CHAPTER 6
MODEL RESULTS

Project Purpose

The purpose and objectives of the modeling effort were to:

- Estimate an annual phosphorus load from external sources to the Rock River surface water system and the relative significance of phosphorus loading from nonpoint and point sources.

- Estimate the changes in annual phosphorus loading from the application of global nonpoint source best management practices and point source controls.

- Compare the phosphorus loading generated from the model to selected water quality monitoring stations within the basin (nine sites funded by RRP).

The comparison of the phosphorus loadings generated by SWAT to the monitoring stations funded by the RRP s are presented in Chapter 5. The other objectives are summarized in the below.

Explanation of Phosphorus Management Scenarios

Under existing land use and management conditions (scenario 1), the model predicted a total basin average annual phosphorus load of approximately 1,680,000 pounds. Point sources accounted for 41% of this value, and 59% was from nonpoint sources. These numbers are reported as total phosphorus and do not distinguish between the different forms (ortho, soluble, particulate, etc.) of phosphorus.

It is important to note that the cropland BMP practices that were analyzed were limited to two options: modifications in tillage practices, and adoption of recommended nutrient application rates. No other BMP practices (i.e. urban controls and riparian buffer strips, etc.) were simulated. Thus, *the loads depicted by SWAT under these management scenarios do not necessarily represent the lowest attainable loads*. Estimates in load reduction from the application of other nonpoint BMPs is summarized in "A review of Agricultural and Urban Best Management Practices for the Reduction of Phosphorus Pollution", (Chad Cook, May 1999). This document is available through the WDNR (PUBL-SS-943-99). The results listed in this document should be used as a guide only as many of the BMPs discussed are influenced by site-specific criteria.

The implementation of alternative tillage practices was limited to conventional tillage being changed to conservation tillage and existing conservation tillage being phased into no-till. In the opinion of UW-Extension staff and county LCD staff, changing from conventional tillage to no-till systems was not likely to immediately to occur.

Implementation of improved nutrient management was limited to fertilizer applications. Since no infrastructure currently exists for "manure trading", manure application rates remained unchanged. Fertilizer application rates were reduced from the existing average application rates to the recommended application rates. Actual application rates should be based on soil test values, however, since this data was too specific for the scope of the project, application rates were set a UW-Extension "generic" recommended rates.

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Six scenarios were analyzed to access the impact of global BMP practices on phosphorus loads.

1. Current agricultural practices with current point source discharges. This includes relative comparison by watershed of point and non-point sources.

2. Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till with current point source discharge levels.

3. Current tillage practices with nutrient management practices employed and current point source discharge levels.

4. Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till and nutrient management practices with current point source discharge levels.

5. Current agricultural practices with point source discharge phosphorus concentrations reduced to 1 mg/l (the level designated in NR217).

6. Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till and nutrient management practices employed with point source discharge levels at 1 mg/l.

The table below summarizes the management scenarios described above.

Phosphorus Loading Management Approaches Analyzed by SWAT

Management Scenario	Nonpoint Source (cropland) Management		Point Source Management
	Tillage Practices	Nutrient Management	Effluent Concentrations
1	Current	Current	Current
2	Improved	Current	Current
3	Current	Improved	Current
4	Improved	Improved	Current
5	Current	Current	NR 217 levels
6	Improved	Improved	NR 217 levels

The bar chart shown on Figure 6.1 summarizes results under each management scenario for the entire Rock River Basin. This chart is followed by a series of charts (Figures 6.2 trough 6.26) that show phosphorus loads under the six scenarios for each watershed. These figures also include a comparison of between point and nonpoint sources of phosphorus.

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Figure 6.1
Total Average Annual Phosphorus Loads for the Entire Rock River Basin (by Management Scenario)

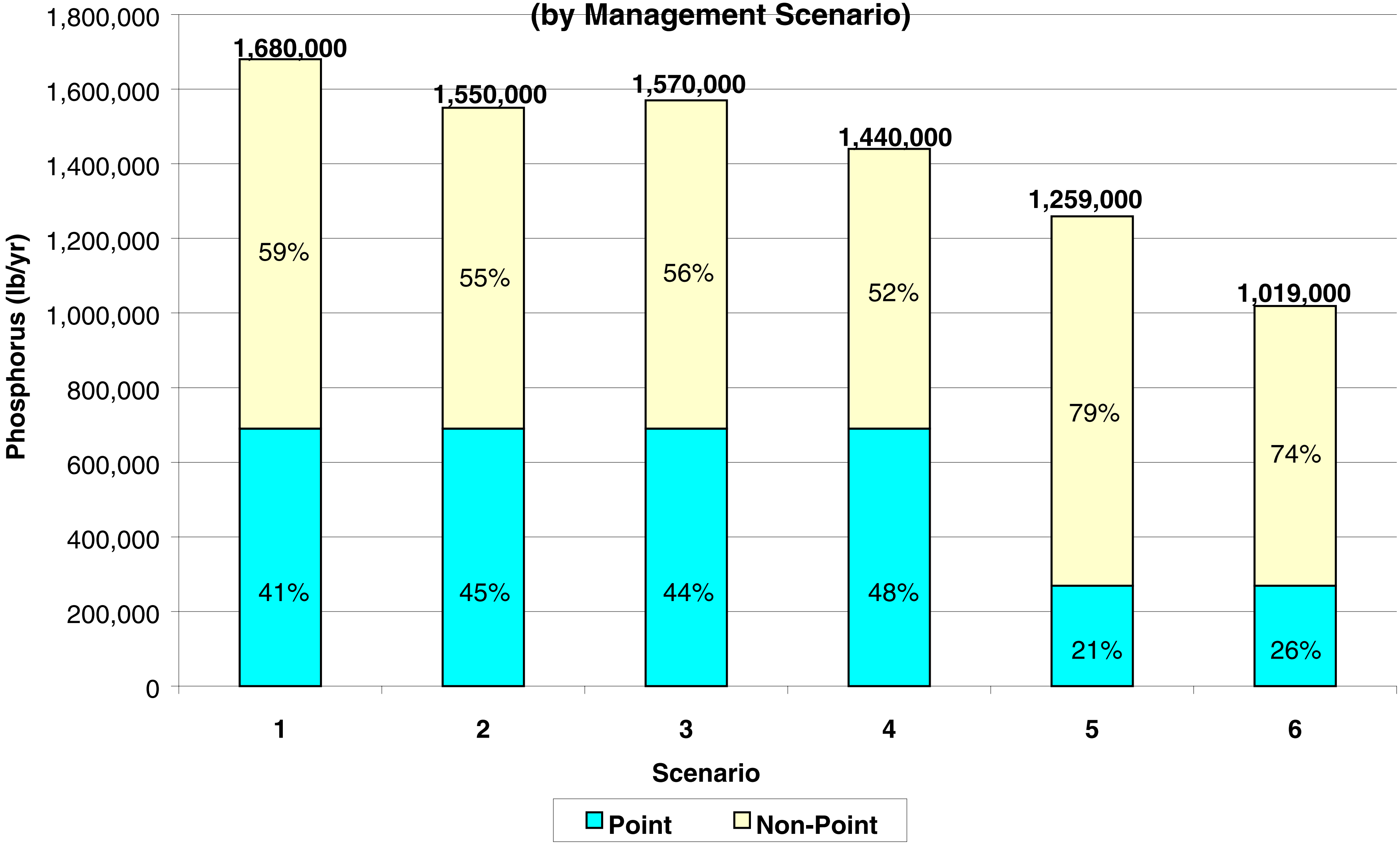

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Figure 6.2
Average Annual Phosphorus Loads
Turtle Creek Watershed (LR01)

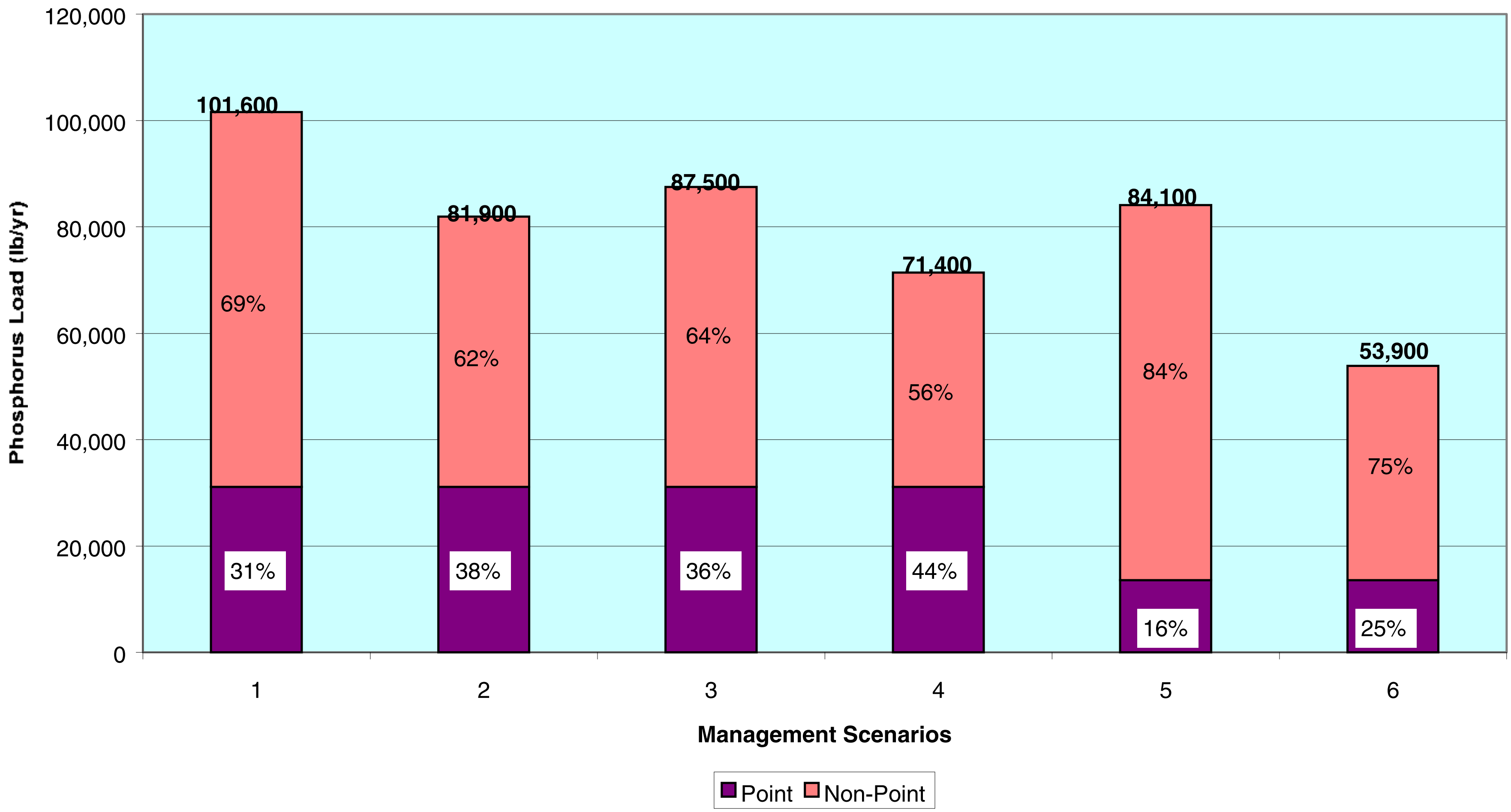

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Figure 6.3 Average Annual Phosphorus Loads Blackhawk Creek, Bass Creek, Rock River at Milton, and Marsh Creek Watersheds (LR02, LR03, LR04, and LR05)

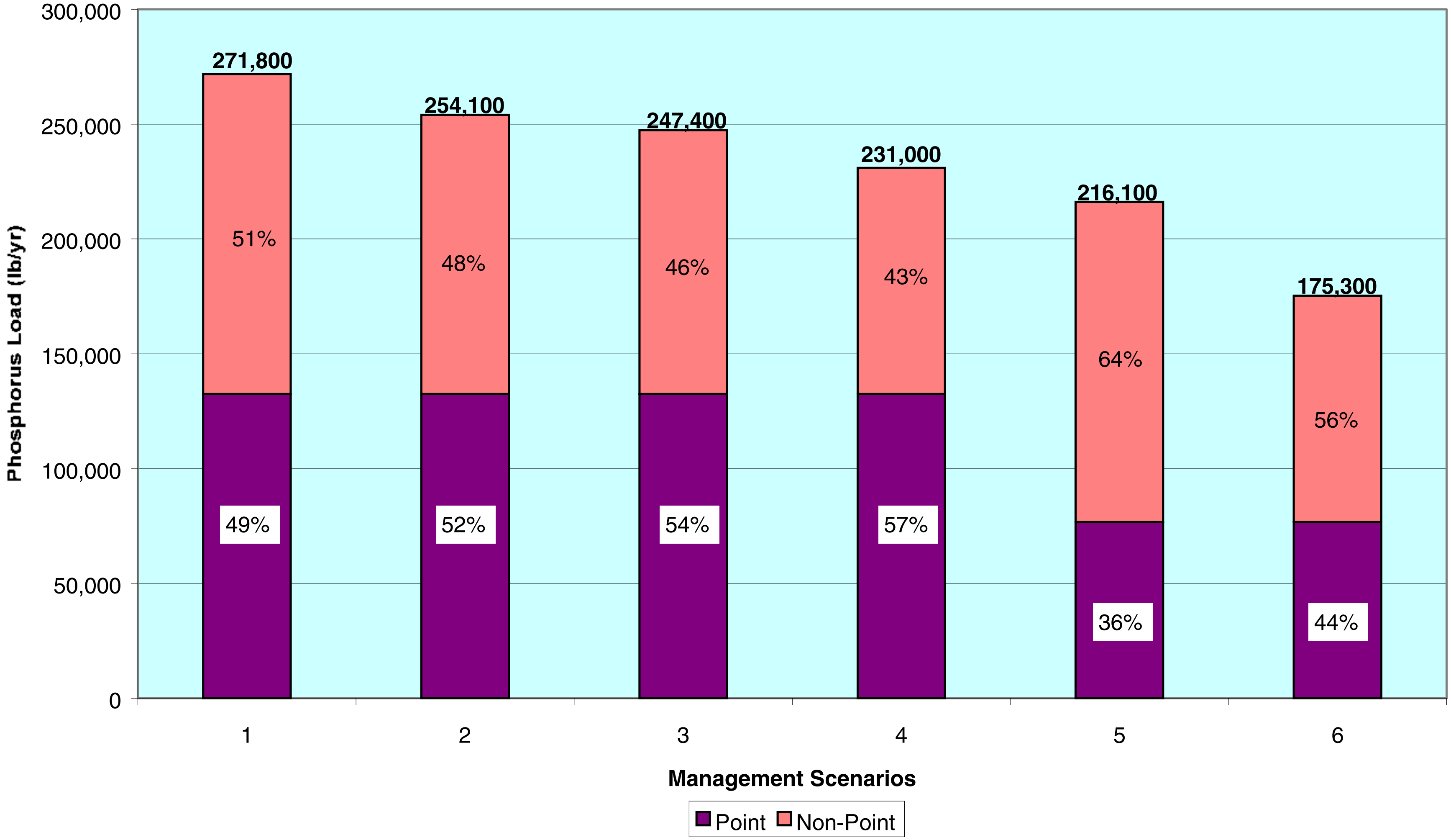

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Figure 6.4
Average Annual Phosphorus Loads
Yahara River and Lake Kegonsa Watershed (LR06)

