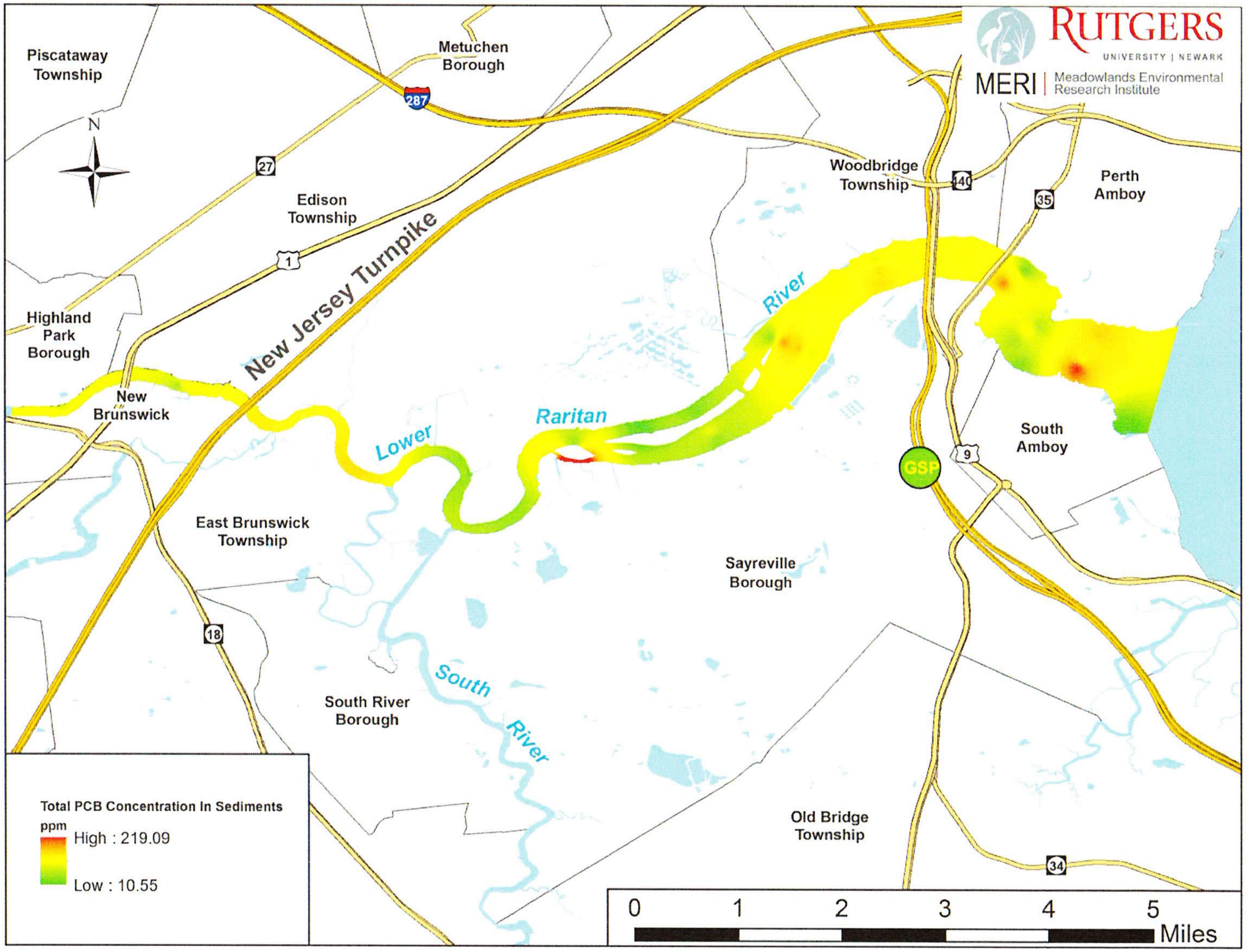
Figure 25. Spatial interpolation showing the distribution of total PCBs in the lower Raritan River surficial sediment



Contamination compared to the natural metal accumulation in the river sediment

The Geochemical Index (Igeo) of these samples was calculated by finding available background sediment concentration values derived from the local natural geology. This index value represents the degree of anthropogenic contaminant enrichment of the observed sediment beyond the natural background value from the local geology.

The index is the logarithmic ratio of the observed concentration value to the background geologic source concentrations. The background values referenced for these calculations were documented in 'Characterization of Ambient Levels of Selected Metals and Other Analytes in New Jersey Soils: Year 1, Urban Piedmont Region' (BEM Systems Inc., 1997). The Igeo values fall into several classes that describe the degree of sediment contamination, with values less than 1 assigned 'practically uncontaminated, 1-2 being 'mildly contaminated', 2-3 being 'moderately contaminated', and Igeo values larger than 3 assigned as 'contaminated'.

The geospatial analysis of Lower Raritan sediment data (Figures 26-38) revealed several trace metals had significant concentrations from anthropogenic sources with Geoaccumulation Indices exceeding 2. These trace elements include: As (Figure 27), Cd (Figure 29), Cu (Figure 31), Hg (Figure 33), Se (Figure 35), and Ag (Figure 36). Interestingly Pb only shows mildly increased contamination along the T3 and T2 transects, barely exceeding the background sediment levels.

Except for Silver, Arsenic, Copper, and Mercury none of the other metals that exceed either ERL or ERM criteria values (Table 3) show significant enrichment in the sediment when compared to the background values.

Figure 26. Spatial interpolation of the geoaccumulation index showing concentration of Antimony in the lower Raritan River surficial sediment compared to natural background levels

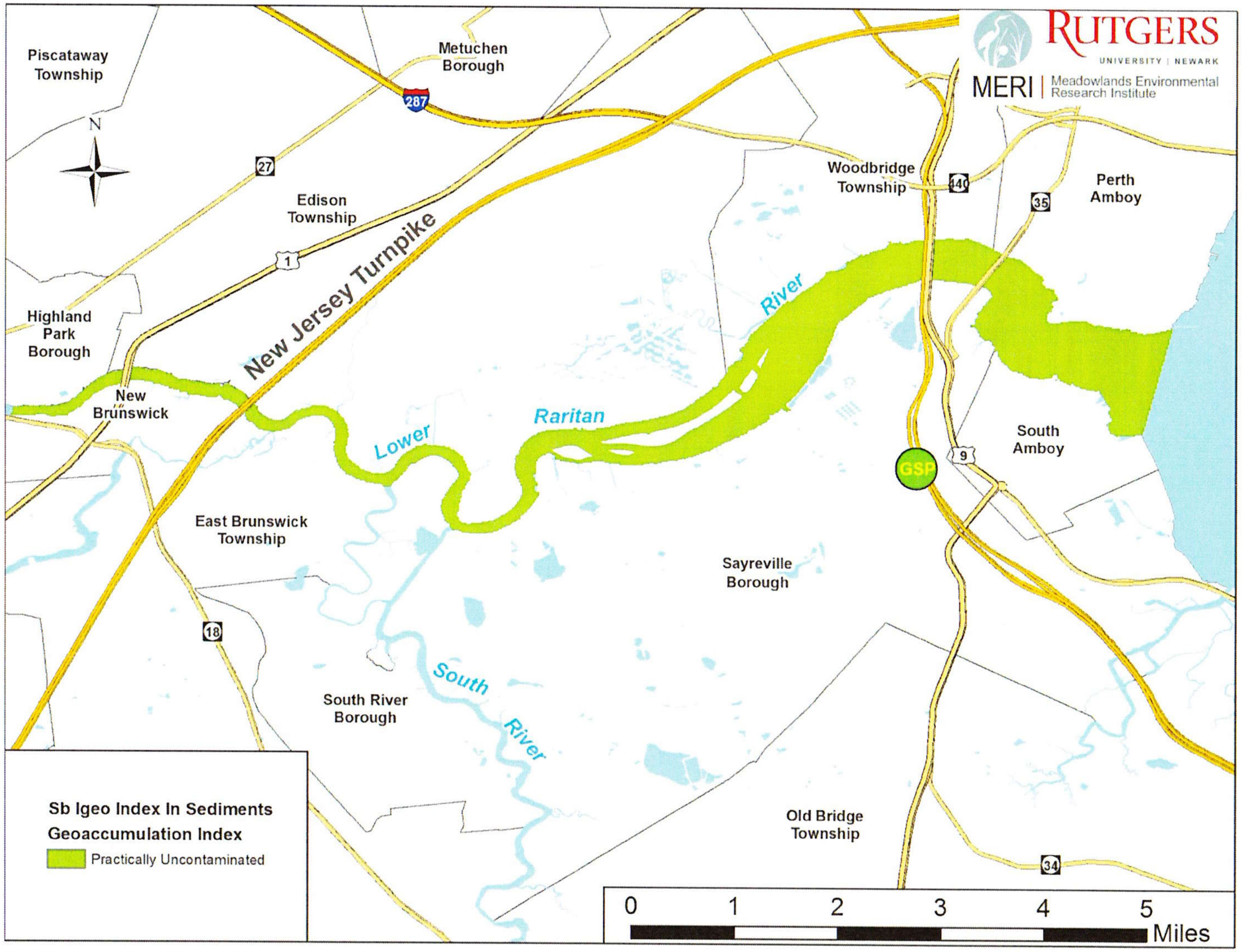


Figure 27. Spatial interpolation of the geoaccumulation index showing concentration of Arsenic in the lower Raritan River surficial sediment compared to natural background levels

