  | 17.7  | 6 |
| RB1100 | 6.09  | 23.62 | 111.85  | 4834.1  | 24.3  | 6 |
| RB0240 | 10.14 | 58.62 | 195.36  | 4865.3  | 43.5  | 6 |
| RB1110 | 13.30 | 54.76 | 247.59  | 7500.7  | 41.5  | 6 |
| RB1120 | 7.18  | 37.73 | 148.14  | 4662.9  | 31.5  | 6 |
| RB0270 | 13.40 | 77.64 | 287.96  | 6962.6  | 56.4  | 6 |
| RB1140 | 12.87 | 65.31 | 237.79  | 7230.7  | 43.5  | 6 |
| RB0290 | 0.69  | 1.31  | 12.22   | 192.2   | 1.3   | 6 |
| RB1170 | 0.65  | 1.66  | 6.70    | 184.6   | 1.3   | 6 |
| RB0300 | 0.22  | 1.12  | 50.75   | 156.1   | 1.4   | 3 |
| RB0320 | 0.32  | 2.12  | 10.07   | 202.8   | 1.8   | 6 |
| RB0330 | 13.29 | 72.49 | 298.18  | 8225.0  | 55.6  | 6 |
| UH1020 | 3.50  | 26.29 | 54.90   | 1908.6  | 18.3  | 6 |
| UH1030 | 4.28  | 57.78 | 124.02  | 3865.8  | 36.0  | 6 |
| UH0030 | 6.98  | 77.19 | 217.23  | 5777.8  | 53.0  | 6 |
| UH0040 | 1.43  | 13.21 | 20.60   | 630.0   | 7.2   | 6 |
| UH1050 | 3.01  | 12.00 | 92.83   | 1433.1  | 11.3  | 6 |
| UH0140 | 8.27  | 61.14 | 181.60  | 4258.6  | 38.8  | 6 |
| UH1080 | 5.21  | 31.07 | 116.57  | 2859.1  | 22.4  | 6 |
| UH0180 | 6.18  | 47.79 | 176.52  | 3616.7  | 34.5  | 6 |
| JB0120 | 1.20  | 48.65 | 1469.36 | 29240.4 | 116.7 | 6 |
| JB0080 | 8.12  | 20.37 | 90.90   | 2588.4  | 20.1  | 6 |
| JB1010 | 12.99 | 40.41 | 223.66  | 4811.2  | 39.8  | 6 |
| JB0020 | 0.14  | 1.32  | 8.01    | 149.8   | 1.3   | 6 |
| JB1150 | 0.55  | 0.73  | 2.05    | 51.6    | 1.2   | 6 |
| JB1030 | 7.72  | 21.92 | 153.01  | 3318.1  | 16.7  | 6 |
| JB0150 | 11.88 | 36.05 | 122.64  | 4067.8  | 48.7  | 6 |
| JB1170 | 2.59  | 13.01 | 38.74   | 1270.2  | 9.8   | 6 |
| JB1040 | 1.77  | 5.92  | 22.43   | 472.9   | 5.1   | 6 |
| JB1060 | 8.96  | 44.63 | 122.27  | 3088.9  | 35.7  | 6 |
| JB1080 | 0.54  | 1.18  | 46.90   | 130.0   | 1.5   | 4 |
| JB0330 | 3.76  | 17.65 | 58.80   | 1315.9  | 12.4  | 6 |
| JB0310 | 0.20  | 1.44  | 4.07    | 85.2    | 1.4   | 6 |
| JB0180 | 7.85  | 35.11 | 151.12  | 4252.2  | 27.6  | 6 |
| JB0060 | 0.99  | 2.41  | 5.42    | 115.4   | 2.3   | 6 |
| JB1100 | 0.76  | 1.18  | 14.21   | 71.1    | 1.1   | 3 |
| JB1110 | 8.54  | 38.82 | 111.11  | 3733.3  | 63.8  | 6 |
| JB0220 | 0.78  | 2.71  | 7.04    | 148.6   | 2.0   | 6 |
| JB0260 | 0.45  | 1.72  | 7.94    | 116.6   | 2.0   | 6 |
| JB1190 | 0.50  | 0.99  | 2.31    | 61.7    | 0.8   | 6 |
| JB1120 | 0.64  | 1.38  | 3.04    | 82.8    | 1.3   | 6 |
| JB1200 | 0.25  | 1.43  | 8.91    | 74.3    | 2.5   | 3 |
| JB1130 | 0.86  | 0.57  | 4.55    | 108.3   | 3.2   | 6 |
