SusWater Project Memo "Overview of existing studies and concepts and suggestion of relevant biophysical indicators" *Appendix 7-4, by Zinke, P. (NTNU), December 2016*			Indicator Type (DPSIR)					Reference								
								EU	EU	NO	NO	EU	EU	EU	EU	
Sort	**Name**	**Unit**	**D**	**P**	**S**	**I**	**R**	**EEA**	**WFD** EU-B	**WFD**	**Nature-Index**	**REFORM**	**MARS** No in Ref	**DESSIN**	**SENSOR** (Code)	**Other references** See reference list
1	Elevation about sea level (climate zone)				x				x	x						
1	Latitude / longitude				x				x							
1	Precipitation				x				o							
1	Water yield	mm			x							x				
1	Annual runoff ratio (coefficient)			x	x	x						x				
1	Mean air temperature			x	x	x			o							
1	Air temperature range				x				o							
1	Water temperature (Bakken et al.: Reduction of summer temperature and probability of population effects)	degree C			x	x								(x)		Bakken et al. (2016)
1	Size of drainage area (river)	km2			x				x	x		x				
1	Size of lake (surface area)	km2			x				x	x						
1	Depth of lakes (mean depth)	m			x				o	x						
1	(Area of) large surface water bodies	%			x							x				Large & Gilvear (2015)
1	Geology (WFD types): % silicious, % calcareour, % organic, % mixed/other	%			x				x			x				
1	Land cover (CORINE Level 1): % artifical surfaces, % agricultural areas, % forest and semi-natural areas, % wetlands	%		x	x	x						x			ENV7.1	Large & Gilvear (2015)
1	Land cover (CORINE Level 2): % area of rapid runoff, % area of intermediate runoff, % area of delayed runoff	%		x	x	x						x				
1	Land cover types: Palaeochannels, wetlands, floodplain forest, opem water bodoes, agriculture, woodland plantation, urban/paved/mining area	%														Large & Gilvear (2015)
1	Area in danger of eutrophication	%													ENV6.1	
1	High nature value farmland														ENV6.4	
1	Spatial cohesion														ENV6.5	
1	Area of exposed aquifers	%			x							x				
1	Area of permeability classes	%			x							x				
1	Area of glaciers and perpetual snow	%			x							x				
1	Connection to ground water bodies													x		
1	Soil erosion rate	t/(ha*year)		x	x	x						x				
1	Soil water erosion														ENV3.1	
1	Soil sealing														ENV 3.2	Large & Gilvear (2015)
1	Area with potential source of coarse sediment	%			x							x				
1	Valley shape				x				o							
1	Valley confinement				x							x				
2	River discharge category				x				o							
2	Flow regime type				x							x		(x)		
2	Water residence time				x									x		
2	(Visible) surface flow duration	% of days per year												x		
2	Minimum ground water volume in the aquifer (storage?)													x		
2	Average annual flow	m3/s			x							x		(x)		
2	Average monthly flow	m3/s			x							x				
2	Annual water level fluctuations (RH); range in m per year	m		x	x					x			x BInd06	(x)		
2	Base flow index (BFI)				x							x				
2	Low water: Change in the lowerst mean weekly value (Summer and winter combined)				x	x								(x)		Bakken et al. (2016
2	Qminreg/Qminnat Winter				x	x				x						
2	Qminreg/Qminnat Sommer				x	x				x						
2	Morphologically meaningful discharges (Qpmedian, QP2, QP10)	m3/s			x							x				
2	Extremes: Median, LQ, UQ of 1- and 30-day max and min flows, and month of most frequent occurrence	m3/s			x							x				
2	Flood: Change of flood peak and frequency (reflects probability for habitat degradation)				x	x										Bakken et al. (2016)
2	Flood: Probability of flooding and flood damages of nearby roads/settlements													x		
2	Mean duration of high pulses within each year	days / year		x	x	x							x BInd04			
2	Mean duration of low pulses within each year	days / year		x	x	x							x BInd05	(x)		

2	Length of river reach affected by hydro-peaking	% of total length in km				x										Bakken et al. (2016)
2	Hydropeaking amplitude (Qmax/Qmin)					x										Bakken et al. (2016)
2	Temporal distribution of hydro-peaking (irregulary / regulary)					x										Bakken et al. (2016)
2	Time (date/season) of hydro-peaking				x											Bakken et al. (2016)
2	Hydropeak frequency (number of days with hydropeaking /year)	days / year		x	x	x						x				Bakken et al. (2016)
2	Water abstraction rate														ENV2.2	
2	Change of water availability in wells because of changed river water level															
2	Drinking water: volume (or costs for other solutions because of river changes)															
2	Irrigation: volume (number?) of water withdrawals during a season															
2	Industry: volume of water supply within a given period	m3														
