Metadata Sheet Template

Title:	**Nutrient Pollution.**
Indicator Number:	**4. Indicator number / code: 4**
Cluster:	**Water Quality**
Rationale:	River nutrient pollution is caused mainly by agricultural activities (fertiliser use and wastes from livestock), urban wastewater, and atmospheric deposition of nitrogen. Contamination by nutrients (particularly forms of nitrogen and phosphorous) increases the risk of eutrophication in rivers, which can pose a threat to environmental and human health (e.g. algal blooms, decreases in dissolved oxygen, increase in toxins making water unsafe for humans and wildlife, etc.). This indicator considers river pollution from nitrogen and phosphorus. The indicator is based on 2 sub-indicators: dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorous (DIP), which are the nutrient forms that rapidly contribute to eutrophication and have strong anthropogenic sources. Five risk categories for each sub-indicator were developed based on published national river water quality criteria, with a risk factor of 5 being the highest risk for eutrophication and 1 the lowest. The combined NP indicator for each basin was then calculated as the higher of the 2 sub-indicator risk factors.
Interlinkages:	The river nutrient pollution indicator has linkages with the TWAP LME component. The same river watershed model (NEWS) was used for calculating N and P for both the River Basin and LME components. Both of these components used amounts as well as nutrient ratios in the development of sub-indicators and a combined indicator, although the approaches differed due to differences in freshwater and marine ecosystem responses to nutrients. Furthermore, the base year conditions and the scenario for future projections (2030 and 2050) was the same for both components.
Description:	The river nutrient pollution indicator is divided into two sub-indicators corresponding to nitrogen (N) and phosphorus (P) nutrient forms representative of water quality impairment: dissolved inorganic N and P (DIN, DIP). Each sub-indicator represents annual-scale mean river nutrient concentration for the entire basin. This assessment is originally derived for Global NEWS 2 basins (Mayorga et al, 2010; Seitzinger et al, 2010) by assuming that the mean annual concentration at the basin mouth (where the mainstem river drains to the coast or to endorheic terminal points) is representative of river channel concentrations across the basin. Concentration values for TFDD basins are calculated based on spatial intersection with Global NEWS 2 basins, as described under "Computation". The Global NEWS 2 model run used here is referred to as the Realistic Hydrology Model Run for reference year 2000 (RH2000), and corresponds to near-contemporary conditions using the year 2000 as a reference for all basin model inputs and forcings (Mayorga et al, 2010). RH2000 is based on observed climate forcings and river discharge corrections from river gage observations, and was developed to represent contemporary conditions more realistically than the year-2000 reference model run used in the Millennium Ecosystem Scenarios (MEA) assessment presented in Seitzinger et al. (2010) and related publications. For future projections (2030 and 2050), model inputs and forcings were based on the Global Orchestration (GO) scenario of the MEA (Seitzinger et al. 2010). The GO scenario is an internally consistent, plausible

