CHAPTER 3.F

WATER QUALITY

A. INTRODUCTION

This chapter first provides a general description of the current New York State Department of Environmental Conservation (NYSDEC) use classifications for the primary surface waterbodies in and around New York City, then describes the water quality standards for each classification and whether the primary waterbodies meet these standards. While Chapter 3.E, "Water Supply," describes the concerns and issues related to drinking water supply, this chapter addresses the potential impacts on the water quality in larger waterbodies, rivers, ponds, and streams that support aquatic life. This general description is then followed by specific information on water quality conditions within each representative study area where available, and an assessment of potential effects to water quality within the representative study areas and the primary surface waterbodies of the City from the application of the mosquito adulticides under the *Mosquito-Borne Disease Control Program.*

B. EXISTING CONDITIONS

USE CLASSIFICATIONS OF MAJOR NEW YORK CITY SURFACE WATERS

Water quality within the waters surrounding New York City that comprise the New York Harbor has been monitored for about 90 years. The New York City Department of Environmental Protection (NYCDEP) conducts an annual survey of water quality in New York Harbor by collecting water samples at 53 stations that have been established in four designated regions: the Inner Harbor Area, the Upper East River-Western Long Island Sound, the Lower New York Bay-Raritan Bay, and Jamaica Bay. As part of this monitoring program, NYCDEP collects samples to evaluate water quality, sediment characteristics, hydrology, phytoplankton, and macroinvertebrates two to four times in the summer months, with additional sampling events in October, February, March, and April. NYCDEP records water quality parameters such as temperature, salinity, density, dissolved oxygen (DO), water clarity, pH, total suspended solids (TSS), nutrients, chlorophyll a, plankton and coliforms. NYCDEP (1999) summarizes the results of the current survey as well as trends in the parameters over the monitoring period for the program. This monitoring program does not include monitoring for the active ingredients in New York State registered adulticides.

6 NYSCRR (Official Compilation of Codes, Rules, and Regulations of the State of New York) Part 703 presents the surface water standards for each use classification assigned to the State's surface waters. Table 3.F-1 presents selected standards for the use classifications that apply to waters in and around New York City that relate to the water quality parameters measured as part of the New York Harbor Water Quality Survey.

Table 3.F-1
NYSDEC Standards for Fresh and Saline Waters Found Within New York City

Class	Definition	Fecal Coliform	Total Coliform # of Colonies/100mL	DO (never less than) mg/L	PH	Malathion µg/L
SA	Saline surface waters—best usages are shellfishing for market purposes, primary and secondary contact recreation and fishing. Water quality should be suitable for fish propagation and survival.	No standard.	The median most probable number (MPN) value in any series of representative samples shall not be greater than 70.	5.0	The normal range shall not be extended by more than 0.1 of a pH unit.	0.1
SB	Saline surface waters—best usages are primary and secondary contact recreation and fishing. Waters should be suitable for fish propagation and survival.	Monthly geometric mean less than or equal to 200 colonies/100 mL from five or more samples.	The monthly median value and more than 20 percent of the samples, from a minimum of 5 examinations, shall not exceed 2,400 and 5,000, respectively.	5.0	The normal range shall not be extended by more than 0.1 of a pH unit.	0.1
SC	Saline surface waters—best usage is for fishing and primary and secondary contact recreation. Water quality should support fish propagation and survival.	Monthly geometric mean less than or equal to 200 colonies/100 mL from five or more samples.	The monthly median value and more than 20 percent of the samples, from a minimum of 5 examinations, shall not exceed 2,400 and 5,000, respectively.	5.0	The normal range shall not be extended by more than 0.1 of a pH unit.	0.1
I	Saline surface waters—best usages are secondary contact recreation and fishing. Water quality should be suitable for fish propagation and survival.	Monthly geometric mean less than or equal to 2,000 colonies/100 mL from 5 or more samples.	The monthly geometric mean from a minimum of 5 examinations shall not exceed 10,000.	4.0	The normal range shall not be extended by more than 0.1 of a pH unit.	No Standard
SD	Saline surface waters—best usage is fishing. Water quality should be suitable for fish survival.	No standard.	No standard for Class SD.	3.0	The normal range shall not be extended by more than 0.1 of a pH unit.	No Standard
AA	Fresh surface waters—best usages are for drinking, water supply, primary and secondary contact recreation, and fishing. Water quality should be suitable for fish propagation and survival.	No standard.	The monthly median value and more than 20 percent of the samples from a minimum of 5 examinations, shall not exceed 50 and 240, respectively.	For non-trout waters, the minimum daily average shall not be less than 5.0 mg/L, and shall never be less than 4.0 mg/L.	The normal range shall not be extended by more than 0.1 of a pH unit	0.1
B	Fresh surface waters—best usages are primary and secondary recreation and fishing. Water quality should be suitable for fish propagation and survival.	Monthly geometric mean less than or equal to 200 colonies/100 mL from 5 or more samples.	The monthly median value and more than 20 percent of the samples from a minimum of 5 examinations, shall not exceed 2,400 and 5,000, respectively.	Minimum daily average shall not be less than 5.0 mg/L, and shall never be less than 4 mg/L.	The normal range shall not be extended by more than 0.1 of a pH unit.	0.1

The results of the New York Harbor Water Quality Survey (NYCDEP, 1998a, 1999) suggest that the water quality of New York Harbor has improved significantly since the 1970s as a result of many measures undertaken by the City that include: eliminating raw dry-weather sewage discharges; reducing illegal discharges; increasing the capture of wet-weather related floatables; and reducing the toxic metals loadings from industrial sources.

The Hudson Raritan Estuary still receives pollutant loadings from numerous municipal and industrial wastewater sources in addition to non-point runoff originating within the watershed. Out of the approximately 27,000 cubic feet per second of freshwater inflow to the estuary, approximately 81 percent comes from tributaries, approximately 15 percent from municipal point sources, approximately 4 percent from the more than 1,000 stormwater outfalls, 1 percent from the approximately 650 combined sewer overflows (CSOs), and 0.3 percent from the approximately 400 direct industrial discharges (Hydroqual, Inc., 1991 in NYCDEP, 1998a). These nontributary sources represent a flow of 5,300 cubic feet per second (NYCDEP, 1998a).

Stormwater runoff from impervious surfaces, such as the streets, parking lots, buildings and houses of urban and suburban areas contains a variety of pollutants. NYCDEP has estimated that approximately 48 percent of the storm water flow to the Harbor comes from New Jersey, 18 percent from Westchester County, 11 percent from New York City and the remainder from upstream. In addition to the stormwater collected and discharged through the stormwater collection system, somewhere between 70 and 80 percent of the City's approximately 6,300 miles of sewers are combined sewers—carrying sewage and industrial waste during dry weather, and rainwater and surface runoff plus wastewater when it rains (Gaffoglio, 1990 in NYCDEP, 1998a). When this combined flow exceeds the hydraulic capacity of the Water Pollution Control Plants (WPCPs) it is discharged directly to the Harbor, and the excess flow beyond capacity is discharged directly, causing a temporary degradation of water quality (NYCDEP, 1998a).

The following sections provide a brief summary of the water quality conditions in the four sampling regions of the New York Harbor Water Quality Survey. Where available, specific water quality information is presented for the representative study areas located within the sampling regions.

Inner Harbor Area

The Inner Harbor Area includes the Hudson River, the lower portion of the East River up to the Harlem River, New York Harbor to just south of the Narrows, Kill Van Kull, and Arthur Kill. This area includes the waters of the East River at the Upper East Side Representative Areas. With the exception of Kill Van Kull and Arthur Kill, the waters making up the Inner Harbor Area are classified by NYSDEC as Class I saline surface waters. The best usages of Class I waters are secondary contact recreation and fishing. The water quality should be suitable for fish propagation and survival. Kill Van Kull and Arthur Kill are classified as Class SD saline surface waters. The best usage of Class SD waters is fishing. The water quality of these waters should be suitable for fish survival. This classification may be given to waters that cannot meet the requirements for primary and secondary contact recreation and fish propagation.