| JB1140 | 0.94  | 4.07  | 9.44    | 240.1   | 2.6   | 6 |

|        |       |        |         |         |       |   |
|--------|-------|--------|---------|---------|-------|---|
| JB0390 | 0.14  | 12.61  | 40.20   | 1001.9  | 7.9   | 6 |
| RB1010 | 3.34  | 21.31  | 55.89   | 1452.2  | 15.0  | 6 |
| JB0410 | 6.58  | 29.21  | 106.79  | 2240.8  | 24.0  | 6 |
| JB0420 | 0.44  | 0.97   | 2.41    | 27.4    | 0.9   | 3 |
| RB0010 | 0.25  | 3.98   | 32.20   | 239.5   | 2.6   | 6 |
| JB0430 | 2.94  | 14.02  | 33.08   | 817.9   | 8.5   | 6 |
| RB1020 | 0.71  | 2.03   | 10.43   | 146.7   | 2.7   | 6 |
| RB1030 | 0.51  | 0.79   | 3.75    | 36.2    | 0.7   | 3 |
| RB1040 | 2.14  | 12.99  | 36.70   | 946.4   | 12.1  | 6 |
| UH0080 | 2.46  | 15.41  | 25.00   | 520.6   | 7.5   | 6 |
| UH0100 | 6.01  | 49.64  | 250.15  | 2416.8  | 48.5  | 6 |
| UH0110 | 2.94  | 9.95   | 15.66   | 890.2   | 5.6   | 6 |
| UH0200 | 15.80 | 87.79  | 332.67  | 6455.2  | 48.8  | 6 |
| UH0230 | 5.60  | 24.83  | 81.39   | 1677.9  | 21.3  | 6 |
| UH0260 | 2.66  | 17.75  | 26.77   | 513.0   | 9.3   | 6 |
| UH1140 | 1.22  | 6.06   | 20.63   | 481.4   | 4.2   | 6 |
| UH0290 | 0.25  | 2.22   | 4.35    | 73.1    | 1.5   | 6 |
| UH1040 | 1.14  | 3.19   | 15.01   | 827.8   | 3.7   | 6 |
| UH1070 | 12.87 | 59.90  | 180.67  | 4936.2  | 36.8  | 6 |
| UH1060 | 1.20  | 6.43   | 14.37   | 559.5   | 4.3   | 6 |
| 2800   | 10.50 | 23.20  | 469.00  | 5373.5  | 127.0 | 6 |
| 2000   | 5.60  | 41.00  | 490.00  | 2520.3  | 62.9  | 3 |
| 2100   | 5.80  | 140.00 | 430.00  | 3047.4  | 175.2 | 3 |
| 1600   | 5.00  | 6.80   | 390.00  | 1077.9  | 28.7  | 4 |
| 2300   | 5.00  | 3.60   | 20.00   | 132.9   | 15.5  | 4 |
| 2200   | 5.00  | 49.00  | 320.00  | 1858.9  | 70.1  | 3 |
| 2400   | 5.00  | 4.40   | 28.00   | 167.1   | 15.3  | 4 |
| 2500   | 12.70 | 19.70  | 752.00  | 5596.5  | 144.2 | 3 |
| 85A00  | 59.00 | 120.00 | 1600.00 | 17987.0 | 337.3 | 6 |
| 2900   | 20.00 | 29.60  | 676.00  | 7882.4  | 169.9 | 6 |
| 3000   | 15.50 | 33.40  | 743.00  | 7558.9  | 212.1 | 6 |
| 2600   | 18.00 | 370.00 | 1200.00 | 9665.2  | 578.1 | 3 |
| 2700   | 13.50 | 21.10  | 1700.00 | 7391.5  | 198.3 | 3 |
| 3300   | 15.10 | 30.80  | 717.00  | 7560.9  | 185.2 | 6 |
| 86A00  | 35.00 | 20.00  | 500.00  | 6879.2  | 107.6 | 6 |
| 63A00  | 15.00 | 26.00  | 540.00  | 5406.3  | 109.1 | 6 |
| 3200   | 23.80 | 21.00  | 481.00  | 5984.0  | 116.8 | 6 |
| 3100   | 9.50  | 92.00  | 970.00  | 5231.2  | 106.6 | 3 |
| 3400   | 9.10  | 22.40  | 332.00  | 5157.2  | 83.5  | 6 |