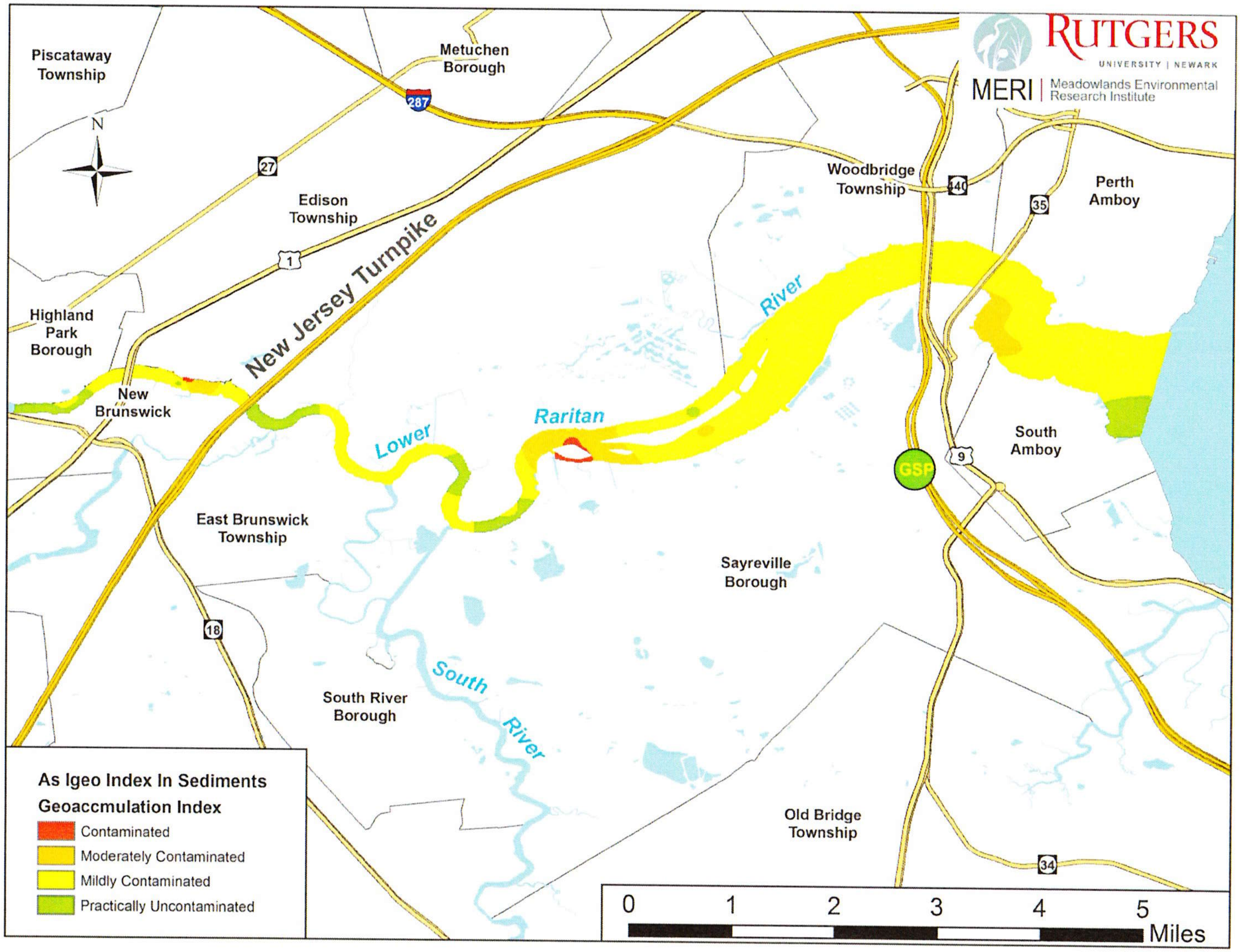


Figure 28. Spatial interpolation of the geoaccumulation index showing concentration of Beryllium in the lower Raritan River surficial sediment compared to natural background levels

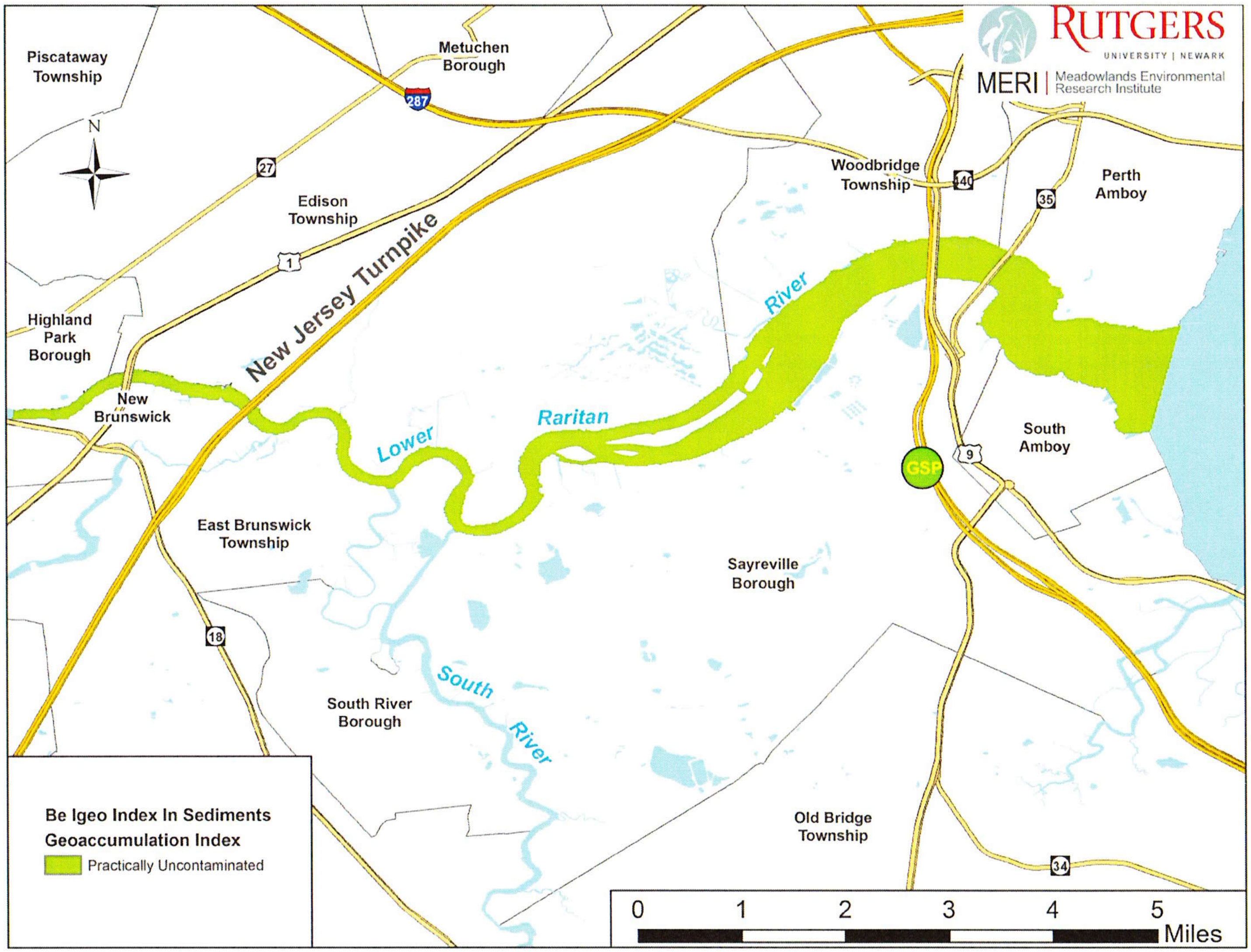


Figure 29. Spatial interpolation of the geoaccumulation index showing concentration of Cadmium in the lower Raritan River surficial sediment compared to natural background levels