According to the 1998 New York Harbor Water Quality Regional Summary (NYCDEP, 1999a) the waters of the Inner Harbor Area meet the fecal coliform standard at most sampling locations. However, temporary increases in fecal coliform concentrations may occur during wet weather due to increased fecal coliform loadings that follow a rain event. Recorded increases from below 100, to 100 to 200 colonies/100 mL in the Upper Hudson River, a portion of the Lower East River, and Upper New York Bay, and increases from 201 to 2,000 colonies/100 ml in other portions of the Harbor, are

still less than the maximum cell count set for Class I waters. Overall, fecal coliform concentrations in this area have declined dramatically, improving water quality from the early 1970's when levels were well above 2,000 colonies/100 mL (NYCDEP, 1999a).

In 1998, dissolved oxygen (DO) concentrations in the Inner Harbor Area were on average well above the 4 mg/L standard for Class I. Only a station on the Arthur Kill had a minimum DO value below 3 mg/L. DO concentrations have increased over the past 29 years from an average that was below 3 mg/L in 1970 to above 5 mg/L in 1998, a value fully supportive of ecological productivity (NYCDEP, 1999a).

Chlorophyll a concentrations greater than 20 µg/L are considered suggestive of eutrophic conditions. Within the Inner Harbor Area, only a station at Tottenville on the Arthur Kill had an average chlorophyll a concentration greater than 20 µg/L. Concentrations at most of the other stations were below 10 µg/L (NYCDEP, 1999a).

Upper East River-Western Long Island Sound

The Upper East River-Western Long Island Sound area includes the northern portion of New York Harbor, from Hells Gate in the East River up to western Long Island Sound. This area would include the Hunts Point/Soundview representative study area, the Upper East Side and the College Point representative study areas. Most of this sampling area is classified by NYSDEC as Class I saline surface waters, with the same recommended uses and standards as the Inner Harbor Area. The area east of the Bronx-Whitestone Bridge is designated as Class SB saline surface waters. The best usages of Class SB saline waters are primary and secondary contact recreation and fishing. These waters should be suitable for fish propagation and survival.

In 1998, fecal coliform concentrations for this area were in compliance with the standards. The summer geometric mean for the majority of the sites were less than 100 colonies/100 mL. Higher concentrations, indicating poorer water quality, were recorded for Flushing Bay, but were still below the maximum cell count set for these surface water use classes. As was the case for the Inner Harbor Area, fecal coliform concentrations increased during wet weather conditions in the upper East River from Hell Gate to Throgs Neck, with the exception of Flushing Bay, but were still at a level appropriate for fishing. Overall, fecal coliform concentrations in this area have declined over the past 20 years, thereby improving water quality (NYCDEP, 1999a).

Average summer DO values for 1998 met and exceeded 4 mg/L, the standard for Class I waters. Bottom water values at three of the five stations within the Class SB area (western Long Island Sound) were below the 5 mg/L standard for bathing waters. In general there has been an increase in DO of over 1 mg/L for both top and bottom since 1970. DO in bottom waters has risen from below fishable (4 mg/L) to above the bathing standard (5 mg/L). DO concentrations, however, appear to be highly variable. An increasing gap between surface and bottom water improvements since the mid-1980s suggests two separate water masses or stratification of the water column (NYCDEP, 1999a).

Chlorophyll a concentrations in 1998 were similar to previous years, with the average summer concentration measuring 17.2 µg/L. This concentration generally suggests moderately eutrophic conditions (NYCDEP, 1999a).

Jamaica Bay

The Jamaica Bay area includes the bay itself out to Rockaway Inlet, and the tidal basins connected to the bay. The Jamaica Bay and Environs/Paerdegat Basin representative study area and Edgemere/Far Rockaway representative study area are included in this sampling region. The open water areas of the

bay are classified as SB saline surface waters. Sheepshead Bay, Paerdegat Basin, Spring Creek, Bergen Basin, Head of Bay, Hawtree Basin, Shellbank Basin, and Fresh Creek are all Classified as I saline surface waters. These basins have reduced water quality due to direct surface runoff, stormwater, and CSOs, and poor flushing. Uses that are currently impaired by poor water quality in Jamaica Bay include shellfishing, bathing, fish consumption, wildlife habitat, and aesthetics (Ringenary, 1999).

During the summer of 1998, fecal coliform concentrations were well below the maximum cell count set for Class I waters for all stations except Sheepshead Bay, which had a geometric mean of 211 colonies/100 mL and a high of 500 colonies/100 mg/L. During wet weather, fecal coliform concentrations may be greater than the maximum cell count set for this class in some areas of the northern portion of the bay. Fecal coliform concentrations have improved (decreased) noticeably since 1990 due to sewage system operational improvements and decreases in illegal discharges, decreasing from 200 to 20 colonies/100 mL (NYCDEP, 1999a).

In 1998, the average summer DO concentrations exceeded the 5.0 mg/L standard for SB saline waters at all sampling sites. A minimal DO concentration below 3.0 was observed at Beach Channel and Bergen Basin. Average DO concentrations in the bay have increased over the past 29 years, with top waters sometimes reaching over 8 mg/L. DO however, is highly variable between and within years, with an increasing gap between surface and bottom waters (NYCDEP, 1999a).

Chlorophyll a concentrations in Jamaica Bay are high, and indicative of eutrophic conditions. Water turnover within the bay is slow, about 35 days. This slow turnover is partially due to the construction of JFK Airport in the 1960s that led to the removal of over 70 million cubic meters of bottom material, changing the mean depth from 3 to 16 feet. Chlorophyll concentration is highly variable between stations, ranging from a high of 84.8 µg/L at Fresh Creek, to a low of 0.5 µg/L off Coney Island. The average chlorophyll a concentration for the bay was 41.3 µg/L, well above the 20 µg/L considered indicative of eutrophic waters. Chlorophyll a concentrations in Jamaica Bay have increased greatly since the late 1980s—the average rate of increase is close to 10 µg/L every 2 years for the period from 1986 to 1995 (NYCDEP, 1999a).

Lower New York Bay-Raritan Bay

The most oceanic of the survey areas, the Lower New York Bay-Raritan Bay vicinity is a 100-square-mile area composed of open shallow waters bounded by Coney Island to the north, Staten Island to the west, and New Jersey Middlesex and Monmouth counties to the south. This sampling area covers the Lemon Creek/Wolfe's Pond representative study area, and the ocean side of the Edgemere/Far Rockaway representative study area. The majority of the lower New York Bay and Raritan Bay is classified as use Class SB saline surface waters, with areas of SA near Rockaway Inlet and offshore from Princess Bay and Huguenot Beach. The best uses of classification SA saline surface waters are shellfishing for market purposes, primary and secondary contact recreation, and fishing. The water quality of these waters should be suitable for fish propagation and survival (NYCDEP, 1999a).

In the summer of 1998, fecal coliform concentrations within this area were far below the maximum cell count for Class SB and SA, with all locations having geometric mean values less than 15 colonies/100 mL. Unlike other areas, most of the sampling locations did not show increased concentrations following a rain event. This lack of an increase following a rain event is attributable to the flushing and dilution (i.e., ebb and flow of tides in the Hudson River) that occur in this area. Fecal coliform concentrations have also declined significantly since the early 1970s, from less than 200 colonies/100 mL to average levels below 5 colonies/100 mL which led to the opening of shellfishing

beds off the Rockaways and off Princess Bay and Huguenot Beach in Raritan Bay (NYCDEP, 1999a).

Average summer DO concentrations for 1998 were always above the 5 mg/L standard. Individual DO measurements rarely dropped below the standard and were never less than 3.0 mg/L. DO concentrations for surface waters have increased from around 6 mg/L in 1970 to nearly 8 mg/L. The increase for bottom waters during this same time frame was from about 5.5 mg/L to nearly 7 mg/L (NYCDEP, 1999a).

The sampling stations off Staten Island all had average chlorophyll a concentrations near or greater than 20 µg/L, indicative of eutrophic conditions. Phytoplankton blooms are reported to have become more numerous in this area. The eastern stations close to Rockaway Inlet had average concentrations less than 20 µg/L due to greater flushing. Average chlorophyll a concentrations have been on the rise since 1994 but have remained close to 20 µg/L since about 1996 (NYSDEC, 1999).

USE CLASSIFICATIONS OF OTHER SURFACE WATERS WITHIN THE REPRESENTATIVE STUDY AREAS

The New York City waters described above are the major waters surrounding the City. However, there are bodies of water within the representative study areas, such as streams, rivers, ponds, and lakes that are not included in those areas described above. The use classifications for these other waterbodies are described below by representative study area.