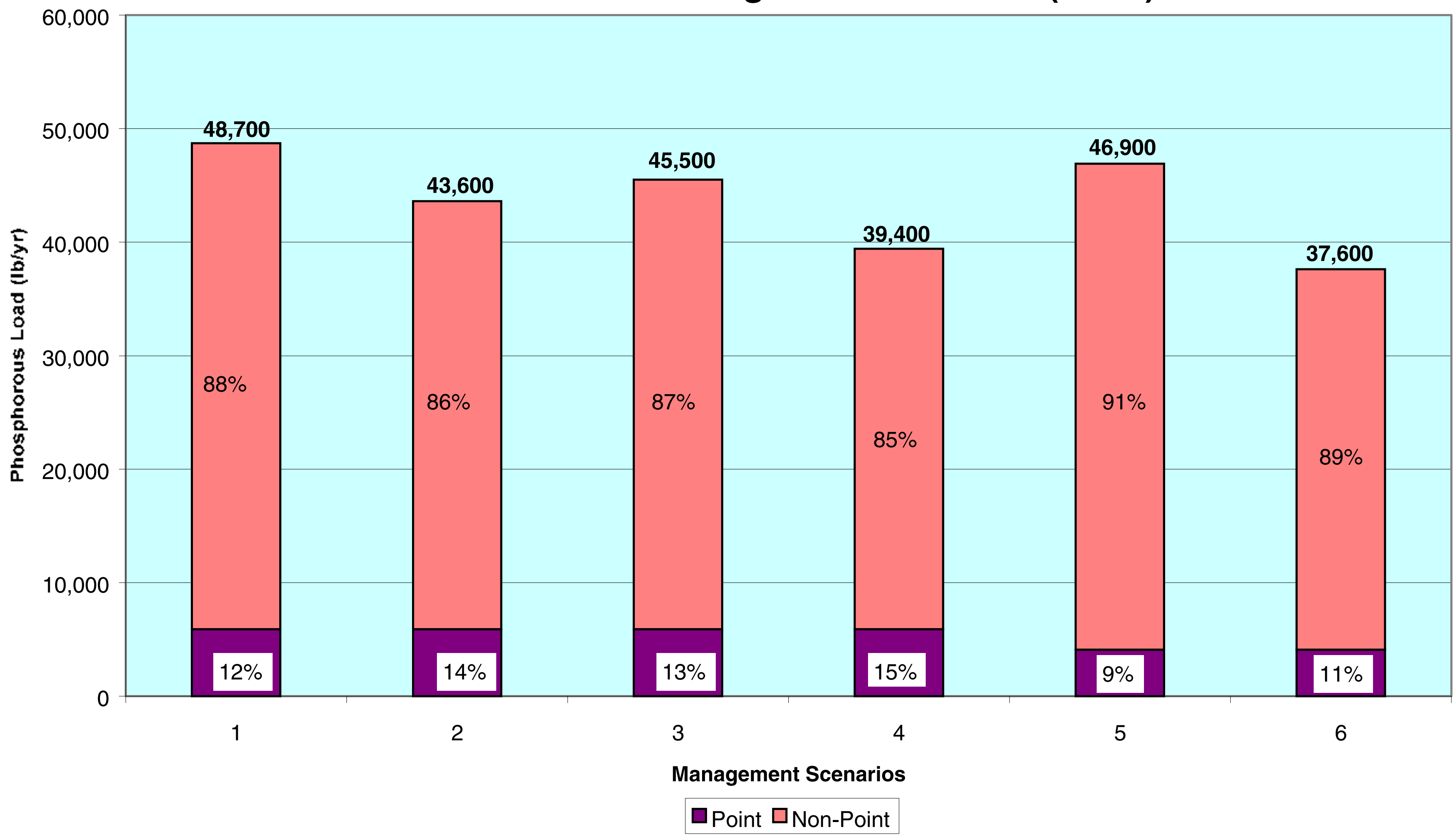

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Figure 6.5
Average Annual Phosphorus Loads
Badfish Creek Watershed (LR07)

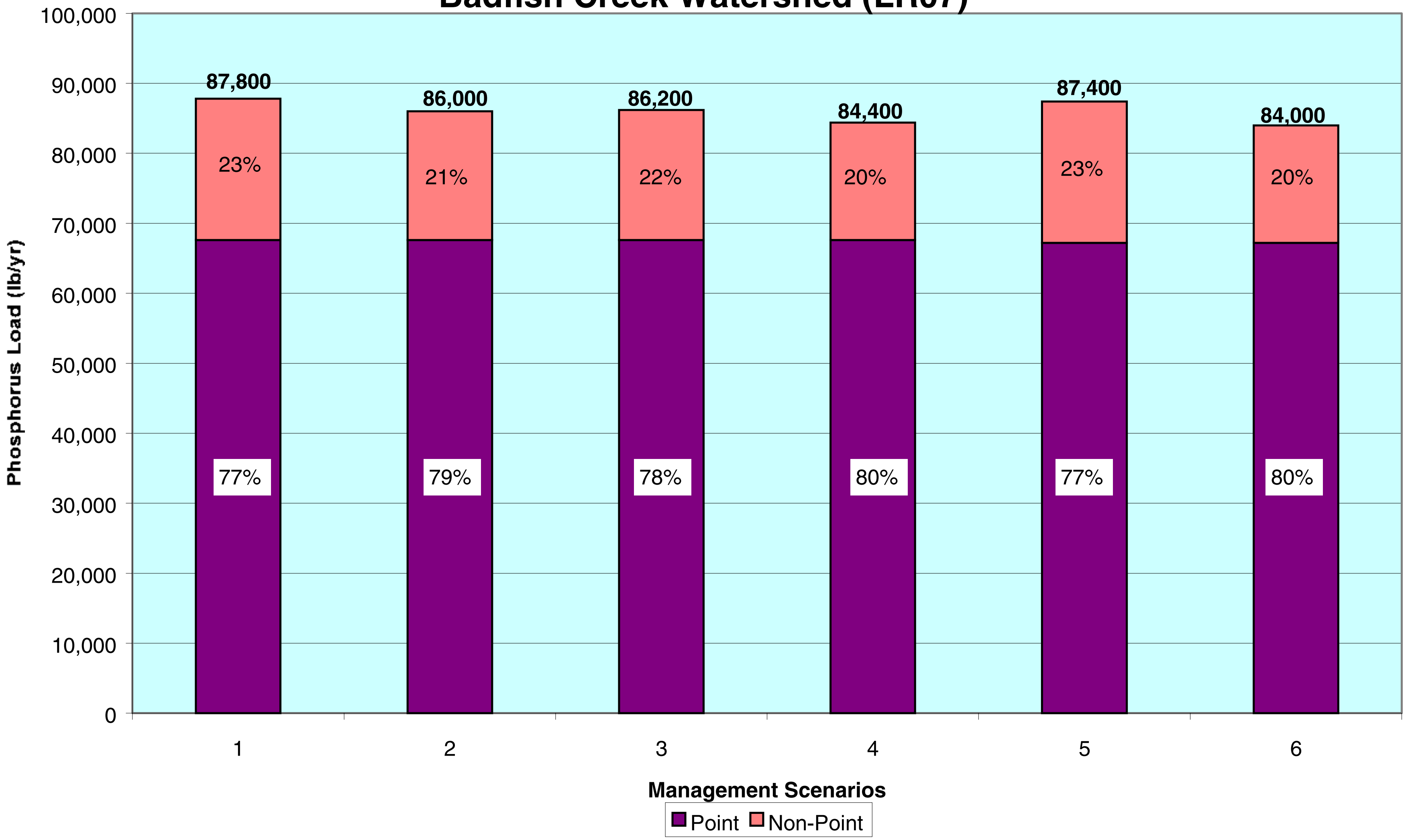

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Figure 6.6
Average Annual Phosphorus Loads
Yahara River and Lake Monona Watershed (LR08)

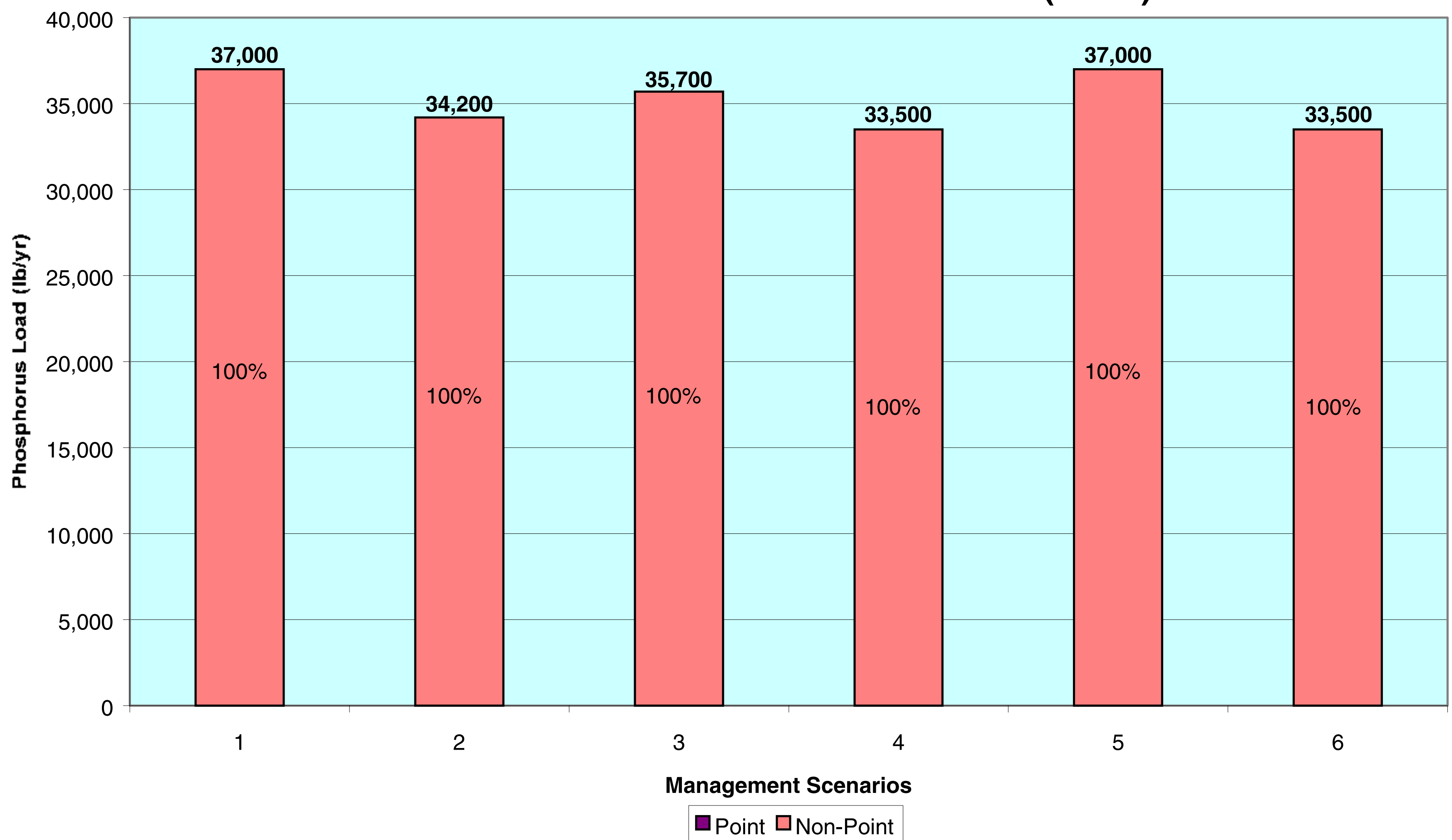

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Figure 6.7
Average Annual Phosphorus Loads
Yahara River and Lake Mendota Watershed (LR09)

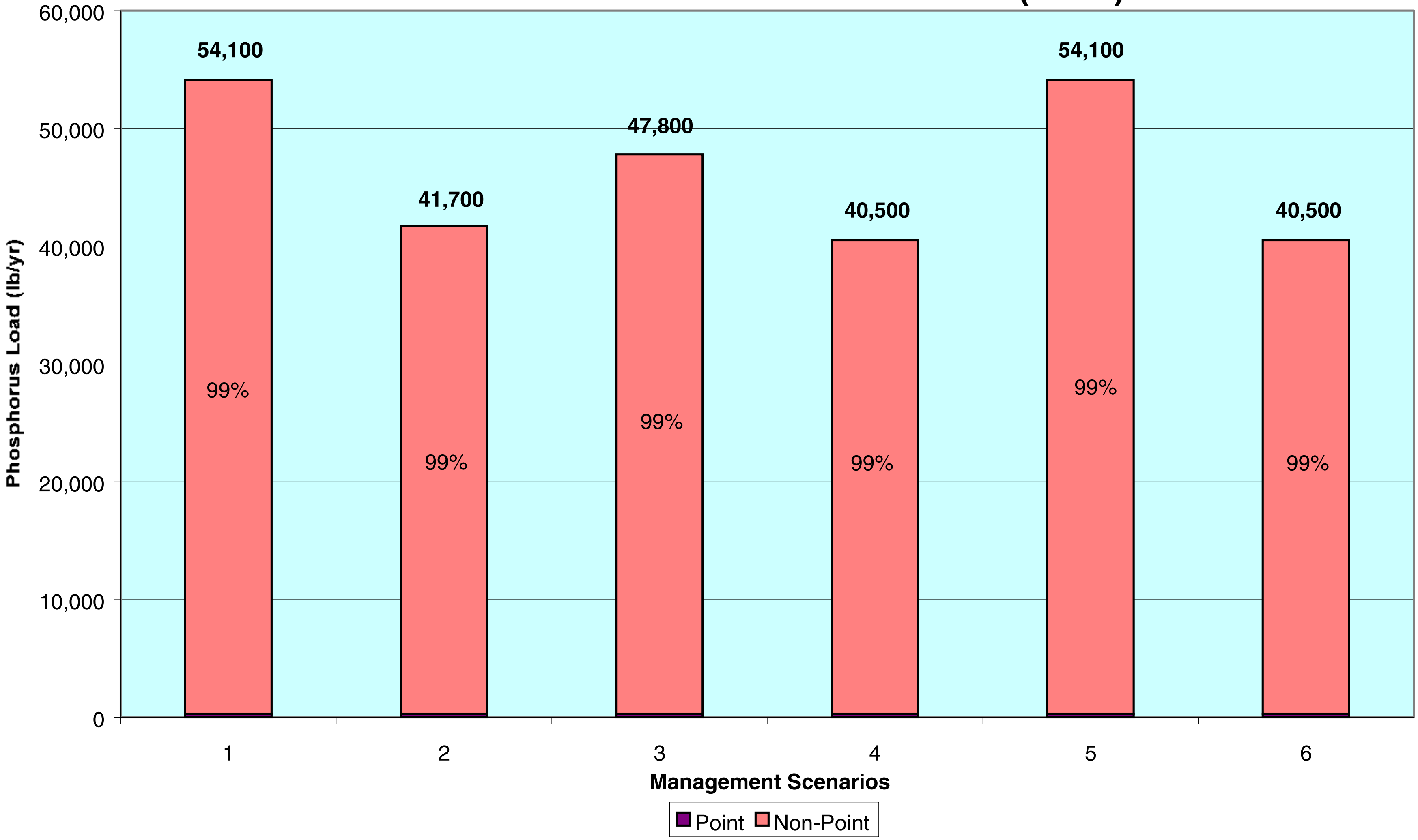

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Figure 6.8
Average Annual Phosphorus Loads
Six Mile and Pheasant Branch Creeks Watershed (LR10)