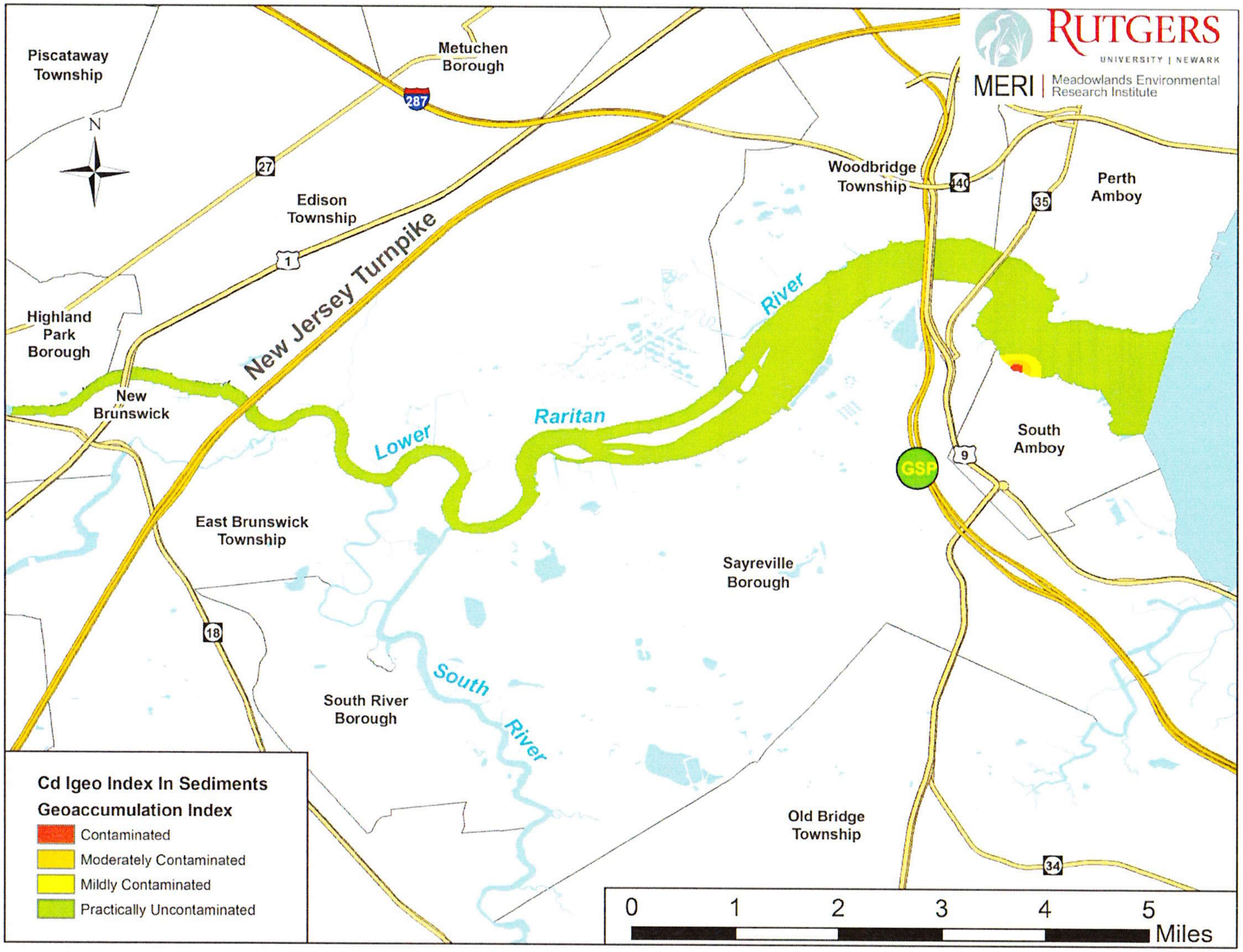


Figure 30. Spatial interpolation of the geoaccumulation index showing concentration of Chromium in the lower Raritan River surficial sediment compared to natural background levels

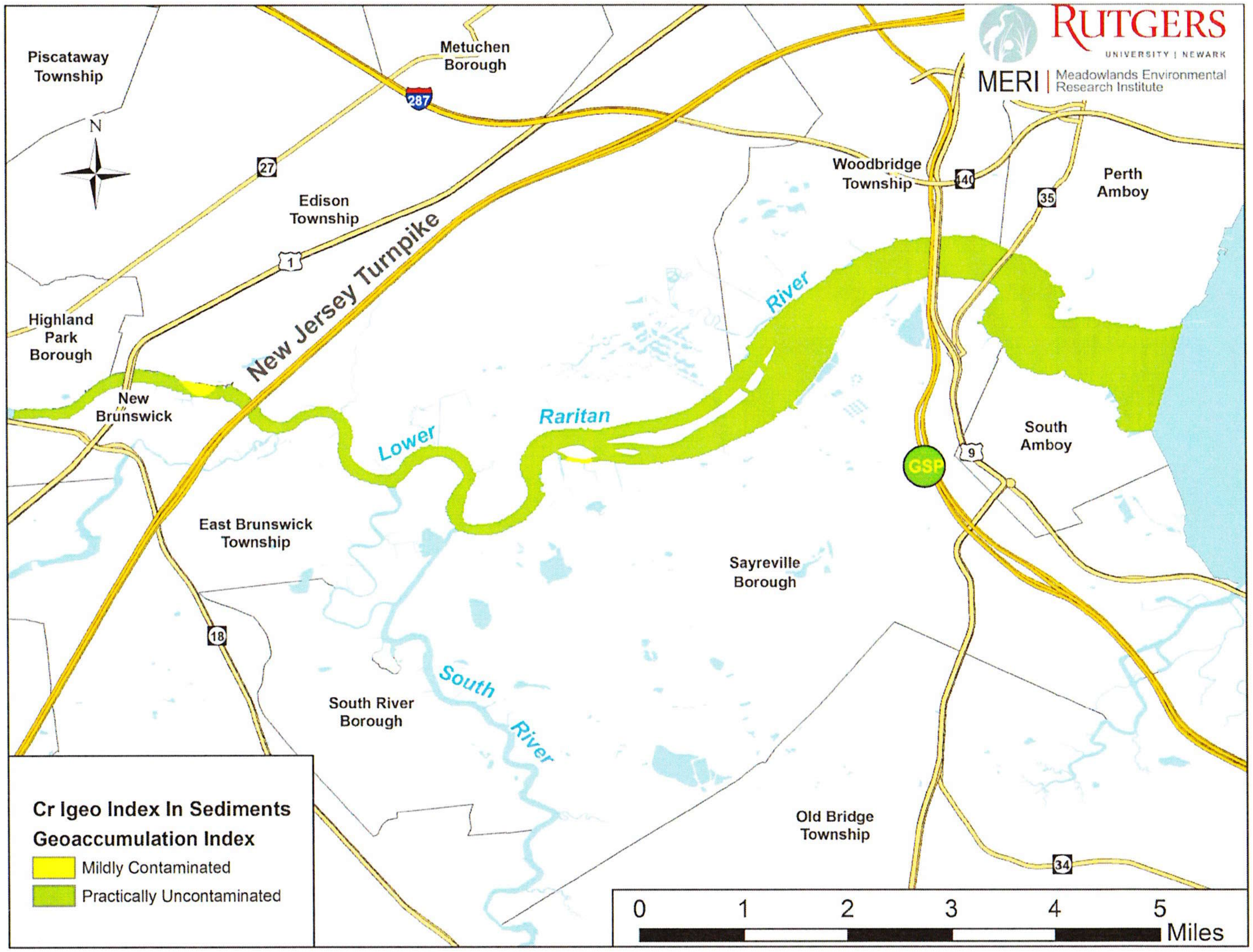


Figure 31. Spatial interpolation of the geoaccumulation index showing concentration of Copper in the lower Raritan River surficial sediment compared to natural background levels