Jerome Park/Van Cortlandt Park South Representative Study Area

The two major bodies of water within this representative study area are Jerome Park Reservoir and Van Cortlandt Lake. NYSDEC classifies Jerome Park Reservoir as Class AA waters. However, Jerome Park Reservoir is a drinking water reservoir (Croton System), and no other uses are allowed in order to preserve water quality. Van Cortlandt Lake has been designated as Class B surface waters. The goal for Class B is suitability of the waterbody for primary and secondary contact recreation (swimming and boating), fishing, and fish propagation and survival.

Upper East Side Representative Study Area

The waterbodies within Central Park, are classified by the NYSDEC as Class B surface waters. As described previously, the goal for Class B is suitability of the water for primary and secondary contact recreation, fishing, and fish propagation and survival. The Central Park Conservancy collects water quality samples from the Central Park waterbodies, with the exception of the Reservoir, daily during the summer, and weekly in the winter. The waters of Central Park, provided by the New York City water supply, are chlorinated and have historically always been less than the maximum cell count set for Class B waters (Kruzansky, 2000). The Reservoir is currently under the jurisdiction of the NYCDEP and is classified as Class AA surface waters. The Reservoir is no longer used as a drinking water supply.

Lemon Creek/Wolfe's Pond Park Representative Study Area

The upper freshwater portion of Lemon Creek and the adjacent Bloeser's Pond are classified as Class B fresh surface water. The goal for Class B is suitability of the waterbody for primary and secondary contact recreation (swimming and boating), fishing, and fish propagation and survival. The lower estuarine portion of Lemon Creek is classified as Class SC saline surface water. SC saline surface waters are best used for fishing. The water quality should support fish propagation and survival and should be suitable for primary and secondary contact recreation. NYCDEP has found that waters

within the Lemon Creek watershed have more fecal coliform colonies than allowed for Class B and SC waters and are below the standard for DO due to illegal sewer connections, failing septic systems, stormwater runoff, and septic systems (NYCDEP, 1998b).

Wolfe's Pond and Acme Pond, and the streams connecting to them are also classified as Class B freshwater bodies. The NYCDEP documented in 1999 that these waters have more fecal coliform colonies than allowed for Class B surface waters but exceeded the minimum DO standards (NYCDEP, 1999b).

C. FUTURE WITHOUT THE PROPOSED ACTION

Based on the infrastructure investments of the City of New York and surrounding counties, it is expected that water quality within and near the City of New York will improve due to these ongoing efforts. While the proposed *Mosquito-Borne Disease Control Program* is not targeted to improve regional water quality, there are likely to be changes in water quality for the surface waters in and surrounding New York City without the application of the mosquito adulticides under the *Mosquito-Borne Disease Control Program.*

As mentioned previously, the City of New York has implemented a program of aggressive and innovative measures to control the input of pollutants to the major waterbodies surrounding the City as well as continual development and upgrade of the sewage treatment system. The City has constructed new WPCPs, such as Red Hook (1989) and North River (1991), and upgraded existing plants, such as Coney Island (1994) and Owl's Head (1995). The process for upgrading the Newtown Creek plant is underway. Other measures to improve water quality include identifying illegal connections to the sewer system and abating dry weather flow, monitoring for illegal flow, increased surveillance and maintenance of regulators and pumping stations, improved WPCP operations to reduce bypassing from these sources, implementing a storm water program to characterize storm water runoff from five different land use locations, control of construction and contaminated site runoff, implementation of a spill response program, stenciling of catch basins, and enforcement against improper disposal of spent vehicle fluids. In addition to these programs, the City is in the process of a multi-year CSO Abatement Program that includes the construction of CSO abatement facilities that will hold the overflows in large underground tanks during and immediately after storm events. After the rainfall subsides, the previously uncaptured sewage would be pumped to the WPCPs for treatment before discharge to the waterways (NYCDEP, 1998a). These programs have resulted in the water quality improvements that have been documented in the New York Harbor Water Quality Surveys. Because these programs are ongoing, and will also result in the development of additional facilities such as those to treat CSOs, water quality improvements are expected to continue into the future within the New York Harbor Area.

NYCDEP has also developed a water quality management plan for the Lemon Creek and Wolfe's Creek Pond areas that involves the construction of sanitary and stormwater sewers to reduce the discharge of untreated stormwater to these waterbodies, along with the discharge from nonfunctioning and functioning septic systems. The construction and operation of these infrastructure improvements will result in improved water quality within both of these watersheds.

D. POTENTIAL WATER QUALITY IMPACTS

As presented earlier in Table 3.F-1, malathion is the only active ingredient in the adulticides considered in the *Mosquito-Borne Disease Control Program* for which a water quality standard (0.1 µg/L for certain classes) has been established. Therefore, only the discussion of malathion will refer to the relationship to a water quality standard. The projected concentrations in surface water from the proposed *Mosquito-Borne Disease Control Program* operations were evaluated as part of the ecological risk assessment presented in Chapter 3.D, "Natural Resources." This section incorporates the results of that evaluation in assessing potential water quality impacts. Because the potential impact to water quality will depend on certain physical and chemical characteristics of the adulticide, as well as the characteristics of the New York City environment, this discussion is organized by active ingredient. Potential impacts to the representative study areas and other waterbodies will be discussed for each adulticide. Extensive research was performed to examine other water quality monitoring studies and data.

ORGANOPHOSPHATES

Malathion

Malathion is an organophosphate adulticide that is soluble in water and moderately bound to soils; it therefore has the potential to leach to groundwater or surface waterbodies. However, it appears to degrade rapidly in the presence of active soil microbial activity and degradation is most rapid in moist soils. Where microbial activity is absent, malathion can be fairly stable (it undergoes little photodegradation and little hydrolysis in acidic conditions). This would suggest that in areas of the City where waterbodies are surrounded by wetlands or well vegetated areas such as the College Point representative study area (Flushing Airport property), the Jamaica Bay and Environs/Paerdegat Basin representative study area (Paerdegat Basin and Bergen Beach area), Jerome Park/Van Cortlandt Park South (Van Cortlandt Lake), Upper East Side Representative Area (the waterbodies of Central Park), and Lemon Creek/Wolfe's Pond Park (Lemon Creek wetland system and Wolfe's Pond and Acme Pond), potential degradation to water quality from malathion carried in surface runoff occurring after a spray event should be reduced because these vegetated areas would act as a buffer. When malathion was applied in Texas as part of the boll weevil eradication program, wide buffer strips (125 to 700 feet) with high vegetation appeared to decrease malathion drift to sensitive areas to the point that it was not detected in surface waters, while narrower vegetated buffers and shorter vegetation did not protect waterbodies (Montague et al., 2000).

However, concentrations of malathion in stormwater runoff discharged directly to these waterbodies, such as the case for urban areas, would not be affected by surrounding vegetation and may result in potential degradation to water quality. USEPA (Montague et al., 2000) concluded that malathion applied in urban areas is more likely to affect water quality than in agricultural areas, because the impervious surfaces such as asphalt and concrete are devoid of soil bacteria that degrade malathion (the primary degradation route), and stormwater may be discharged to waterbodies with little chance of water quality improvement provided by stormwater management measures. In fact, routine monitoring programs have detected malathion in tributaries and retention ponds near urban areas. A drinking water reservoir in Florida was found to be contaminated with malathion even though the reservoir did not receive direct aerial application of the adulticide (Montague et al., 2000).

Monitoring programs in Florida and California required as part of the medfly treatment campaign have found higher concentrations of malathion in surface waters in urban areas than agricultural areas. In California medfly treatment areas, malathion levels in streams were found to be highly

influenced by rainwater runoff (Ando et al., 1996). In 1994, 8 aerial applications of malathion bait mixture were made to a residential region of Riverside County, California. Malathion was applied at two-week intervals at night between 9 PM and 2 AM. Three sensitive areas within the treatment zone were identified and flagged to avoid treatment with malathion, a 2.8-hectare (ha) lake and two natural habitat regions containing threatened or endangered species. The monitoring program measured malathion ground deposition (soil, turf, lettuce, sand and stainless steel plates, background samples and 12 hours post-spraying samples collected for soil, turf, and lettuce, sand and steel were measured over a 32-day period), ambient air concentration (before, during and 24 and 48 hours post-spraying), and surface water concentration (before spraying, immediately after spraying, and during rain runoff periods).

