SWAMP
Surface Water Ambient Monitoring Program

TOXICITY IN CALIFORNIA WATERS: LOS ANGELES REGION

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EXECUTIVE SUMMARY E

Toxicity testing has been used to assess effluent and surface water quality in California since the mid-1980s. When combined with chemical analyses and other water quality measures, results of toxicity tests provide information regarding the capacity of water bodies to support aquatic life beneficial uses. This report summarizes the findings of monitoring conducted by the Surface Water Ambient Monitoring Program (SWAMP) and associated programs between 2001 and 2010.

As in Anderson et al. (2011), the majority of data presented in this report were obtained from monitoring studies designed to increase understanding of potential biological impacts from human activities. As such, site locations were generally targeted in lower watershed areas, such as tributary confluences or upstream and downstream of potential pollutant sources. Only a minority of sites was chosen probabilistically (i.e., at random). Therefore, these data only characterize the sites monitored and cannot be used to make assumptions about unmonitored areas.

Freshwater toxicity was uncommon (seen at 15% of sites) and all marine water samples were non-toxic. Freshwater sediment toxicity was common (observed at 44% of sites), and low magnitude toxicity was pervasive in marine sediments. Where freshwater sediment toxicity was observed, it tended to be of higher magnitude, with 33% of freshwater sediments showing severe toxicity. Freshwater water column toxicity tended to be of lower magnitude; 4% of sites demonstrated severe water column toxicity.

Freshwater toxicity to *Pimephales promelas* and *Ceriodaphnia dubia* occurred at comparable rates, with 13% of sites toxic to *P. promelas* and 8% of sites toxic to *C. dubia*. Severity of toxicity to the two species was also comparable, with 4% and 2% of sites severely toxic to the two species, respectively. The two high conductivity sites whose water was examined with *Hyalella azteca* showed no toxicity. Ninety percent (90%) of the marine sediment samples examined using *Eohaustorius estuarius* showed toxicity, while toxicity was not detected at the one marine site whose sediment was examined using *Mytilus galloprovincialis*.

There were no significant associations between water or sediment toxicity and land use. Water toxicity was not widespread at any level of urban intensity, but the small number of sites that showed severe water toxicity were all located in highly urbanized areas.

The frequency and intensity of sediment toxicity appeared to be greater at sites with a greater percentage of upstream urban land (within one kilometer), but the pattern was not quantifiable due to the small number of sites examined.

As discussed in Anderson et al. (2011), the principal approach to determine whether observations of toxicity in laboratory toxicity tests are indicative of ecological impacts in receiving waters has been to conduct field bioassessments of macroinvertebrate communities. These studies have included “triad” assessments of chemistry, toxicity and macroinvertebrate communities, the core components of SWAMP. One recommendation for future SWAMP monitoring is to conduct further investigations on the linkages between surface water toxicity and receiving system impacts on biological communities.

SECTION 1 INTRODUCTION

The California State Water Resources Control Board published a statewide summary of surface water toxicity monitoring data from the Surface Water Ambient Monitoring Program (SWAMP) in 2011 (Anderson et al., 2011; http://www.waterboards.ca.gov/water_issues/programs/swamp/reports.shtml). This report reviewed statewide trends in water and sediment toxicity collected as part of routine SWAMP monitoring activities in the nine California water quality control board regions, as well as data from associated programs reported to the California Environmental Data Exchange Network (CEDEN) database. The report also provided information on likely causes and ecological impacts associated with toxicity, and management initiatives that are addressing key contaminants of concern. The current report summarizes a subset of the statewide database that is relevant to the Los Angeles Region (Region 4). Source programs, test counts and sample date ranges are outlined in Table 1.

Table 1
Source programs, water and sediment toxicity test counts and test dates for Los Angeles regional toxicity data included in this report.

Toxicity Test Type	Program	Test Count	Sample Date Range
Water Column	SWAMP	313	10/29/01 – 6/11/09
Sediment	Statewide Urban Pyrethroid Monitoring	12	1/3/07 – 1/8/07
	Stream Pollution Trends (SPoT)	7	5/19/08 – 5/22/08
	Other SWAMP	17	1/13/03 – 6/7/05

The Los Angeles Region is bounded by two counties, Ventura and Los Angeles, and is approximately 6,300 square miles. The Region is dominated by the Los Angeles metropolitan area, and contains three major rivers, including the Los Angeles, San Gabriel, and Santa Clara Rivers. In addition, the Region contains the Ventura River to the north, and shared responsibility for the Santa Ana River to the south. The Region contains numerous smaller watersheds, including the Ballona Creek, Malibu Creek, and Calleguas Creek watersheds. While most of the Region's watersheds are dominated by highly urbanized land uses, some areas, such as the Santa Clarita Valley, contain mixed use, primarily urban mixed with orchard agriculture and nurseries. The Calleguas Creek watershed drains through the Oxnard Plain, and here it is heavily influenced by run-off from row crop agriculture.

SECTION 2
SCOPE AND METHODOLOGY

This study examined all toxicity data included in the SWAMP and CEDEN databases from toxicity tests whose controls showed acceptable performance according to the Measurement Quality Objectives of the 2008 SWAMP Quality Assurance Project Plan (SWAMP, 2008). The attached maps (Figures 6-14) show locations of sites sampled for toxicity by SWAMP and partner programs and the intensity of toxicity observed in the water and sediment samples collected at those sites. Sites are color-coded using the categorization process described in Anderson et al. (2011), which combines the results of all toxicity tests performed on samples collected at a site to quantify the magnitude and frequency of toxicity observed there. At sites where both water and sediment toxicity data were collected, two toxicity categories were calculated to separately summarize the degree of toxicity in water and in sediment. Toxicity test results reported in the Los Angeles Region included freshwater exposures of the cladoceran *Ceriodaphnia dubia* and the fathead minnow *Pimephales promelas*, with the amphipod *Hyalella azteca* used to examine freshwater samples above the conductivity range optimal for *C. dubia* health. Freshwater sediment samples were tested using *H. azteca*. *Mytilus galloprovincialis* was used to test all marine water samples, while marine sediments were tested using *Eohaustorius estuarius* and *M. galloprovincialis*. Only survival endpoints are considered in the measures of toxicity reported here; therefore all sites identified as toxic showed a significant decrease in test animal survival in one or more samples (Table 2).

Table 2
Species-specific maximum levels of toxicity observed at sites tested with *E. estuarius*, *H. azteca* and *M. galloprovincialis* sediment toxicity tests, and *C. dubia*, *P. promelas*, *H. azteca* and *M. galloprovincialis* water column toxicity tests.

Species	Test Type	Number of Sites	Maximum Toxicity Level Observed			
			Non-Toxic	Some Toxicity	Moderately Toxic	Highly Toxic
E. estuarius	Sediment	36	20	9	0	7
H. azteca		18	10	2	0	6
M. galloprovincialis		10	1	9	0	0
C. dubia	Water Column	114	106	1	3	4
P. promelas		109	95	12	0	2
H. azteca		2	2	0	0	0
M. galloprovincialis		35	35	0	0	0

Several steps were followed to determine the toxicity of individual samples, and to categorize the toxicity of individual sites:

1. Standardize the statistical analyses: When data were submitted to the SWAMP/CEDEN databases, reporting laboratories evaluated the potential toxicity of samples using a variety of statistical protocols. In order to standardize the analysis of the entire data set, all control – sample comparisons were re-analyzed using the proposed EPA Test of Significant Toxicity (Anderson et al., 2011; Denton et al., 2011; U.S. EPA, 2010). Individual samples were categorized as not toxic, toxic or *highly* toxic (see 2 below).

2. Calculate the High Toxicity Threshold: The High Toxicity Threshold is determined for each species' endpoint from the entire dataset summarized in the Statewide Report (Anderson et al., 2011). This threshold is the average of two numbers, both expressed as a percentage of the control performance. The first number is the data point for the 99th percentile of the Percent Minimum Significant Difference (PMSD) in the Statewide Report. The second value is the data point for the 75th percentile of Organism Performance Distribution of all toxic samples, representing an organism's response on the more toxic end of the distribution. This average serves as a reasonable threshold for *highly* toxic samples.

3. Determine the Toxicity Category for each site: The magnitude and frequency of toxicity at each sample collection site was categorized (Table 3) according to Anderson et al. (2011) and Bay et al. (2007) as "non-toxic", "some toxicity", "moderately toxic", or "highly toxic". Throughout this document the terms some, moderately and highly will be italicized when in reference to these categories.

Table 3
Data conditions used to determine toxicity categories for any given sample collection site.

Category	Conditions for Categorization
Non-toxic	No sample is ever toxic to any test species
Some Toxicity	At least one sample is toxic to one or more species, and all of the species' responses fall above their species-specific High Toxicity Threshold
Moderate Toxicity	At least one sample is toxic to one or more species and at least one of the species' responses falls below their respective High Toxicity Threshold
High Toxicity	At least one sample is toxic to one or more species and the mean response of the most sensitive species falls below its respective High Toxicity Threshold

Effluent toxicity data were collected in the Los Angeles Region during 2001 - 2010, but were not included in the SWAMP and CEDEN databases, and were not examined in this study due to the difficulty of obtaining electronic replicate-level data in a timely fashion.

SECTION 3 REGIONAL TOXICITY

From 2001 - 2010 in the Los Angeles region, freshwater toxicity was uncommon (seen at 15% of sites) and all marine water samples (tested with mussel embryos *M. galloprovincialis*) were non-toxic (Figure 1). Freshwater sediment toxicity (tested with the amphipod *H. azteca*) was common (observed at 44% of sites), and low magnitude toxicity was pervasive in marine sediments (Figure 2). Where freshwater sediment toxicity was observed, it tended to be of higher magnitude, with 33% of freshwater sediments showing *high* toxicity. Freshwater water column toxicity tended to be of lower magnitude; 4% of sites demonstrated *high* water column toxicity.

TOXICITY BY SPECIES

Freshwater toxicity to *P. promelas* and *C. dubia* occurred at comparable rates, with 13% of sites toxic to *P. promelas* and 8% of sites toxic to *C. dubia*. Severity of toxicity to the two species was also comparable, with 4% and 2% of sites *highly* toxic to the two species, respectively. The two high conductivity sites whose water was examined with *H. azteca* showed no toxicity (Figure 3). Ninety percent (90%) of the marine sediment samples examined using *E. estuarius* showed toxicity, while toxicity was not detected at the one marine site whose sediment was examined using *M. galloprovincialis* (Figure 4).