| 3700   | 13.30 | 27.70  | 665.00  | 7032.4  | 142.8 | 6 |
| 65A00  | 16.00 | 25.00  | 440.00  | 4653.0  | 96.9  | 6 |
| 3500   | 5.00  | 8.47   | 271.00  | 1833.5  | 62.8  | 3 |
| 64A00  | 19.00 | 25.00  | 600.00  | 5680.2  | 93.2  | 6 |
| 3600   | 9.70  | 66.00  | 640.00  | 5266.0  | 96.0  | 3 |
| 3800   | 8.27  | 17.30  | 282.00  | 3986.2  | 89.2  | 6 |
| 3900   | 8.12  | 17.50  | 371.00  | 3823.5  | 296.5 | 3 |
| 4000   | 8.01  | 19.00  | 347.00  | 4035.9  | 87.0  | 6 |
| 68A00  | 14.00 | 21.00  | 450.00  | 4589.6  | 76.8  | 6 |
| 4100   | 5.00  | 5.43   | 62.20   | 1038.4  | 24.1  | 6 |
| 69A00  | 9.30  | 16.00  | 230.00  | 2868.2  | 46.6  | 6 |
| 71A00  | 0.00  | 1.30   | 16.00   | 173.6   | 0.6   | 6 |
| 70A00  | 5.30  | 5.70   | 110.00  | 1089.2  | 97.1  | 3 |
| 4400   | 15.40 | 35.10  | 538.00  | 7770.4  | 142.8 | 6 |
| 72A00  | 17.00 | 25.00  | 410.00  | 5845.5  | 92.0  | 6 |

|        |       |       |         |         |        |   |
|--------|-------|-------|---------|---------|--------|---|
| 89A00  | 2.30  | 2.50  | 27.00   | 893.6   | 4.7    | 6 |
| 5100   | 8.10  | 24.30 | 261.00  | 4182.4  | 74.7   | 6 |
| 1700   | 3.10  | 29.00 | 310.00  | 1801.3  | 45.0   | 3 |
| 42A00  | 0.00  | 7.20  | 91.00   | 1096.3  | 23.6   | 6 |
| 5700   | 1.20  | 9.50  | 44.00   | 646.1   | 7.8    | 6 |
| 4900   | 13.20 | 23.60 | 383.00  | 5759.5  | 85.7   | 6 |
| 87A00  | 31.00 | 9.00  | 510.00  | 3917.1  | 55.5   | 3 |
| 5400   | 12.50 | 35.90 | 436.00  | 6307.9  | 103.6  | 6 |
| 47A00  | 22.00 | 20.00 | 287.00  | 3460.9  | 62.9   | 6 |
| 48A00  | 0.00  | 4.50  | 44.00   | 2542.5  | 1.6    | 6 |
| 5600   | 6.40  | 56.00 | 330.00  | 5910.6  | 58.0   | 6 |
| 5500   | 10.60 | 19.90 | 493.00  | 4682.7  | 102.2  | 6 |
| 49A00  | 5.60  | 1.40  | 78.00   | 1851.9  | 11.8   | 6 |
| 88A00  | 2.80  | 3.80  | 69.00   | 925.0   | 10.7   | 6 |
| 44A00  | 8.70  | 17.00 | 207.00  | 2958.7  | 43.9   | 6 |
| 4800   | 21.90 | 39.50 | 572.00  | 9824.5  | 110.8  | 6 |
| 84B00  | 4.80  | 6.20  | 390.00  | 5815.9  | 19.0   | 6 |
| 4600   | 5.00  | 7.04  | 169.00  | 2135.0  | 29.9   | 6 |
| 51A00  | 6.60  | 13.00 | 120.00  | 943.6   | 16.1   | 6 |
| 56A00  | 16.00 | 22.00 | 264.00  | 4797.3  | 49.0   | 6 |
| 55A00  | 52.00 | 59.00 | 616.00  | 6832.4  | 137.8  | 6 |
| 59A00  | 55.00 | 70.00 | 512.00  | 9156.0  | 129.0  | 6 |
| 01A00  | 6.20  | 75.00 | 341.00  | 8531.6  | 57.3   | 6 |
| 02A00  | 6.30  | 21.00 | 78.00   | 2177.8  | 12.7   | 6 |
| 03A00  | 7.70  | 7.30  | 300.00  | 3050.7  | 17.5   | 6 |