2	Flood protection: valuable area not exposed to flood damage ("ungått skade")															
3	Form and shape of main river bed				x				o							
3	Distance from river source				x				o							
3	Average riparian corridor width				x							x				
3	Bankfull channel width	m			x							x				
3	Mean wetted width				x				o							
3	River confinement (alluvial plain width/bankfull river width)				x							x				Large & Gilvear (2015)
3	Average bankful channel depth	m			x							x				
3	Mean water depth				x				o							
3	Dominating water depth (When?)	m			x											Pulg et a. (2011)
3	Dominating flow velocity (When?)	m/s			x											Pulg et a. (2011)
3	Bankful channel width:depth ratio				x							x		(x)		
3	Bankful sinuosity index				x							x				Large & Gilvear (2015)
3	Braiding index				x							x				
3	Anabranching index				x							x				
3	Changes in sinuosity/braiding/anabranching index					x						x				
3	(Area of) floodplain accessible to flood water	%			x							x				
3	Riparian corridor continuity				x							x				
3	Valley side connectivity															Large & Gilvear (2015)
3	Active channel complexity (ratio of bend apices to exposed bars and backwaters)															Large & Gilvear (2015)
3	Average number of secondary channels				x											Large & Gilvear (2015)
3	Tributaries along sector/reach				x											Large & Gilvear (2015)
3	Channel gradient or average channel gradient				x							x				Large & Gilvear (2015)
3	Gradient				x											Pulg et a. (2011)
3	Mean water slope				x				o							
3	Flow energy (stream power)				x				o							
3	Specific stream power				x							x				
3	Geomorphic unit (Riffle, Stryk, …)	Class			x											Pulg et a. (2011)
3	Amount and distribution of spawning areas				x											Bakken et al. (2016)
3	Water level change rate (during hydro-peaking)	cm/h			x	x										Bakken et al. (2016)
3	Change of water-covered area during flow reduction (hydro-peaking)	%				x										Bakken et al. (2016)
3	Water-covered area (after/before)				x	x				x						
3	Netto reduction of water-covered area (after/before regulation)	%		x	x	x										Anonymus 2011
3	Other effects on fish fauna: other habitat reductions					x										Bakken et al. (2016)
3	Solid transport			x	x	x			o							
3	Suspended sediment load	t/year		x	x	x						x				
3	Bedload	t/year			x							x				
3	Sediment budget (channel sediment store)			x	x	x						x				
3	Eroded soil delivered to channel			x	x	x						x				
3	Land surface instabilities connected to channel	t/year		x	x	x						x				
3	Bed sediment size (D50, dominant size); Bed substrate (spawning gravel)	m		x	x	x			o			x		(x)		Pulg et a. (2011)
3	Bank sediment size (D50, dominant size)	m			x							x				
3	Number of high channel blocking structures			x	x	x						x				
3	Number of medium channel blocking structures			x	x	x						x				
3	Presence of transversal migration barriers			x	x	x								x		
3	Number of high spanning/crossing structures			x	x	x						x				
3	Number of medium spanning/crossing structures			x	x	x						x				

3	Number of high/medium/low blocking or spanning/crossing structures			x	x	x						x				
3	Presence of channel and floodplain geomorphic features/units typical of river type			x	x	x						x				
3	Bars, benches, islands	% area of bankful channel		x	x	x						x				
3	Eroding banks (as % active channel bank length)	%		x	x	x						x				
3	Laterally aggrading banks (% active channel bank length)	%		x	x	x						x				
3	Retenion of in-channel sediment (% area of bankful channel)	%		x	x	x						x				
3	Lateral channel migration rate	m/year		x	x	x						x				
3	Width of erodible corridor				x							x				
3	Changes in active channel widht/depth/W-D-ratio					x						x				
3	Presence of geomorphic features/units indicative of narrowing/widening				x	x						x				
3	Presence of geomorphic features/units indicative of incision/aggradation				x	x						x				
3	Changes in bed sediment structure indicating incision/aggradation					x						x				
3	Proportion of river bed that is artifically reinforced			x	x	x						x				Large & Gilvear (2015)
3	Proportion of potentially erodible channel margin				x							x				
4	Riparian corridor vegetation cover/structure			x	x	x						x				
4	Riparian corridor physical habitat mosaic															Large & Gilvear (2015)
4	Vegetation along river shore (e.g. large trees to provide shadow)				x									(x)		Pulg et a. (2011)
4	Presence /abundance of wild flowers													x		
4	Presence / abundance of (non-native) species that cause allergic reactions or have a high water demand													x		
4	Biomass potential														ENV 5.1	