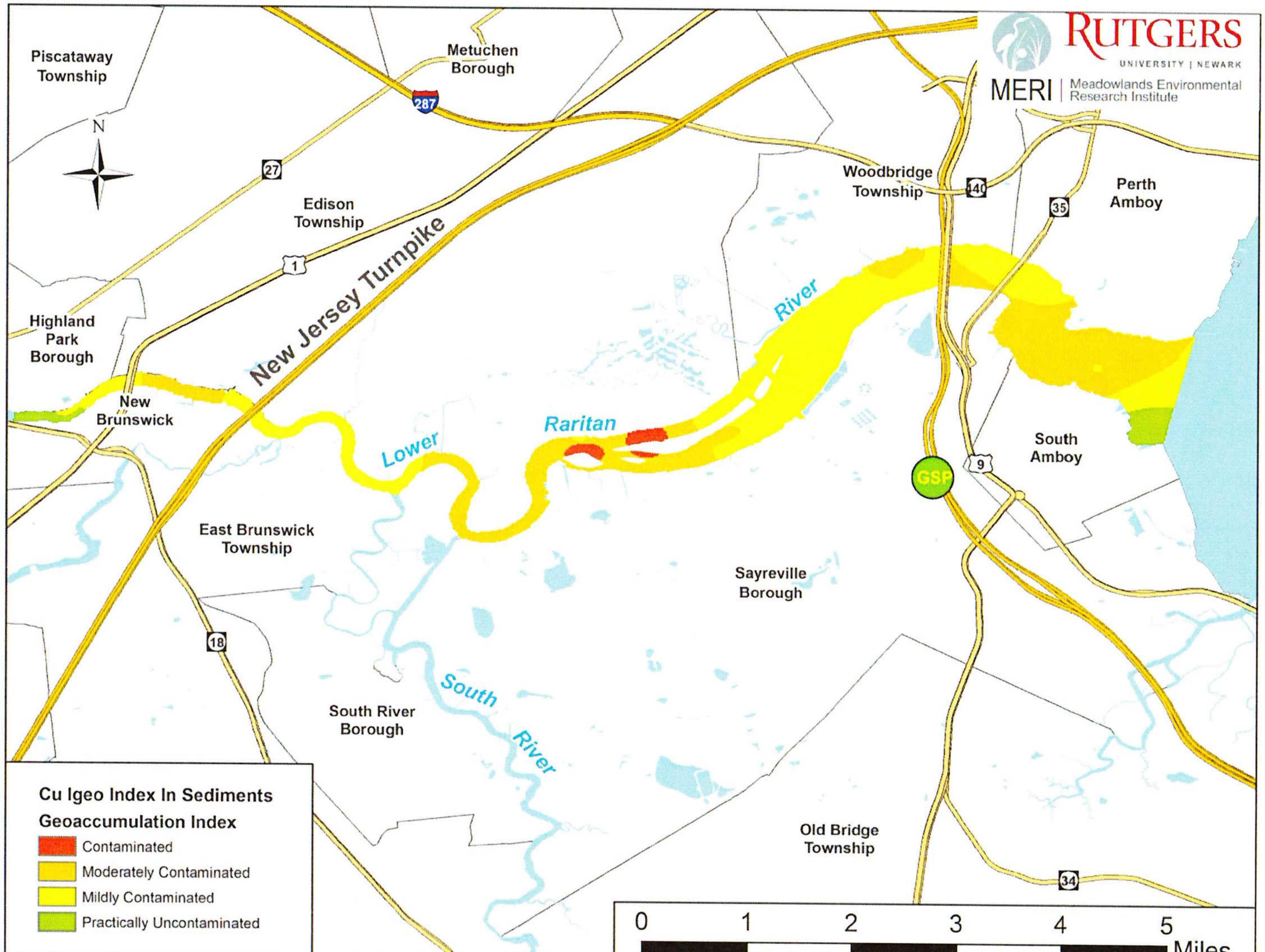


Figure 32. Spatial interpolation of the geoaccumulation index showing concentration of Lead in the lower Raritan River surficial sediment compared to natural background levels

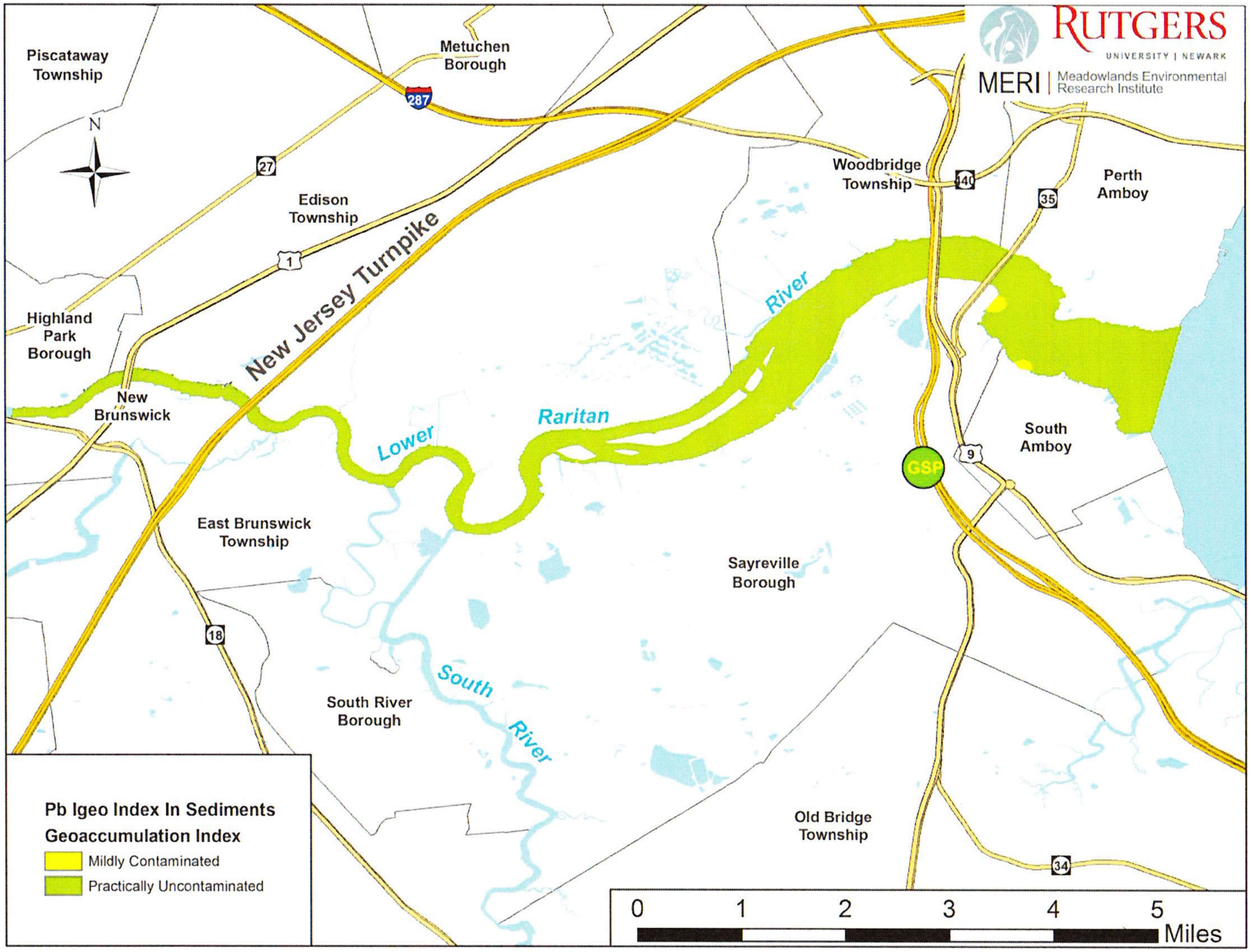


Figure 33. Spatial interpolation of the geoaccumulation index showing concentration of Mercury in the lower Raritan River surficial sediment compared to natural background levels

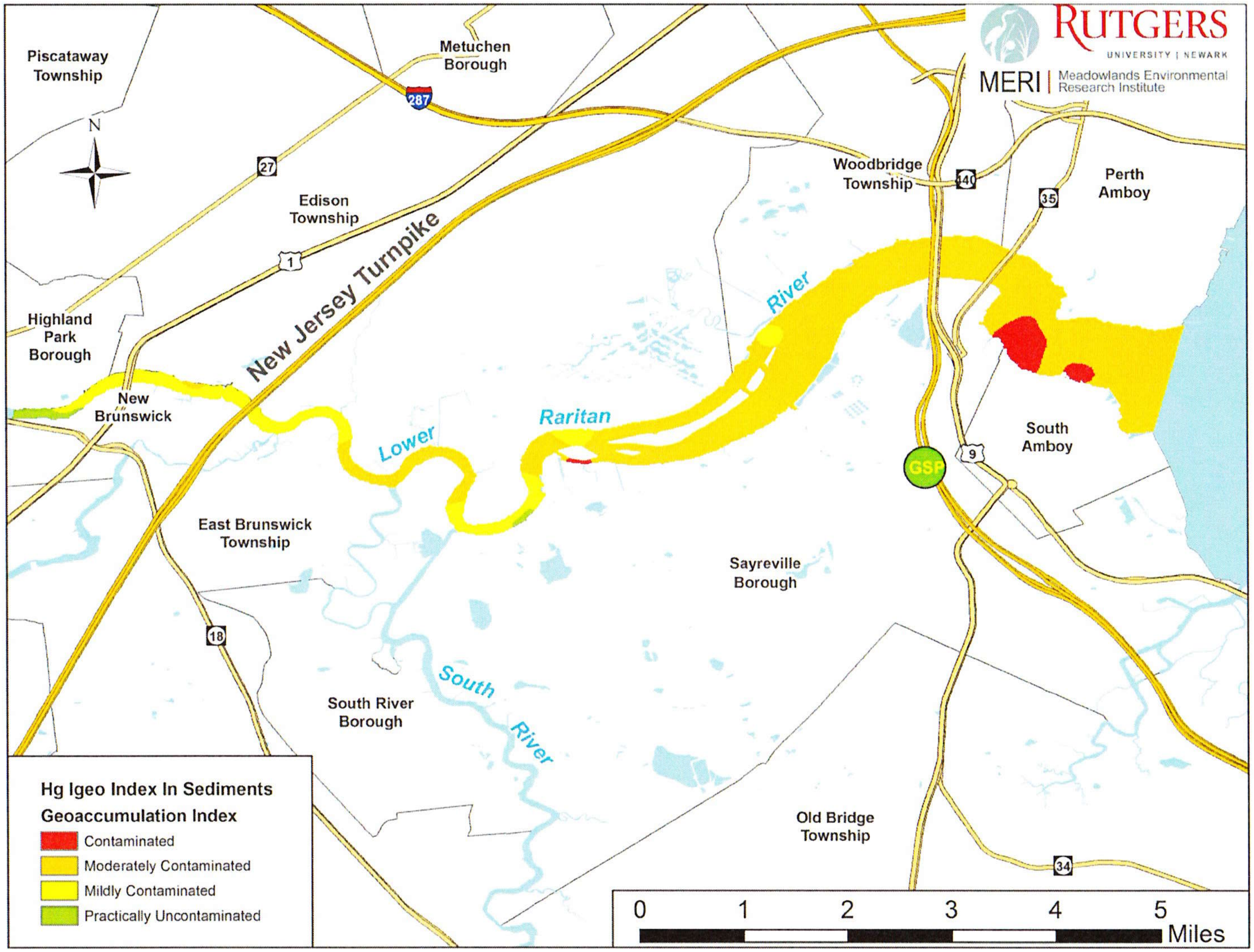


Figure 34. Spatial interpolation of the geoaccumulation index showing concentration of Nickel in the lower Raritan River surficial sediment compared to natural background levels