| 73B00  | 1.70  | 0.70  | 18.00   | 219.1   | 1.8    | 6 |
| 05A00  | 36.00 | 17.00 | 485.00  | 7168.0  | 114.0  | 6 |
| 05A00  | 36.00 | 17.00 | 485.00  | 7168.0  | 114.0  | 6 |
| 74A00  | 20.00 | 12.00 | 650.00  | 6475.7  | 127.6  | 6 |
| 74A00  | 20.00 | 12.00 | 650.00  | 6475.7  | 127.6  | 6 |
| 06A00  | 0.00  | 2.40  | 33.00   | 453.4   | 12.8   | 6 |
| 28A00  | 15.00 | 18.00 | 520.00  | 4363.1  | 98.3   | 3 |
| 1200   | 1.80  | 10.00 | 180.00  | 1586.1  | 14.4   | 6 |
| 1300   | 5.00  | 5.50  | 70.00   | 654.4   | 16.7   | 6 |
| 1400   | 14.00 | 89.00 | 1500.00 | 8350.6  | 131.4  | 3 |
| 08A00  | 5.40  | 7.20  | 160.00  | 3082.5  | 29.4   | 6 |
| 0100   | 4.20  | 71.00 | 210.00  | 2594.4  | 118.6  | 6 |
| 1500   | 5.00  | 2.90  | 48.00   | 207.3   | 15.6   | 4 |
| 09A00  | 16.40 | 14.30 | 298.00  | 3818.2  | 154.4  | 6 |
| SR600  | 42.00 | 45.00 | 1800.00 | 16417.0 | 721.9  | 3 |
| SR500  | 38.00 | 30.00 | 1600.00 | 13818.0 | 685.5  | 3 |
| SR100  | 34.00 | 29.00 | 1700.00 | 12318.3 | 666.8  | 6 |
| SR200  | 30.00 | 35.00 | 1300.00 | 12585.0 | 573.9  | 3 |
| SR700  | 37.00 | 38.00 | 1600.00 | 14600.0 | 707.9  | 3 |
| SR300  | 32.00 | 28.00 | 1200.00 | 11254.0 | 478.6  | 3 |
| SR800  | 36.00 | 36.00 | 1565.00 | 14249.3 | 711.8  | 3 |
| SR400  | 30.00 | 26.00 | 1200.00 | 12053.9 | 1061.5 | 3 |
| SR900  | 30.00 | 29.00 | 1300.00 | 11874.0 | 765.8  | 3 |
| SR1000 | 33.00 | 32.00 | 1400.00 | 12611.4 | 498.3  | 3 |
| 0200   | 5.00  | 21.00 | 60.00   | 820.6   | 47.6   | 3 |
| 75A00  | 34.00 | 28.00 | 1800.00 | 13785.0 | 480.5  | 3 |
| 10A00  | 33.00 | 28.00 | 900.00  | 8193.0  | 702.6  | 3 |
| HP600  | 25.00 | 23.00 | 1400.00 | 13245.5 | 377.9  | 6 |
| HP500  | 40.00 | 36.00 | 2000.00 | 14341.0 | 667.6  | 3 |

|        |       |        |         |         |         |   |
|--------|-------|--------|---------|---------|---------|---|
| HP100  | 41.00 | 38.00  | 2000.00 | 15575.0 | 808.9   | 3 |
| HP200  | 46.00 | 38.00  | 1700.00 | 14682.0 | 761.7   | 3 |
| HP700  | 41.00 | 39.00  | 3000.00 | 17397.0 | 712.9   | 3 |
| HP300  | 37.00 | 31.00  | 3000.00 | 15974.2 | 1715.5  | 3 |
| HP400  | 8.60  | 7.20   | 340.00  | 3292.3  | 134.0   | 6 |
| HP800  | 24.00 | 23.00  | 1100.00 | 9430.1  | 503.7   | 3 |
| HP900  | 21.00 | 20.00  | 760.00  | 7064.4  | 380.4   | 3 |
| HP1000 | 13.00 | 14.00  | 410.00  | 5528.0  | 186.7   | 6 |
| 76A00  | 2.80  | 1.80   | 50.00   | 509.8   | 26.5    | 3 |
| 276A00 | 34.70 | 36.90  | 0.00    | 9679.4  | 426.2   | 6 |
| 277B00 | 24.20 | 29.70  | 0.00    | 7880.8  | 325.1   | 6 |