4	Occurrence of endangered species															
4	Presence / abundance of edible or medicinal species															
4	Presence /abundance of invasive species on the floodplain													x		
4	Lateral gradient and patchiness in riparian vegetation cover classes				x							x		x		
4	Dominant riparian tree species				x							x				
4	Deadwood														ENV6.3	
4	Presence/abundance of large wood				x							x				
4	Abundance of isolated wood pieces/inc-channel wood accumulations/channel-blocking jams/ wood in the riparian corridor				x							x				Pulg et a. (2011)
4	Aquatic/riparian encroachment					x						x				
4	Riparian/riverbank woodland															Large & Gilvear (2015)
4	Abundance of submerged, emergent and floating-leaved macrophytic vegetation (NI: "Vannplanter innsjø") Unit: Percent coverage; plant volume invested; abundance sum	see left			x						x		x BInd11	(x)		
4	Aquatic plant extent/patchiness/species,morphotypes				x							x				
4	Coverage of aquatic vegetation	%			x											Pulg et a. (2011)
4	Trophical index aquatic plants (TIc)	none			x	x				x	x					
4	Water level index (WIc)	none			x	x				x						
4	Growing season mean of water column chlorophyll-a concentration	micro-g/l			x					x	x		x BInd08			
4	Biovolume of toxic/nuisance phytoplankton species	mm3/l, mg/l?			x	x				x	x		x BInd10	(x)		
4	Trophical Index (PTI)	none			x	x				x	x?					
4	Maximum volume of cyano-bacteries (toxic/nuisance)	mg/l			x	x				x						
4	Acidification index periphyton (AIP); Begroing elver (forsuringsindex)				x	x				x	x					
4	Heterotrophic growth (bacteria, fungae) - org. Impact	Percent coverage			x	x				x						
4	*Herbertus stramineus*										x					
4	*Herbertus dicranus*										x					
4	*Hygroamblystegium varium*										x					
4	*Isothecium holtii*										x					
5	Average Score per Taxon (ASPT)	Average score per taxon			x					x	x		x BInd12	(x)		
5	Abundance ratios of invertebrate functional feeding groups	Dimensionless			x								x BInd13	(x)		
5	Relative abundance of invasive alien invertebrate species (number of individuals, OR abundance classes, OR biomass)	see left		x	x	x					x?		x BInd14	(x)		
5	MultiClear				x	x				x						
5	LAMI (Lake Acidification Macroinvertebrate Index)				x	x				x						
5	Forsuringsindex 1 (Raddum)				x	x				x	x					
5	Threshold indicators: Gammarus sp., Lepidurus arcticus, Astacus astacus				x	x				x						

5	*Astacus astacus*									x	x						
5	Benthic fauna, expected community (bunndyr elver forventningssamfunn)										x						
5	RAMI (River Acidification Macroinvertebrate Index)				x	x				x							
5	Forsuringsindex 2				x	x				x							
5	Threshold indicators: Margaritifera margaritifera, Astacus astacus				x	x				x							
5	*Margaritifera margaritifera*									x	x						
5	Total fish abundance (incl abundance of comercially relevant fish)	expressed as fish			x					x			x BInd15	x			
5	Presence / abundance of game fish species													x			
5	*Aspius aspius*										x						
5	*Salmo trutta*										x						
5	*Salmo salar (Ecotype)*										x						
5	*Blicca bjoerkna*										x						
5	*Sander lucioperca*										x						
5	*Myoxocephalus quadricornis*										x						
5	*Cottus poecilopus*										x						
5	*Salmo salar (Ecotype)*										x						
5	*Salmo salar*										x						
5	*Larus canus*										x						
5	*Pandion haliaetus*										x						
5	*Cinclus cinclus*										x						
5	*Podiceps auritus*										x						
5	*Cygnus cygnus*										x						
5	*Gavia stellata*										x						
5	*Fulica atra*										x						
5	*Anas platyrhynchos*										x						
5	*Gavia arctica*										x						
5	*Actitis hypoleucos*										x						
5	*Aythya fuligula*										x						
5	*Lutra lutra*										x						
5	*Vulpes lagopus*										x						
5	Norwegian fish alteration index (NEFI)				x	x				x							
5	Pelagic fish index (WS-FBI)				x	x				x							
5	Effective fish population size				x												Bakken et al. (2016)
5	Norm on spawning population	number of fish															Anonymus 2011
5	Percentage (real) spawning population	%		x	x	x											Anonymus 2011
5	"Normal" harvest potential	kg fish															Anonymus 2011
5	Percentage (real) harvest potential	%		x	x	x											Anonymus 2011
5	Occurrence/number of salmon hybrids among spawning fish (diploid or triploid)			x	x	x											Anonymus 2011
5	Degree of genetic influence from farmed salmon (measured with genetic markers)			x	x	x											Anonymus 2011
5	Changed selection because of selective harvesting or environmental changes			x	x	x											Anonymus 2011