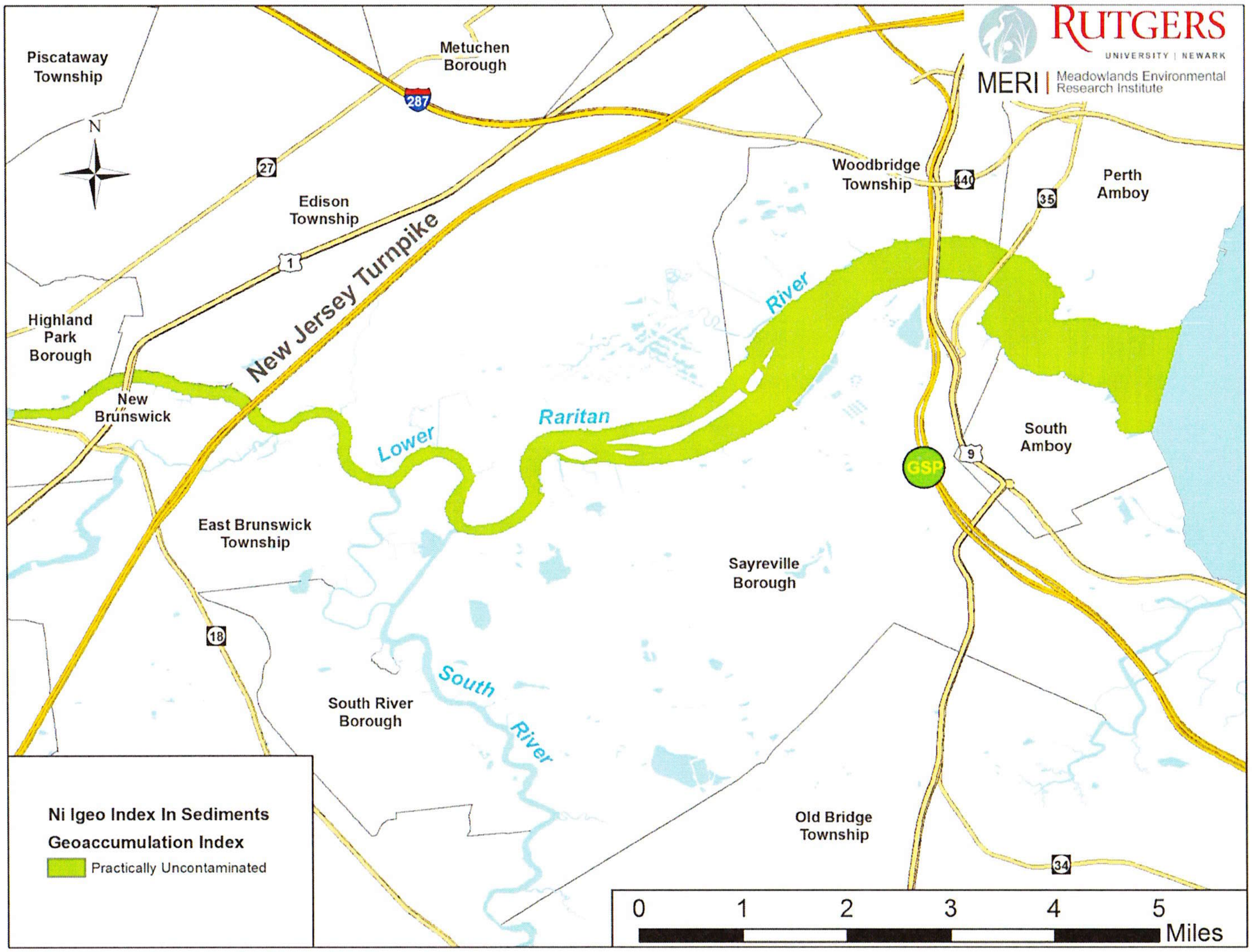


Figure 35. Spatial interpolation of the geoaccumulation index showing concentration of Selenium in the lower Raritan River surficial sediment compared to natural background levels

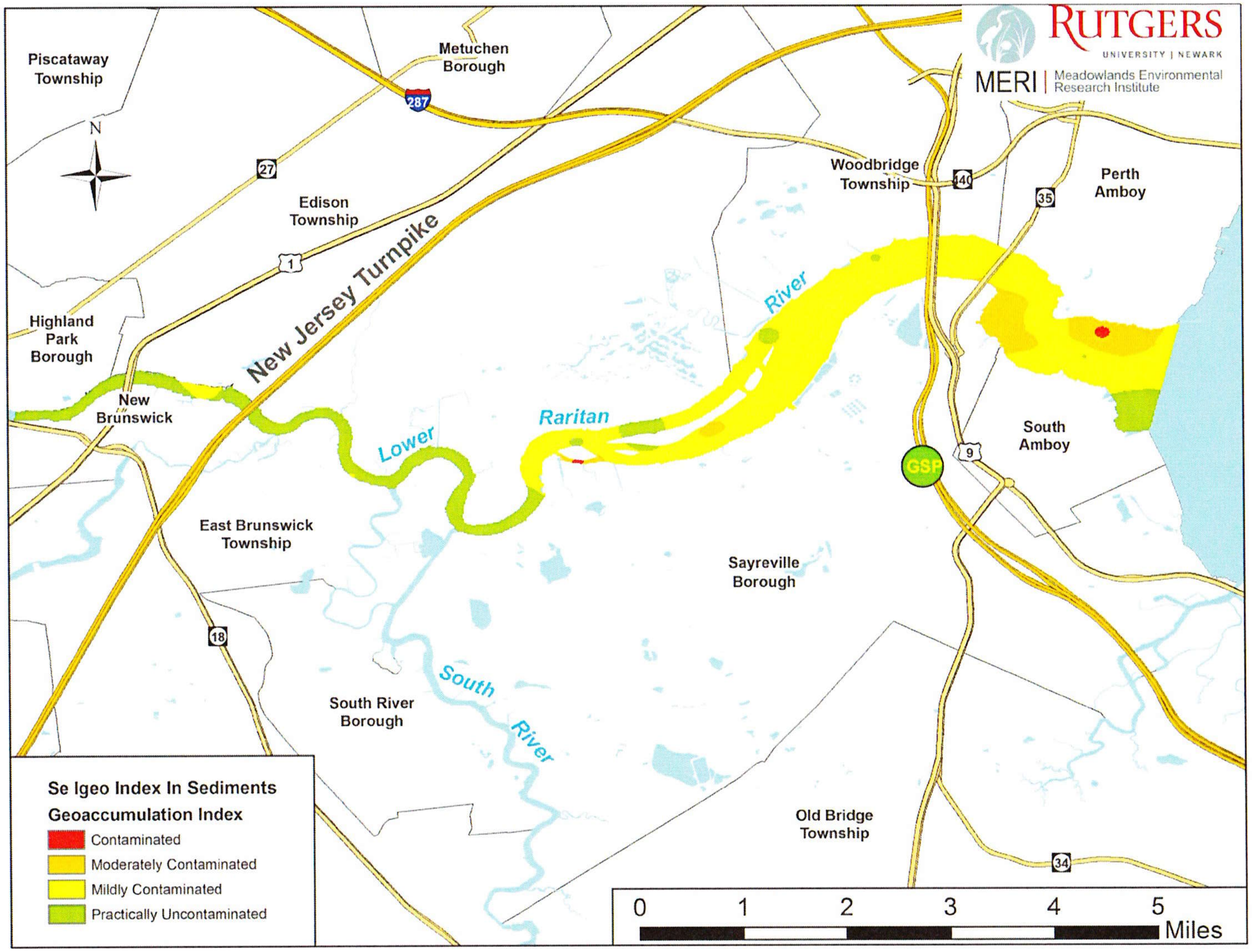


Figure 36. Spatial interpolation of the geoaccumulation index showing concentration of Silver in the lower Raritan River surficial sediment compared to natural background levels