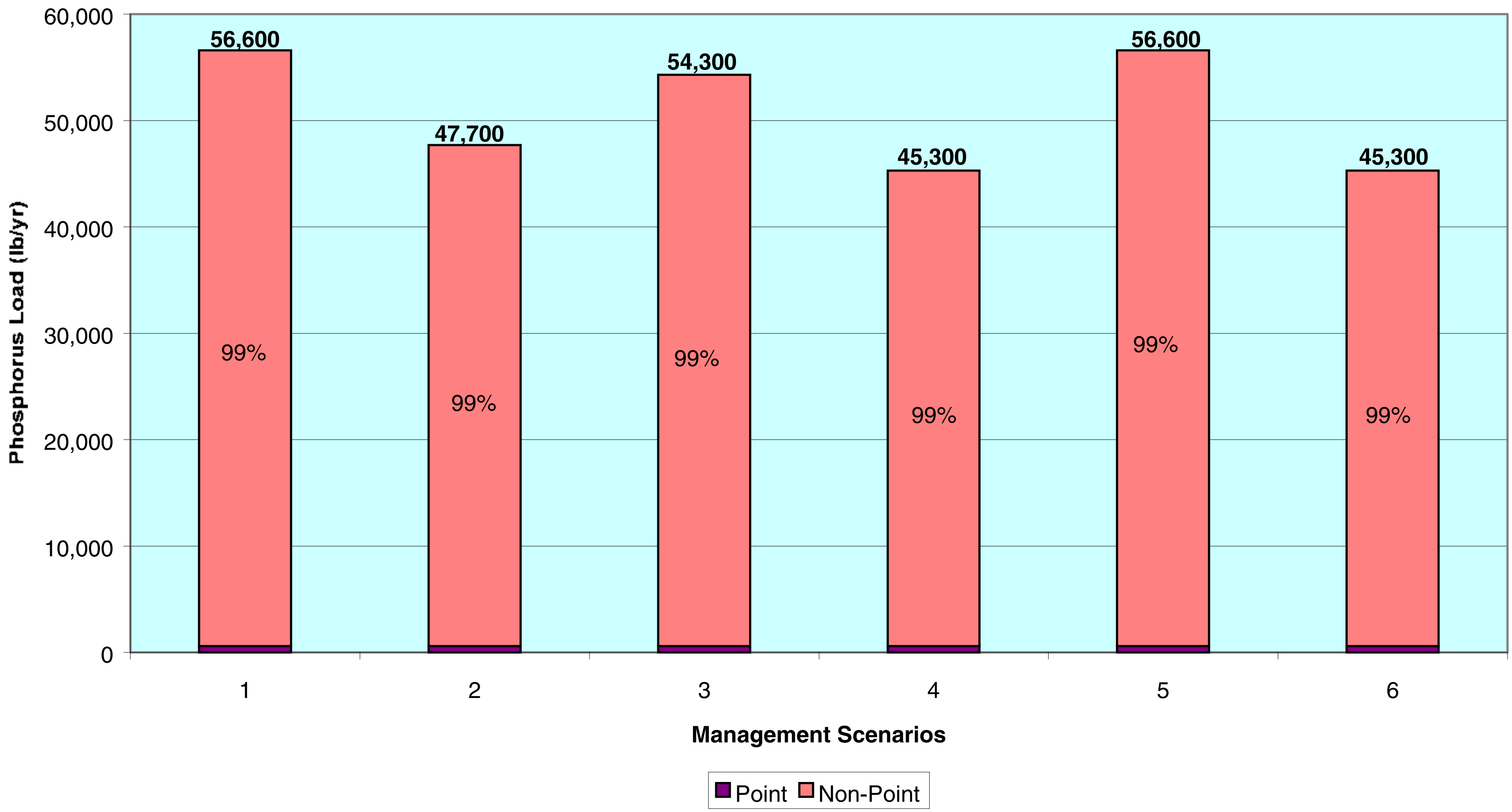

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Figure 6.9
Average Annual Phosphorus Loads
Lower Koshkonong Creek Watershed (LR11)

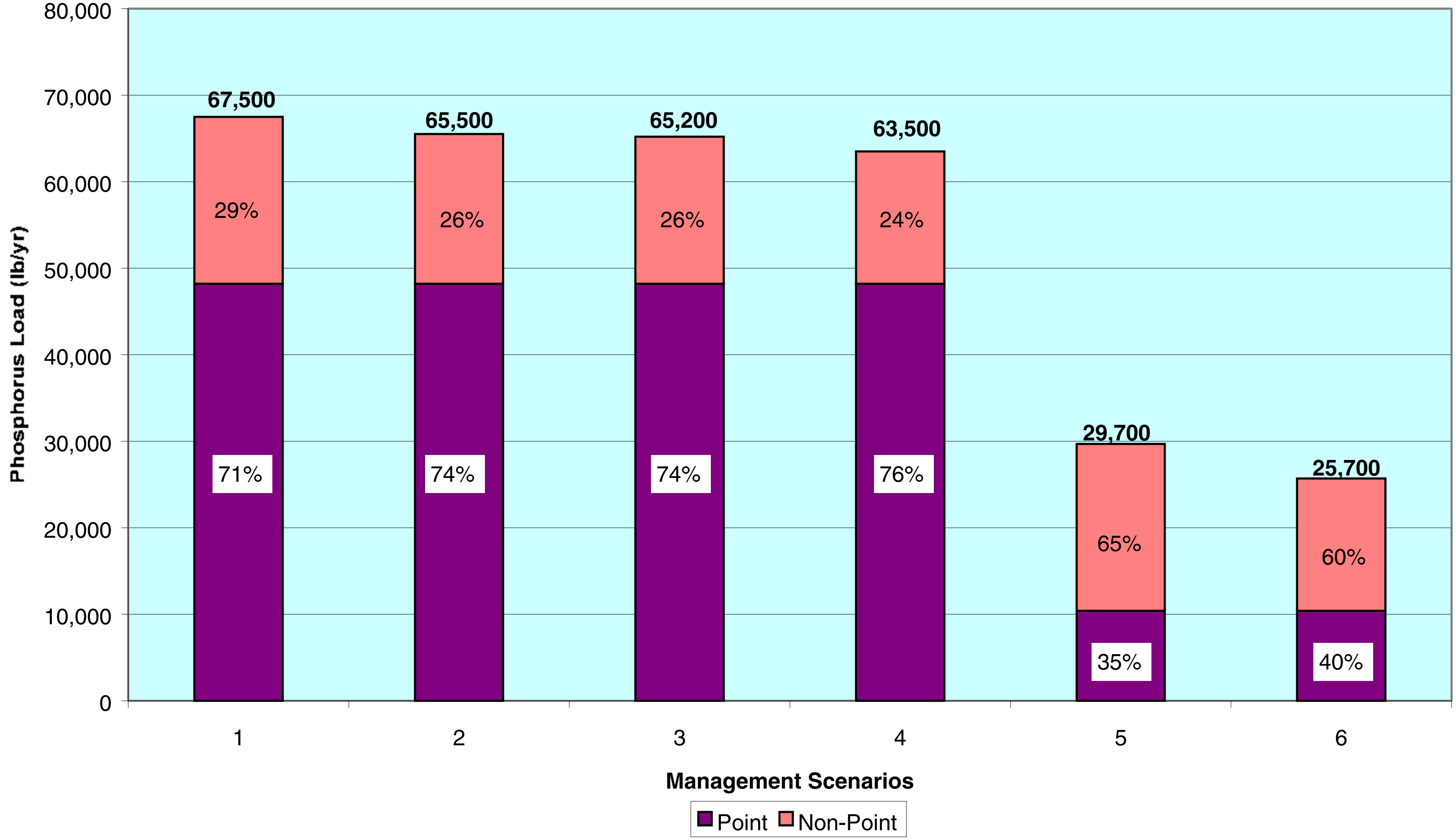

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Figure 6.10
Average Annual Phosphorus Loads
Upper Koshkonong Creek Watershed (LR12)

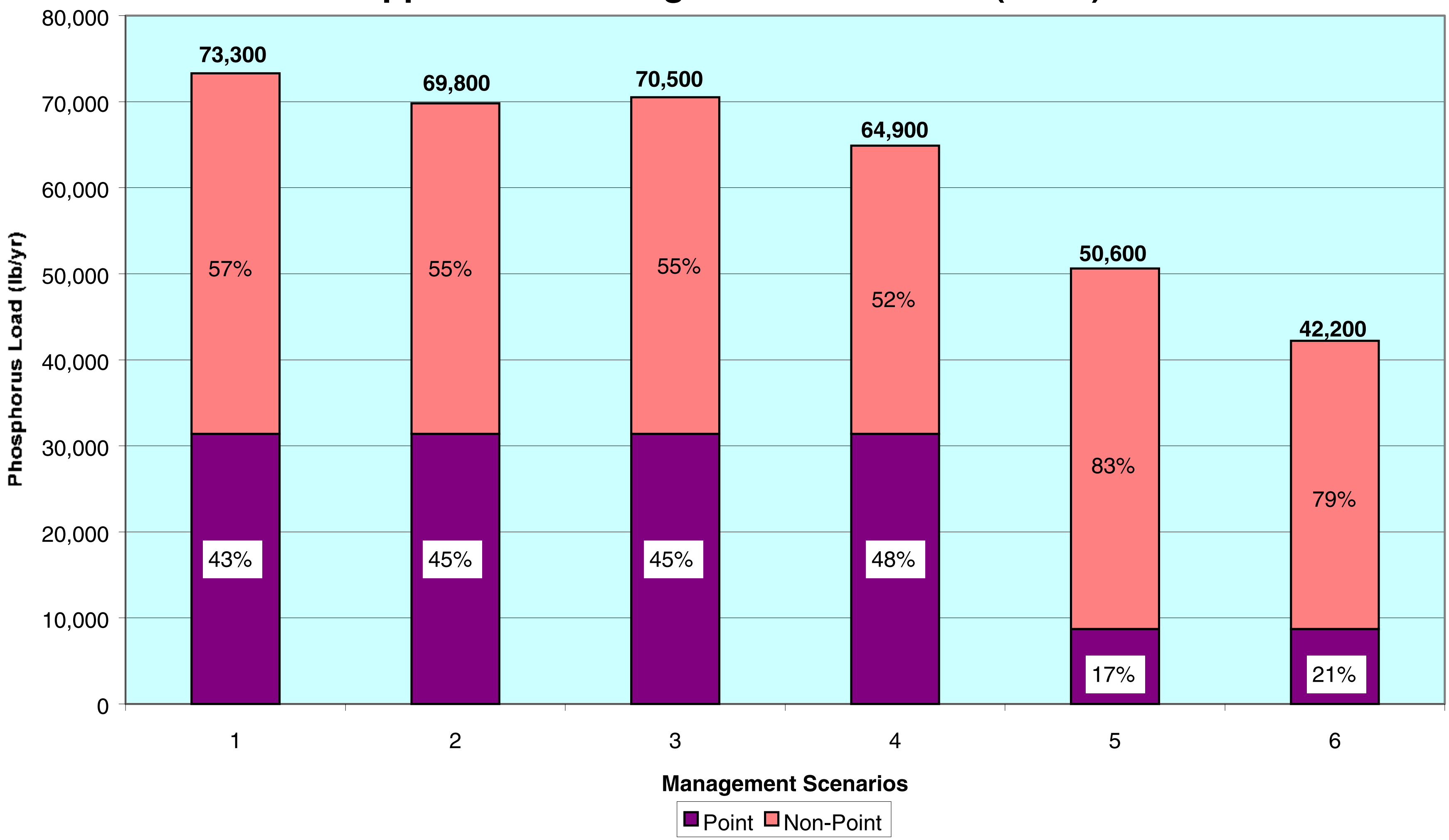

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Figure 6.11
Average Annual Phosphorus Loads
Bark River Watershed (LR13)