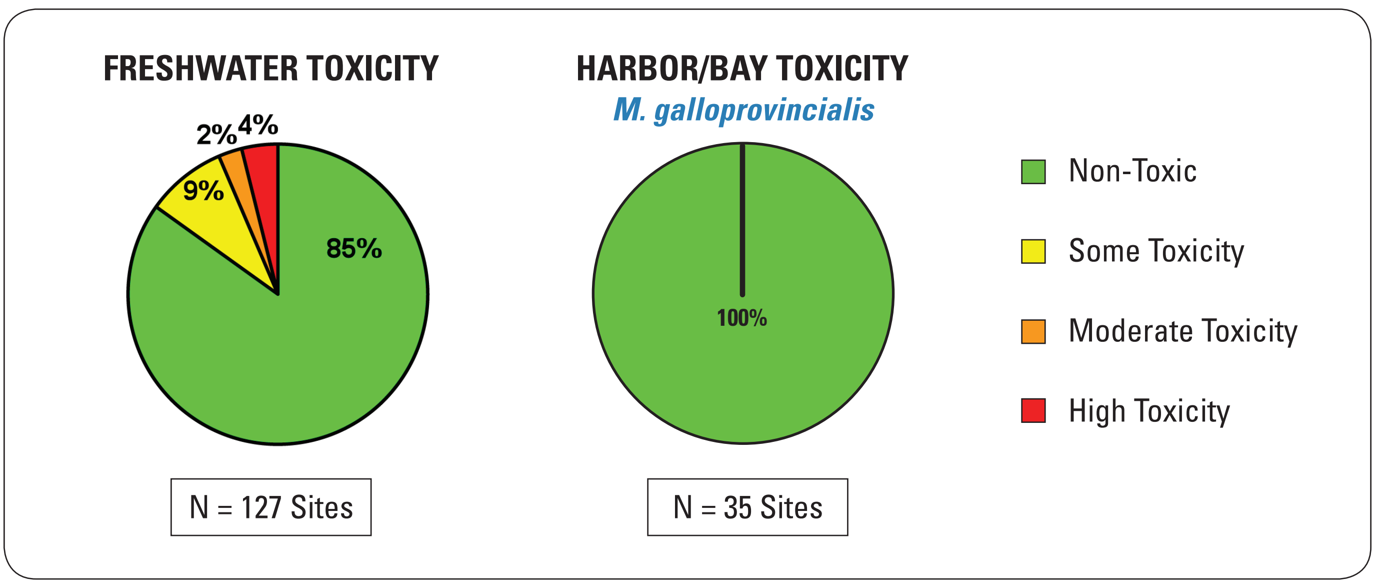

Figure 1. Magnitude of toxicity in water samples in the Los Angeles Region of California.

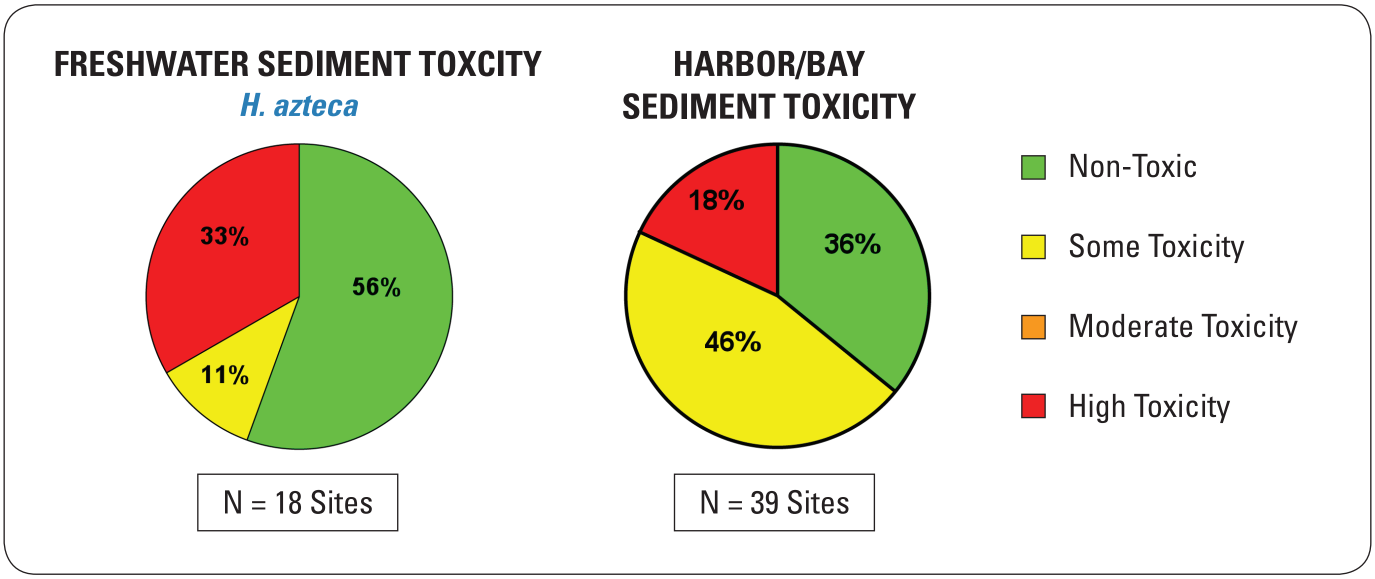

Figure 2. Magnitude of toxicity in water samples in the Los Angeles Region of California.

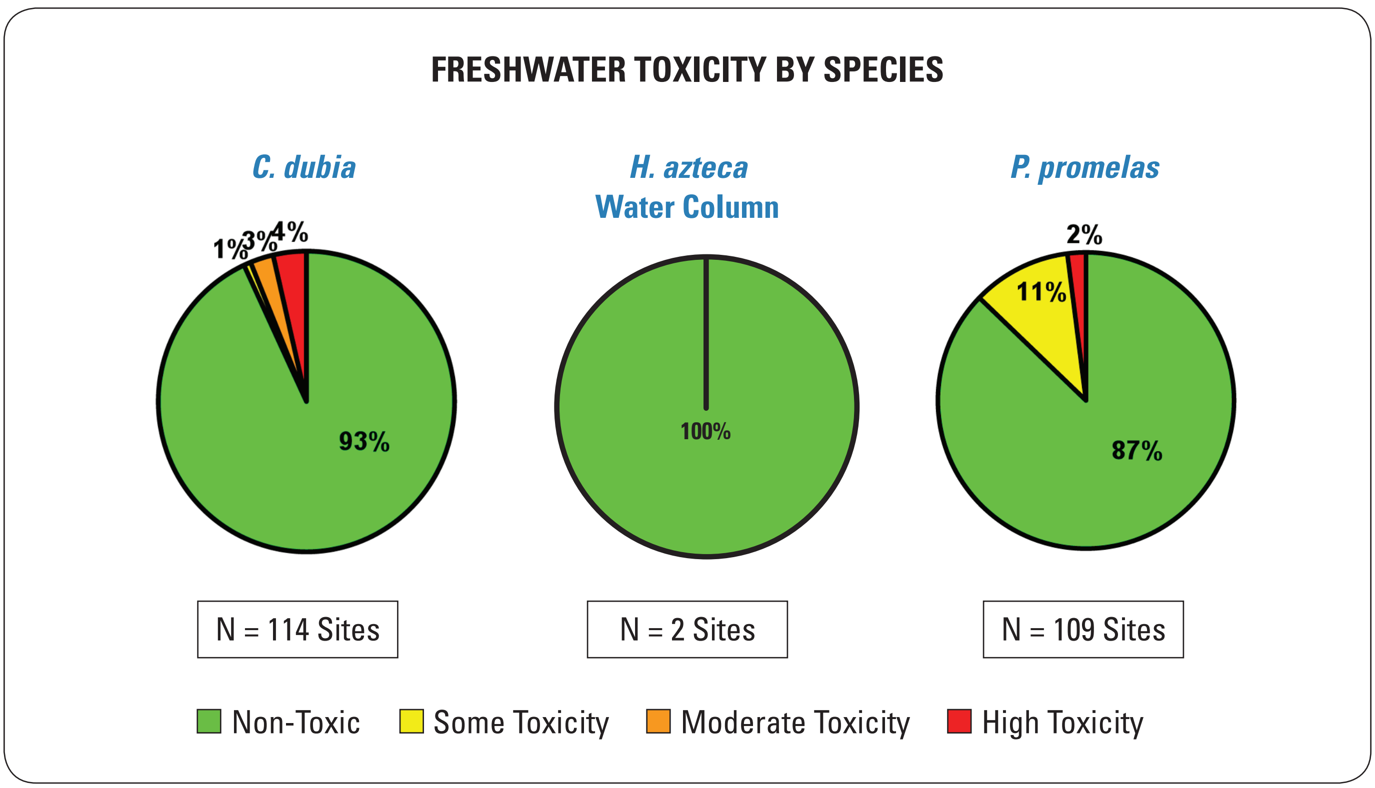

Figure 3. Magnitude of toxicity to individual species in freshwater samples from the Los Angeles Region of California. Not pictured is *M. galloprovincialis*, which was exposed to 35 marine water samples, all of which were found to be non-toxic.

