A Primer on Nutrients in the Kansas River

Terminology

TMDL = Total Maximum Daily Load – the maximum amount of pollutants a stream can carry while still meeting water quality standards. Three TMDLs are now in place for the Kansas River from Junction City to Ogden, Ogden to Lecompton and Lecompton to Kansas City. TMDLs comprise Wasteload Allocations from permitted point sources, Load Allocation from unregulated non-point sources and a Margin of Safety which acts as a hedge against insufficient reduction and allocation to meet the endpoints of the TMDL.

303d List = A list, produced every two years, identifying those streams and lakes that are not meeting some aspect of water quality standards; these waters will need a TMDL to reset the budget for those pollutants which indicates how much reduction in loadings will be necessary. The Kansas River has been cited as impaired for phosphorus since the 2008 303d list.

Wasteload Allocation = the desired loading allocated to point sources which are implemented as limits in NPDES permits. For phosphorus, point sources get a mass-based limit in pounds per day that is computed as a rolling 12-month average. Wasteload Allocations are computed as the product of the design flow of the wastewater treatment plant in million gallons per day and the desired concentration of phosphorus in the wastewater, based on the level of treatment technology that is put in place.

BNR = Biological Nutrient Removal – a technology that uses bacteria uptake of phosphorus to lower the concentrations in the wastewater. The phosphorus becomes biosolids or sludge which is disposed of via land application or at the landfill. This is the first level of technology treatment expected from mechanical wastewater plants. The general goals for nutrient concentrations in the wastewater are either 8 mg/l total nitrogen and 1.5 mg/l total phosphorus or 10 mg/l TN and 1 mg/l TP

ENR = Enhanced Nutrient Removal – the introduction of either alum or ferric compounds to tie up the phosphorus beyond what is possible with bacteria, creating more sludge. Goals for nutrient concentrations in wastewater produced by an ENR process would be 5 mg/l TN and 0.5 mg/l TP.

LOT = Limits of Technology – for Kansas, additional treatment such as filtration that can take nutrients down to the lowest level considered economically feasible. Goals for nutrient concentrations in LOT wastewater are 3 mg/l TN and 0.3 mg/l TP. KDHE has yet to impose such conditions on any discharger.

Load Allocation = the mass loading from non-point sources that contribute pollutants such as nutrients to streams. Because of the diffuse and widespread nature of non-point sources, it is difficult to compute exact values of load allocation except in snapshots at specific flow conditions. As runoff increases, the load allocation does as well. Hence, it's typically easier to compute Load Allocations on an annual basis and as the difference of subtracting Wasteload Allocations and Margins of Safety from TMDLs.

Milestones = because nutrients are expressed as narrative, not numeric criteria in Kansas water quality standards, some measure of desired concentration is needed to base the TMDL (expressed as pounds per day computed as the product of streamflow rate and the milestone concentration). These milestones are set as a median concentration that should be indicative that control measures on point and non-point sources have successfully reduced nutrient loading into the river. Typically, phosphorus TMDLs come in two phases, the first to make reductions from current levels to an initially desired

concentration, for the Kansas River, that's 0.2 mg/l. Designated uses of recreation, aquatic life and drinking water are assessed against endpoints expressed in the TMDL. If, after Phase I, the endpoints do not indicate full support of the three designated uses, Phase II commences with a goal of further reducing the median phosphorus concentration in the Kansas below 0.18 mg/l.

Endpoints = because nutrients are expressed in the water quality standards as narrative criteria describing the adverse impacts to aquatic life, recreation and drinking water to be avoided from having elevated nutrients, those water quality standards need some quantitative measure to demonstrate the three designated uses are being met. For Kansas streams, those endpoints reflect both desired biology and chemistry. For conditions to reflect adequate nutrient levels that do not impair the three designated uses, 4-5 endpoints are established for a stream.

a. The macroinvertebrate community should be diverse and composed of pollutant intolerant species, yielding an Aquatic Life Use Support (ALUS) index score of 14 or more.
b. Chlorophyll a levels in the river should be below 10 ug/l
c. pH values should remain between 6.5 and 8.5
d. Dissolved oxygen levels should remain above 5 mg/l and the percent saturation of DO remain below 110%.

Should all these endpoints be achieved over three consecutive years, the three designated uses of the stream are presumed to be attained and the impairment is removed from the Kansas River.

Current estimated values for phosphorus, chlorophyll a and ALUS scores is given below. The upper river is not too bad, but not yet achieving the necessary endpoints. The river degrades notably at its lower end.