During this monitoring program, the highest concentrations occurred during the 24-hour period following the spray events. Surface water samples collected from the creek that drained an area receiving malathion had detectable concentrations of malathion of 24.4, 2.02 and 1.04 µg/L following three spray events. Surface water samples collected in rain runoff water had a maximum concentration of 203 µg/L two days following one of the spray events. When monitored over a 6-hour period during precipitation runoff, the concentration dropped to half the initial concentration at the end of the recording period. Malathion concentration in rain runoff also appeared to be less when more than one precipitation event occurred within the 2-week spray interval. The authors concluded that rain could wash malathion off various treated surfaces and transport it to drainage systems. Concentrations in the lake that was not to receive treatment were 3.62, 0.27 and 1.40 µg/L following three different spray events. Some malathion was detected just before the second spray event, which indicated residues had not completely decomposed 14 days after the previous spray event.

A similar monitoring program conducted in Ventura County, California, during the 1994-1995 medfly eradication program (Bradley et al., 1997), sampled malathion in tributaries draining agricultural, and urban areas that had been treated with aerial application of malathion, as well as in surface water downstream from the confluence of these tributaries. The average malathion concentration contained in stream water draining a portion of the application area was 44 µg/L, and ranged from 39.1 to 50.3 µg/L. No setback area was established for this stream so it received direct application of malathion. As was the case for the Riverside County study, malathion concentrations in surface water during rain runoff events was highest within the first few hours after rain began then decreased steadily over time. The highest concentration observed during a rain event was 787.10 µg/L.

Water quality monitoring associated with the cooperative medfly projects in Florida has yielded similar impacts associated with the application of malathion. In 1997 (APHIS, 1997) surface water samples collected from waters that had no setback from aerial malathion treatment had concentrations of malathion that averaged 13.3 µg/L (range from below detection limit of 0.1 µg/L to high of 460 µg/L) between 1 and 18 hours post-treatment. The Florida standard for malathion in surface waters is 0.1 µg/L. The average background concentration was 1.8 µg/L, and ranged from a low below detection level to a high of 44.0 µg/L. Bodies of water that were clearly visible or defined as "major" bodies received a 200 to 300 meter (656 to 984-foot) no-spray buffer. The average post-spray malathion concentration at monitored protected surface waters was 2.8 µg/L, with the range of concentrations from below detection to 30 µg/L, and the median was 0.8 µg/L. In general, most samples collected from protected waterbodies had concentrations below 1 µg/L. Most background concentration levels were also below the quantification level. Water samples collected before each treatment indicated that malathion was not accumulating in protected or unprotected waters even after 8 to 10 weekly treatments. However, unprotected detention ponds that received runoff water did have high levels of malathion between treatments. One such pond had a median concentration of 11 µg/L and

was located in a densely populated suburban environment; another pond with a median pre-treatment concentration of 4.3 µg/L collected runoff from a parking area. Both ponds were shallow. The other surface waterbodies sampled also received stormwater runoff but the drainage areas were more vegetated, and the volume of water available to dilute the runoff was greater.

The environmental monitoring program for the cooperative medfly project in Umatilla, Florida (APHIS 1998a) recorded a range of malathion concentration in surface waters following treatment, from non-quantifiable trace levels to 8.1 µg/L, with a mean of 0.9 µg/L. Post-treatment surface water samples collected for Bradenton, Florida (APHIS, 1998b) ranged from a trace to 75 µg/L, with a median of 2.7 µg/L. The high concentration was found at a location on the Manatee River, where the large flow volume_and tidal conditions should promote the dilution, dispersion and degradation of malathion. Investigators attributed the high concentration to the discharge of stormwater from the surrounding urban land near the sampling point. The other high concentration was found in another waterbody that received stormwater runoff from an urban area, Wares Creek (29 µg/L), after a storm event (APHIS 1998b). Post-treatment water quality samples collected in Sebring, Florida, following malathion application for medfly (APHIS, 1998c) contained malathion concentrations averaging 1.5 µg/L, with a median of 0.85 µg/L and a maximum of 9.3 µg/L, 4 hours after application. Water samples collected at these same locations within 1 day of commencement of rainfall (1 to 5 days post-treatment) ranged from nondetect to 0.85 µg/L. The sampled waterbodies were large and researchers concluded the lake water volume was sufficient to dilute the malathion entering through stormwater runoff. Water samples collected in two small creeks draining urban land and citrus groves 6 days following malathion spraying for medfly eradication measured 0.81 µg/L and 0.41 µg/L, greater than the State standard (SWAMP, 1997a). Water samples collected in one of these same creeks during an application had a malathion concentration of 37 µg/L (SWAMP, 1997b).

Where malathion has been applied, large waterbodies with high flow rates have been found to be adequately flushed such that malathion does not reach concentrations that are acutely toxic to fish (Montague et al., 2000). This should be the case for New York City waters such as the East River, Hudson River, or Raritan Bay. USEPA (Montague et al., 2000) has concluded that most fish kills in malathion usage areas have been in small streams or ponds where low flow rates allowed concentrations to exceed toxic levels for fish, or where large precipitation events brought a large pulse of malathion into small waterbodies. As presented earlier, the New York State malathion water quality standard for most of the waters in and around New York City is 0.1 µg/L. Some of the concentrations recorded in Florida and California following the application of malathion for medfly eradication, which were different programs compared to the City's Proposed Action, exceeded this standard.

In Chapter 3.D, "Natural Resources," the estimated exposure concentration in a pond and in runoff from ULV application evaluated for the Tier I ecological risk assessment was 0.0258 mg/L (mg/L, or 25.8 µg/L), which is higher than the State water quality standard. The hazard quotient (HQ) for malathion calculated for the Tier I ecological risk assessment indicated potential effects to aquatic organisms. The concentrations collected as part of the post-treatment monitoring program in Florida and California suggest that the estimated malathion concentration from the Tier I assessment are feasible when malathion is applied directly to a waterbody. The estimated concentration for runoff developed as part of the Tier I ecological risk assessment is even greater than through deposition from drift, 4.0603 mg/L (4060.3 µg/L). The concentrations measured in Florida and California associated with rain events suggest that the model used in the Tier I analysis for this study greatly overestimates the possible concentration of malathion in runoff following aerial application.

The estimated concentration of malathion in a pond (0.0061 mg/L, or 6.1 µg/L), and runoff (0.9533 mg/L or 953.3 µg/L) from truck application developed as part of the Tier I ecological risk assessment are lower than aerial application; however, these conservative predictions exceeded the standard. The HQ calculated for truck application also indicated potential effects to aquatic organisms. Again, the model appears to overestimate the runoff concentration since it is far larger than the concentrations observed in the referenced monitoring studies in California or Florida where some waters received direct application. The concentrations estimated for the Tier I risk assessment assume the worst case condition of direct application to a pond or the total application rate applied to surface runoff with no degradation.

The Tier II risk assessment estimated the exposure concentrations of malathion in ponds and wetlands under conditions representative of the resources found within New York City and the *Mosquito-Borne Disease Control Program.* The estimated exposure concentrations of malathion in Turtle Pond, Central Park, due to drift occuring during nearby truck application was 0.00021884 milligrams per liter (mg/L) (0.22 ?g/L) without partitioning to the sediment, and 0.00018285 mg/L (0.18 ?g/L) with partitioning to the sediment. Both of these estimated concentrations exceed the State water quality standard and sugggest that water quality in ponds near areas sprayed by truck may be adversely impacted. These estimated concentrations also resulted in HQs that suggested potential risks to crustaceans, aquatic insect larvae, and fish. HQs for other ponds found in the Representative Areas suggested similar ecological risks.

The Tier II assessment of the potential risk associated with multiple applications of malathion by truck near Turtle Pond (day 1, 4, 14, 17, 27, 30, 40, 43, 53, and 56) would result in an estimated maximum exposure concentration of 0.39960 ?g/L without partitioning and 0.33388 ?g/L with partitioning, an estimated maximum 96-hour concentration of 0.29390 ?g/L without partitioning and 0.24556 ?g/L with partitioning, and a maximum 90-day average of 0.12249 ?g/L without partitioning and 0.11154 ?g/L with partitioning. These estimated exposure concentrations from the multiple application scenario exceed the State water quality standard, and therefore suggest a significant potential water quality impact from the multiple application scenario. Chapter 3.D, "Natural Resources," addresses the potential impacts from drift and deposition onto freshwater ponds.