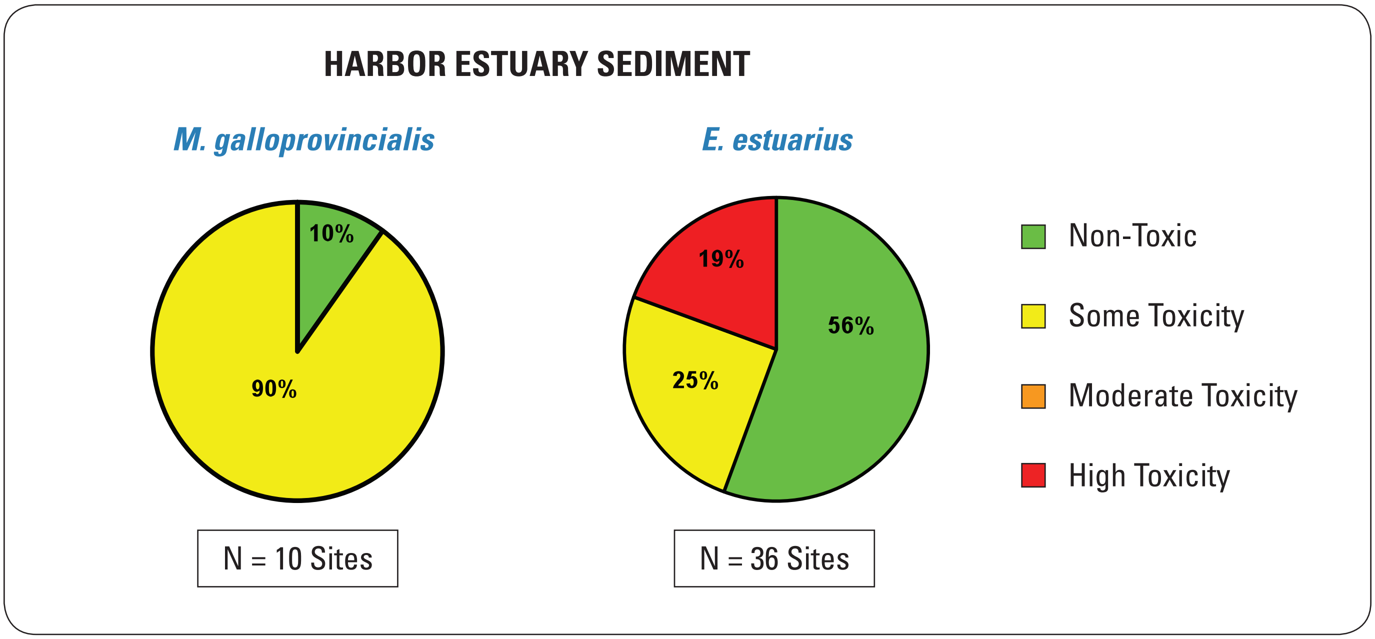

Figure 4. Magnitude of marine sediment toxicity to individual species in samples collected from the harbor and salt water channels of Los Angeles.

SECTION 4
RELATIONSHIPS BETWEEN LAND USE AND TOXICITY

Land use was quantified as described in Anderson et al. (2011), around stream, canal and ditch sites at which samples were collected for testing in water column or sediment toxicity tests. Using ArcGIS, polygons were drawn to circumscribe the area within one kilometer of each site that was upstream of the site, in the same catchment, and within 500 meters of a waterway draining to the site. Land use was categorized according to the National Land Cover Database. All "developed" land types in the land cover database were collectively categorized as "urban". "Cultivated crops" and "hay/pasture" were categorized together as "agricultural". All other land types were categorized as "other" for the purpose of this analysis. Percentages of each land use type were quantified in the buffers surrounding the sample collection sites. Urban land category represents sites with nearby upstream land use of greater than 10% urban and less than 25% agricultural areas. Agricultural land category represents sites with nearby upstream land use of greater than 25% agricultural and less than 10% urban areas.

In the Los Angeles region, water toxicity was examined at sites over a wide range of urban land use intensity (N = 132 sites) while sediment toxicity was examined at a much smaller number of sites, most of which were intensely urbanized (N = 19 sites, 13 of which had > 80% urban land use in 1 km upstream buffers). There were no significant associations between water or sediment toxicity and land use. Water toxicity was not widespread at any level of urban intensity, but the small number of sites that showed severe water toxicity were all located in highly urbanized areas (Figure 5-A).

The frequency and intensity of sediment toxicity appeared to be greater at sites with a greater percentage of upstream urban land (within one kilometer), but the pattern was not quantifiable due to the small number of sites examined (Figure 5-B). The only two sites that showed reduced *H. azteca* survival in areas of < 80% urban land were Calleguas Creek on the Oxnard Plain, surrounded by agricultural land (408CAL006) and Castaic Creek near Santa Clarita in an agricultural-urban area (403SUP085). Greater *H. azteca* sediment toxicity in urban areas has been reported previously by Weston et al. (Weston et al., 2005). Data from SWAMP's Stream Pollution Trends Monitoring Program (SPoT) showed a strong correlation between urban land cover, chemical contamination and toxicity in a statewide analysis of 2008 SPoT data (Hunt et al., 2011). In the analysis of statewide trends in toxicity based on SWAMP data collected from 2001 - 2010, water toxicity was better correlated with agricultural land uses and sediment toxicity was correlated with both urban and agricultural land uses (Anderson et al., 2011).

Although it was not possible to use the Los Angeles' regional data set to examine associations between toxicity and agriculture, these associations are well established (de Vlaming et al., 2000; Weston et al., 2004; Holmes et al., 2008).

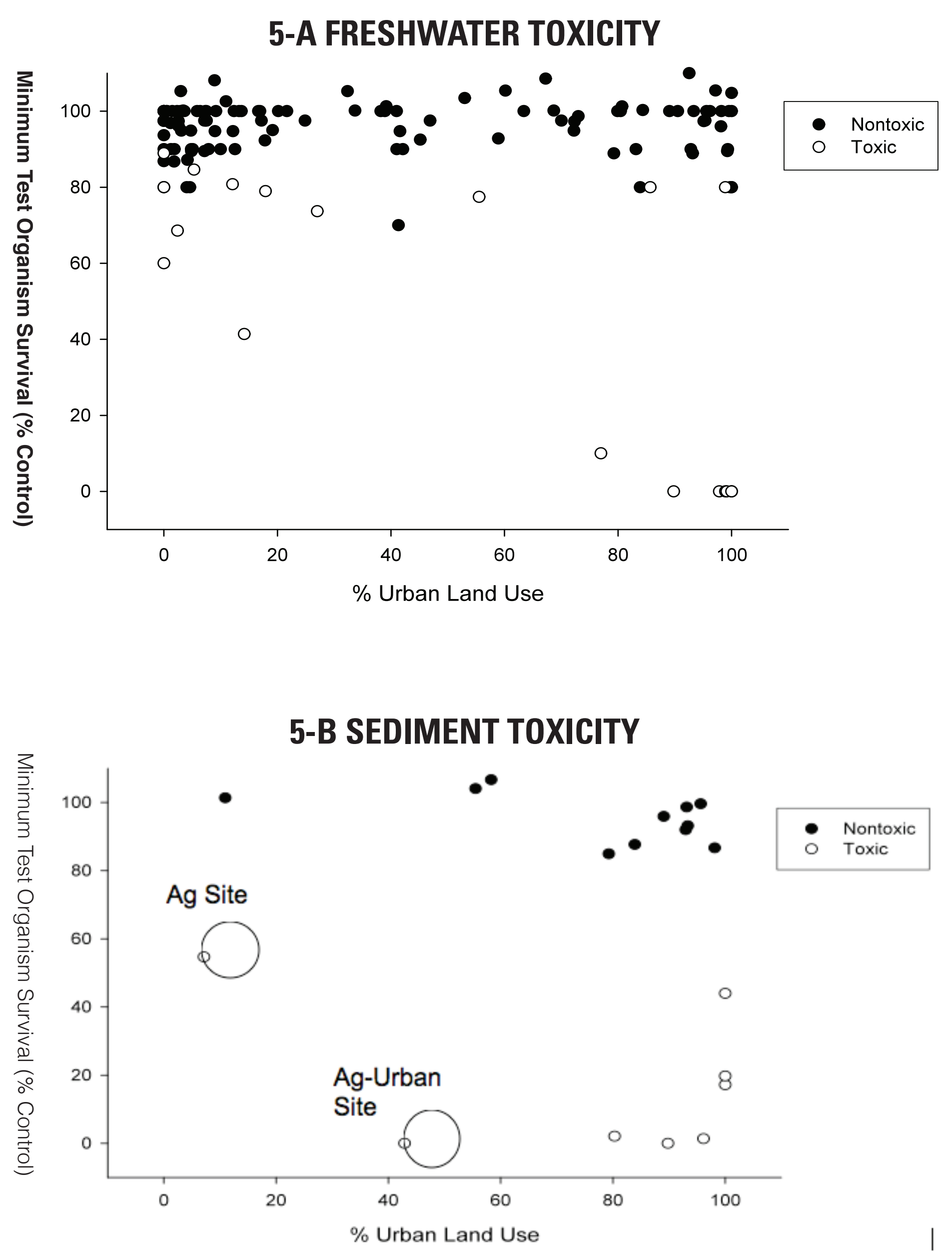

Figure 5. Relationships between toxicity and intensity of urban land use. (A) water column toxicity, (B) sediment toxicity. Data from all species tested in each matrix were combined, and the minimum survival of any test species at each site is depicted.

SECTION 5
GEOGRAPHICAL PATTERNS IN TOXICITY

Patterns in freshwater and marine water and sediment toxicity are presented for the different geographical areas of the Los Angeles region in Figures 6 – 14, at the end of this report.

FRESHWATER

Many sites examined for freshwater toxicity in the Los Angeles region were non-toxic. Sites showing *moderate* to *high* water toxicity were concentrated in the most urbanized areas. Some sites in the western urban-agricultural valleys and the less developed waterways of the northern mountains also showed *some* toxicity. Much of the *moderate* to *high* freshwater toxicity involved mortality of *C. dubia*, while most of the detections of less intense toxicity involved *P. promelas*. Sediments showed *high* toxicity in the same urban areas as freshwater samples.

The most *high C. dubia* freshwater toxicity was found in Santa Clarita (403STCBQT), Thousand Oaks (408CAL011), and in places throughout the city of Los Angeles including Aliso Canyon Wash (412LAR024), the Los Angeles River (412LARBLL), a tributary to Tujunga Wash (412LAR025), Verdugo Wash at the Los Angeles River (412LARVGO), and Rio Hondo at the Los Angeles River (412LARRHO). *High P. promelas* toxicity was found at two sites, Rio Honda in July 2005 (412LARRHO) and Escondido Canyon Creek in March 2003 (404SMB017). Escondido Canyon Creek, a waterway in a less developed watershed near Malibu, was non-toxic to *C. dubia*.