| 278B00 | 19.70 | 25.80  | 0.00    | 7119.3  | 1631.7  | 3 |
| 273A00 | 57.50 | 78.40  | 0.00    | 23208.2 | 6839.0  | 3 |
| 274A00 | 37.10 | 45.30  | 0.00    | 12001.5 | 524.5   | 6 |
| 275A00 | 31.30 | 31.30  | 0.00    | 9579.1  | 376.7   | 6 |
| IS100  | 5.40  | 1.60   | 150.00  | 1830.8  | 13.3    | 6 |
| IS200  | 4.10  | 1.70   | 80.00   | 798.3   | 7.2     | 6 |
| IS300  | 9.80  | 3.80   | 270.00  | 2824.9  | 23.9    | 6 |
| IS700  | 5.60  | 2.10   | 110.00  | 1539.1  | 10.2    | 6 |
| IS400  | 7.20  | 2.20   | 190.00  | 2228.9  | 15.2    | 6 |
| IS500  | 12.00 | 2.30   | 300.00  | 2500.3  | 21.5    | 3 |
| IS600  | 7.50  | 1.80   | 170.00  | 1902.4  | 15.7    | 6 |
| IS800  | 16.00 | 5.40   | 420.00  | 5188.2  | 41.4    | 6 |
| IS900  | 14.00 | 5.90   | 400.00  | 7158.9  | 43.6    | 6 |
| IS1000 | 16.00 | 5.10   | 480.00  | 4884.1  | 39.3    | 6 |
| 296B00 | 43.60 | 40.70  | 0.00    | 11108.6 | 532.4   | 3 |
| 270A00 | 24.60 | 30.80  | 0.00    | 5738.9  | 437.5   | 6 |
| 271A00 | 7.14  | 11.70  | 0.00    | 1316.1  | 91.9    | 6 |
| 272A00 | 16.90 | 20.10  | 0.00    | 4187.4  | 186.4   | 6 |
| 0300   | 2.20  | 160.00 | 770.00  | 7154.9  | 338.2   | 3 |
| 269C00 | 19.10 | 23.50  | 0.00    | 7048.9  | 446.7   | 6 |
| 267A00 | 23.10 | 34.90  | 0.00    | 3487.1  | 644.9   | 3 |
| 268B00 | 24.70 | 27.40  | 0.00    | 8026.4  | 780.1   | 6 |
| 264A00 | 8.00  | 7.60   | 0.00    | 2146.1  | 84.6    | 6 |
| 266A00 | 18.50 | 27.20  | 0.00    | 6270.5  | 257.0   | 6 |
| 33A00  | 2.80  | 4.00   | 130.00  | 1754.2  | 8.8     | 6 |
| 263B00 | 27.90 | 51.10  | 0.00    | 7083.8  | 487.6   | 6 |
| 262A00 | 5.20  | 10.30  | 0.00    | 895.5   | 70.4    | 6 |
| 261C00 | 2.53  | 3.01   | 0.00    | 335.6   | 27.9    | 6 |
| 260B00 | 21.40 | 23.50  | 0.00    | 7115.0  | 305.2   | 6 |
| 259B00 | 38.60 | 55.70  | 0.00    | 18334.1 | 5668.4  | 3 |
| 258C00 | 32.10 | 35.40  | 0.00    | 8561.3  | 351.8   | 6 |
| 224A00 | 49.50 | 56.50  | 0.00    | 28591.4 | 13630.8 | 8 |
| 221A00 | 19.50 | 38.60  | 0.00    | 3656.8  | 259.5   | 3 |
| 227A00 | 53.70 | 82.80  | 0.00    | 16405.1 | 1414.1  | 6 |
| 223A00 | 31.30 | 30.20  | 0.00    | 8426.0  | 464.6   | 6 |
| 220A00 | 27.30 | 32.30  | 0.00    | 8583.5  | 314.1   | 6 |
| 95A00  | 22.00 | 18.00  | 1300.00 | 4986.1  | 251.9   | 4 |
| 8A00   | 12.00 | 230.00 | 1800.00 | 14110.1 | 571.2   | 3 |
| 222A00 | 46.50 | 38.30  | 0.00    | 11082.5 | 396.0   | 3 |
| 294A00 | 78.40 | 52.50  | 0.00    | 13542.4 | 2053.7  | 3 |
| 230A00 | 31.60 | 33.40  | 0.00    | 7086.4  | 438.6   | 3 |