The Tier II risk assessment evaluated the potential risk to Jamaica Bay and Lemon Creek from stormwater discharge following a single application of the adulticides. The estimated exposure concentration of malthion for Jamaica Bay was 0.37574 ?g/L, taking into account partitioning to the land surface and degradation through photolysis. This concentration suggested a potential significant adverse impact to crustaceans and mollusks. The Tier II assessment of potential risk to aquatic organisms in Lemon Creek from stormwater discharge following a spray event estimated an exposure concentration of 0.063 mg/L within 250 feet of the discharge point, taking into account partitioning with the land surface and some degradation. This concentration suggested a potential significant adverse impact to crustaceans, aquatic insect larvae, fish and amphibians. All of these concentrations exceed the State water quality criterion for malathion, suggesting that stormwater discharge following a spray event has the potential to result in significant adverse water quality impacts.

Post-treatment monitoring conducted in California and Florida suggest that the application of malathion has the potential to impact water quality and exceed the State standard in surface waters that do not have large flow volumes, particularly in small waterbodies receiving stormwater runoff. Therefore, the larger waterbodies surrounding the City such as the Hudson River, East River, New York Harbor, and Raritan Bay should have less chance of measurable increases in malathion than

ponds receiving stormwater runoff, such as Van Cortlandt Pond, or the tidal basins of Jamaica Bay such as Paerdegat Basin.

Naled

Like malathion, naled is an organophosphate adulticide that is water soluble. Naled does not bind strongly to soils, and is not highly soluble in water (EXTOXNET, 2000). It will tend to remain in the aqueous phase and does not partition to soil or the atmosphere to a significant degree (Laird and Abel, 1999). Naled and its degradation products (dichlorvos) are transformed by chemical hydrolysis, indirect photolysis (photolysis in the presence of a chemical photosensitizer such as acetone) in water, and biodegradation. Transport from soils and/or water is primarily through volatilization (Peckenpaugh, 1997). The USEPA (Peckenpaugh, 1997) reports that under terrestrial, aquatic, and forestry field conditions, naled dissipates rapidly, with half-lives less than 2 days. The dissipation of dichlorvos is also rapid. Therefore, although the water solubility of naled and dichlorvos suggest that it may be mobile in the environment, transported in surface runoff to surface waters, it is rapidly degraded and should be available for runoff for only one or two days post-application. Although naled and dichlorvos are mobile in soils (mobility is lower in clay-rich soils), because it is rapidly degraded, it is also not likely to leach to groundwater (Peckenpaugh, 1997).

According to the USEPA (Peckenpaugh, 1997) naled applied to a pond in Florida and a pond in Mississippi, at a rate of 0.4 pounds of active ingredient per acre (compared to the ULV rate for truck application of 0.02 pounds of active ingredient per acre, or for aerial application of 0.052 to 0.10 pounds of active ingredient per acre approved for mosquito control), in five application events over a 2-week period, dissipated from the pond water with a half-life of less than one day. The maximum naled concentration was 0.018 mg/L in the Florida site and 0.006 mg/L in the Mississippi site. In general, the concentration of naled decreased through the water column from surface to the bottom. After each application, naled concentration was always less than 0.002 mg/L one day post-treatment in Florida, and less than 0.001 mg/L at the Mississippi site. The maximum dichlorvos concentration was 0.013 mg/L in Florida, and 0.014 mg/L in Mississippi. Neither naled nor dichlorvos was detected in sediment samples (limit of detection 0.01 mg/L) from the two ponds.

In a pond and stream within a 24-acre pine forest that received aerial application of naled (DIBROM) at the same rate as the ponds discussed above (0.4 pounds of active ingredient per acre), the maximum concentration of naled/dichlorvos was less than 5 µg/L (0.005 mg/L) at 0, 1, and 3 days post-treatment (Pechenpaugh, 1997).

The Tier I ecological risk assessment presented in Chapter 3.D, “Natural Resources,” estimated an exposure concentration of naled from aerial application at a rate of 0.1 pounds of active ingredient per acre as 0.0112 mg/L in a pond and 1.76 mg/L in runoff. The estimated exposure concentration of naled from ground application at a rate of 0.0200 pounds of active ingredient per acre was 0.0022 mg/L for the hypothetical pond and 0.3531 mg/L for surface run-off. The HQ calculated for naled as part of the ecological risk assessment indicates a potential effect to aquatic organisms. As discussed previously, these projected exposure concentrations do not take into account half-life, and for the hypothetical pond, assume that all of the adulticide is deposited on the surface. The estimated exposure concentration from aerial and truck application of naled to a pond presented in the Tier I ecological risk assessment are similar to the recorded values for the two ponds discussed by USEPA (Peckenpaugh 1997) but are probably an overestimate since the application rate for the USEPA-reported studies was higher.

The Tier II risk assessment estimated a concentration of naled in Turtle Pond resulting from drift during truck application of 0.00008105 milligrams per liter (mg/L or parts per million [ppm]) without partitioning and 0.00007932 mg/L with partitioning. These concentrations suggest a potential adverse impact to crustaceans but are much lower than those estimated in the Tier I assessment, or recorded in the previously mentioned field studies. The HQs for naled in other ponds suggested a similar risk. The Tier II assessment of the risk associated with multiple truck applications of naled to the area around Turtle Pond (day 1, 4, 14, 17, 27, 30, 40, 48, 53, and 56) resulted in the following estimated exposure concentrations: maximum concentration-0.00010748 mg/L without partitioning, 0.00010518 mg/L with partitioning; maximum 96-hour concentration-0.00005998 mg/L without partitioning and 0.00005870 mg/L with partitioning, and 90-day maximum average concentration 0.00002132 mg/L without partitioning and 0.00002086 mg/L with partitioning. In all cases, the HQ suggested a potential adverse impact to crustaceans. The maximum concentration was higher than the estimated concentration from the single application, but the maximum 96-hour concentration, and maximum 90-day average concentration, was lower than the single application, suggesting dissipation between applications.

The Tier II assment of the risks to aquatic organisms of Jamaica Bay and Lemon Creek from the discharge of stormwater following, truck application of naled estimated an exposure concentration of 0.00026314 mg/L in Jamaica Bay and 0.055 mg/L in Lemon Creek. These estimated concentrations suggested a potential adverse impact to crustaceans in Jamaica Bay, and to crustaceans, aquatic insect larvae, fish and green algae in Lemon Creek. Both of these assessments suggest a temporary change in water quality from the discharge of stormwater following a spray event.

The estimated exposure concentrations from Tier I and II suggest that for surface waters such as ponds or lakes such as the waterbodies of Central Park within the Upper East Side representative study area, Van Cortlandt Lake within Jerome Park/Van Cortlandt Park South representative study area, or Acme Pond and Wolfe's Pond within the Lemon Creek/Wolfe's Pond representative study area, or streams with a low flow volume the application of naled at the labeled rate for mosquito control may result in negative effects to water quality. However, these increases in pesticide concentration should be short-term because of the short half-life reported for naled in water. Larger waterbodies such as those of the New York Harbor system should not be measurably affected by the application of naled for mosquito control because of their large volume of water and the fairly rapid dissipation in the environment.

PYRETHROIDS

Active Ingredients

Permethrin

Permethrin is a synthetic pythrethroid that is almost insoluble in water and very soluble in organic solutions. It binds strongly to soil particles and sediments and is not easily desorbed (WHO, 1990). Permethrin is not easily leached from soil and is not very mobile in a wide range of soil types (EXTOXNET, 2000). These characteristics suggest that permethrin is not likely to enter the water column and affect water quality even if it is carried to surface waters bound to soil particles. Its affinity to soil and sediment, including suspended sediments in the water column (TOXNET, 2000) should also minimize its concentration in the water column even if washed off impermeable surfaces by stormwater, since many of the waters around New York City are turbid. In addition, permethrin carried by surface runoff to CSOs should also bind with organic matter in the CSOs. Setback

requirements used for sumithrin in New York City for 2000 should minimize water quality impacts associated with the application of permethrin at its labeled rate.