FRESHWATER SEDIMENT

High toxicity of freshwater sediments was seen at many of the sites sampled in Los Angeles, Simi Valley and Santa Clarita. From 2007 - 2008, *H. azteca* showed 100% mortality in four sites: Bouquet Canyon Creek and Castaic Creek in Santa Clarita (403STCBQT and 403SUP085), Arroyo Simi (408SUP059), and the Los Angeles River near Lake Balboa (412SUP100). Ballona Creek showed *high H. azteca* mortality at sites approximately one kilometer downstream from the confluence with the Sepulveda Channel in both 2007 and 2008 (404SUP093 and 404BLNAxx). Less intense but still substantial freshwater sediment toxicity was observed on the Oxnard Plain in Calleguas Creek between Revlon Slough and Conejo Creek (408CAL006).

MARINE WATER AND SEDIMENT OF LOS ANGELES HARBOR

Water samples collected throughout Los Angeles Harbor were non-toxic to *M. galloprovincialis*. Sediment samples showed pervasive low levels of toxicity to *E. estuarius*, with survival rates in bight/harbor samples ranging from 61 - 88% of control survival. Note that the majority of marine toxicity testing conducted during this time period was conducted in collaboration with the Southern California Bight Regional Monitoring Program. The Southern California Bight sampling presented here comprises the subset of the larger Bight 2003 data set most relevant to coastal sediment quality in the Los Angeles region. A more detailed analysis of the Bight 2003 toxicity and chemistry data is available through the Southern California Coastal Water Research Project (SCCWRP).

SECTION 6
CAUSES OF TOXICITY

Correlation analyses and Toxicity Identification Evaluations (TIEs) were used to determine causes of water and sediment toxicity statewide (Anderson et al., 2011a). The results of these analyses showed that the majority of toxicity was caused by pesticides.

FRESHWATER

High C. dubia toxicity found at 408CAL011 in 2001 and at 403STCBQT in 2001 and 2003 was associated with toxic concentrations of chlorpyrifos or diazinon.

A toxicity identification evaluation (TIE) was conducted with a water sample from 403STCBQT using *C. dubia*. Toxicity results and chemical analysis with enzyme-linked immunosorbent assays indicated that the organophosphate pesticide diazinon was the primary cause of the observed toxicity.

In contrast, organophosphates were not detected during events of *high C. dubia* toxicity in Verdugo Wash and Rio Honda in 2005. *High P. promelas* toxicity was also observed during the 2005 toxic event in the Rio Honda. Pyrethroid insecticides were not included in the 2005 analytical work, and the toxicity seen in that year may have resulted from contamination by these compounds, given the widespread pyrethroid toxicity identified in urban creeks in other areas of California (e.g., Holmes et al., 2008). No chemicals above toxicity thresholds for *P. promelas* were detected in the analysis of toxic water from Escondido Canyon Creek (404SMB017 - near Malibu). Although not included in the current dataset, extensive toxicity testing and TIEs were conducted in the Calleguas Creek watershed from 1995 to 1999. Investigations in the lower watershed (Revlon Slough, Santa Clara Drain and Beardsley Wash) indicated that toxicity of samples to the *C. dubia* was due to elevated concentrations of the organophosphate pesticide chlorpyrifos, while causes of intermittent toxicity to fathead minnows (*Pimephales promelas*) and the alga *Selenastrum capricornutum* were less clear. Investigations at sites in the middle and upper reaches of the watershed (Arroyo Simi and Conejo Creek) indicated that the pesticide diazinon was the probable cause of receiving water toxicity to *C. dubia*. Elevated ammonia was the cause of toxicity to fathead minnows in the upper watershed sites (Anderson et al., 2002).

The limited findings based on Los Angeles regional SWAMP data are consistent with correlation analyses and TIEs used to determine causes of water and sediment toxicity statewide (Anderson et al., 2011). The results of these analyses showed that the majority of toxicity was caused by pesticides. TIE studies and pesticide detections have come from toxic water samples collected from elsewhere in California. These have demonstrated that water toxicity to *C. dubia* is caused primarily by a combination of organophosphate and pyrethroid pesticides (de Vlaming et al., 2000; Bacey et al., 2005; Holmes et al., 2005; AquaScience, 2007; AEAL, 2008). Recent water column TIEs with *H. azteca* have identified pyrethroids as the most major toxicants of concern in urban runoff, and have found that toxicity of agricultural runoff was caused by mixtures of organophosphates and pyrethroids (Weston and Lydy, 2010a, b). Toxicity to fish was not common or generally severe between 2001 and 2010, and few water samples reached a level fish toxicity sufficient to initiate a TIE.

FRESHWATER SEDIMENT

Elevated *H. azteca* mortality was seen in urban samples from the Los Angeles Region collected between 2007 and 2008. It is likely that the urban sediment toxicity observed in these samples was caused by sediment-bound pyrethroid pesticides, as seen in studies performed in recent years throughout California. The majority of sediment TIEs and chemical analyses of toxic sediments have identified pyrethroid pesticides as the primary cause of toxicity. Other studies have shown sediment toxicity is due to the organophosphate pesticide chlorpyrifos, or to mixtures of chlorpyrifos and pyrethroids (Weston et al., 2005; Amweg et al., 2006; Weston et al., 2009).

A study conducting statewide sediment toxicity testing found that urban creek sediments in the Los Angeles Region caused a high magnitude of amphipod mortality (using *H. azteca*). Significant mortality was observed in sediments from Arroyo Simi, Ballona Creek, the Los Angeles River, Walnut Creek, and Bouquet Canyon Creek. Pyrethroid pesticides were detected in every sediment sample. The pyrethroids most commonly detected at toxic concentrations were bifenthrin and cypermethrin (Holmes et al., 2008).

The SWAMP's Stream Pollution Trends monitoring program (SPoT) has been conducting contamination and toxicity surveys in several watersheds throughout the Los Angeles Region since 2008. These include sites on the Ventura River, the Los Angeles River, Ballona Creek, Bouquet Canyon Creek, Sespe Creek (reference station), the Santa Clara River Estuary, Calleguas Creek, and the San Gabriel River. Results from 2008 showed sediment toxicity at Ballona Creek and Calleguas Creek, and both sites had toxic concentrations of pyrethroids. SPoT results from 2010 showed *high* toxicity at Bouquet Canyon Creek and toxicity at Ballona Creek and in the San Gabriel River. This toxicity could also be explained by elevated pyrethroid concentrations.

In 2010, SPoT began conducting dual temperature toxicity testing at a subset of sites, to help diagnose toxicity due to pyrethroids. Increased toxicity in samples tested at lower temperatures suggests the presence of pyrethroids. Results showed *moderate* toxicity in sediment from Ballona Creek and the San Gabriel River when tests were conducted at 23 °C, and *high* toxicity at these sites when tests were conducted at 15 °C. In addition, dual temperature tests conducted using samples from the Los Angeles River showed no toxicity at 23 °C and *high* toxicity at 15 °C. All of these sites contained toxic concentrations of pyrethroids

MARINE WATER

Significant toxicity to the amphipod *Holmesimysis costata* was observed in a brackish water column sample from station 408CAL004. Two TIEs were attempted with this organism with no success because of control mortality. Because this was a brackish water sample (conductivity ~4000 uS/cm), the sample was tested with the freshwater amphipod *H. azteca*. No toxicity was observed. A final TIE was conducted with the mysid *Americamysis bahia* as a surrogate for *H. costata*. It was determined that the original mysid toxicity was caused by an ionic imbalance in the water (MPSL unpublished data).

MARINE SEDIMENT

Several regional studies have correlated sediment toxicity in the harbors and bays of the Los Angeles Region with chemical and non-contaminant factors. These include studies in Long Beach/Los Angeles Harbor conducted for the Bay Protection Toxic Cleanup Program (Anderson et al., 2001a), and later studies in the Southern California Bight conducted for the Bight 2003 Regional Monitoring Program. These studies have correlated amphipod mortality (usually *Eohaustorius estuarius*) with increased concentrations of metals and organic chemical constituents, as well as mixtures of chemicals represented by sediment quality guideline quotient values (Anderson et al., 2001a; Bay et al., 2005). Recent TIE research and sediment spiking studies conducted to establish toxicity thresholds (e.g., LC50s) have established that metals and the organochlorine pesticide chlordane are likely not responsible for *E. estuarius* mortality, despite the fact that these constituents often correlate with amphipod mortality in statewide datasets (Phillips et al., 2011). This argues for the importance of continued development of TIE methods for marine sediments, and for developing LC50 data for specific chemicals of concern.

Sediment TIEs have been reported for two marine sites in the Los Angeles Region: Consolidated Slip and Ballona Creek Estuary. Sediment TIEs were conducted using samples from the Consolidated Slip area of LA harbor in 2006 as part of an effort to validate U.S. EPA marine sediment TIE procedures (Anderson et al., 2007). A combination of whole sediment and interstitial water TIEs were conducted on a dilution series of samples, and these suggested sediment toxicity to amphipods was caused by mixtures of organic chemicals which were dominated by hydrocarbons. The likely constituents responsible for toxicity were polycyclic aromatic hydrocarbons (PAHs; Anderson et al., 2007).

In addition, Lao et al. (Lao et al., 2010) reported results of toxicity tests, chemical analyses, and abbreviated TIEs conducted on sediments collected from the Ballona Creek Estuary in 2007 and 2008. Results indicated toxicity to the amphipod *E. estuarius* was likely due to mixtures of pyrethroid pesticides, particularly bifenthrin and cypermethrin. Not all toxicity of Ballona Creek Estuary samples could be explained by pyrethroid concentrations, and undetected or unmeasured constituents could have contributed to the toxicity of some of the samples.

SECTION 7
ECOLOGICAL IMPACTS ASSOCIATED WITH TOXIC WATERS

Field bioassessments provide information on the ecological health of streams and rivers, and bioassessments of macroinvertebrate communities have been used extensively throughout California. When combined with chemistry, toxicity, and TIE information, these studies indicate linkages between laboratory toxicity and ecosystem impacts.