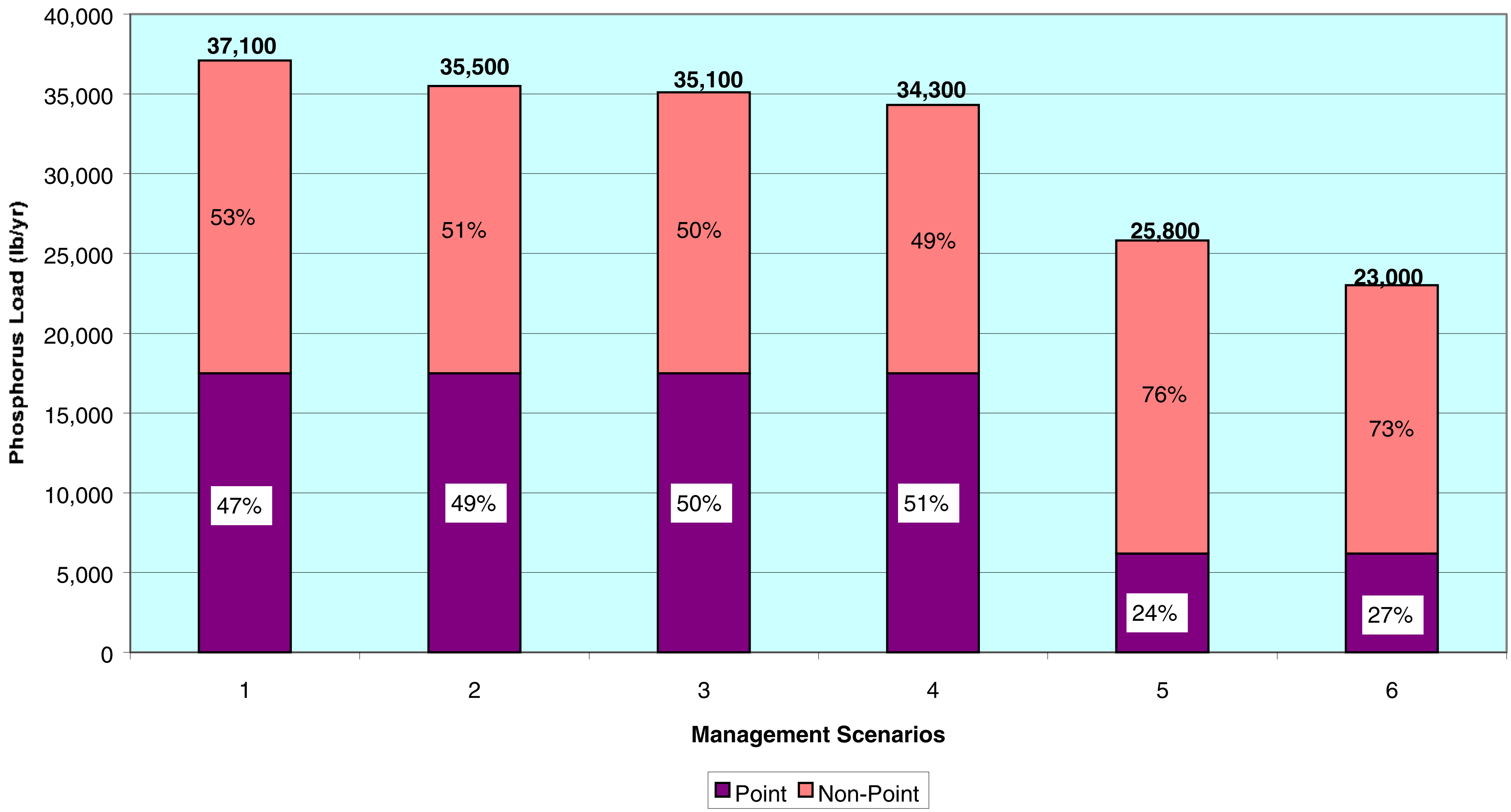

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Figure 6.12
Average Annual Phosphorus Loads
Whitewater Creek Watershed (LR14)

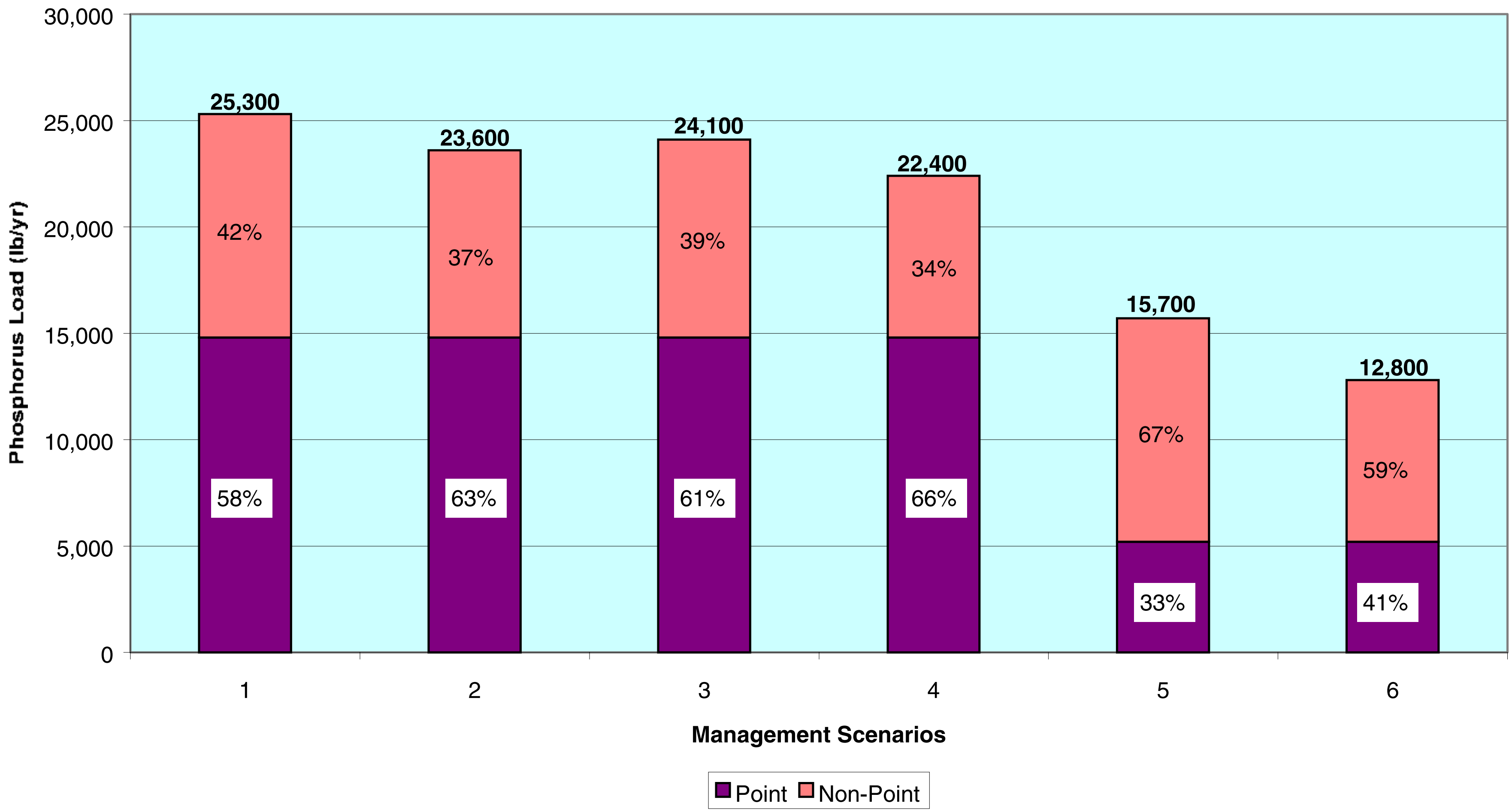

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Figure 6.13
Average Annual Phosphorus Loads
Scuppernong River Watershed (LR15)

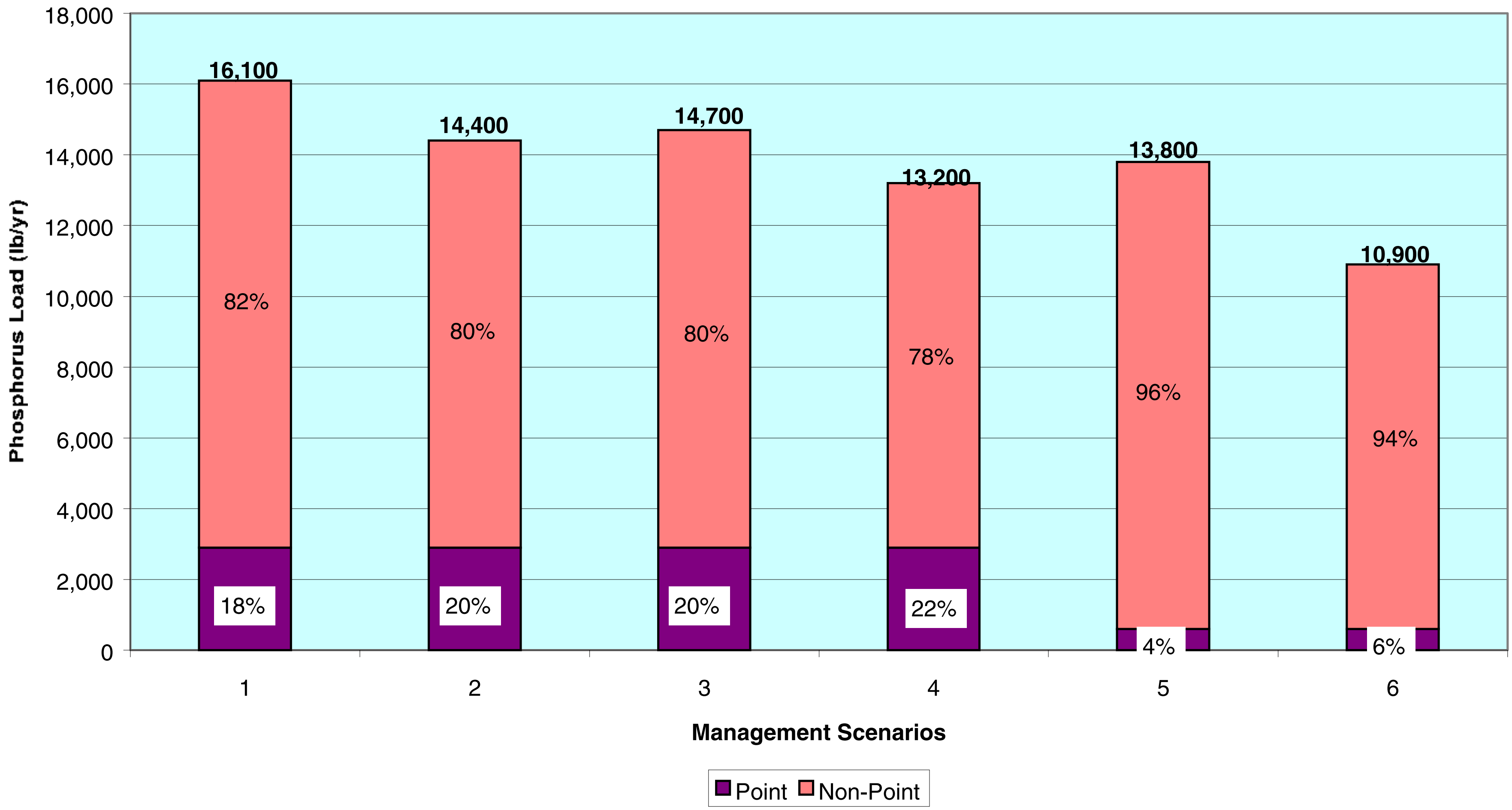

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Figure 6.14
Average Annual Phosphorus Loads
Middle Rock River Watershed (UR01)

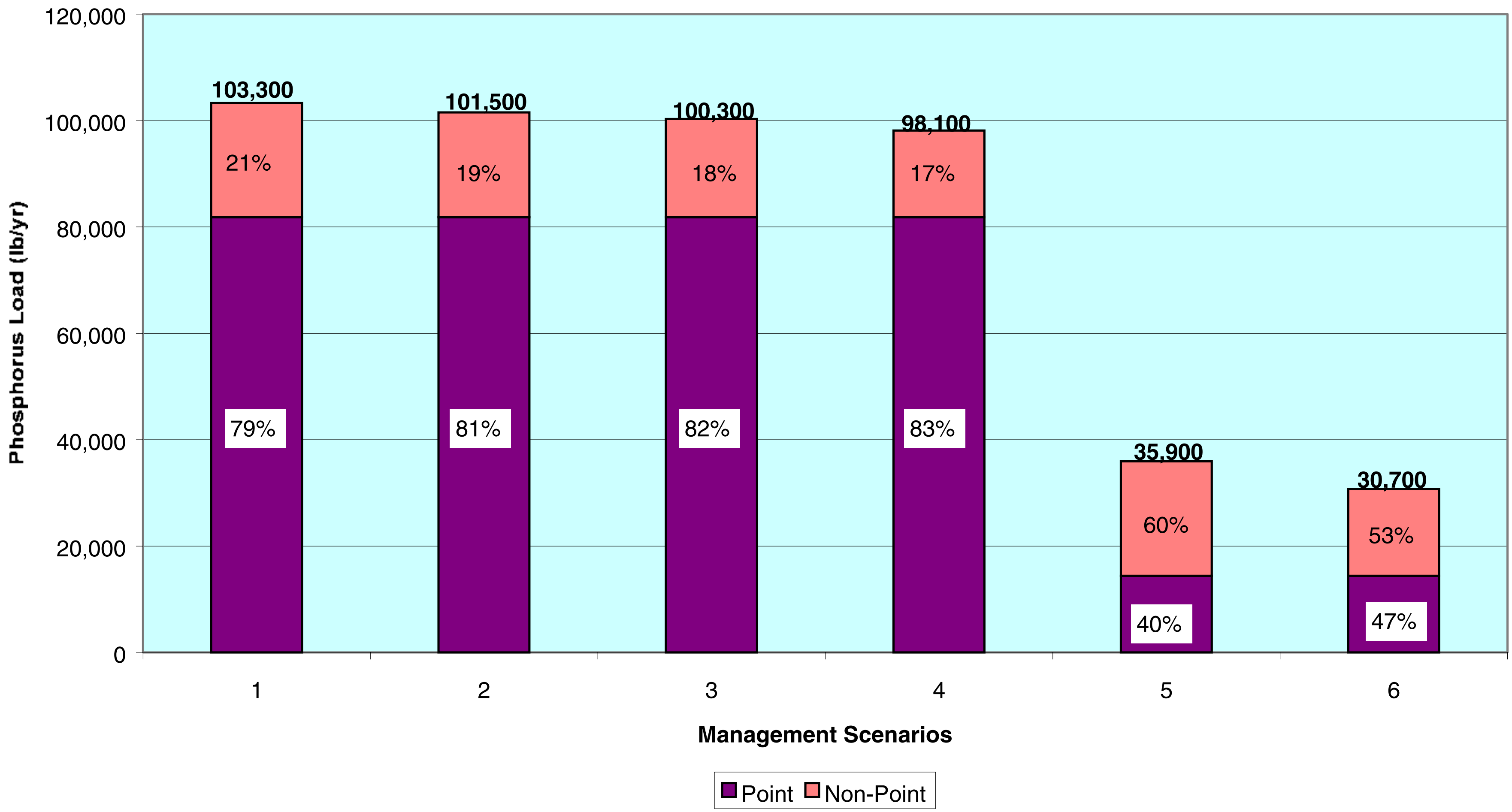

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Figure 6.15
Average Annual Phosphorus Loads
Lower Crawfish River Watershed (UR02)