5	Other effects on fish fauna: parasites					x											Bakken et al. (2016)
5	Other effects on fish fauna: infections					x											Bakken et al. (2016)
5	Probability/conditions of mosquito development													x			
5	Trends in farmland birds														ENV 6.2		
5	Presence / abundance of bird species													x			
5	Presence / abundance of mammals													x			
5	Presence / abundance of reptiles													x			
5	Presence / abundance of frog species													x			
5	Presence / abundance of butterfly species													x			
5	Occurrence of endangered species - animals													x			
5	Presence / abundance of "invasive" wildlife													x			
5	Presence / abundance of "appreciated" fish and wildlife species													x			
5	Presence / abundance of abnormalities in wildlife susceptible to pollution-induced mutations, such as amphibians													x			
5	Presence / abundance of wildlife known to harm humans, damage property, or that are commonly feared													x			
6	Chloride			x	x	x			o								
6	Total phosphorus concentration in the water column	micro-g/l		x	x								x BInd02	(x)			
6	Total nitrogen concentration in the water column	micro-g/l		x	x								x BInd03	(x)			

6	Ammonium	mg/l		x	x	x				x						
6	pH			x	x	x				x						
6	ANC (acid neutralizing capacity)	micro-equ/l		x	x				o	x				(x)		
6	Overskridelser tålegrenser forsuring										x					
6	Other effects on fish fauna: acidification			x	x	x										Bakken et al. (2016)
6	LAL (anorganic aluminium)	micro-g/l		x	x					x						
6	salmon aluminium			x	x					x						
6	Secchi depth (SD)	m			x	x				x				(x)		
6	Turbidity (STS; anorganic content at least 80 %)	mg/l			x					x						
6	Lime content (Ca-concentration)	mg/l		x	x	x				x						
6	Alkanlinity (Alk)	meq/l		x	x	x				x						
6	Organic content: Colour	mg Pt/l		x	x	x				x						
6	Organic content: TOC	mg/l		x	x	x				x						
6	Biological oxygen demand (BOD)			x	x	x				x						
6	Oxygen			x	x	x				x				(x)		
6	Concentration of heavy metals and organic pollutants	mg/l		x	x	x				x				(x)		
6	Other effects on fish fauna: pollution			x	x	x										Bakken et al. (2016)
6	Fecal coliforme bacteria	E. coli /100 ml														
6	GAL-activity (detection of sewage contamination)	ppb MU/hour														Tryland et al. 2016
6	NH3 emission														ENV1.1	
6	NO x emission														ENV1.2	
6	N and P surplus														ENV2.1	
6	Carbon sequestration														ENV 4.1	
6	Methane and nitrous oxide emission														ENV 4.2	
6	CO2 emission														ENV 4.3	
7	Presence and type of odors of human origin													x		
7	Presence / type of natural odors													x		
7	Presence / type of anthropogeneous noise/sounds													x		
7	(Presence of) sound of flowing water													x		
8	Vicinity to roads / public transport													x		
8	Presence and route of paved trails													x		
8	Presence and route of unpaved trails and paths													x		
8	Visible buildings/infrastructure close to the river or lake													x		
8	Presence of touristic infrastructure such as picknick tables, toilets, …													x		
8	Presence of homeless people or camps, and presence of crime													x		
8	Presence / number of other tourists/users													x		
8	Presence / abundance of garbage and/or graffiti along water ways													x		
8	Generation of municipal waste by tourists														ENV8.1	
9	Eco Region (Norway)				x					x						
9	Ecological status of surface water body	5 classes			x								x BInd01			
9	Nature Index										x					
9	Chlorophyll-a to total phosphorus ratio (Chl:TP)	none			x								x BInd09			
9	RH / (2xSD)			x	x					x						
9	Salmon population status			x	x	x										Anonymus 2011
9	River type				x							x				
9	Presence of aquatic-plant dependent geomorphic units/features				x							x				
9	Presence of wood- or riparian tree-dependent geomorphic units/features				x							x				
9	Proportion of riparian corridor under functioning riparian vegetation			x	x	x						x				
9	Proportion of riparian corridor under mainly mature trees, shrubs, shorter vegetation and bare (recruitment sites)				x							x				
9	Active channel dynamism("naturalness), dep on embankments, nr of weirs etc															Large & Gilvear (2015)
9	Amount of naturally-forested land in the riparian corridor of the water body	land in the riparian		x	x	x							x BInd07			
9	Bathing water quality													(x)		
9	Drinking water quality													(x)		
9	Forest fire risk														ENV9.1	