A comprehensive series of studies linking water and sediment toxicity with impacts on resident macroinvertebrates in California was conducted in the Salinas River. In these studies, diazinon and chlorpyrifos from agriculture runoff caused water and sediment toxicity, and also were associated with reductions in population densities of resident pesticide-sensitive benthic invertebrates such as the amphipod *H. azteca* and mayflies of the genus Procloeon. (Anderson et al., 2003a; Anderson et al., 2003b; Phillips et al., 2004). The influence of habitat quality on macroinvertebrates was also assessed and it was concluded that habitat was a less important factor than pesticides (Anderson et al., 2003b).

While no similar series of studies has been conducted in the Los Angeles Region, the findings of the Salinas River studies are likely to be broadly applicable wherever benthic communities are exposed to toxic water and sediment. Throughout California, toxicity testing and bioassessment have revealed similar geographical patterns of impaired waterways, with more severely impaired waterways occurring in areas of the most intense agricultural and urban land uses (Anderson et al., 2011; Ode et al., 2011). Benthic community impairment can have many causes other than contaminated water and sediment, however, and this impairment can therefore be expected to be found more frequently than toxic conditions (Hall et al., 2007; Hall et al., 2009; Ode et al., 2011). This is evident in the streams of the Los Angeles Region, where many benthic communities were classified as “degraded” or “very degraded”, but the severity of water and sediment toxicity was observed to vary widely among sites, even within the most heavily urbanized areas (Anderson et al., 2011; Ode et al., 2011, this document). When benthic community impairment is detected, it is often difficult to use bioassessment to parse the effects of multiple stressors, even when used in concert with chemical analysis and quantification of habitat parameters (Bacey and Spurlock, 2007). Examination of toxicity can show potential limitations placed on community composition by impaired water and sediment quality, and can therefore play an essential role in stressor identification after a site is determined to be ecologically impaired.

Monitoring conducted by the SPoT monitoring program overlaps with the Southern California Monitoring Coalition (SMC) stormwater monitoring at six stations. This should allow correlations between SPoT sediment toxicity and contamination data with SMC bioassessment metrics and habitat quality assessment data. As these data are incorporated into the SWAMP/CEDEN databases, they will allow evaluations of the relationships between in stream toxicity and benthic macroinvertebrate communities at SPoT stations in the Ventura, Santa Clara, Los Angeles and San Gabriel Rivers, as well as Ballona and Calleguas Creeks.

MARINE HABITATS

Triad studies linking sediment toxicity test results with chemical analyses and benthic community surveys were conducted in Long Beach/Los Angeles harbor in the late 1990s. These studies showed that at many sites, benthic community impacts were linked to sediment toxicity and high contaminant concentrations (Anderson et al., 2001b). Principal components analyses showed a significant positive correlation between higher amphipod survival and a higher Relative Benthic Index score. Spearman rank correlations comparing toxicity test results with benthic community metrics also showed significant positive correlations between amphipod survival in the toxicity tests, the total number of crustacean species measured in samples from these stations, and the total number of species measured in these stations.

Monitoring of sediments in the San Diego Region as part of Bight 2003 surveys found greater contamination in bays, harbors and estuaries relative to off-shore stations. Much greater sediment toxicity was observed in samples from inland continental shelf habitats, and these stations had greater enrichment by anthropogenic contaminants. These stations also demonstrated greater disturbance of benthic macroinvertebrate communities, resulting in lower biodiversity (SCCWRP, 2007).

SCCWRP conducted toxicity tests of stormwater discharged from Ballona Creek in 1996 – 1998 and assessed whether stormwater plumes entering the near shore environment had any measureable impacts on marine ecosystems (Bay, 1999). Ballona Creek stormwater samples were highly toxic to sea urchin fertilization, and chemical analyses and TIEs indicated toxicity was likely due to metals (copper and zinc). Toxicity was also observed in stormwater plumes in the marine receiving system offshore of the Ballona Creek discharge. Unexplained dry weather toxicity was also detected in the marine waters in this study. Measures of chemicals in sediments off shore of the Ballona Creek discharge indicated higher concentrations of chemical mixtures relative to a reference site in Santa Monica Bay, but no sediment toxicity was observed and no impacts on benthic macroinvertebrates were observed.

SECTION 8
MONITORING RECOMMENDATIONS

An examination of toxicity monitoring sites with data recorded in the SWAMP/CEDEN databases shows that the majority of toxicity seen in the region can be attributed to pesticides. Based on these results, we offer the following recommendations:

- Increasing evidence of pyrethroid toxicity in water suggests the need for more water testing with the amphipod *Hyalella azteca*. This should be encouraged for RMC stormwater and other ambient NPDES monitoring in the Los Angeles Region, as well as water column toxicity monitoring in the marine environment adjacent to stormwater discharges.

- Consider the importance of emerging contaminants of concern in future water and sediment monitoring (e.g., algal toxins, additional pesticides such as fipronil).

- Data from SWAMP regional and SPoT monitoring programs should be useful in detecting changes in toxicity patterns over larger spatial and temporal scales, as there is a need for consistency in monitoring to capture emerging trends.

- Continue coordination of SWAMP with other monitoring programs (e.g., RMC stormwater and other NPDES monitoring, RMP). Linkages between SPoT measures and bioassessments conducted as part of the SMC would help strengthen the in situ ecological context of toxicity and chemical monitoring data.

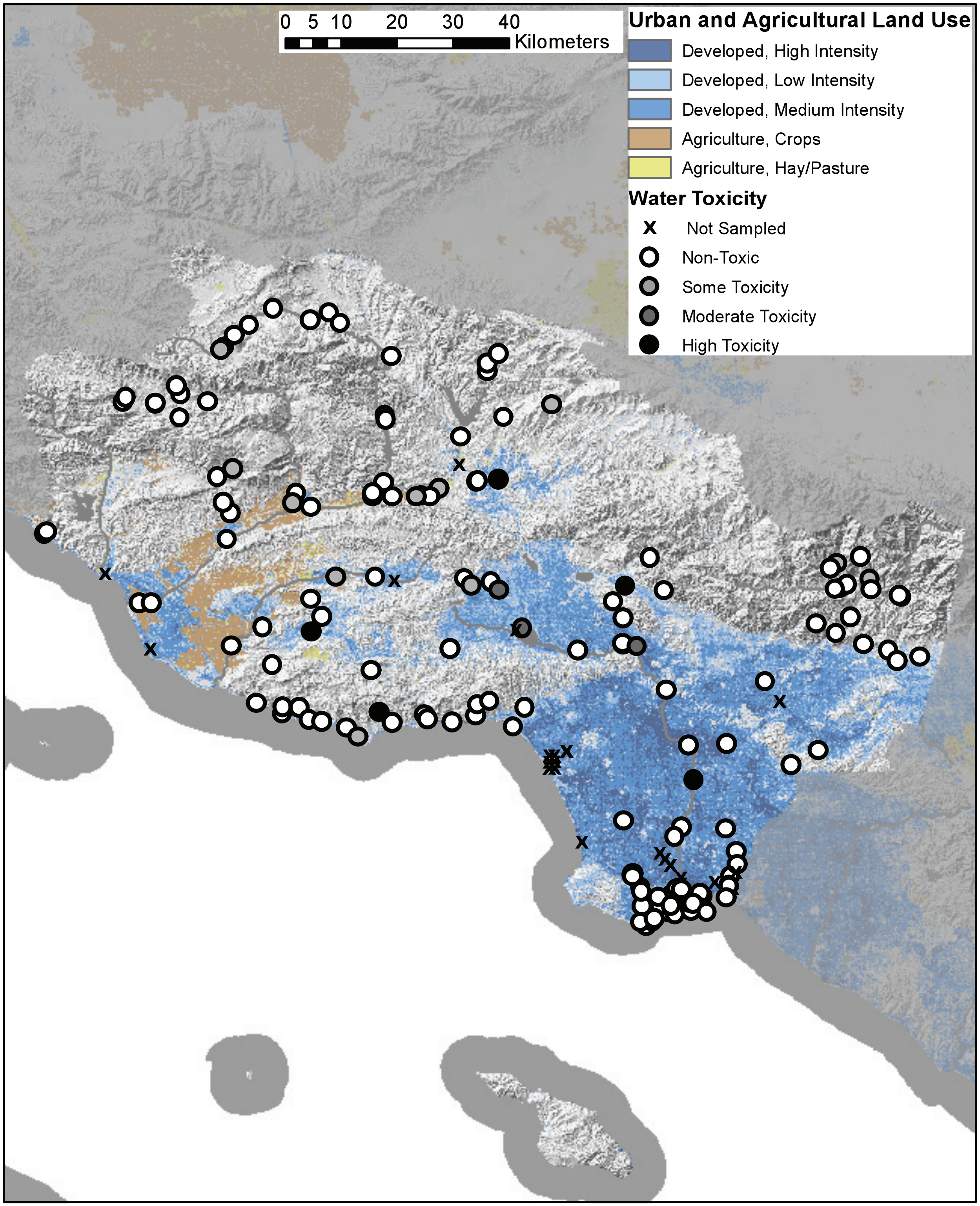

Figure 6. Magnitude of marine water and freshwater toxicity at sites in the Los Angeles Region of California based on the most sensitive species (test endpoint) in water samples collected at each site.