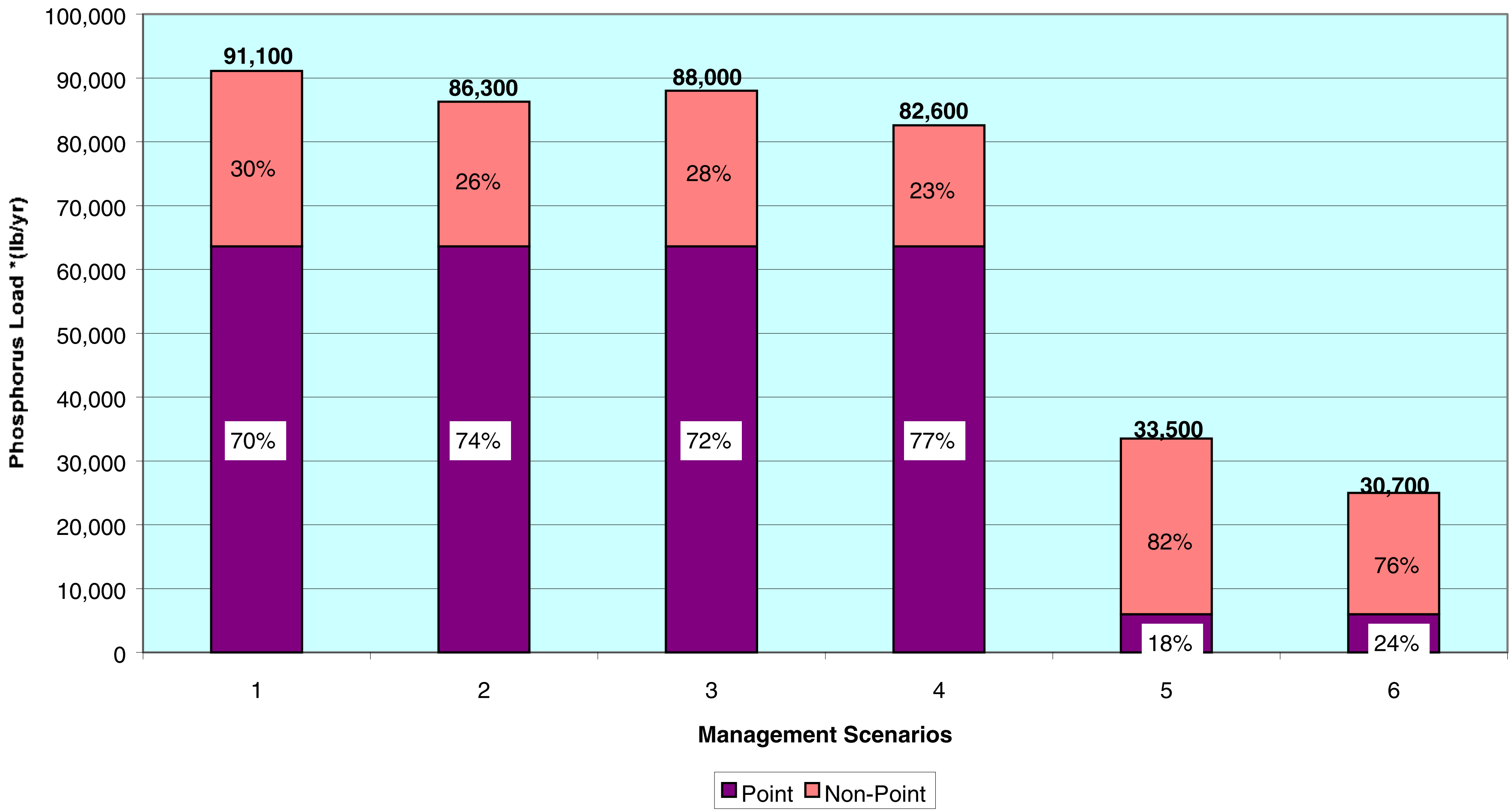

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Figure 6.16
Average Annual Phosphorus Loads
Beaver Dam River Watershed (UR03)

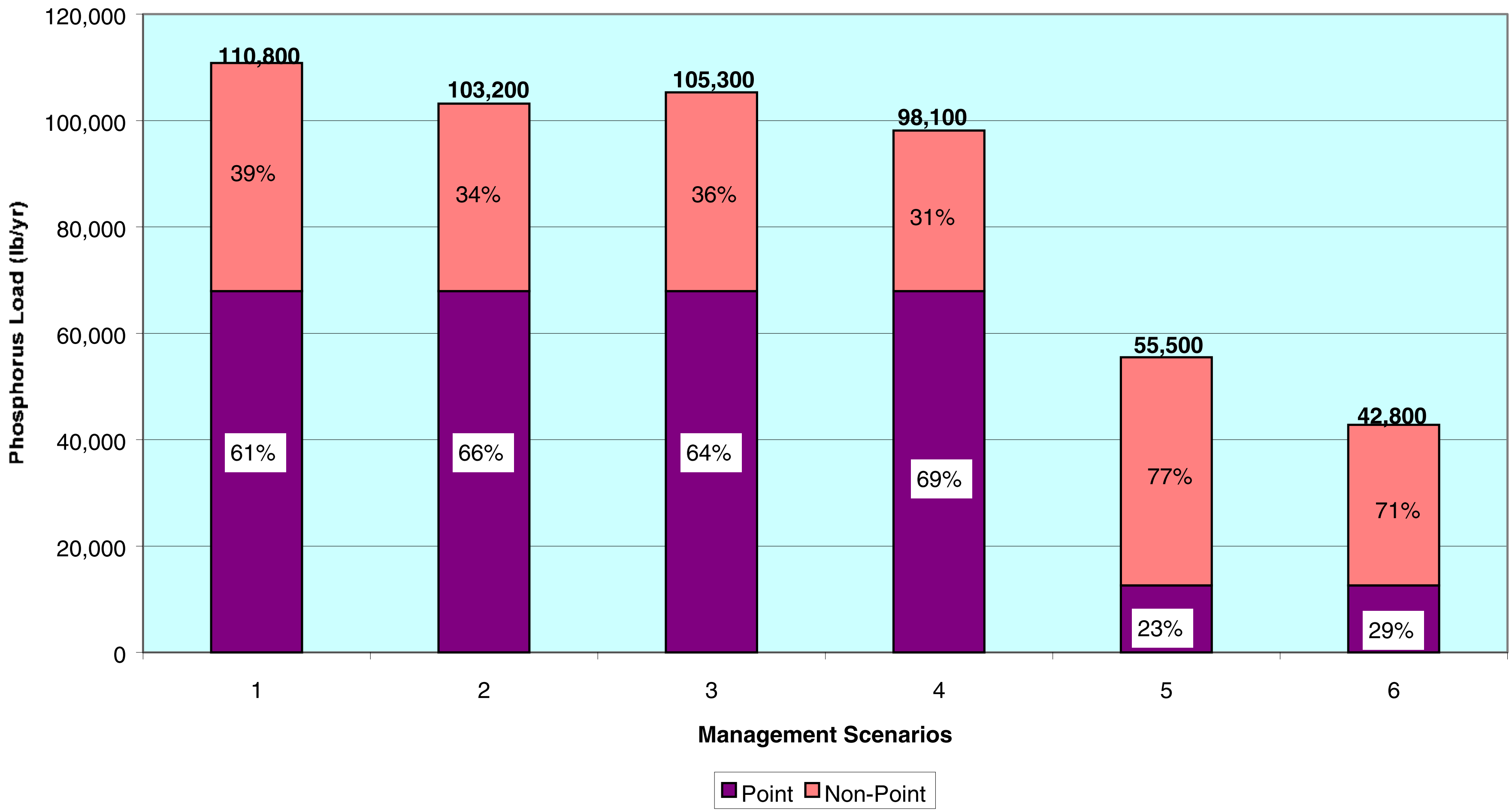

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Figure 6.17
Average Annual Phosphorus Loads
Calamus Creek Watershed (UR04)

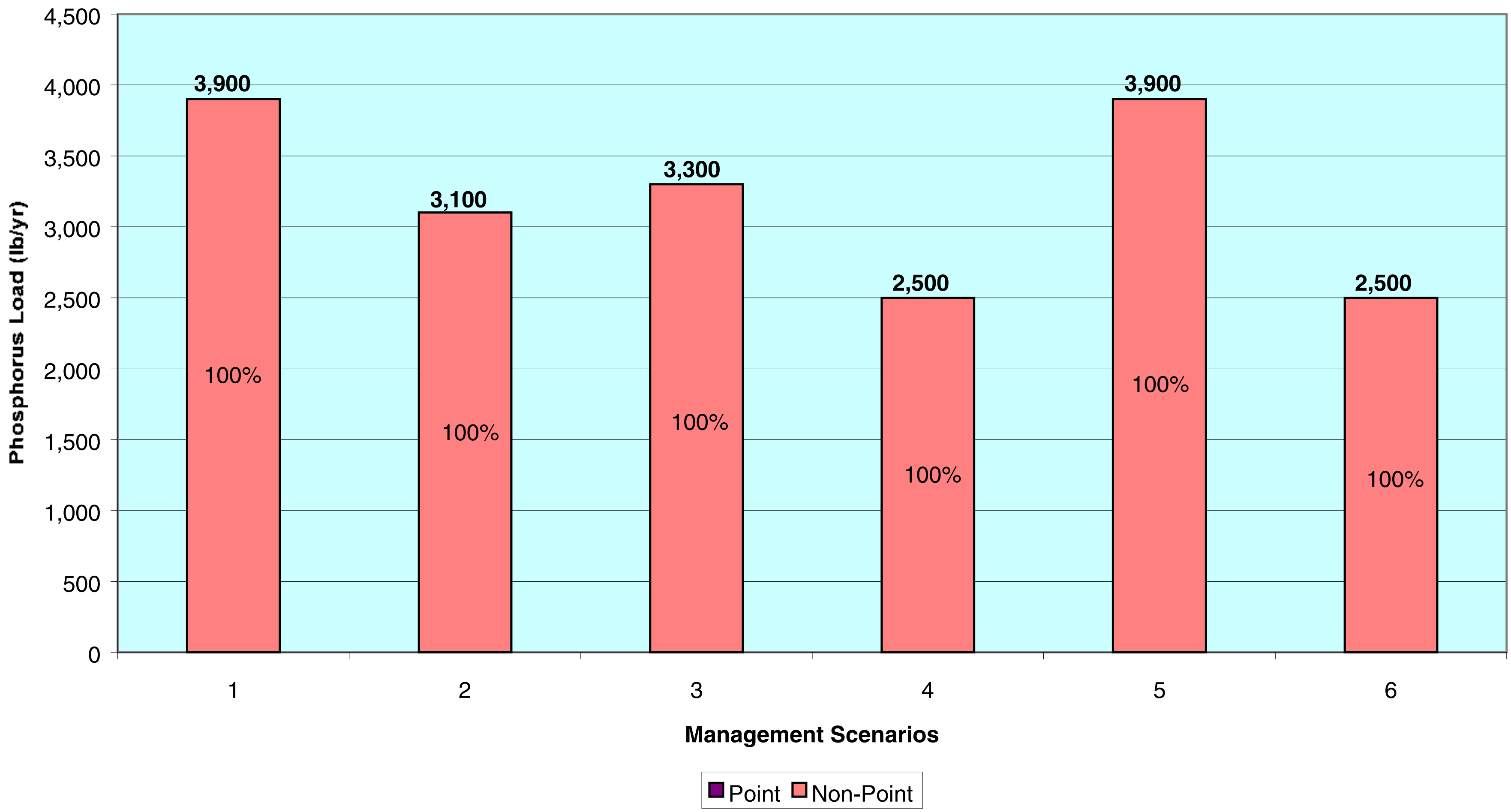

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Figure 6.18
Average Annual Phosphorus Loads
Maunesha River Watershed (UR05)

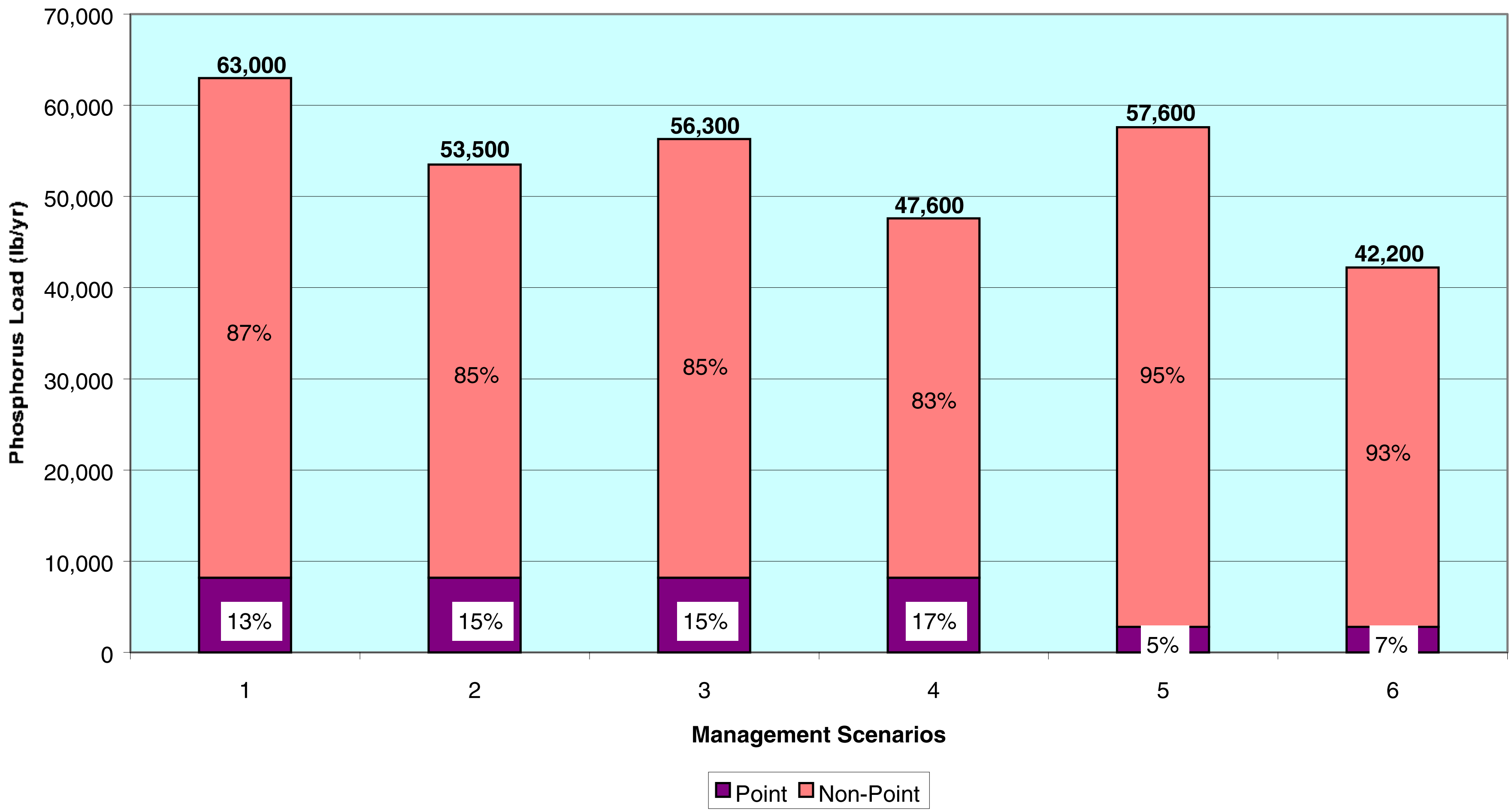

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Figure 6.19
Average Annual Phosphorus Loads
Upper Crawfish River Watershed (UR06)