Kansas R Station	Total Phosphorus	Chlorophyll a	ALUS Index Score
Ogden	0.265 mg/l	----------	----------
Wamego	0.261 mg/l	20 ug/l	10
Willard	0.210 mg/l	42 ug/l	11
Lecompton	0.241 mg/l	48 ug/l	10
DeSoto	0.285 mg/l	53 ug/l	10
Kansas City	0.338 mg/l	----------	2

Relative Contributions

Phosphorus is the targeted nutrient for TMDLs because of its persistent elevated concentrations in Kansas streams. Point source impacts are most keenly felt at lower flows because there are no runoff contributions. Simultaneously, those low flow conditions are not turbid and not turbulent, very supportive of algal growth once temperatures rise. At low flows on the Kansas the first targeted action is to work on phosphorus reduction from point sources, followed by phosphorus reduction from reservoir releases from Milford, Tuttle Creek and Perry reservoirs, which is driven by upstream non-point sources.

As runoff develops, load contributions from the tributaries to Kansas River begin to influence the phosphorus levels of the river but depending upon the clarity of the river and if the flows become turbulent, corresponding algal growth and production may be diminished. Again, the reservoirs have a

role in this by leveling off peak flows from the major tributaries. Additionally, as runoff continues to rise, the ability of placed BMPs to influence the loading of nutrients diminishes particularly as the scale of contributing land area increases beyond the subwatersheds where BMPs have been emphasized.

KDHE now has enough data from wastewater dischargers to the Kansas River to assess their rolling averages of phosphorus load against their allotted Wasteload Allocation. Many of the dischargers are within their allocation, either because they have invested in treatment (Manhattan, Olathe), or because they are not discharging at their design flow rates (Futamura). Future investment in nutrient removal will need to be done through integrated planning for wastewater, stormwater, combined sewer overflows and public water supply (Jo Co, Lawrence, Topeka). In some cases, operational changes may only be what's needed to reduce nutrient using existing technology.

2018 Rolling Averages for Total Phosphorus vs. WLA for Kansas River Dischargers

City and WWTP	Total Phosphorus WLA	Current 12-mo Rolling Average TP
Junction City SW	20.9 #/d	10.75 #/d
Junction City East	19.63 #/d	4.5 #/d
Ft. Riley Camp Funston	25.06 #/d	32.1 #/d
Manhattan	91.91 #/d	22.6 #/d
Topeka North	100.26 #/d	269.1 #/d
Goodyear	20.05 #/d	7.35 #/d
Topeka Oakland	133.68 #/d	62.75 #/d
Sherwood WWTP	20.05 #/d	28.5 #/d
Futamura	32.42 #/d	18.43 #/d
Lawrence	104.42 #/d	190.2 #/d
Lawrence - Wakarusa	58.48 #/d	9.89 #/d
Jo Co – Mill Creek	156.63 #/d	327.9 #/d
Jo Co – Nelson	125.31 #/d	345 #/d
BPU – Plant #20	58.48 #/d	89.6 #/d
Olathe – Cedar Creek	64.74 #/d	23.1 #/d
Olathe – Harold Street	26.73 #/d	14.72 #/d
Gardner – Kill Creek	20.88 #/d	19.4 #/d

Urban Stormwater

Urban stormwater certainly contributes loads but must be put in the context of the overall land use of the watershed. Locally, the impacts of urban runoff can be significant, but as the watershed scale increases, the water quality of the river becomes influenced by the rural land use that proportionately dwarfs the developed area of the cities. Urban stormwater for the major cities is regulated through the NPDES program and MS4 permits. These permits do not have specific limits for nutrients but instead call for placement of appropriate BMPs within the corporate limits of the city.

In Wichita, an off-site implementation program was developed for their stormwater program, which allowed developers to pay into a fee system in lieu of investing in expensive BMPs in their development projects. Responsibility for maintaining hydraulic control of runoff and protection of public health and downstream infrastructure remains with the developer but the incremental cost of adding BMPs for water quality purposes is offset. Instead of those water quality investments being made in the city where: 1) they are expensive, and, 2) they yield little environmental benefit to the watershed as a whole, the off-site program takes those monies and invests in the rural watershed, where: 1) a greater number of BMPs can be supported for a given urban dollar, and, 2) the impact of those BMPs is far greater for reducing loads in the watershed.

The emphasis of the Wichita project is sediment, but a similar arrangement can be made for nutrients. Some contractual arrangement is necessary to transfer the city dollars to a rural interest, such as a WRAPS group. These are not considered trades in the water quality sense, because current EPA policy has specific rules on how trading between point sources and non-point sources must occur. But it is a provision in every city's MS4 permit to allow them the latitude to explore this option.