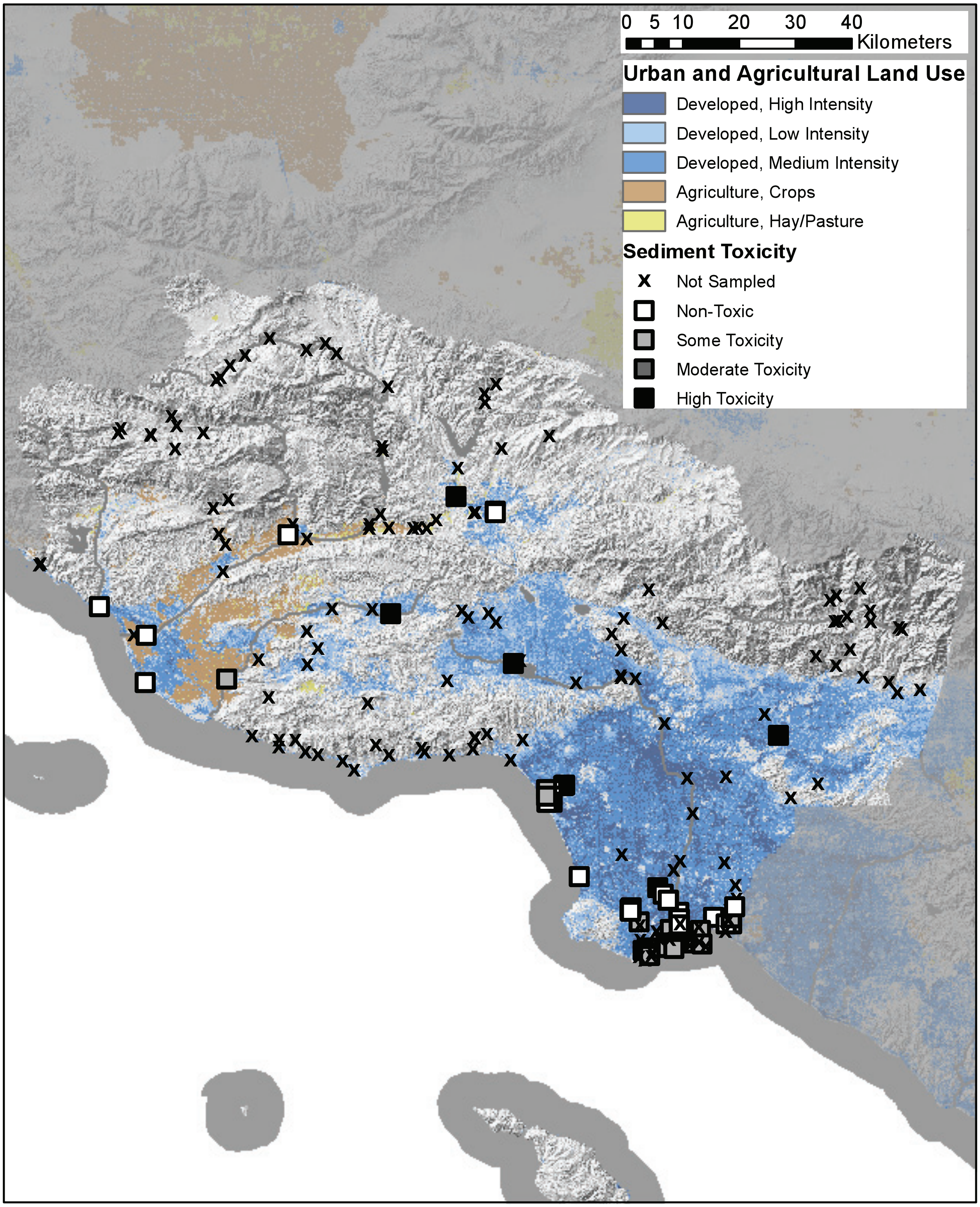

Figure 7. Magnitude of marine and freshwater sediment toxicity at sites in the Los Angeles Region of California based on the most sensitive species (test endpoint) in water samples collected at each site.

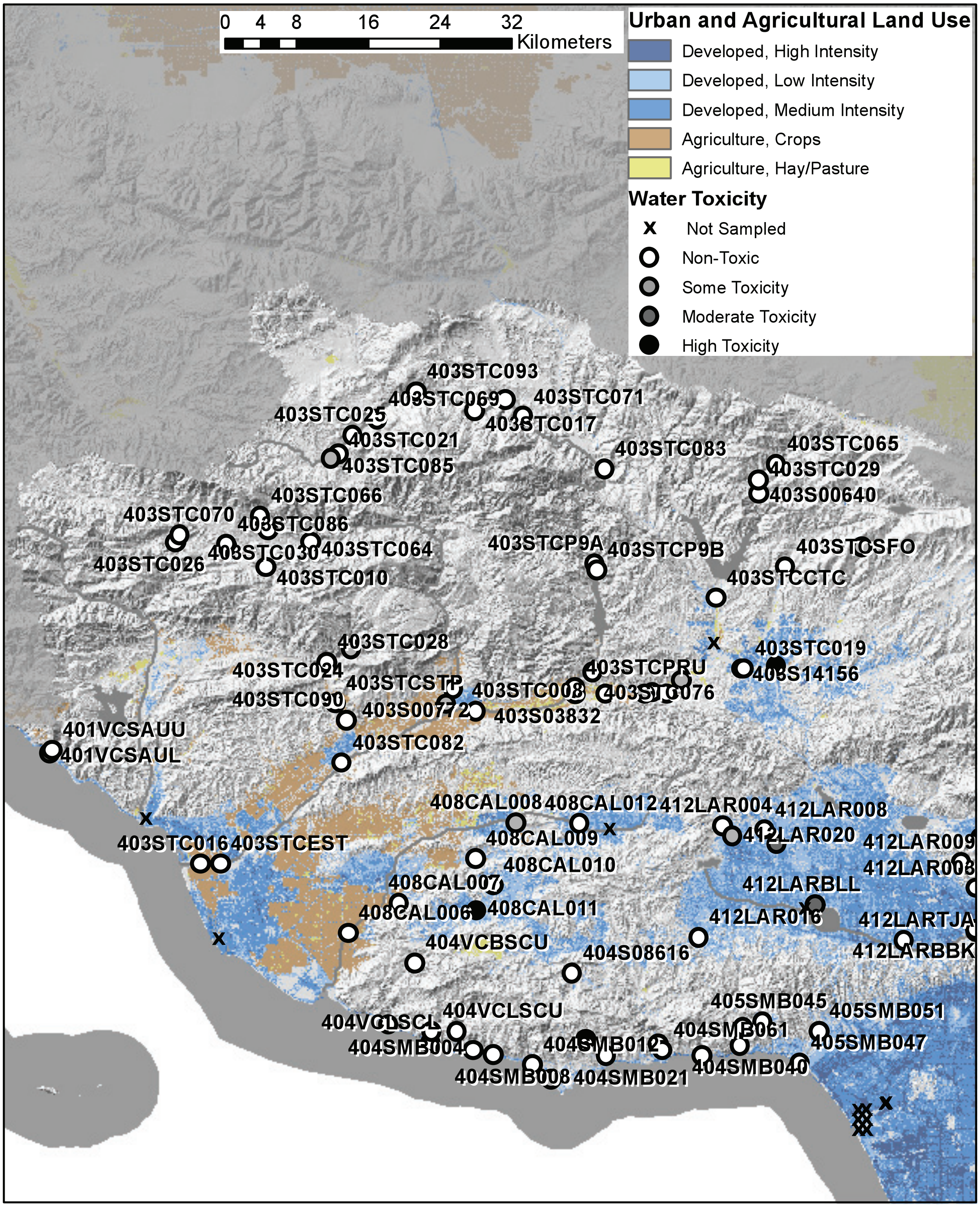

Figure 8. Magnitude of freshwater toxicity at sites in the western Los Angeles Region of California based on the most sensitive species (test endpoint) in water samples collected at each site.

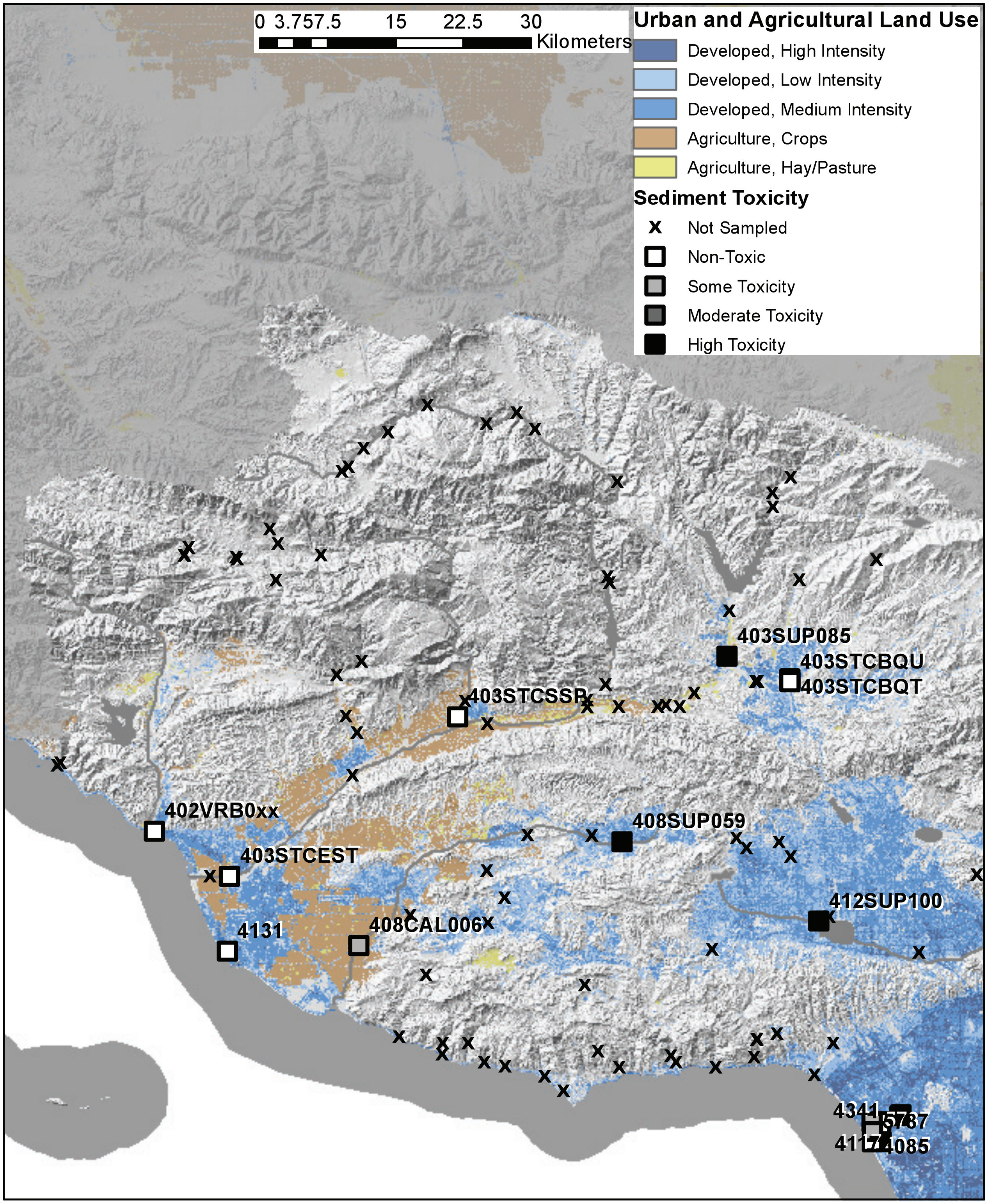

Figure 9. Magnitude of marine and freshwater sediment toxicity at sites in the western Los Angeles Region of California based on the most sensitive species (test endpoint) in water samples collected at each site.