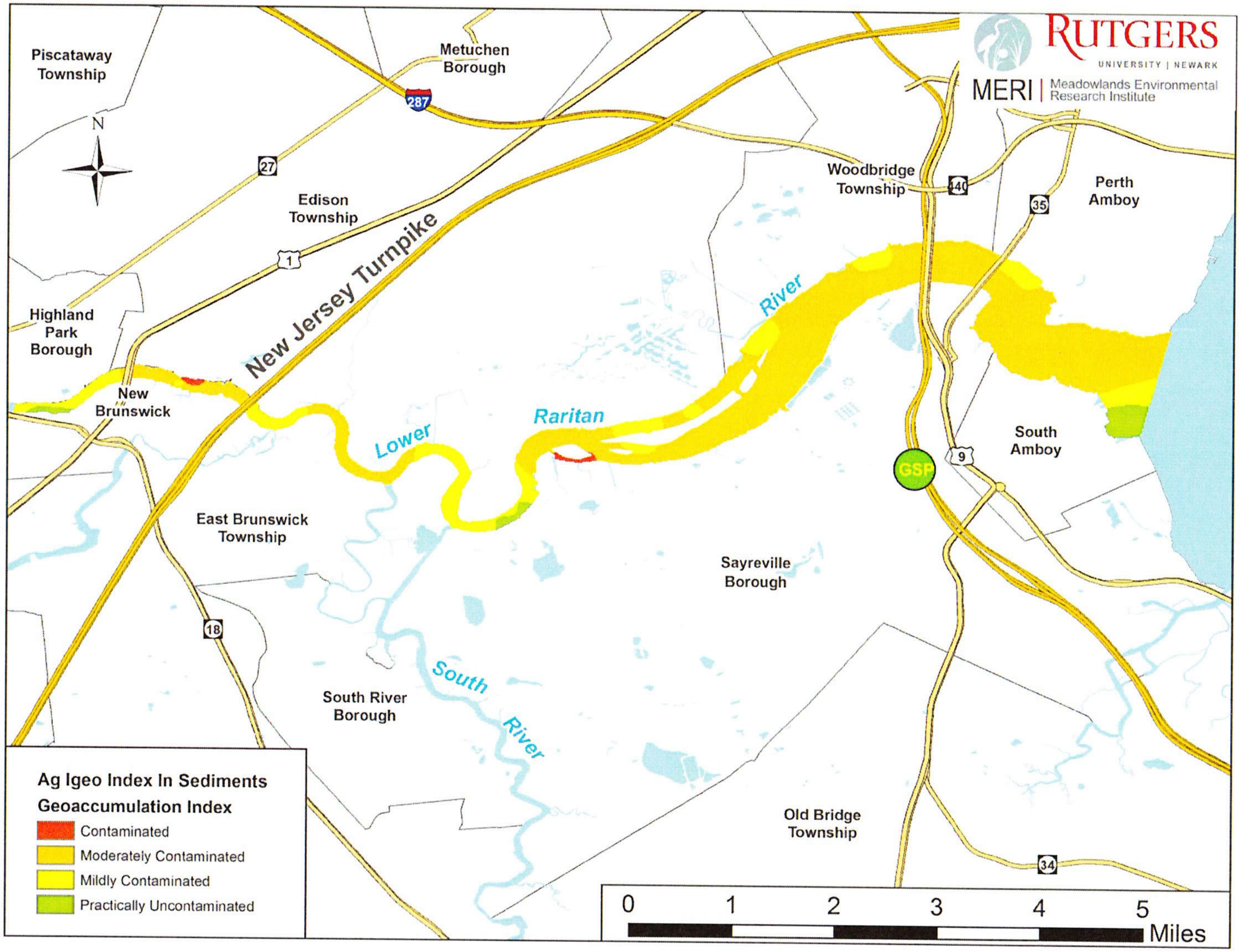


Figure 37. Spatial interpolation of the geoaccumulation index showing concentration of Thallium in the lower Raritan River surficial sediment compared to natural background levels

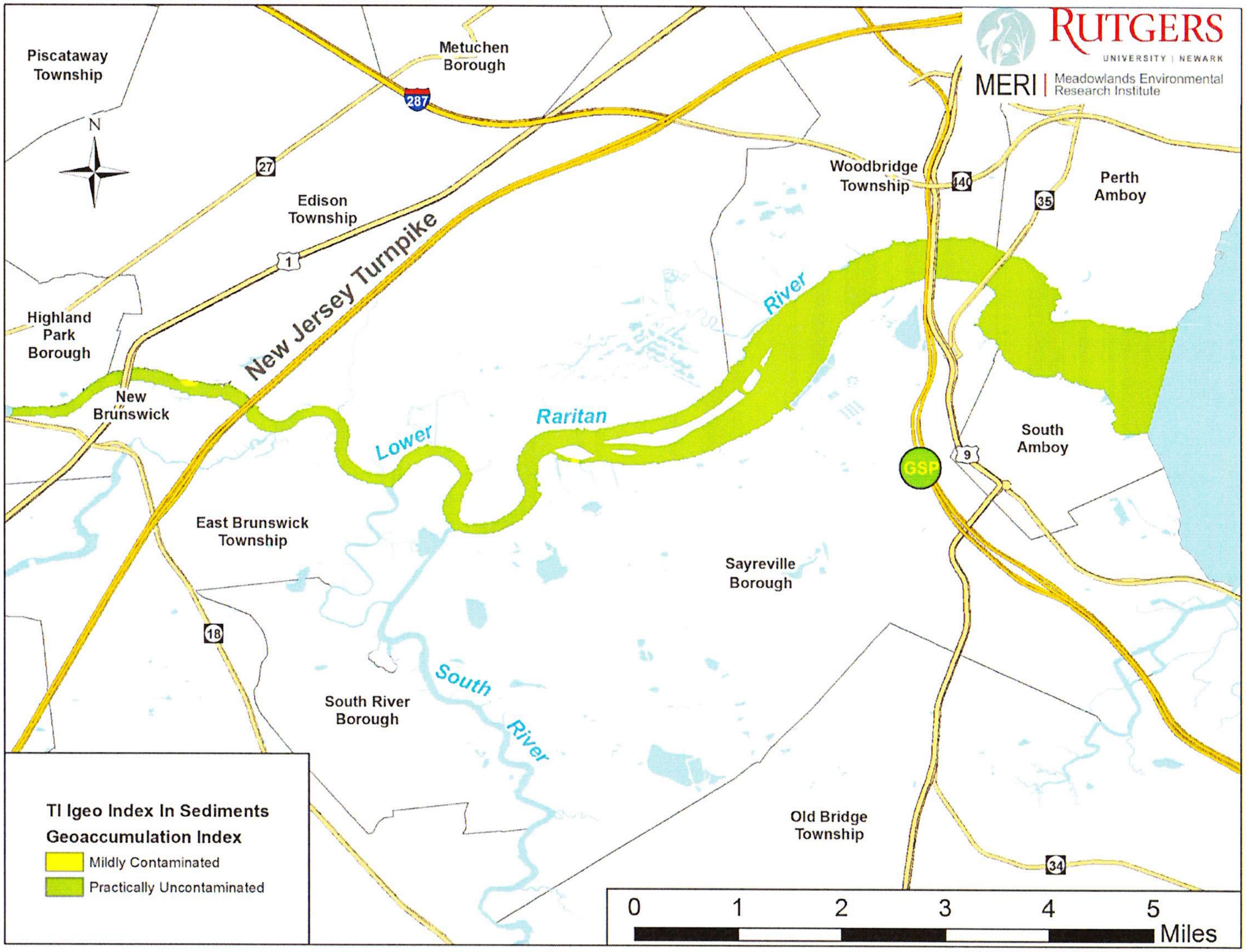
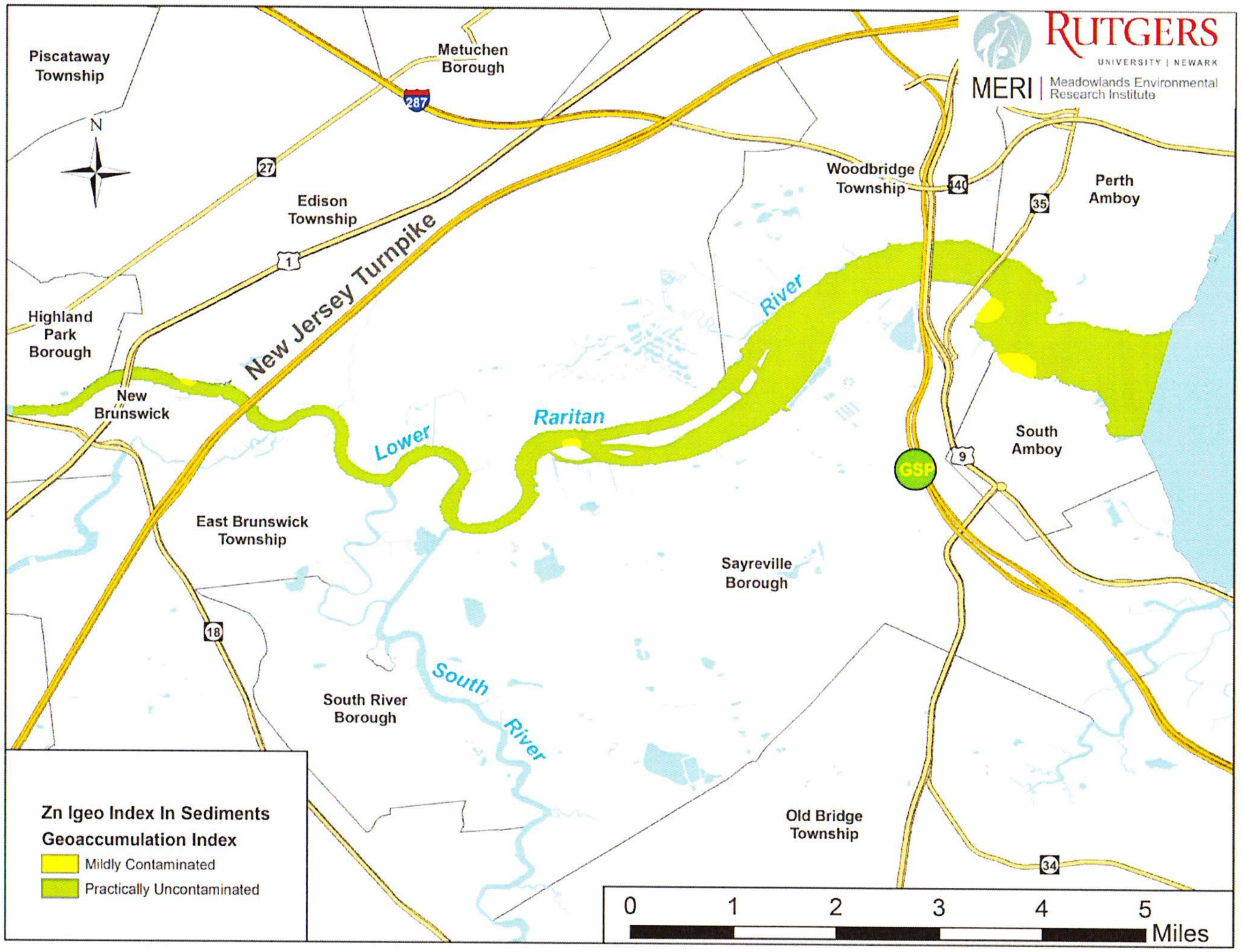