| 219A00 | 21.70 | 29.40  | 0.00    | 5172.8  | 374.1   | 6 |
| 8B00   | 9.20  | 170.00 | 1200.00 | 11272.6 | 382.0   | 3 |



|        |        |        |         |          |        |   |
|--------|--------|--------|---------|----------|--------|---|
| 7A00   | 19.00  | 170.00 | 1200.00 | 9908.3   | 473.1  | 3 |
| 225A00 | 36.50  | 35.70  | 0.00    | 8820.9   | 403.1  | 6 |
| 229A00 | 36.20  | 37.60  | 0.00    | 9959.3   | 377.5  | 6 |
| 7B00   | 9.50   | 170.00 | 1300.00 | 10477.2  | 450.1  | 3 |
| 228B00 | 28.70  | 37.80  | 0.00    | 7616.7   | 308.0  | 6 |
| 218A00 | 94.10  | 47.70  | 0.00    | 14886.0  | 583.8  | 3 |
| 284B00 | 50.90  | 48.70  | 0.00    | 11439.7  | 479.1  | 3 |
| 257C00 | 38.10  | 49.90  | 0.00    | 10840.8  | 536.9  | 6 |
| 256B00 | 28.40  | 40.10  | 0.00    | 12120.1  | 447.0  | 6 |
| 21A00  | 21.60  | 191.00 | 1630.00 | 8541.7   | 386.9  | 3 |
| 93A00  | 57.00  | 33.00  | 2900.00 | 22277.0  | 445.0  | 3 |
| 22A00  | 33.00  | 26.00  | 1140.00 | 7241.1   | 316.9  | 3 |
| 255A00 | 28.50  | 36.40  | 0.00    | 8062.8   | 394.6  | 6 |
| 94A00  | 56.00  | 31.00  | 2200.00 | 12975.8  | 375.2  | 3 |
| 217A00 | 55.80  | 46.30  | 0.00    | 33316.6  | 805.4  | 1 |
| 233C00 | 10.60  | 4.57   | 0.00    | 1059.8   | 42.0   | 6 |
| 19A00  | 52.00  | 30.00  | 1130.00 | 12488.0  | 488.6  | 6 |
| 61A00  | 35.00  | 30.00  | 3015.00 | 15591.0  | 862.8  | 3 |
| 18A00  | 71.00  | 110.00 | 2150.00 | 23333.0  | 971.4  | 6 |
| 7C00   | 34.00  | 230.00 | 2000.00 | 13968.9  | 757.5  | 3 |
| 286B00 | 56.90  | 46.30  | 0.00    | 12954.2  | 903.7  | 3 |
| 232A00 | 29.30  | 30.20  | 0.00    | 11160.7  | 336.0  | 6 |
| 285A00 | 430.00 | 70.60  | 0.00    | 46265.6  | 7532.1 | 4 |
| 77A00  | 780.00 | 150.00 | 0.00    | 172669.0 | 4155.3 | 3 |
| 17A00  | 38.00  | 54.00  | 2420.00 | 14237.0  | 605.8  | 3 |
| 231A00 | 29.50  | 40.10  | 0.00    | 6700.8   | 404.9  | 6 |
| 283A00 | 37.10  | 23.70  | 0.00    | 8511.7   | 394.5  | 3 |
| 60A00  | 48.00  | 28.00  | 1900.00 | 11531.0  | 459.8  | 3 |
| 293A00 | 8.32   | 13.20  | 0.00    | 1932.0   | 55.4   | 6 |
| 216A00 | 38.00  | 31.70  | 0.00    | 9028.9   | 439.7  | 3 |
| 16A00  | 14.00  | 24.00  | 606.00  | 4004.4   | 175.2  | 3 |
| 282A00 | 37.80  | 40.30  | 0.00    | 10408.6  | 529.2  | 6 |
| 0600   | 5.00   | 27.00  | 160.00  | 1647.8   | 65.8   | 3 |
| WA100  | 38.00  | 16.00  | 960.00  | 7310.1   | 196.1  | 3 |
| WA200  | 28.00  | 43.00  | 1200.00 | 9294.9   | 1211.6 | 3 |