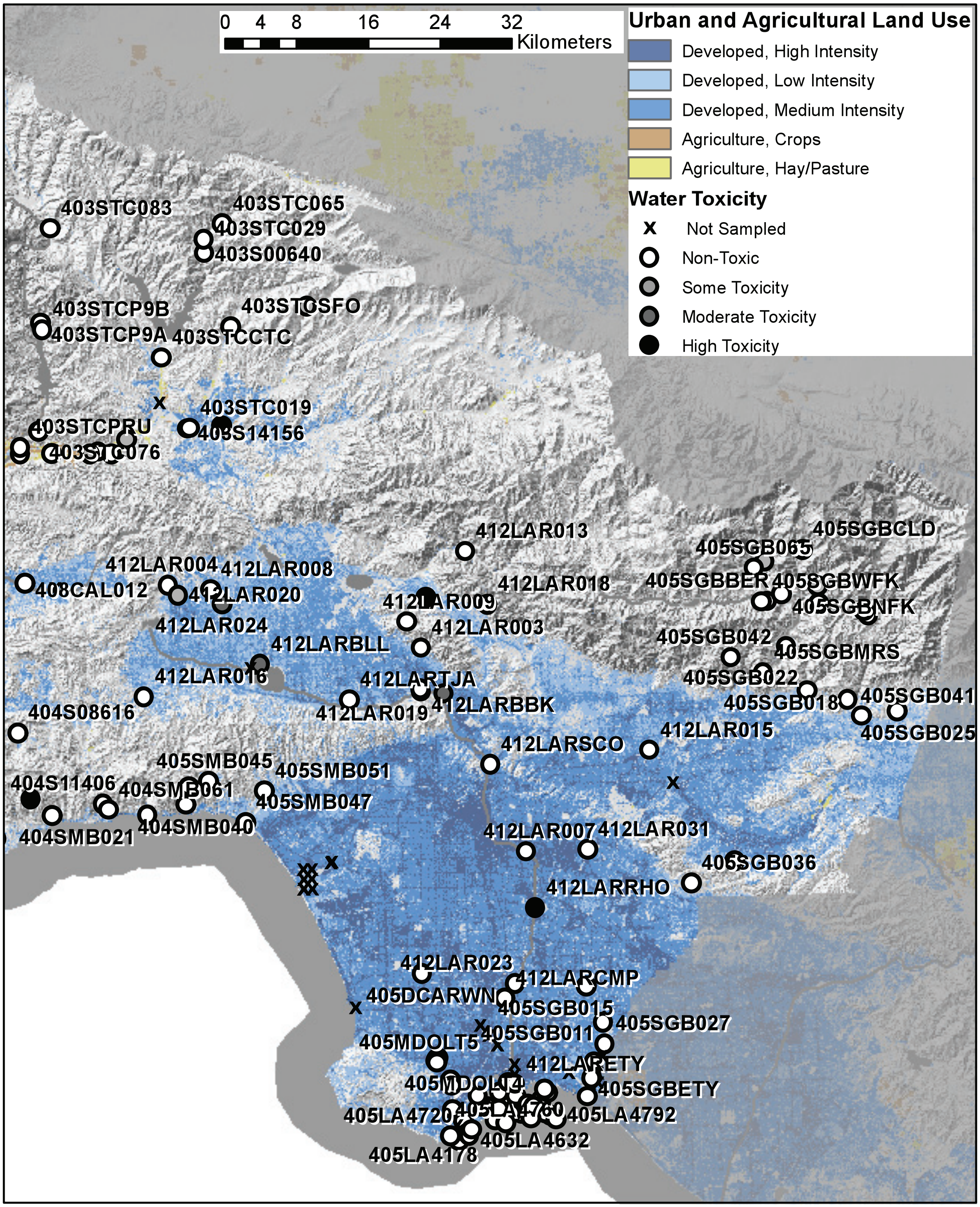

Figure 10. Magnitude of marine water and freshwater toxicity at sites in the eastern Los Angeles Region of California based on the most sensitive species (test endpoint) in water samples collected at each site.

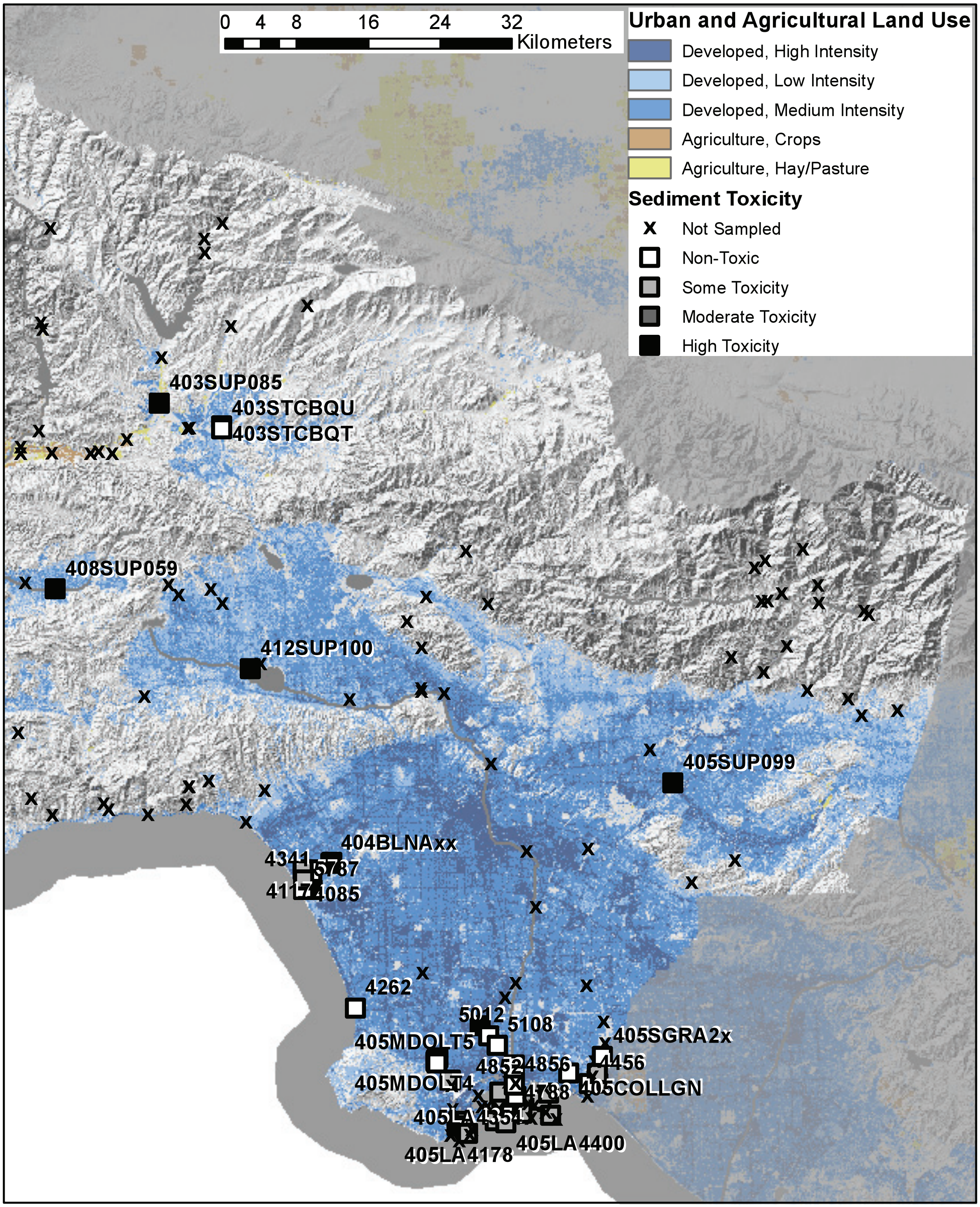

Figure 11. Magnitude of marine and freshwater sediment toxicity at sites in the eastern Los Angeles Region of California based on the most sensitive species (test endpoint) in water samples collected at each site.