Figure 38. Spatial interpolation of the geoaccumulation index showing concentration of Zinc in the lower Raritan River surficial sediment compared to natural background levels



Comparing current and historical sediment contamination records in the lower Raritan River sediment

Five historic sampling locations (2000-2006) are available to compare with MERI's findings from 2017 (Figure 39). When comparing the EPA and MERI datasets at the 5 overlapping sampling locations (P1-P5) (Figure 40. A-K), we find that the concentration trends remained the same for every trace metal. MERI's data from 2017 show higher concentrations of cadmium, mercury, and selenium compared to EPA's data from 2000-2006. The EPA data showed higher amounts of nickel, antimony, and zinc in 2000-2006 compared to 2017, this could be explained by natural attenuation over time. It's interesting to note that between 2000-2006 and 2017, peak concentrations of silver, arsenic, copper, and lead moved slightly upriver (Figure 40b, E, and H).

When comparing matching PCB congener and OCP data from 2000-2006 to 2017 f (Figure 41. A-J), we see that concentration levels remained about the same. Our data indicates that natural attenuation seems to be accruing with the majority of PCB congeners. PCB 128 was the only one that showed higher concentrations in 2017 compared to 2000-2006. Worth mentioning is that MERI's metal analysis was performed on dry sediment samples and the organics were analyzed from wet sediment, while there is no information regarding studies that contributed to the EPA-STORET records. .

Figure 39. Map of the study area showing the original sampling locations from EPA's STORET database and MERI's current sampling locations

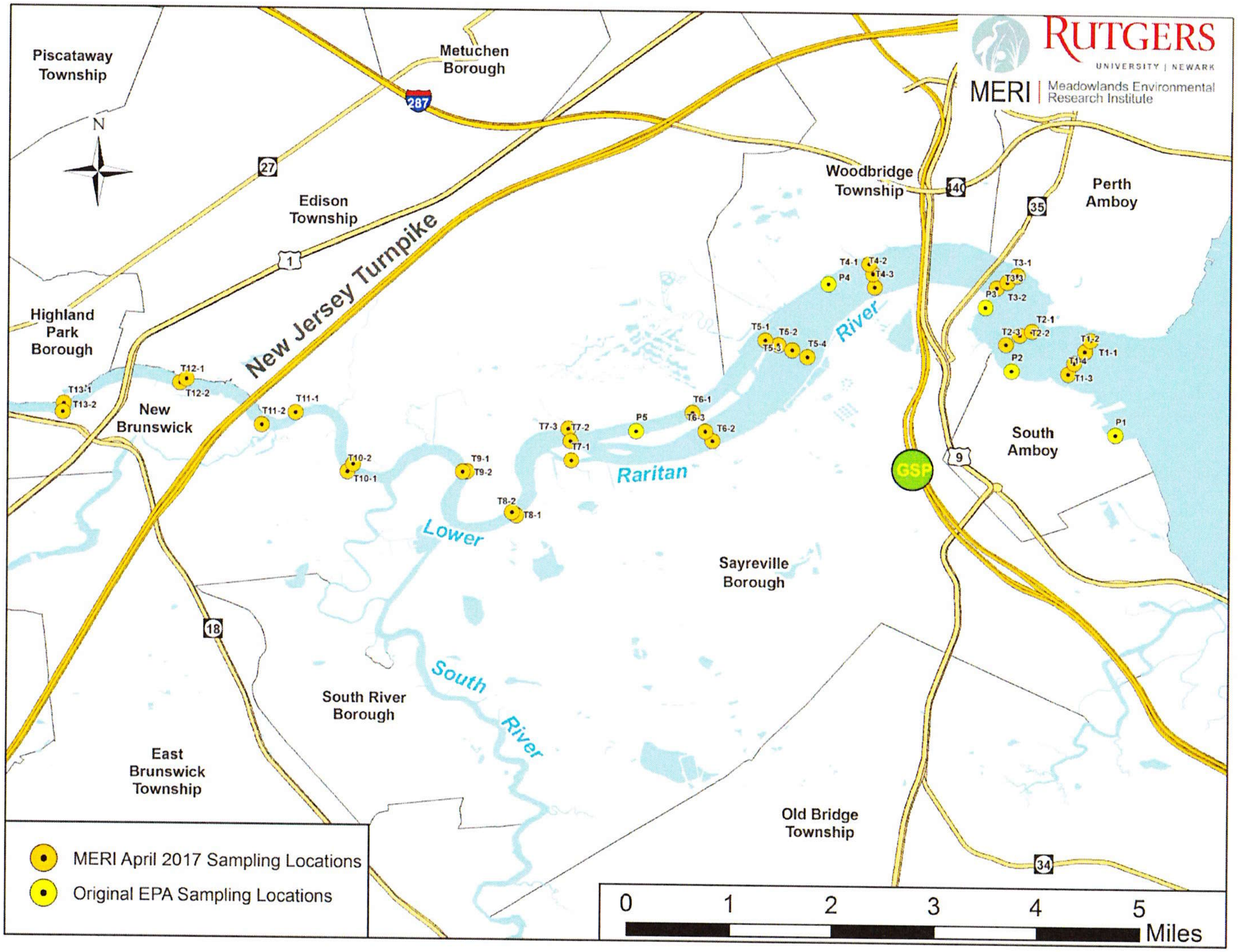


Figure 40. Summary of current (2017) and historical (2000-06) sediment metals concentration compared at five distinct sampling locations (P1-P5) from the bay up to New Brunswick