| WA400  | 32.00  | 24.00  | 920.00  | 7912.4   | 243.7  | 3 |
| WA300  | 20.00  | 26.00  | 640.00  | 6580.5   | 272.7  | 3 |
| WA500  | 3.10   | 2.10   | 71.00   | 613.5    | 17.9   | 3 |
| WA600  | 19.00  | 13.00  | 600.00  | 5018.2   | 244.7  | 3 |
| WA800  | 37.00  | 19.00  | 930.00  | 8583.2   | 431.6  | 3 |
| WA700  | 10.00  | 8.00   | 310.00  | 3048.7   | 98.6   | 3 |
| WA900  | 9.80   | 7.20   | 320.00  | 2598.5   | 145.2  | 3 |
| 236A00 | 47.00  | 63.40  | 0.00    | 13844.7  | 1100.1 | 6 |
| 295B00 | 40.30  | 20.80  | 0.00    | 7982.0   | 277.2  | 3 |
| 15A00  | 22.00  | 14.90  | 394.00  | 4731.8   | 130.4  | 6 |
| 235A00 | 37.30  | 44.90  | 0.00    | 11700.2  | 714.2  | 6 |
| WA1000 | 35.00  | 26.00  | 1300.00 | 10459.9  | 449.5  | 3 |
| 23A00  | 44.00  | 49.00  | 1240.00 | 21305.0  | 912.4  | 6 |
| 234B00 | 25.00  | 43.50  | 0.00    | 6492.2   | 401.0  | 6 |
| 287B00 | 5.94   | 3.44   | 0.00    | 1297.5   | 51.8   | 6 |
| 0900   | 5.00   | 15.00  | 93.00   | 1089.0   | 99.0   | 3 |
| 34A00  | 27.00  | 27.00  | 1300.00 | 6588.0   | 210.7  | 3 |
| 254A00 | 17.70  | 25.40  | 0.00    | 5899.7   | 259.5  | 6 |
| 253A00 | 32.50  | 36.40  | 0.00    | 8168.1   | 346.0  | 6 |

|        |        |        |         |         |        |   |
|--------|--------|--------|---------|---------|--------|---|
| 215B00 | 47.50  | 47.20  | 0.00    | 9183.1  | 335.2  | 3 |
| 252C00 | 24.30  | 32.90  | 0.00    | 7111.9  | 253.4  | 6 |
| 214A00 | 42.80  | 63.20  | 0.00    | 7790.4  | 272.9  | 3 |
| 213A00 | 46.60  | 64.40  | 0.00    | 18403.8 | 1160.3 | 6 |
| 288B00 | 4.44   | 14.70  | 0.00    | 655.5   | 21.2   | 6 |
| 12A00  | 58.00  | 55.00  | 2040.00 | 11197.0 | 650.7  | 3 |
| 91A00  | 78.00  | 21.00  | 1400.00 | 5955.0  | 207.1  | 3 |
| 0500   | 9.40   | 190.00 | 1300.00 | 11103.1 | 547.2  | 3 |
| 239A00 | 33.00  | 41.60  | 0.00    | 9220.8  | 374.5  | 6 |
| 238A00 | 39.60  | 50.60  | 0.00    | 12057.7 | 501.1  | 6 |
| 251B00 | 27.40  | 33.60  | 0.00    | 7479.7  | 347.2  | 6 |
| 250A00 | 1.48   | 0.31   | 0.00    | 62.4    | 3.8    | 6 |
| 289A00 | 50.60  | 66.80  | 0.00    | 18312.1 | 640.3  | 6 |
| 0400   | 5.00   | 16.00  | 71.00   | 515.3   | 39.2   | 3 |
| 290B00 | 49.60  | 66.10  | 0.00    | 20328.8 | 920.9  | 6 |
| 210A00 | 21.40  | 36.70  | 0.00    | 4226.3  | 153.0  | 6 |
| 14A00  | 33.00  | 34.00  | 1180.00 | 10307.6 | 861.0  | 3 |
| 242A00 | 33.80  | 28.20  | 0.00    | 8203.8  | 350.5  | 3 |
| 211B00 | 37.20  | 56.70  | 0.00    | 14350.8 | 642.5  | 6 |
| 291A00 | 173.00 | 134.00 | 0.00    | 14088.5 | 464.6  | 6 |