The estimated exposure concentration for permethrin derived as part of the Tier I ecological risk assessment is 0.0053 mg/L in the hypothetical pond from aerial application, and 0.8297 in runoff from aerial application; and 0.0024 mg/L in the hypothetical pond and 0.3707 mg/L in runoff from truck application. The HQ calculated for permethrin using the estimated exposure concentration in the Tier I risk analysis indicates it has the potential to cause adverse effects in fish, crustaceans, and insect larvae. However, these estimated concentrations did not assume any partitioning of the adulticide to soil or sediments (which this adulticide tightly binds to), setbacks from the surface water, or degradation of any kind. Therefore, the possible concentration of permethrin in surface waters is likely over estimated.

The Tier II assessment (see Chapter 3.D, "Natural Resources") for the pond and runoff scenarios incorporated partitioning to sediment and organic carbon. The estimated concentration of permethrin in Turtle Pond due to drift from nearby truck application (0.00008510 mg/L without partitioning and 0.00001143 mg/L with partitioning was less than the exposure concentration estimated for Tier I but suggested a potential adverse impact to crustaceans and aquatic insect larvae.The Tier II assessment of the risks associated with the multiple application scenario (day 1, 4, 14, 17, 27, 30, 40, 43, 53, and 56) resulted in the following estimated exposure concentrations in Turtle Pond: maximum concentration-0.00012579 mg/L without partitioning and 0.00001689 mg/L without partitioning; maximum 96-hour average-0.00007659 mg/L without partitioning and 0.00001029 mg/L with partitioning, and maximum 90-day average-0.00003098 mg/L with partitioning and 0.00000416 mg/L with partitioning.While the maximum concentration from multiple applications is somewhat higher than the single application, suggesting potential adverse impact to crustaceans and aquatic insect larvae, the maximum 96-hour and maximum 90-day average estimated concentrations suggest that the concentration decreases between applications, with the potential to affect only crustaceans. The analyses suggests that water quality effects may occur from the truck application of permethrin but that they should be temporary.

In the Tier II assessment of the risks to aquatic organisms in Jamaica Bay and Lemon Creek, truck application of permethrin resulted in an exposure concentration of 0.00000771 mg/L in Jamaica Bay, and 0.0012 mg/L in Lemon Creek from the discharge of stormwater following a spray event. These estimated concentrations suggested a potential adverse impact to crustaceans in Jamaica Bay, and to crustaceans, fish, and aquatic insect larvae in Lemon Creek, and a temporary adverse effect to water quality from the discharge of stormwater that occurs after a spray event.

Resmethrin

Resmethrin is also a pyrethroid insecticde. Like sumithrin and permethrin it is not very soluble in water, but is very soluble in organic solutions. These characteristics suggest it would have an affinity for soil and sediment particles, which reduces its tendency to enter the water column. It has been found to be tightly bound to soil and is not expected to be mobile or to contaminate groundwater (EXTOXNET, 2000). In aquatic systems it will partition to the sediment from water (TOXNET, 2000). Resmethrin can degrade readily through biodegradation, hydrolysis and photodegradation (TOXNET 2000). Resmethrin is known to break down quickly in sunlight in soil, which would be pertinent if there were sunlight before a rain event that resulted in runoff of the active ingredient (0.2 hour half-life, see Appendix 3.D-1, "Ecological Risk Assessment"), and water exposed to light (20 minute half-life distilled water, 47 minute half-life sea water, see Appendix 3.D-1, "Ecological Risk Assessment"), which would also lessen the potential impact of resmethrin on water quality. However,

in aquatic environments with less light penetration, resmethrin dissipates more slowly (36.5 day half-life).

The estimated exposure concentration for resmethrin derived as part of the Tier I ecological risk assessment is 0.0008 mg/L in the hypothetical pond from aerial application, and 0.1236 mg/L in runoff from aerial and truck application. The HQ calculated for resmethrin in the Tier I risk analysis indicates it has the potential to cause adverse effects in fish and crustaceans. Because the estimated concentrations did not assume any photodegradation or partitioning of the adulticide to soil or sediments, it likely overestimates the possible concentration of resmethrin in surface waters.

As discussed for permethrin, the Tier II assessment (see Chapter 3.D, "Natural Resources") for the pond and runoff scenarios estimated concentrations of resmethrin, taking into account partitioning with sediments in the pond, and with organic carbon on the land surface. The estimated exposure concentration in Turtle Pond following truck application (0.00002837 mg/L without partitioning and 0.00000163 mg/L with partitioning) does not suggest the potential for adverse impacts to aquatic organisms or significant water quality changes from a single application. The Tier II assessment of risks associated with the multiple application scenario resulted in the following estimated exposure concentrations in Turtle Pond: maximum concentration-0.00016851 mg/L without partitioning and 0.00000968 mg/L with partitioning; maximum 96-hour concentration-0.00016235 mg/L without partitioning, and 0.00000933 mg/L with partitioning, and maximum 90-day average of 0.00009901 mg/L without partitioning and 0.00000569 mg/L with partitioning.The maximum and 96-hour concentration suggest a adverse impact to crustaceans and fish, and the 90-day average suggest a potential adverse impact to fish. Both the maximum value and the maximum 96-hour average are much greater than the estimated single application concentration, which suggests that the application schedule would not allow resmethrin to dissipate sufficiently over time to reduce water quality impacts. The Tier II assessment also evaluated the risks associated with applying resmethrin twice, one week apart, the results of which suggested that the maximum exposure concentration and maximum 96-hour average would be lower than the repeat application scenario because it allows more time for resmethrin to dissipate. The estimated concentrations from the repeat application one week apart does not suggest a potential adverse impact to aquatic organisms or significant effects to water quality.

In the Tier II assessment of risks to aquatic organisms in Jamaica Bay and Lemon Creek, truck application of resmethrin resulted in an estimated exposure concentration of 0.00000009 mg/L in Jamaica Bay and 0.000013 mg/L in Lemon Creek from the discharge of stormwater following a spray event. These estimated concentrations do not suggest a potential adverse impact to aquatic organisms in Jamaica Bay but do suggest a risk to crustaceans and fish in Lemon Creek.

The results of the Tier II analyses suggest that implementation of the same setback requirements used for sumithrin in New York City for 2000, and the tendency of this adulticide to bind to sediments and to photodegrade on surfaces, soil and water, should minimize water quality impacts associated with the drift from truck application of resmethrin at its labeled rate. The results of the Tier II assessment suggest that water quality effects from stormwater containing resmethrin would be greater in smaller bodies of water with less volume to dilute the discharge, than to larger bodies such as Jamaica Bay and the New York Harbor.

Sumithrin

Chapter 3.A, "Framework of Analysis," presents a detailed description of sumithrin's and piperonyl butoxide's (PBO's) physical and chemical characteristics. The ecological risk assessment also

discussed the characteristics of this adulticide. Sumithrin is a pythrethroid. It is not very soluble in water but is soluble in organic solvents. The chemical characteristics of this adulticide would suggest that when applied, it should have a greater affinity for organic material in soils and sediments than water, reducing the amount available within the water column. The reported half-life in water (aerobic freshwater) is 7.2 days and the soil dissipation half-life is 2 days. There are no Federal or State water quality standards for this adulticide.

During the spray events conducted by the City from July through September 2000, the adulticide Anvil was applied primarily by truck at the labeled ultra low volume (ULV) application rate for this method at 0.0036 pounds of active ingredient (sumithrin) per acre. (Because this section includes monitoring results from 2000 that included the application of Anvil, and Anvil contains both sumithrin and PBO, discussions of the modeling and monitoring results of PBO are included in this section.) Some areas of Staten Island that were inaccessible by truck were sprayed by air at the same application rate. In order to address the risk of impacts to natural resources, NYSDEC requested that the City sample specific waterbodies within the spray zones before and after the spray event; inspect the specified waterbodies within 24 hours of spraying to check for fish kills or other impacts; establish for aerial applications a 300-foot no-spray setback from open waterbodies, surface waters with emergent marsh vegetation and tidal regions; establish for ground applications a 100-foot no-spray setback around waterbodies; and prevent ground spraying on approaches and bridges over surface waters.