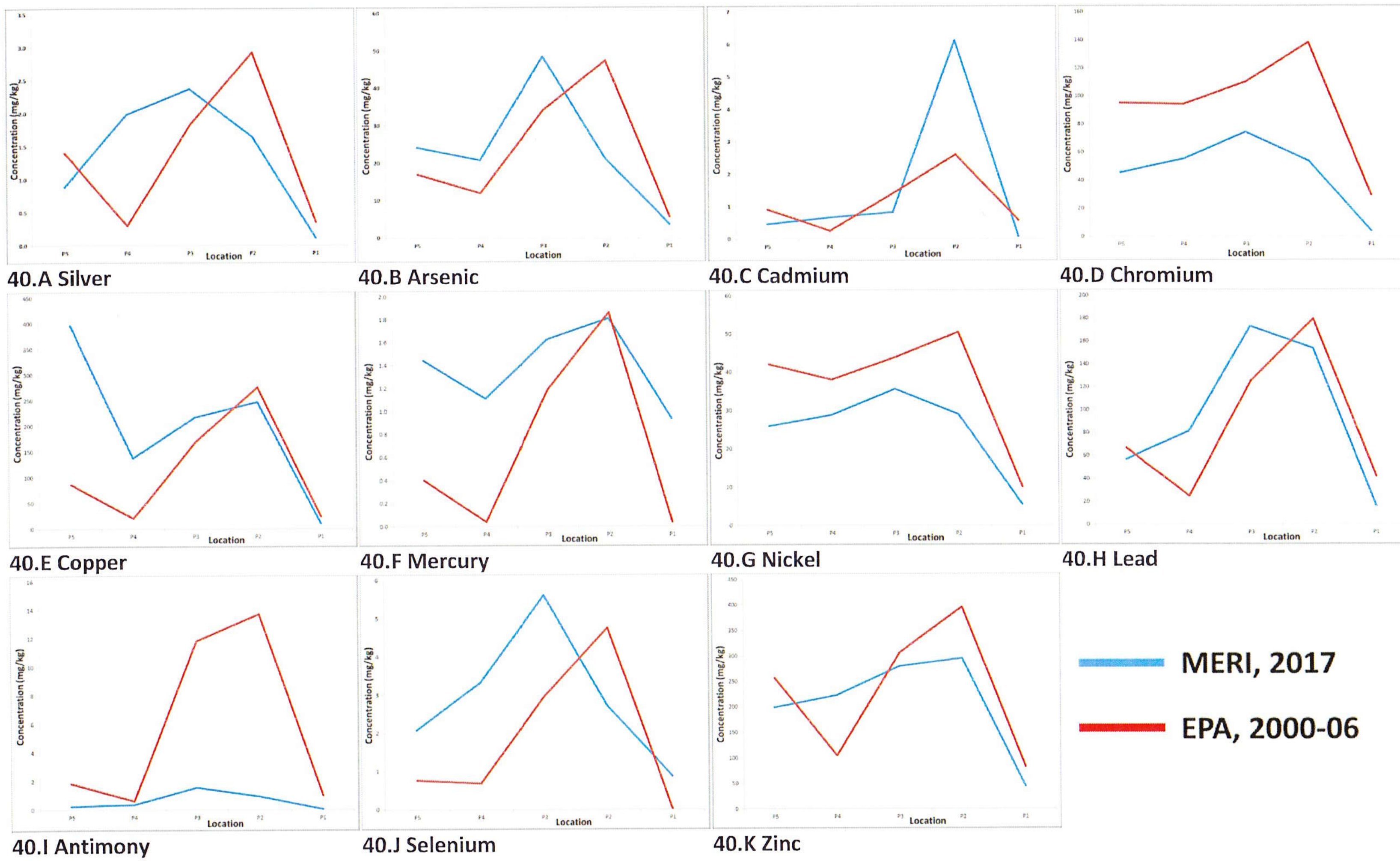
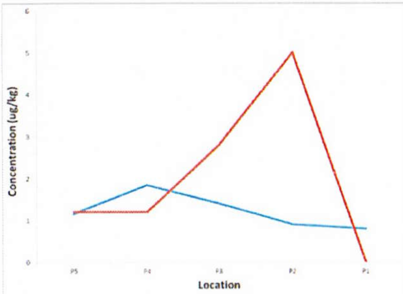
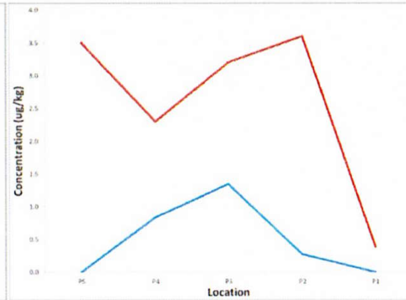


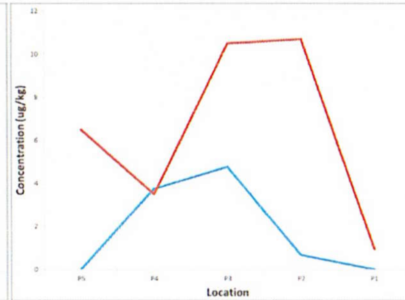
Figure 41. Summary of current (2017) and historical (2000-06) sediment PCB congener and OCP concentration compared at five distinct sampling locations (P1-P5) from the bay up to New Brunswick



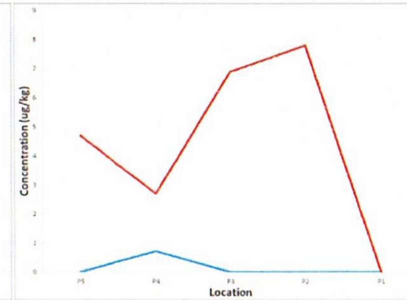
41.A PCB-018



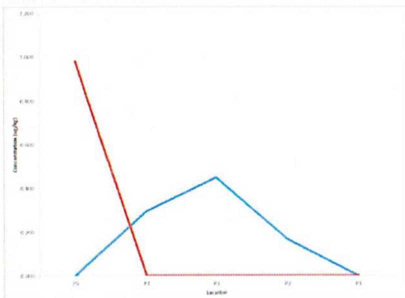
41.B PCB-044



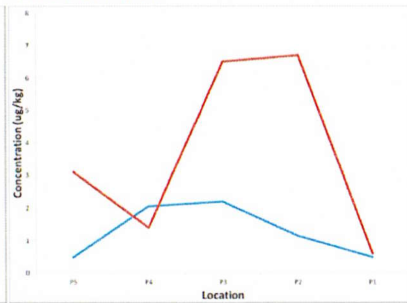
41.C PCB-101



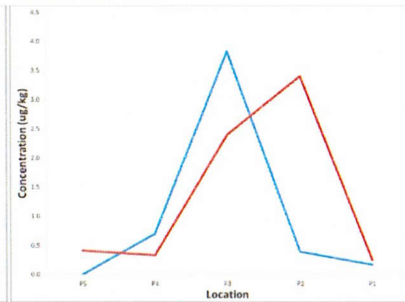
41.D PCB-118



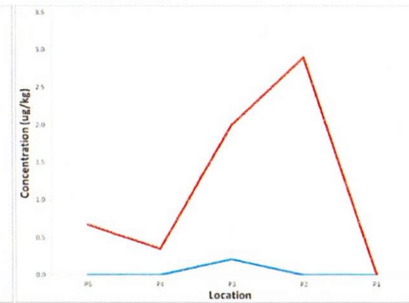
41.E PCB-128



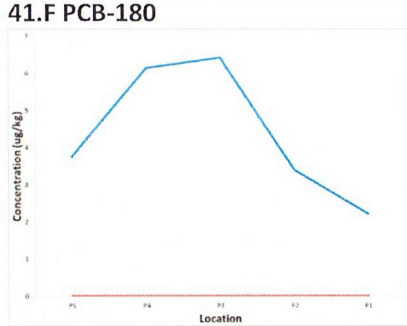
41.F PCB-180



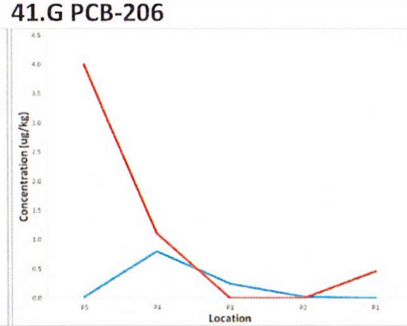
41.G PCB-206



41.H PCB-209



41.I Endrin



41.J Dieldrin

MERI, 2017

EPA, 2000-06

1.4 Conclusions

Water quality measurements were made at the surface and a foot from the bottom during an ebbing of the tide. No measurements were made at very shallow stations (Table 1, N/A). Salinity measurements near the Raritan Bay resulted in values of 13 Practical Salinity Units (PSU). Upriver from transect 7 salinity drops to less than 1 PSU. Before crossing the turnpike overpass on the bay side, salinity on the higher reaches of the water column was slightly lower than salinities near the bottom and these differences disappear upriver. For most of the locations sampled there were no significant differences in turbidity, oxygen reduction potential (ORP), dissolved oxygen and pH between the top and bottom of the water column indicating that overall the water column was well mixed.

Only contaminants associated with the grain size fraction of less than 63 μm are reported in this study. By selecting this grain size threshold we are able to remove grain size as a variable when comparing contaminant concentrations. Table 2 shows the summary statistics for metal concentration and the respective ERL and ERM criteria. On average, Mercury and Nickel were the only metals that exceeded de effects range medium (ERM) screening criteria (Table 3). In other words, 50% of case studies show that benthic organisms would be adversely impacted by existing Hg and Ni concentrations in the Raritan sediments. All metals but Cr and Cd exceeded the ERL criteria where 10% of case studies show an adverse impact to benthic organisms. Beryllium (Be), Antimony (Sb), Selenium (Se) and Titanium (Tl) do not have ERM or ERL criteria. Concentrations of PCB and OCP follow the same pattern across the different sampling stations (Figure 9). In terms of PCB's and OCP, the ERL criteria is exceeded in all cases but for locations P1 and P5. The effects range medium criteria is only exceeded at T7-1 (Crab Island). When metal concentrations are compared to the natural background levels from the local geology, five elements: Hg, As, Cu, Cd, Se, and Ag were found to have concentrations greater than normal background levels.

Discreet hotspots have emerged from this study that may need more attention. These hotspots includes the area on the bay side of the NJ Parkway that encompasses transects T1, T2, and T3. Another well-defined hotspot is along the P7 transect, at Crab Island in Sayreville. Smaller hotspots form along T12 mainly due to the high Cr, As, and Zn concentration and around T5 and T6 with high Zn, Tl, Pb, Ni, and Hg concentrations compared to the rest of the study area.

Chromium, Nickel and Antmony show some degree of attenuation when comparing the five overlapping locations (P1-P5) between 2000-2006 and 2017. Mercury on the other hand showed no indication of attenuation and 5 out of 4 locations showed increased concentrations in 2017. Organic contaminants on the other hand by the most part show decreased concentrations in the sediments today compared to 2000-06.

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