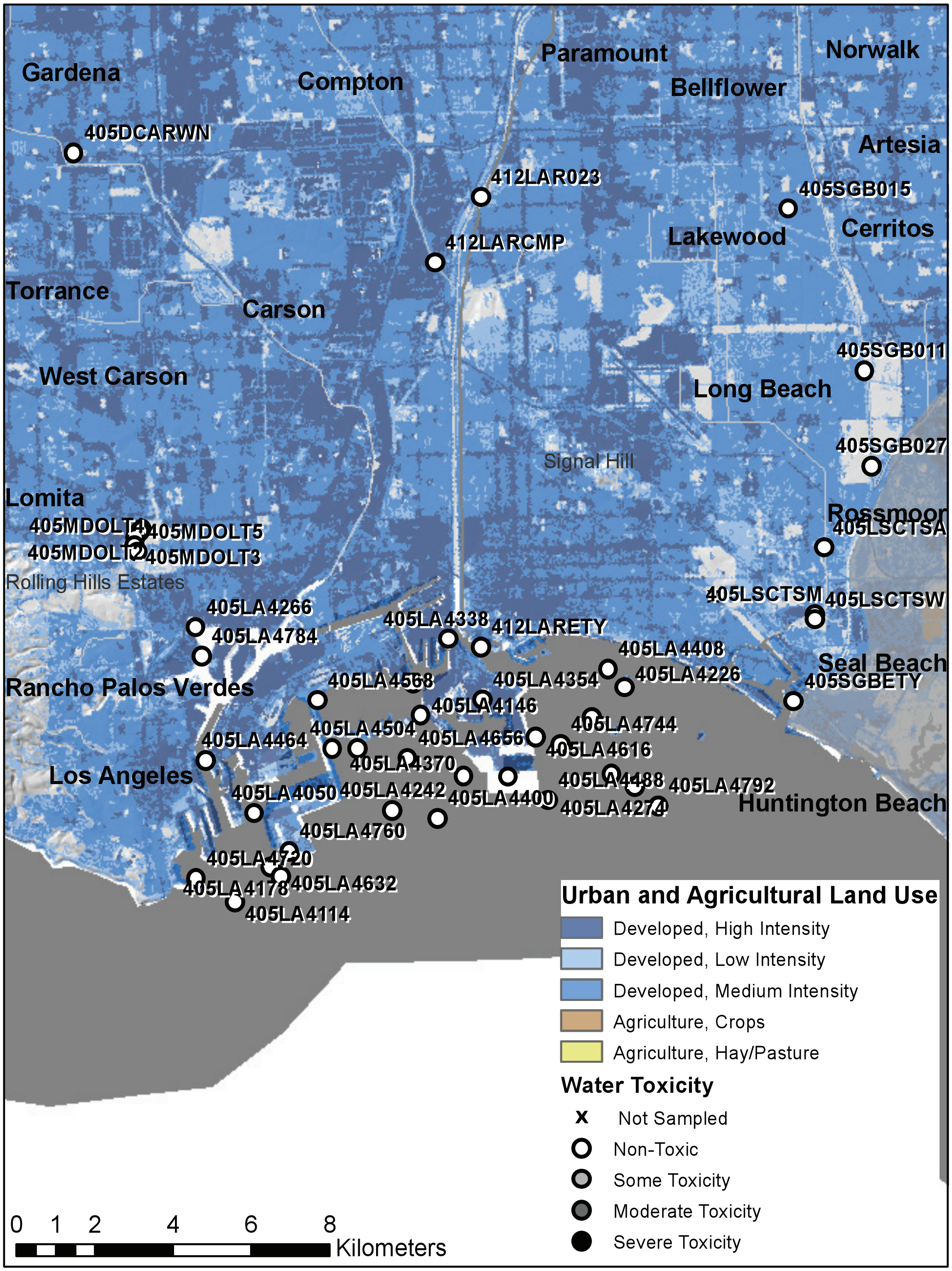

Figure 12. Magnitude of marine water and freshwater toxicity at sites in and around Los Angeles Harbor based on the most sensitive species (test endpoint) in water samples collected at each site.

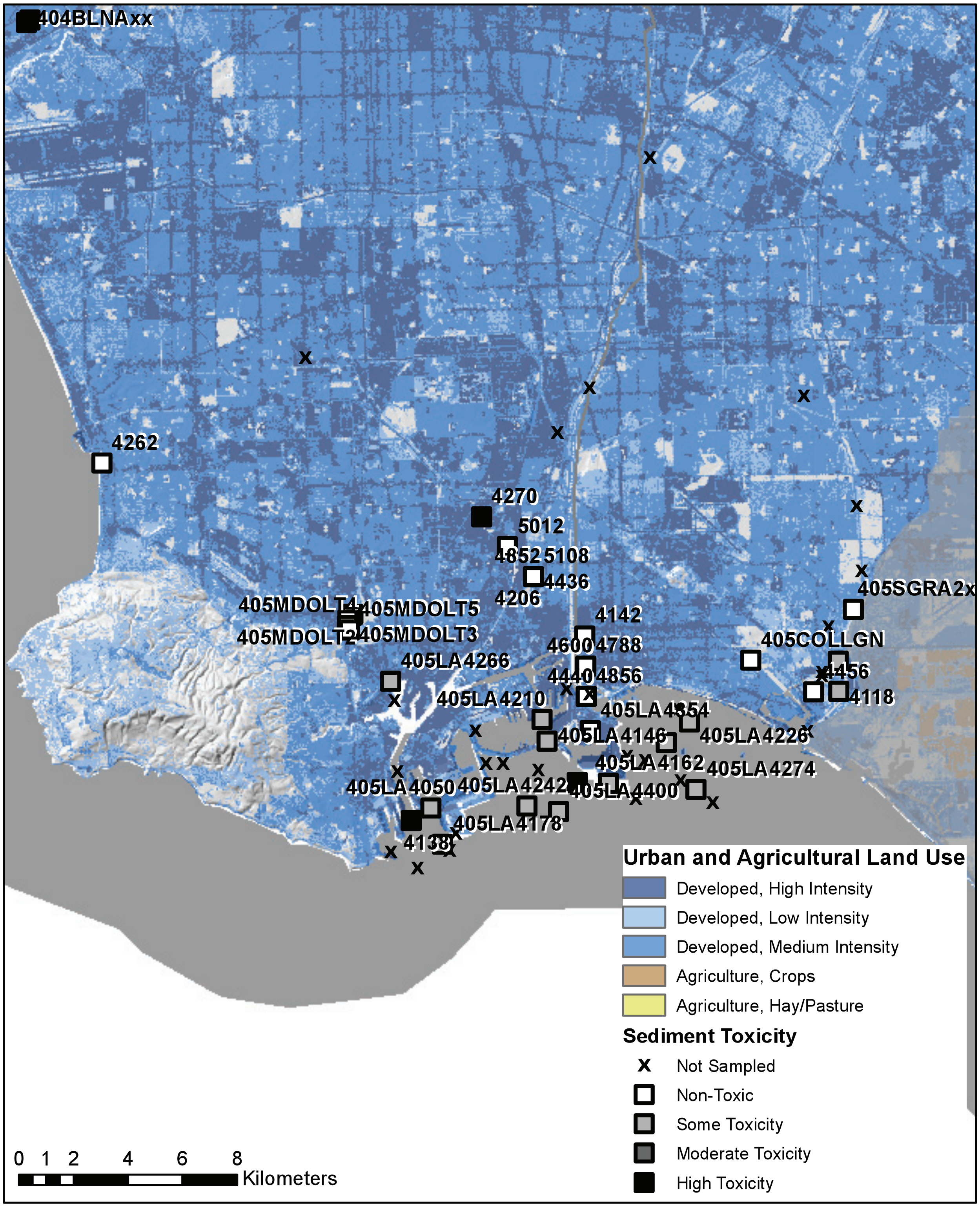

Figure 13. Magnitude of marine and freshwater sediment toxicity at sites in and around Los Angeles Harbor based on the most sensitive species (test endpoint) in water samples collected at each site.

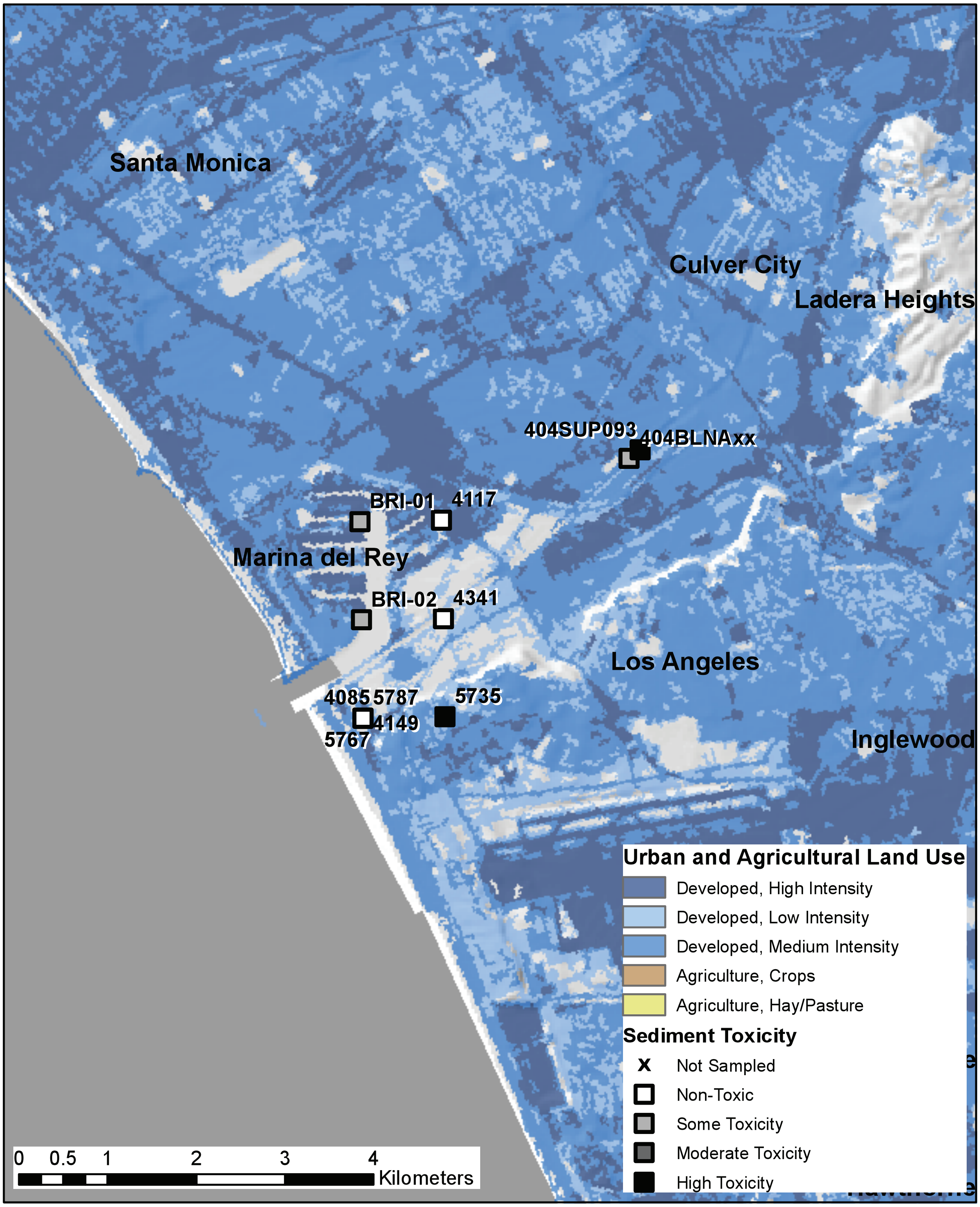

Figure 14. Magnitude of marine and freshwater sediment toxicity at sites in and around Marina Del Rey based on the most sensitive species (test endpoint) in water samples collected at each site.

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