NYCDOH sampled 32 locations for sumithrin and PBO before and after spraying events during the mosquito adulticide applications that occurred during July through September 2000. These locations included the following:

- Staten Island—Clove Lake, Brady's Pond, Eib's Pond, Old Mill Pond, Mt. Loretto Pond, Porzio's Pond, Sharrott's Pond, Mariner's Marsh, Ohrback Lake, Camp Pouch, and Willow Brook Park.
- Queens—Douglaston Golf Course Pond, Forest Park Golf Course Pond, Alley Park Pond, Bay Terrace/Clearview Golf Course, Baisley's Pond/Springfield Gardens, Meadow Lake/ Flushing, Springfield Park Pond, Brookville Park/Conselyea's, and Kissena Park Pond.
- Manhattan—The Lake, Harlem Meer, and Turtle Pond in Central Park.
- Bronx—Harlem River, Crotona Park, Hunt's Point/Bronx River, Pelham Bay/Split-Rock Golf Course, and Van Courtlandt Park Pond.
- Brooklyn—Canarsie/Fresh Creek Basin, Prospect Park Lake, Greenwood Cemetery, and Poly-Prep School.

The locations of sampling and the sampling protocol were specified by NYSDEC (Cryan 2000). Out of the 68 post-application samples collected by the City, only two had concentrations of either sumithrin or PBO greater than the 0.5 µg/L PQL (Practical Quantitation Limit): 1.10 µg/L (0.0011 mg/L) for sumithrin on August 18, 2000, at Mt. Loretto Pond on Staten Island; and 1.03 µg/L (0.00103 mg/L) for PBO and 0.55 µg/L (0.00055 mg/L) for sumithrin for a sample collected on August 5, 2000, at Alley Park Pond on Queens. The PBO concentrations are less than the projected worst case concentrations for PBO estimated in the Tier I ecological risk assessment presented in Chapter 3.D, "Natural Resources," (0.0024 mg/L in a pond and 0.3707 in runoff from truck and aerial application), which, when evaluated as part of the Tier I Ecological Risk Assessment, did not indicate potential risk to aquatic organisms. For sumithrin, the 0.55 µg/L concentration is close to the worst case surface water concentration in a pond (0.0004 mg/L) estimated for aerial and ground application,

that when evaluated as part of the Tier I ecological risk assessment, indicated a potential adverse impact to aquatic organisms, but is less than the estimated worst case concentration in runoff estimated for aerial and ground application (0.0636 mg/L). The 1.10 µg/L concentration for sumithrin is greater than the worst case surface water concentration estimated in a pond for both aerial and ground application for which the estimated HQ suggested some risk to fish. However, this concentration is still considerably less than the worst-case runoff concentrations used in the Tier I risk assessment.

Although the one sample at Mount Loretto Pond does suggest some change in water quality through the presence of sumithrin, there were no reported observations of impacts to aquatic organisms. The concentrations of sumithrin and PBO were less than the 0.5 µg/L PQL at this location and the other locations for other spray events, in spite of repeated applications in some areas such as Staten Island. The 0.5 µg/L PQL can be considered the maximum concentration of sumithrin and PBO at these locations, and the concentration of these two adulticides was probably less than this in many cases. All of this suggests that the application of sumithrin with PBO during the summer and fall of 2000 had little effect on water quality. Future applications of this combination of active ingredients should also have minimal effect on water quality provided similar setback requirements and the other protective measures outlined above are followed.

Representative Study Areas

College Point

Although none of the waterbodies within this representative study area were sampled as part of the year 2000 mosquito adulticide spraying events conducted by New York City, waterbodies within Queens were sampled (see discussion above) that are located within open space areas that would indicate potential impacts to fresh waterbodies such as those found within the Flushing Airport Property. With the exception of Alley Park Pond, none of the samples collected in the ponds following a spray event had concentrations of either active ingredient above the 0.5 µg/L PQL. These results suggest that spraying in 2000 had little effect on water quality for freshwater bodies within this representative study area and that future applications of sumithrin with or without PBO should also have minimal effect on water provided the same protective measures specified by NYSDEC are followed.

Although no samples were taken in the East River, a sample was collected in the Bronx River at Hunts Point, which discharges into the East River. The Bronx River receives CSO overflow, as does the East River in this area. The post-spray sample in the Bronx River was less than the 0.5 µg/L PQL for sumithrin and PBO, suggesting effects to the East River water quality should also be minimal. Additionally, the fairly rapid flushing time for the East River (1.25 days Clarke et al., 1982 in NYCDEP, 1998b) should also reduce potential impacts associated with sumithrin and PBO reaching the river.

Because sumithrin binds tightly to soil particles and sediments, it should bind with organic material in the CSOs when washed off the ground into the CSOs during rain events occurring after an application. This would reduce the concentration of sumithrin in surface water. Sumithrin contained in surface runoff directed to stormwater discharges may also bind with sediments contained in these systems, as well as suspended sediments in the water column of the Bronx River and East River, as well as bottom sediments.

Jamaica Bay and Environs/Paerdegat Basin Area

Although Paerdegat Basin was not sampled in 2000, Fresh Creek, the next basin to the north, was sampled and had no concentration of sumithrin or PBO greater that the 0.5 µg/L PQL. This basin is surrounded by land uses similar to Paerdegat Basin and both receive CSO discharge, and surface runoff. Fresh Creek also receives discharge from a water pollution control plant. The Fresh Creek sample suggests that the tidal basins bordering Jamaica Bay such as Paerdegat Basin, and the waters of Jamaica Bay that they discharge to, may have minimal effects on water quality due to spraying events that follow the precautions specified by NYSDEC for the July through September spraying events, even though the estimated residence time in the bay is 30 to 35 days. As discussed above, because sumithrin binds tightly to organic material and soil, the impacts to water quality should be small even with the discharge of rainfall runoff occurring after a spray event through the CSOs or stormwater discharge. Should sumithrin be contained in surface runoff that is not directed to the stormwater collection system of CSOs, it should bind to the soils and sediments of the upland and wetland plant communities surrounding the bay.

In the Tier II assessment of risks associated with stormwater discharge to Jamaica Bay, truck application of sumithrin resulted in an estimated exposure concentration of 0.00000055 mg/L in Jamaica Bay. This estimated concentration does not suggest a risk to aquatic organisms from the discharge of stormwater following a spray event or a significant adverse impact to water quality.

Edgemere/Far Rockaway

The coves within this representative study area are surrounded by land use similar to Paerdegat Basin and Fresh Creek but appear to have fewer CSOs than the northern tidal basins (NYCDEP, 1998a). Water quality impacts from future applications of sumithrin that follow the same precautions as spraying conducted in 2000 should have minimal water quality impacts in this representative study area as a result of sumithrin's affinity for soil and organic matter discussed previously. No spraying was conducted in the vicinity of the Atlantic Ocean beaches in this part of Queens, as would be similar practice with other spray events and adulticides. Therefore the potential for water quality effects along the shoreline area would be low.

Hunts Point/Soundview

As discussed previously, the sample collected in the Bronx River following a spray event did not have concentrations of sumithrin or PBO greater than the 0.5 µg/L PQL. This suggests that future application of this adulticide with or without PBO should have minimal effect on the water quality of the Bronx River provided that similar precautionary measures with respect to spraying, such as setbacks, are implemented. Another tidal strait that was sampled during July through September 2000, the Harlem River, appears to receive more CSO discharges than the Bronx River (NYCDEP, 1998b), as well as surface runoff. Neither sumithrin nor PBO was measured at concentrations greater than the 0.5 µg/L PQL following an application. Again, sumithrin's affinity for organic matter, and the rapid flushing of the Harlem River, should reduce the likelihood of water quality effects.

Jerome Park/Van Cortlandt Park South

Jerome Park Reservoir was sampled during the July through September 2000 spraying of sumithrin and PBO. The one post-spray sample collected did not have concentrations of either active ingredient greater than the 0.5 µg/L PQL. Because the reservoir receives little surface runoff from the surrounding area, the primary route should be through aerial deposition. The results of this sample suggest that the precautionary measures taken in the spraying of sumithrin during 2000 helped reduce

the amount of sumithrin and PBO reaching the reservoir. The effects of future applications of this adulticide should be minimal provided similar measures are implemented.