| 212A00 | 42.50  | 69.30  | 0.00    | 9872.2  | 420.8  | 3 |
| 292C00 | 39.70  | 54.80  | 0.00    | 11417.2 | 409.8  | 6 |
| 245B00 | 33.60  | 46.10  | 0.00    | 8121.0  | 399.0  | 6 |
| 241A00 | 25.00  | 32.10  | 0.00    | 5588.7  | 296.7  | 6 |
| 248A00 | 27.90  | 28.30  | 0.00    | 10909.9 | 306.1  | 6 |
| 244A00 | 27.60  | 38.80  | 0.00    | 8162.1  | 435.9  | 6 |
| 92A00  | 31.00  | 21.00  | 1200.00 | 10331.0 | 351.1  | 3 |
| 240A00 | 78.60  | 104.00 | 0.00    | 39362.3 | 9940.1 | 3 |
| 247A00 | 3.28   | 7.94   | 0.00    | 460.8   | 42.7   | 6 |
| 13A00  | 28.00  | 22.00  | 764.00  | 28565.7 | 521.5  | 6 |
| 243A00 | 46.30  | 46.60  | 0.00    | 14837.1 | 726.9  | 6 |
| 246A00 | 19.00  | 18.50  | 0.00    | 1195.5  | 41.4   | 6 |
| 97B00  | 43.00  | 33.00  | 2100.00 | 10123.5 | 287.2  | 3 |
| 207A00 | 38.20  | 57.70  | 0.00    | 9016.6  | 386.8  | 6 |
| 208A00 | 28.00  | 29.10  | 0.00    | 8750.8  | 286.6  | 6 |
| 209B00 | 38.50  | 37.00  | 0.00    | 7787.8  | 323.7  | 3 |
| 204A00 | 29.00  | 38.60  | 0.00    | 7544.6  | 249.6  | 6 |
| 205A00 | 30.40  | 35.00  | 0.00    | 8780.9  | 275.8  | 6 |
| 206A00 | 46.50  | 43.80  | 0.00    | 9151.1  | 360.1  | 6 |
| 100A00 | 29.00  | 56.00  | 1400.00 | 8957.5  | 194.4  | 3 |
| 1800   | 5.00   | 3.50   | 76.00   | 263.1   | 15.3   | 4 |
| 62A00  | 190.00 | 29.00  | 1500.00 | 8917.0  | 536.0  | 3 |
| 1000   | 29.00  | 220.00 | 2100.00 | 11450.2 | 562.4  | 3 |
| 96A00  | 64.00  | 25.00  | 2400.00 | 14153.5 | 2017.3 | 3 |
| 201A00 | 28.10  | 36.30  | 0.00    | 9062.4  | 253.8  | 6 |
| 202F00 | 31.20  | 31.10  | 0.00    | 8468.6  | 293.8  | 6 |
| 202B00 | 30.00  | 28.30  | 0.00    | 10008.9 | 327.8  | 6 |
| 203A00 | 36.10  | 38.70  | 0.00    | 7509.1  | 342.0  | 3 |
| 1100   | 30.00  | 220.00 | 2100.00 | 12870.9 | 410.6  | 3 |
| 35A00  | 38.00  | 36.00  | 1860.00 | 9488.1  | 308.1  | 3 |
| 35A00  | 38.00  | 36.00  | 1860.00 | 9488.1  | 308.1  | 3 |
| 99A00  | 18.00  | 18.00  | 1000.00 | 5026.7  | 131.6  | 3 |
| 98A00  | 11.00  | 5.00   | 600.00  | 2105.0  | 43.5   | 4 |
| 83A00  | 14.00  | 13.00  | 250.00  | 2773.6  | 40.1   | 6 |

|       |       |       |         |        |       |   |
|-------|-------|-------|---------|--------|-------|---|
| 1900  | 5.00  | 5.50  | 180.00  | 452.4  | 21.2  | 4 |
| 82A00 | 15.00 | 14.00 | 700.00  | 3723.1 | 122.9 | 3 |
| 26A00 | 14.90 | 16.40 | 1430.00 | 4502.0 | 163.8 | 4 |
| 81A00 | 11.00 | 14.00 | 370.00  | 3600.2 | 156.7 | 3 |

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