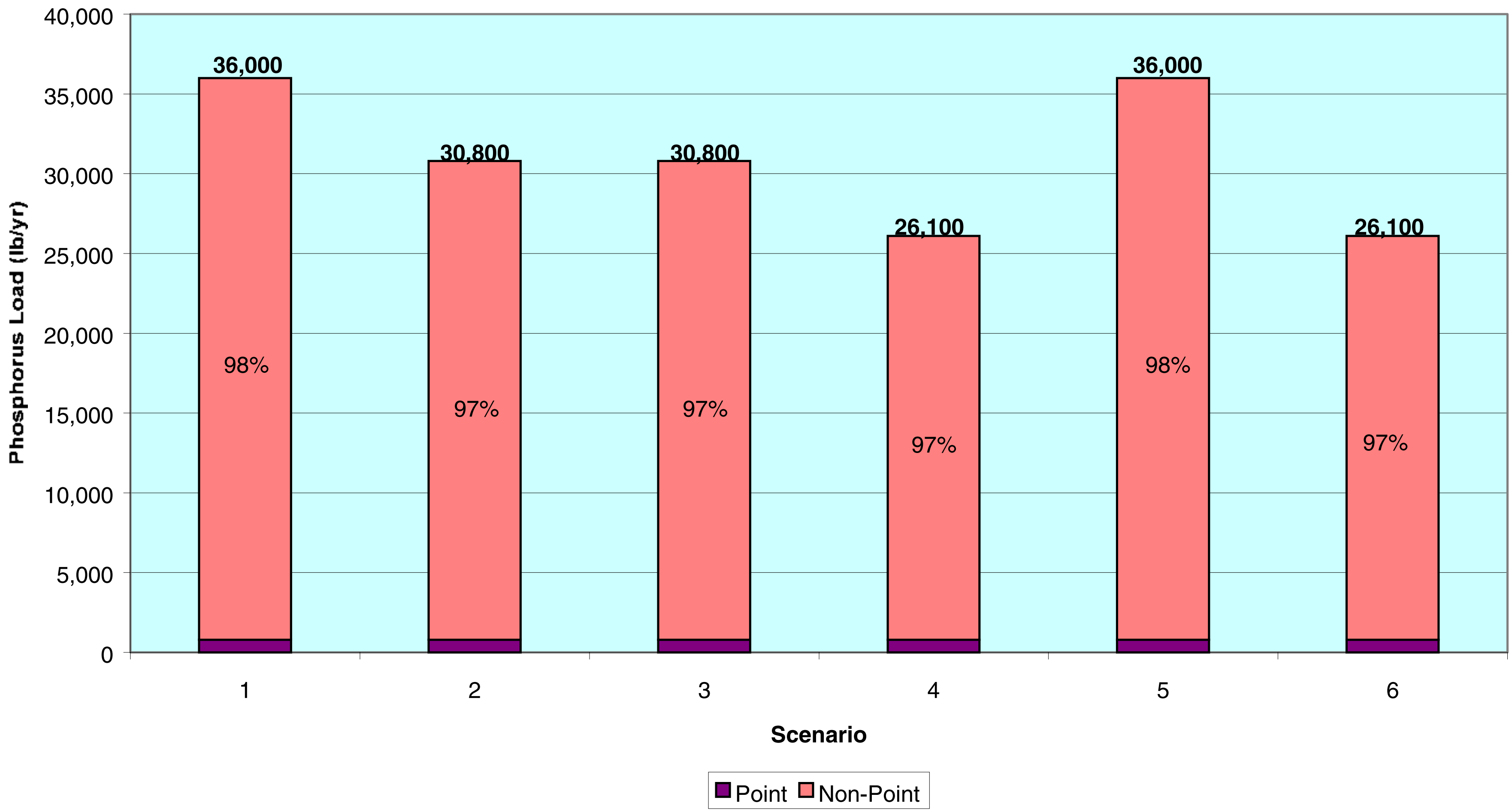

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Figure 6.20
Average Annual Phosphorus Loads
Johnson Creek Watershed (UR07)

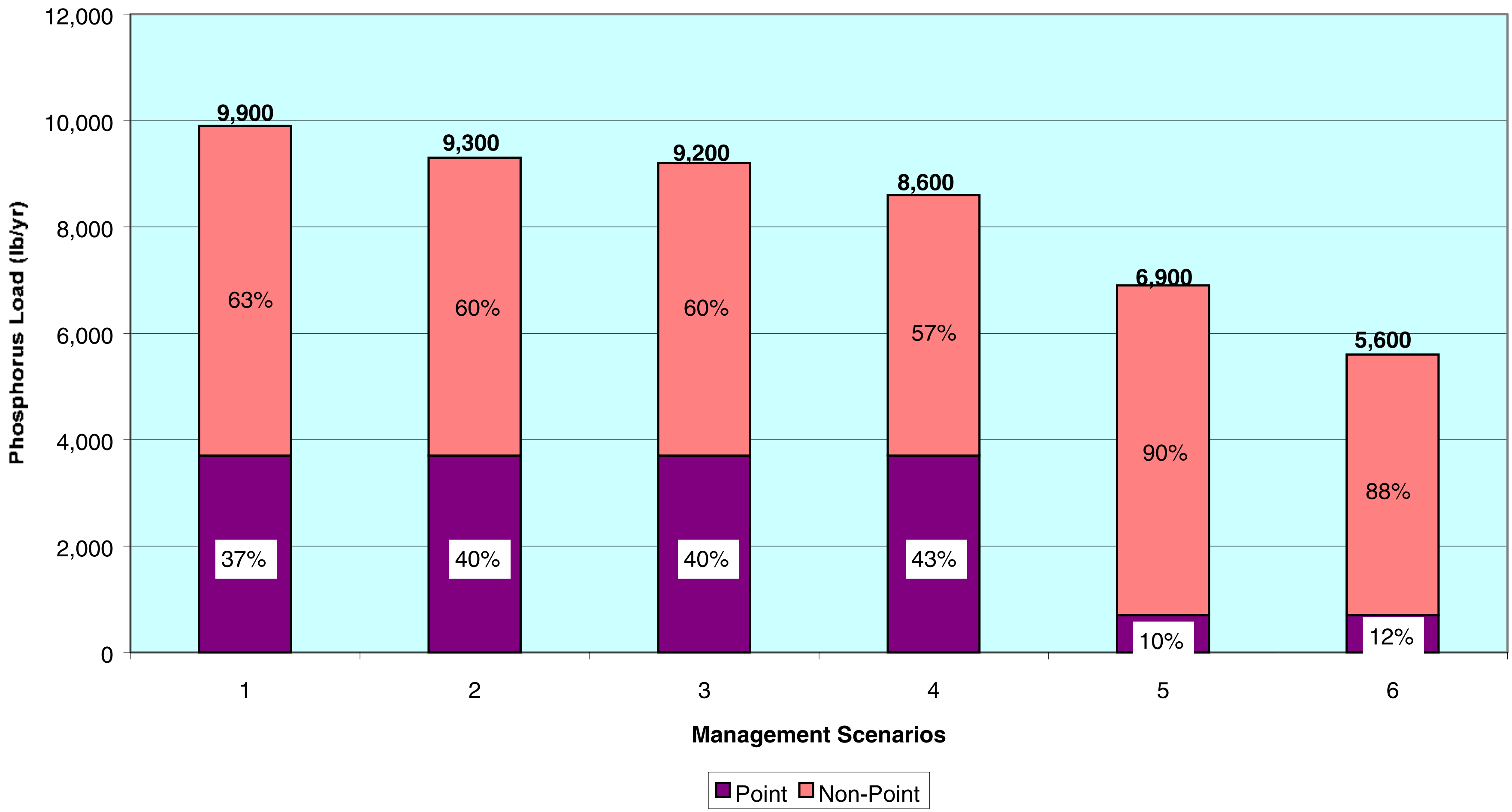

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Figure 6.21
Average Annual Phosphorus Loads
Sinnissippi Lake Watershed (UR08)

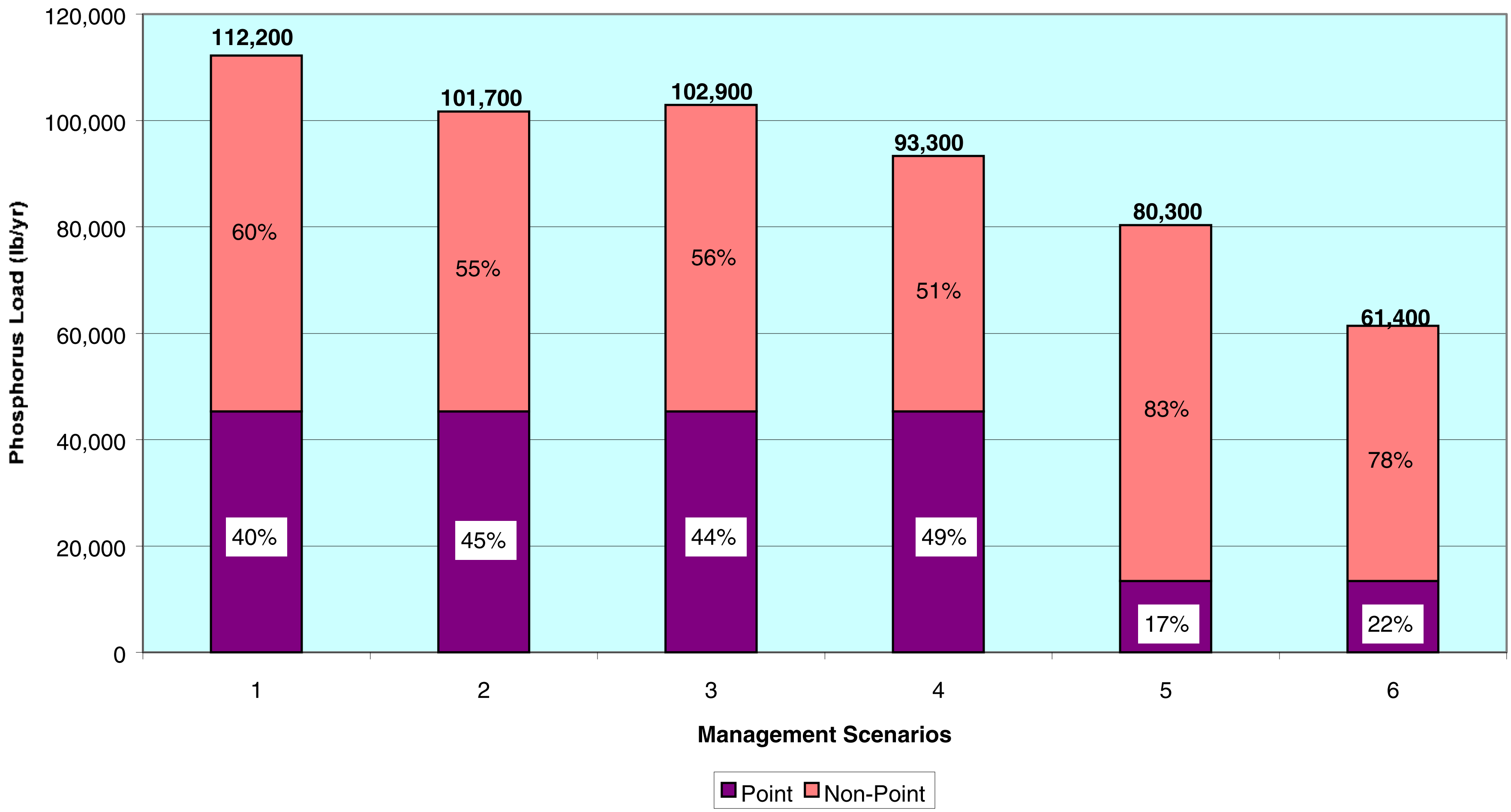

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Figure 6.22
Average Annual Phosphorus Loads
Oconomowoc River Watershed (UR09)

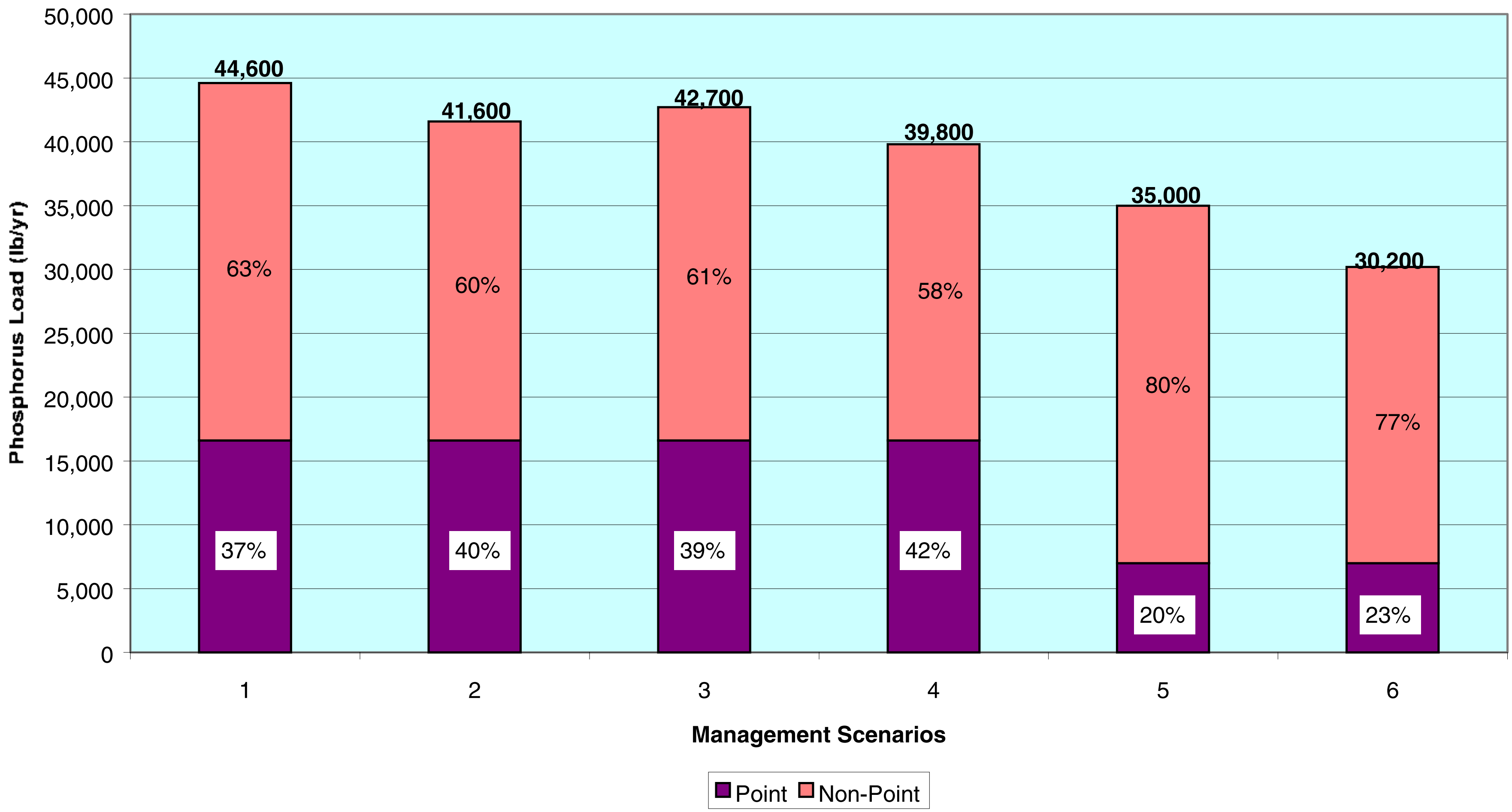

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Figure 6.23
Average Annual Phosphorus Loads
Ashippun River Watershed (UR10)