Van Cortlandt Lake was also sampled during the July through September 2000 spraying events. As described in Chapter 3.D, "Natural Resources," the lake receives stormwater discharge from neighboring areas, highway runoff, and surface runoff from the park. The lake is also shallow, less than 5 feet deep and is therefore a good representative of the shallow hypothetical pond evaluated as part of the ecological risk assessment. No concentrations of sumithrin or PBO were measured as greater than the 0.5 µg/L PQL in the post-spraying samples. This suggests that potential effects from future application of these two active ingredients should be minimal, provided similar protective measures are implemented. Sumithrin in surface runoff from drainage within the park would have the opportunity to bind to soils within the woodland and grass-covered areas surrounding the pond, and would not reach the lake. Sumithrin discharged in stormwater is likely to bind with sediments and not affect water quality.

Upper East Side

Water resources within the Upper East Side representative study area includes the surface waterbodies of Central Park, such as the Lake, the Pond, Turtle Pond, the Reservoir, and Harlem Meer. Except for the reservoir, all receive stormwater runoff from within Central Park. The Central Park reservoir receives freshwater from the upstate water supplies, which subsequently feeds other waterbodies in succession all the way to Harlem Meer. Samples were collected from the Lake, Harlem Meer, and Turtle Pond following several spraying events with sumithrin and PBO from July through September 2000. None of the samples had concentrations of either active ingredient above the 0.5 µg/L PQL, which suggests that water quality effects from future applications of these active ingredients should be minimal, provided similar protective measures are implemented to minimize introduction to surface waters. The vegetated areas surrounding these waterbodies should minimize the likelihood that sumithrin contained in surface runoff would reach the surface water. Water quality effects to the East River should also be minimal, as was discussed for the College Park Representative Study Area.

As discussed in Chapter 3.D, "Natural Resources," the results of the Tier II assessment for Turtle Pond suggest that exposure concentrations for sumithrin and PBO, when applied according to the protocols used for the summer 2000 spraying events, should be below the PQL for sumithrin. The Tier II risk assessment estimated an exposure concentration of sumithrin in Turtle Pond from drift during truck application of 0.00001459 mg/L without partitioning and 0.00000091 mg/L with partitioning, neither one of which suggests a risk to aquatic organisms, and are much lower than the exposure concentration estimated in Tier I or the concentrations found in the two water quality samples collected by the City that exceeded the PQL. The tier II assessment of risk associated with the multiple truck application of sumithrin to Turtle Pond resulted in the following estimated exposure concentrations: maximum concentration-0.00007944 mg/L without partitioning and 0.00000496 mg/L with partitioning; maximum 96-hour concentration-0.00003408 mg/L without partitioning and 0.00000213 mg/L with partitioning, and maximum 90-day average-0.00001517 mg/L without partitioning and 0.00000095 mg/L with partitioning. None of these multiple application estimates, while higher than the single application estimate, suggest the potential for adverse impacts to aquatic resources nor do they suggest a significant adverse effect to water quality.

Lemon Creek/Wolfe's Pond Park

Water resources within this representative study area include the Lemon Creek system, Wolfe's Pond, Acme Pond, streams entering and exiting Acme Pond, and Bloeser's Pond. All of these waters receive surface runoff and stormwater runoff from the surrounding developed areas. NYCDOH conducted post-spray sampling of 10 surface waters on Staten Island. Nine of these locations were ponds, and 7 were sampled more than once because of repeat spraying. The Mt. Loretto Pond sampling site is located on the Mount Loretto Home for Children property, just southwest of Lemon Creek and the Lemon Creek/Wolfe's Pond Park representative study area. The Mt. Loretto sampling location was sampled following spraying on four separate occasions. The highest recorded level of sumithrin was recorded on August 18th, at a level of 1.10 ug/L. Samples collected at this location for subsequent spray events had no detectable concentrations of sumithrin or PBO, in spite of sprayings being only a few days apart at times. Other Staten Island sampling locations that received multiple adulticide applications and sampling also had no detectable level of the two active ingredients, sumithrin and PBO. This suggests that water quality effects from the application of adulticides in 2000 to the Lemon Creek/Wolfe's Pond Park representative study area, and other water resources on Staten Island, were minimal. As discussed for Van Cortlandt Lake, sumithrin in surface runoff should bind to soil and sediments of the woodland and wetland areas surrounding the waters of the Lemon Creek system and the Wolfe's Pond system. Stormwater discharge may have sufficient organic matter to bind some sumithrin. In addition, the propensity for sumithrin to bind to sediments should minimize the concentration of this adulticide in the water column. Furthermore, water quality effects from future applications should also be minimal with truck or aerial applications, provided the same setbacks required for the 2000 spraying are implemented.

In the Tier II assessment of risks associated with stormwater discharge to Lemon Creek, truck application of sumithrin resulted in an estimated exposure concentration of 0.000084 mg/L in Lemon Creek. This estimated concentration does not suggest the potential for adverse impacts to aquatic organisms from the discharge of stormwater following a spray event or a significant adverse impact to water quality.

Synergists

Piperonyl Butoxide

For these analyses, PBO was considered to be an active ingredient. PBO is a synergist that is typically combined with pyrethroids and is never applied alone. PBO enhances the effectiveness of pyrethroids by inhibiting the metabolism of the pyrethroid by mosquitoes. PBO is not expected to volatilize or adsorb to sediment; because of this it is expected to leach from soil and be released in water. It has been found to be resistant to hydrolysis and stable to light. However, in the presence of photosensitizers it may photodegrade in surface waters. Otherwise its degradation in the aquatic environment is unknown (TOXNET, 2000).

The results of the post-spray monitoring conducted in 2000 are discussed above under "sumithrin."

The Tier II risk assessment estimated an exposure concentration of PBO in Turtle Pond resulting from drift during truck application as 0.00008510 mg/L without partitioning and 0.0008414 mg/L with partitioning. Neither concentration suggests a potential risk to aquatic organisms, and both are much lower than that estimated in the Tier I analysis, or measured in any of the surface water samples collected by the City. The Tier II assessment of risk associated with the multiple application of PBO in Turtle Pond resulted in the following estimated exposure concentrations: maximum concentration-0.00071420 mg/L without partitioning and 0.00070609 mg/L with partitioning; maximum 96-hour-

0.00071012 mg/L without partitioning and 0.00070205 mg/L with partitioning; and maximum 90-day average-0.00046467 mg/L without partitioning and 0.00045940 with partitioning. Although all of these concentrations are greater than that estimated for the single application, suggesting the schedule does not allow PBO to dissipate completely between applications, they do not suggest a potential adverse impact to aquatic organisms and do not suggest a significant adverse impact to water quality.

The Tier II assessment of the risk associated with the discharge of stormwater following truck spraying of PBO estimated an exposure concentration of 0.00034057 mg/L in Jamaica Bay and 0.076 mg/L in Lemon Creek. The estimated concentration of PBO in Jamaica Bay does not suggest a potential adverse impact to aquatic organisms or a significant impact to water quality from stormwater discharge. However, the estimated concentration in Lemon Creek does suggest that stormwater discharge has the potential to affect water quality and pose a potential adverse impact to crustaceans, fish and amphibians.

The fact that the City's post-spray monitoring program collected only one sample where the concentration of piperonly butoxide was above the practical quantitation limit suggests that the methods of application and the 100-foot setback from surface waters should minimize the introduction of this adulticide to City waters through drift during truck application. However, stormwater discharge to smaller bodies of water following a spray event does appear to have the potential to affect water quality and pose a potential adverse impact to aquatic organisms.

Inerts

Chapter 3.C, "Public Health," discusses the inert ingredients contained in the adulticides evaluated in this EIS. In most cases the inerts consist of petroleum distillates or white mineral oil. Mineral oil is included in USEPA's list of minimal risk inert ingredients, which include substances that are ubiquitous in nature and not expected to present a hazard to human health or the environment. The amount that would make its way into the City's waters should not affect water quality or aquatic organisms. With respect to petroleum distillates, the volume applied in these ULV formulations will be small, and some of the volume applied will volatilize in the atmosphere or on the ground surface before it reaches the City's waters through stormwater runoff or CSO. Based on the application rates, the range of inerts in pyrethroids range from 3 to 118 times the application rate for sumithrin. Even without the benefit of estimating the volatilization of petroleum distillates, proportioning the sumithrin results by a factor of 100 would result in incremental water quality levels of petroleum distillates that are extremely small. Therefore, the amount of these inerts that would eventually enter the City's waters will be small and inconsequential compared to other sources of these compounds from the region, and should not result in significant impacts to water quality.

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