	global future and focuses on implications for ecosystem services. The forcing data include not only climate change, hydrology, water use, population, and GDP, among others but also nutrient management options for agriculture (crop and livestock) and sewage treatment. GO describes a globalized world with a focus on economic development with rapid economic and urbanization growth, and a reactive environmental management.
Metrics:	Average annual river yields of DIN and DIP were calculated using the Global Nutrient Export from WaterSheds 2 (NEWS 2) model. Output is in kg N or P per year normalized by basin area. Results output is average for the basin, but most input data sets (for sources of pollutants) are calculated at 0.5 degree grids. River concentrations were then calculated as yield divided by water runoff. Basin area – part of NEWS inputs based on STN30 watershed delineations, presented in km^2. The *Computation* section below describes processing steps and data sources in more detail. Sub indicators are based on global river nutrient export modeling results from the Global NEWS group, published in 2010 as Global NEWS 2. More information can be found in the two publications listed below and on the Global NEWS web site: http://www.marine.rutgers.edu/globalnews/ Mayorga, E., S.P. Seitzinger, J.A. Harrison, E. Dumont, A.H.W. Beusen, A.F. Bouwman, B.M. Fekete, C. Kroeze and G. Van Drecht. 2010. Global Nutrient Export from WaterSheds 2 (NEWS 2): Model development and implementation. *Environmental Modelling & Software* **25**: 837-853, doi:10.1016/j.envsoft.2010.01.007 Seitzinger, S.P., E. Mayorga, A.F. Bouwman, C. Kroeze, A.H.W. Beusen, G. Billen, G. Van Drecht, E. Dumont, B.M. Fekete, J. Garnier and J.A. Harrison. 2010. Global river nutrient export: A scenario analysis of past and future trends. *Global Biogeochemical Cycles* **24**: GB0A08, doi:10.1029/2009GB003587
Computation:	The sub-indicator annual-scale nutrient concentrations for TFDD basins were calculated by transferring nutrient model output created for Global NEWS 2 using a slightly modified version of the STN-30p version 6.01 30-minute (0.5 degree) global river system and basins dataset (Mayorga et al, 2010). The computational procedures used are as follows: 1. The final TFDD basin-scale dataset (updated and distributed for the TWAP project in February 2014, as the shape file "RiverBasins_ver_1_20140215.shp") was reprojected to a "geographic" projection (EPSG:4326) as preparation for GIS overlay with NEWS 2 STN-30p basins. In addition, small inconsistencies in geometric type representations (single polygon vs. multi-polygon features, and presence of "geometry collection" types) were corrected during this pre-processing. The TFDD dataset contains 286 basins. 2. To enable the transfer of attributes and data from NEWS 2 basins to TFDD basins, the NEWS 2 STN-30p basins polygon dataset was spatially intersected with the final TFDD basins polygon dataset. The result was 1,881 individual component polygons, each polygon having core basin attributes from the two original GIS datasets. Three very small TFDD basins (CONV/Conventillos, $7km^2$; ELNA/El Naranjo, $24km^2$; PDNL/Pedernales, $320km^2$) had no intersecting NEWS 2 STN-30p basin, and therefore could not be assigned nutrient results. A brief quality assessment of the dataset spatial overlay is presented under Additional

	Notes. 3. NEWS 2 basin-scale data was transferred to TFDD basins as area-weighted means of the component NEWS 2-derived basin polygons for each TFDD basin (from step #2, above). These annual-scale NEWS 2 attributes are: actual runoff (river discharge at the mouth normalized by NEWS 2 basin area), and nutrient yields (river nutrient form loads at the mouth normalized by NEWS 2 basin area) for the each of the 2 nutrient forms (dissolved inorganic N (DIN) and dissolved inorganic P (DIP)). 4. Once NEWS 2 attributes were transferred to TFDD basins, sub-indicator (DIN, DIP) nutrient concentrations (mg N/L or mg P/L) were calculated by dividing the corresponding nutrient yield by runoff. If the TFDD-basin-scale runoff was zero, a nutrient concentration was not calculated and was left as a Null value. For the 3 small TFDD basins that had no intersecting NEWS 2 basins, a nutrient concentration could not be calculated directly and was left as a Null value. 5. Out of the 286 transboundary basins, 153 were classified as “uncertain” (Fig. 3), and thus while included in the maps, are not included in the discussion of results. The “uncertain” flagging is the result of four different tests: if any are true, the flag is set: 1) TFDD basin area < 20,000 km^2; 2) TFDD basin has a corresponding dominant NEWS basin (largest contributing area percentage) made up of < 10 0.5-degree grid cells; 3) the intersection of the TFDD basin with the NEWS/STN30 basin with the largest geographical overlap/overlay with that basin amounts to < 50% of the area of this TFDD basin (an assessment of the geographical coincidence between TFDD and NEWS/STN30 basins); and 4) <60% of the TFDD basin is covered (overlapped) by NEWS/STN30 basins. In NEWS 2 (following an analysis done by the original STN-30p dataset developers), watersheds made up of < 10 0.5° x 0. 5° grid cells (approximately 25,000 km^2 at the equator, and smaller at higher latitudes) are deemed to be uncertain and more unreliable. It should be noted that TFDD basins are predominantly relatively small, with a median basin area of 22,185 km^2. Additional uncertainty in the transferring of results from NEWS 2 to TFDD basins involves the robustness or quality of spatial overlays between TFDD and NEWS basins.
Units:	*mg N/L or mg P/L*
Scoring system:	DIN and DIP concentrations were used to establish 5 ranking categories for the DIN and for the DIP sub-indicators. Published national water quality criteria were used as guidelines for establishing the concentration ranges in each category as indicated below (Table 1). After ranking DIN and DIP for each river basin from 1-5, the higher of the 2 sub-indicator value for a basin was calculated as the combined nutrient (NP) indicator. For DIN:

Conc. Range mg N/L	Risk category	Description
≤0.15	1	Very low
>0.15 and ≤0.50	2	Low
>0.50 and ≤1.00	3	Moderate
>1.00 and ≤2.00	4	High
>2.00	5	Very high

<table>
<tr><td></td><td>For DIP:
<table>
<tr><th>Conc. Range mg P/L</th><th>Risk category</th><th>Description</th></tr>
<tr><td>≤0.01</td><td>1</td><td>Very low</td></tr>
<tr><td>>0.01 and ≤0.03</td><td>2</td><td>Low</td></tr>
<tr><td>>0.03 and ≤0.10</td><td>3</td><td>Moderate</td></tr>
<tr><td>>0.10 and ≤0.50</td><td>4</td><td>High</td></tr>
<tr><td>>0.50</td><td>5</td><td>Very high</td></tr>
</table></td></tr>
<tr><td>Limitations:</td><td>1. Only provides basin averages, so does not identify hotspots within basins. If additional funding becomes available, some sub-basin information on indicators and sources could be provided.

2. As noted above, out of the 286 transboundary basins, 153 were classified as “uncertain” due primarily to their small size.

3. Indicator only considers N and P concentrations, and doesn’t consider factors such as hydrology that can affect ecosystem response to nutrients.</td></tr>
<tr><td>Spatial Extent:</td><td>Global</td></tr>
<tr><td>Spatial Resolution:</td><td>Calculations are based on the polygon representation of basins draining to the coast or to endorheic terminal points. The spatial resolution is therefore highly variable. The raster resolution of the basins dataset used and of the majority of original model drivers is 0.5 degrees.</td></tr>
<tr><td>Year of Publication:</td><td>2010 (publication of original, source Global NEWS 2 results that supported the TWAP analyses)</td></tr>
<tr><td>Time Period:</td><td>2000, 2030, 2050</td></tr>
<tr><td>Additional Notes:</td><td>1. Only TFDD basin-scale results are provided; as the scale of the STN-30p basin definitions is coarser than that of TFDD basins, operating only with TFDD basin units (and not country-basin units) is warranted.

2. Most GIS operations were carried out using PostGIS, the spatial extension of the open-source PostgreSQL Relational Database Management System.

3. It is possible that NEWS 2 STN-30p basins could intersect only a small fraction of a TFDD basin, resulting in poorly supported mean nutrient concentration sub-indicators. We examined this possibility. Excluding the 3 very small TFDD basins (CONV/Conventillos, 7km^2; ELNA/El Naranjo, 24km^2; PDNL/Pedernales, 320km^2) with no intersecting NEWS 2 STN-30p basin, all but 1 TFDD basins have > 50% of their area covered by NEWS 2 basins, and all but 10 TFDD basins have > 80% of their area covered by NEWS 2 basins. We have generated other assessments of reliability of basin-intersection and attribute transfer.</td></tr>
<tr><td>Date:</td><td>19 July 2014</td></tr>
<tr><td>Format:</td><td>Excel (results template provided on Data Portal)</td></tr>
<tr><td>File Name:</td><td>TWAP_RB_indicator_4_results.xlsx (Combined single indicator),
TWAP_RB_indicator_4a_results.xlsx (DIN sub-indicator), and</td></tr>
</table>

	TWAP_RB_indicator_4b_results.xlsx (DIP sub-indicator)
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