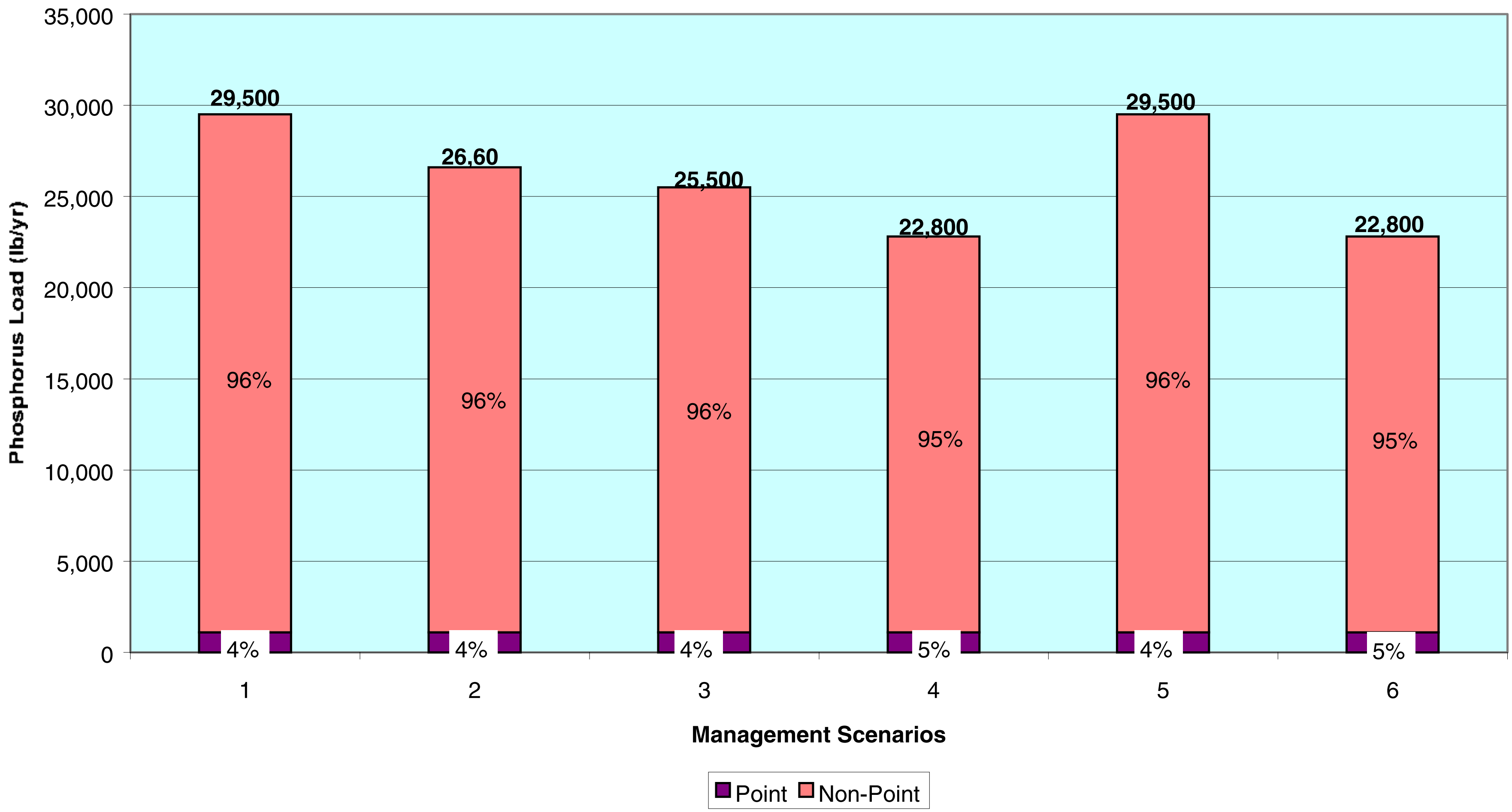

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Figure 6.24
Average Annual Phosphorus Loads
Rubicon River Watershed (UR11)

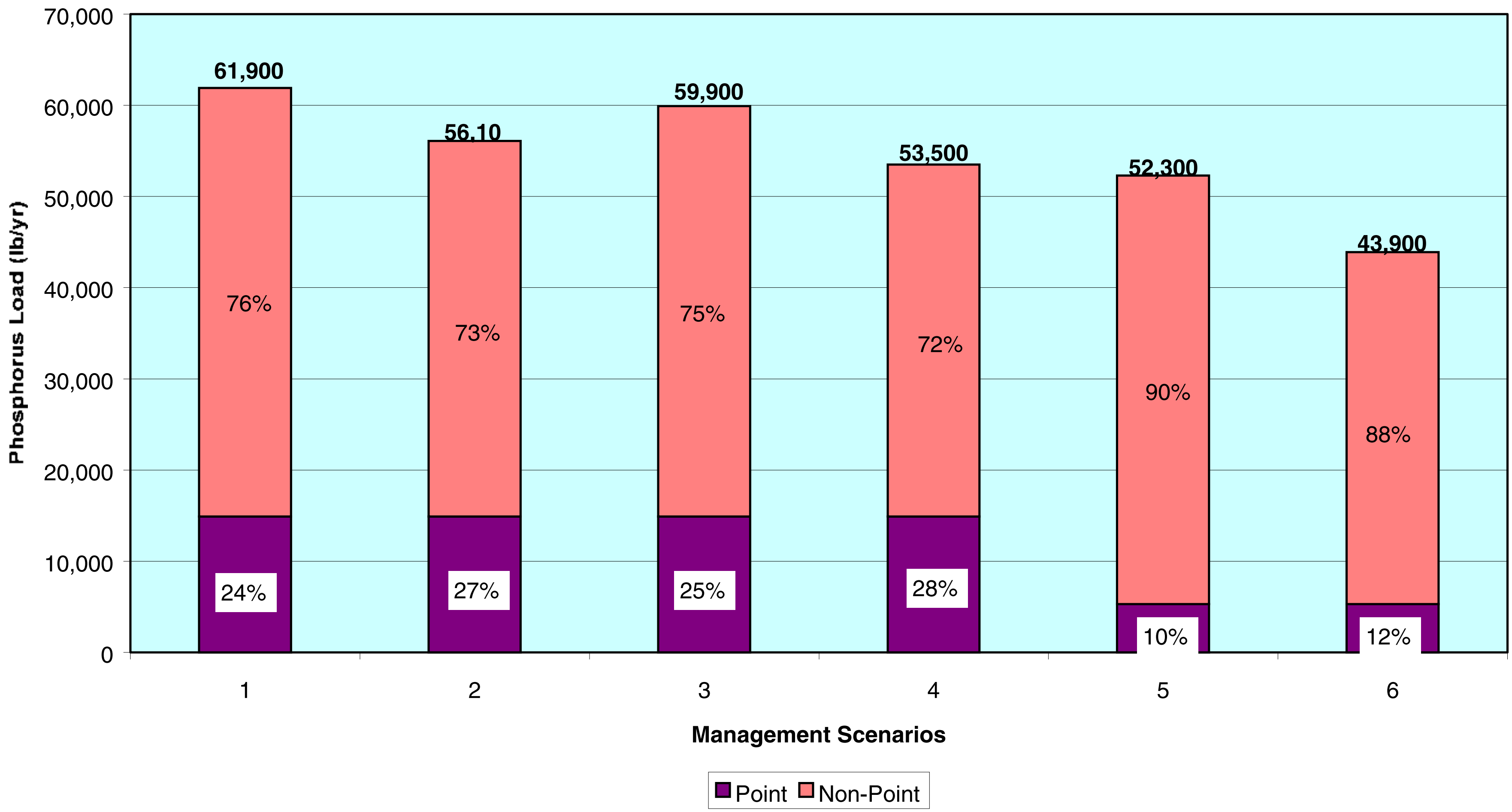

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Figure 6.25
Average Annual Phosphorus Loads
Upper Rock River Watershed (UR12)

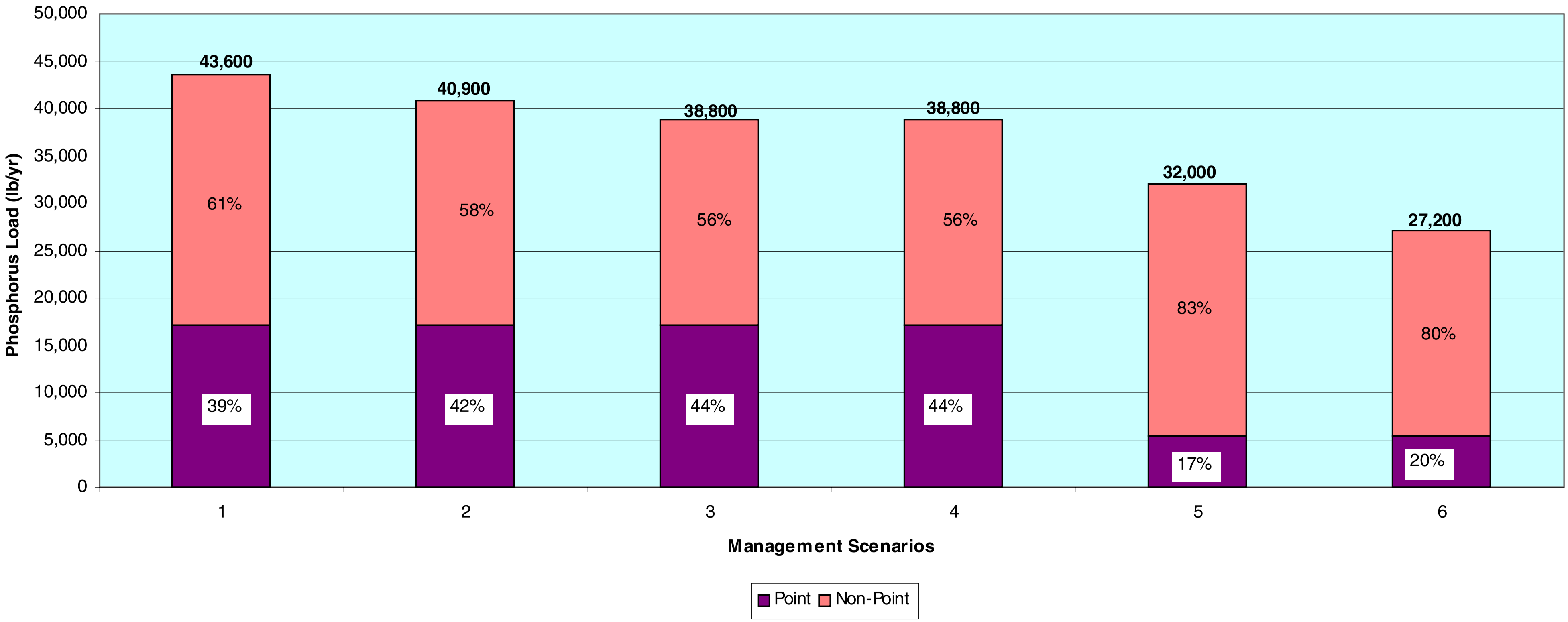

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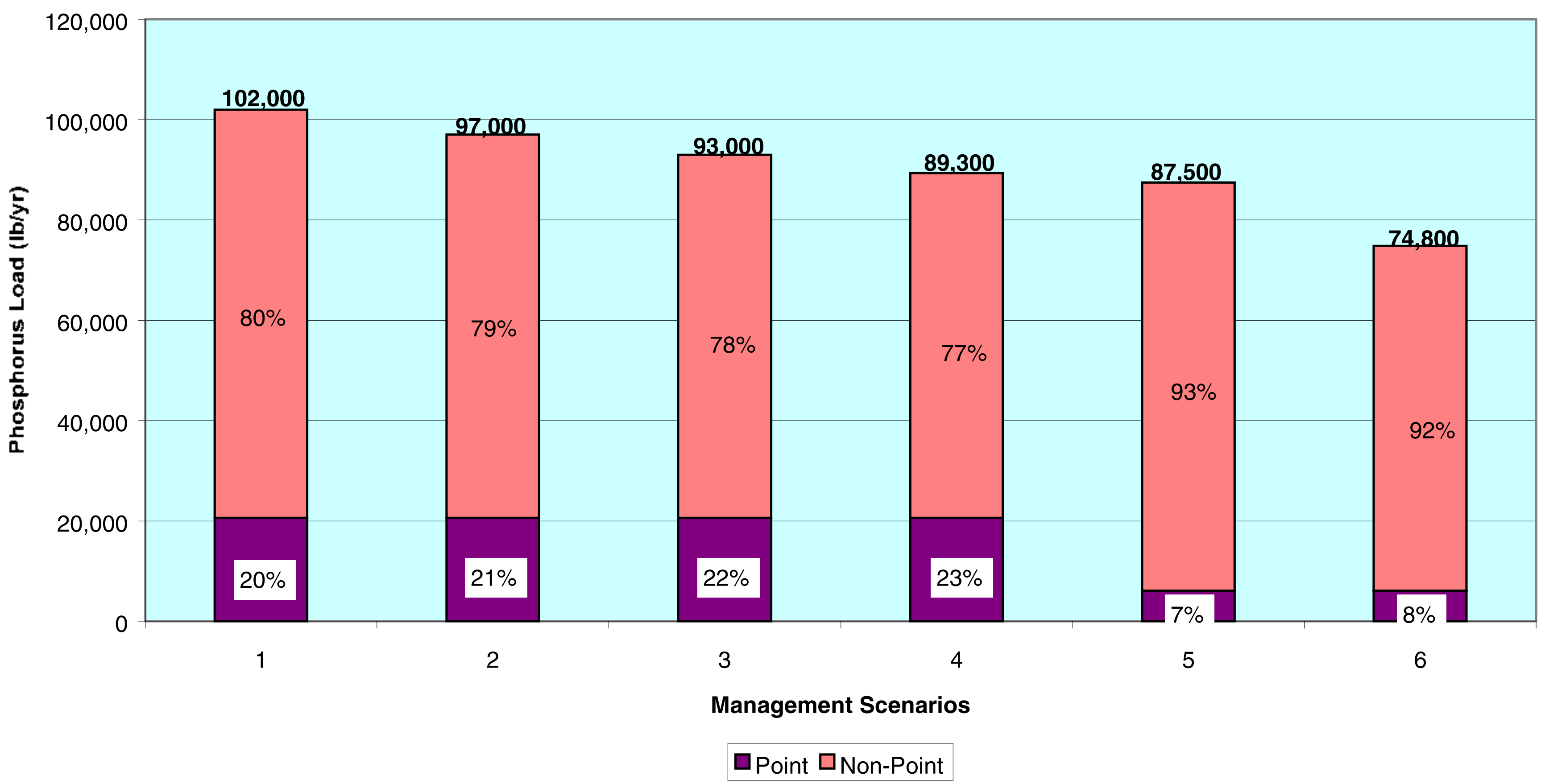
Figure 6.26
Average Annual Phosphorus Loads
East Brach Rock River Watershed UR13



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Targeting Phosphorus Loads

As previously discussed, the smallest geographic unit analyzed by SWAT was a sub-watershed. The Rock River Basin was subdivided into watersheds (28) and sub-watersheds (112). Sub-watersheds ranged in size from 2.0 to 112.7 square miles with an average of 33.1 square miles. In Appendix N is a series of tables ranking the annual phosphorus loads for each sub-watershed and watershed. Figures 6.27 and 6.28 show the annual phosphorus loads by sub-watershed under existing conditions. Figure 6.27 ranks the sub-watersheds by loading rate (lbs./acre/yr.) and 6.28 ranks the sub-watersheds by total load (lbs./yr.).

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Insert Figure 6.27
(Color ArcView Plot)

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Insert Figure 6.28
(Color ArcView Plot)

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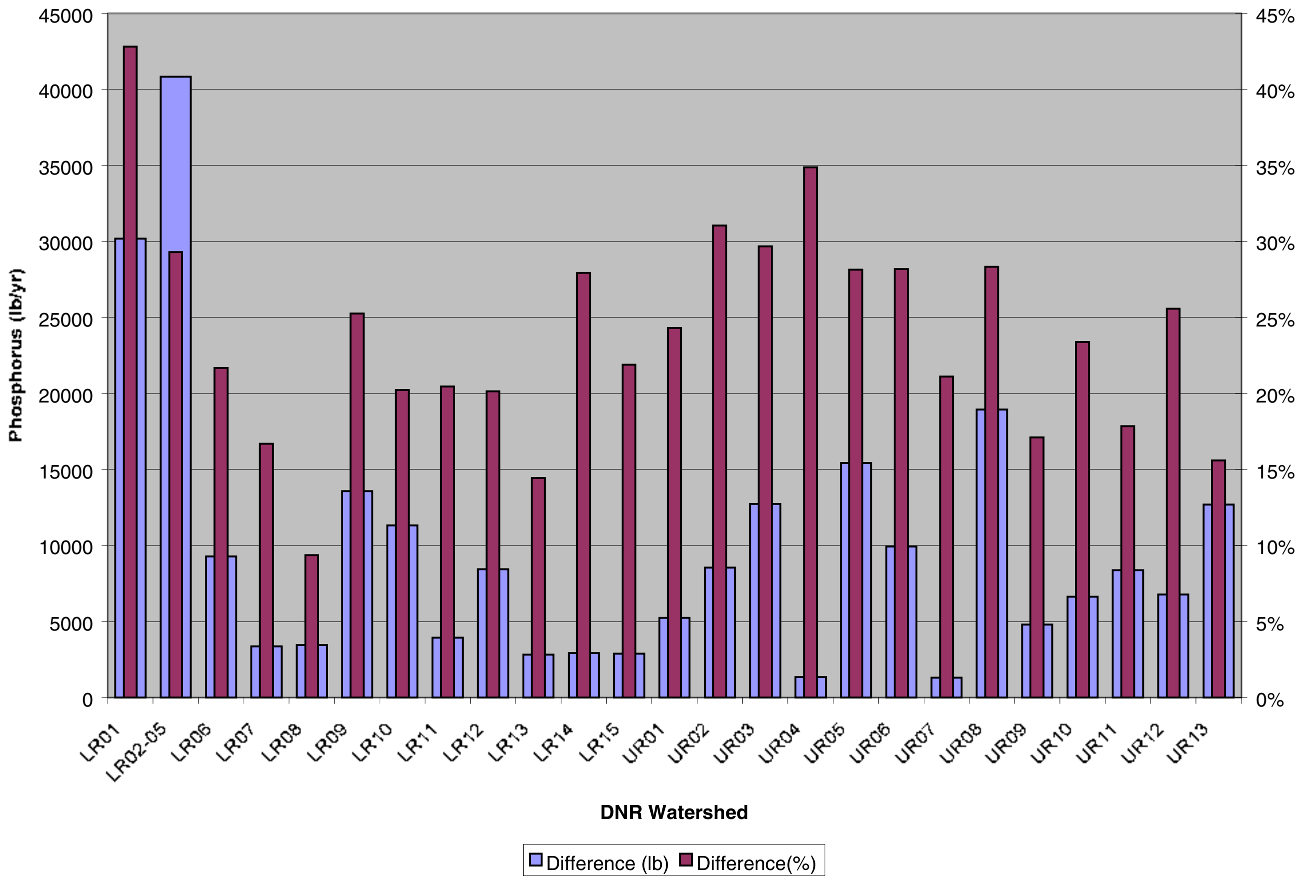
Figure 6.29 summarizes by watershed the reduction in nonpoint phosphorus loads predicted by SWAT from current conditions to the implementation of improved tillage practices and nutrient management practices. Both absolute and relative reductions are shown. This figure summarizes only nonpoint source reductions.

Figure 6.29
Absolute and Relative Phosphorus Reductions
(Scenario 1 to Scenario 4)



Sediment Loading

In addition to phosphorus loads, information was generated on sediment loads from nonpoint sources. Modeling results indicate that under existing conditions, approximately 160,000 tons of sediment are delivered to the waterbodies within the Rock River Basin on an average annual basis. Discrepancies with monitored loads at stream gages may be due to bed-load re-suspension, and scour. SWAT predicted that through the implementation of global improved tillage practices (predominantly conservation tillage), sediment yields could be reduced by almost 20% on a basin-wide basis.

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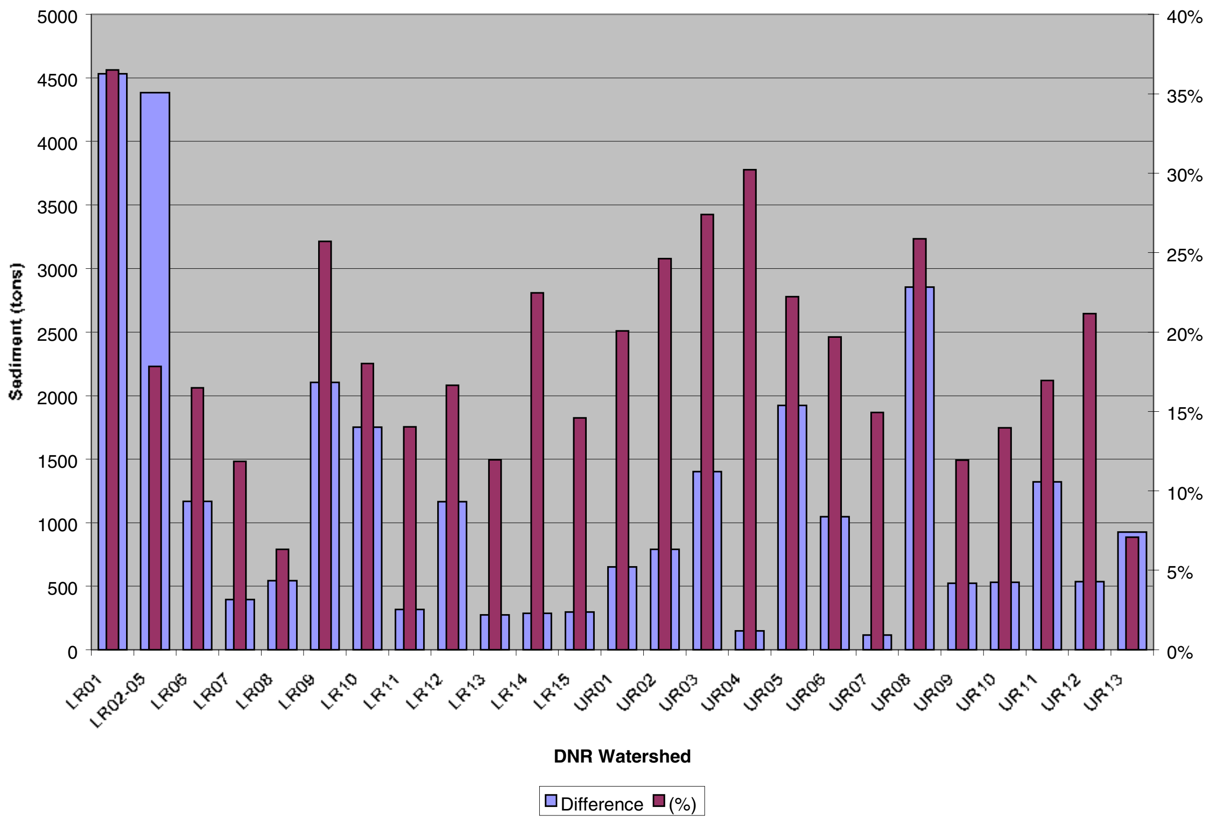
Figure 6.30 summarizes by watershed the reduction in nonpoint sediment loads predicted by SWAT from current conditions to the implementation of improved tillage practices. Both absolute and relative reductions are shown. This figure summarizes only nonpoint sediment reductions from tillage changes.

Figure 6.30
Absolute and Relative Sediment Reductions



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Conclusions

1. Under current conditions, nonpoint sources of phosphorus contribute 59% of the total loading to the Rock River Basin's water resources. The remaining 41% come from point sources. *NOTE: The analysis did not account for other phosphorus sources such as atmospheric deposition, groundwater,.etc.*

2. With global application of improved tillage and nutrient management practices, the basin-wide annual phosphorus load from cropland runoff can be reduced by approximately 224,000 pounds. This is a 14% reduction from the existing total. *NOTE: This reduction only accounts for two agricultural management measures. Other management practices, (such as riparian buffers, manure management, streambank stabilization, barnyard runoff controls, urban stormwater management, and pasture management) were not analyzed. Thus the potential total phosphorus reduction from all nonpoint sources of pollution is greater*.

3. With the complete application of the NR 217 phosphorus effluent standards, the basin-wide annual phosphorus loads from permitted discharges can be reduced by 421,000 pounds (25% reduction from the existing total).

4. The phosphorus loads, the level of potential phosphorus control, and the significance of the sources (point and nonpoint) varies greatly from watershed to watershed throughout the basin. In some cases, point source controls alone produce a significant drop in phosphorus loads while in other watersheds nonpoint source controls or a combination of both point and nonpoint controls is required to reduce loads.

Recommendations

This study concentrated on phosphorus and sediment loads delivered to receiving surface water bodies and did not attempt to relate these loads to the impact on water quality conditions. This was not due to an inability of the model to simulate receiving water quality rather the project's scope of work did not include these analyses.

Possible further modeling studies should be considered. Possible future work should be weighted against the expected improvements in technical understanding. It is important to balance our level of understanding and to work in areas where reducing the existing level of uncertainty will have the biggest effect on management decisions. It is important to agree on the scope, cost and data needs of such projects. Additional modeling and research should not overshadow the need for action. In some cases, models just provide a quantitative answer to a question that has already been answered in a qualitative manner. Thus additional modeling should not be performed in place of or delay the implementation of BMPs with know benefits. Based on the results of the modeling, a summary of recommended actions is listed below. The recommendations listed below are not ranked in any particular order.

- In-stream water quality modeling through either stochastic or quantitative techniques to relate the loads generated in this study to in-stream conditions. This effort should examine the fate of both point and nonpoint sources of phosphorus and the impact of phosphorus (in regards to trophic conditions) on the water resources in the Rock River Basin. The results of this effort could be used to help determine numerical water quality criteria as it relates to the type of water body and its intended use. In other words, the load allocation (LA) and waste load allocation (WLA) portions of a total maximum daily load (TMDL) could be calculated.

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- Continuation of sampling at key locations to provide additional data for development of both numerical and stochastic models. Monitoring records are also needed to generate trends and assess the effectiveness of BMPs.

- SWAT presented a reasonable estimation of loads at the sub-watershed scale, however, a more refined analysis may be warranted to target specific nonpoint BMPs. Past and current research shows that individual fields can contribute significant phosphorus loads to surface waters through runoff and sediment loss. Efforts need to be concentrated on identifying these fields and enacting necessary controls.

- Determine nonpoint phosphorus loads that will occur even with the implementation of all potential BMPs. This scenario represents a best case and will require the inclusion of additional BMPS not addressed in this study. Even under this best case scenario, nonpoint phosphorus loads are not zero. The best case point and nonpoint loads should be compared to water quality standards to evaluate the attainability of instream standards.

It is important that guidelines, BMPs, and restrictions on phosphorus usage have a scientific basis. The models and tools for evaluating water quality and pollutant loads are continually evolving. Improvements in modeling should be matched with improvements in both point source controls and nonpoint BMPs. Given the complexity and magnitude of the problem, there is no single solution; rather various practices will need to be employed.

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