Submitted by	Environmental outcome related to			Flow-ecology questions					Pressure-stress questions							
Organisation	Level 1	Level 2	Level 3	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Pressure	Stress	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Any comments
Arthur Rylah Institute	Ecosystem function	Connectivity	Fish	How we can use the components of flow to maximise the effectiveness of EWAs on fish connectivity for key life history requirements	That EWAs increase connectivity of fishes at the metapopulation-scale	Likely Influence	Quantitative	Koster et al 2014								
Arthur Rylah Institute	Ecosystem function	Process	Fish	What are limiting factors for fish populations/assemblages (size, diversity, condition)	That EWAs increase fish populations	Likely Influence	Establish Influence									
Arthur Rylah Institute	Biodiversity	Species diversity	Fish	What are the important aspects of floodplains for fish recuitment : how does thes use of Floodplain regulators enhance this?	That the use of floodplain regulators does not provide the appropriate conditions for all fish species	Possible Influence	Establish Influence	Mallen-Cooper et al 2008	WQ, V, Invasive spp	Blackwater, Carp						
Arthur Rylah Institute	Biodiversity	Species diversity	Fish	What are the important aspects of floodplains for fish distribution: how does thes use of Floodplain regulators enhance this?	That the use of floodplain regulators does not provide the appropriate conditions for all fish species	Likely Influence	Establish Influence	Mallen-Cooper et al 2008	WQ, V, Invasive spp	Blackwater, Carp						
Arthur Rylah Institute	Biodiversity	Species diversity	Fish	What are the important aspects of floodplains for fish abundance: how does thes use of Floodplain regulators enhance this?	That the use of floodplain regulators does not provide the appropriate conditions for all fish species	Likely Influence	Establish Influence	Mallen-Cooper et al 2008	WQ, V, Invasive spp	Blackwater, Carp						
Arthur Rylah Institute	Biodiversity	Ecosystem diversity	Fish	What are the ecosystem changes likely to occur at the Basin scale after a decade of Ewatering	That multisite watering will provide multiple benefits in a cumlative fashion	Possible Influence	Establish Influence	Bunn papers								
Arthur Rylah Institute	Ecosystem function	Connectivity	Fish	Assessment of fish movement patterns and environmental drivers and threats at multiple spatial and temporal scales utilising a catchment and basin scale telemetry array approach	There is a high level of connectivity between regional populations and hydrological regimes are a major driver of patterns of movement	Likely Influence	Establish Influence	Koster et al 2014	barriers	regulated flows	Is there a high level of connectivity between regional populations and are hydrological regimes a major driver of patterns of movement	Fish regularly move between catchments and over scales of 100-1000s km, but patterns depend strongly on local hydrology and connectivity	Telemetry studies and genetic evidence indicates there may high rates of dispersal within drainage basins by species such as golden perch		Koster et al 2014	
Arthur Rylah Institute	Resilience	Population Resilience	Fish	How do fish reconlonise using flows ? Eg. from refuges after drought using flows	E flows can assist the resilience and recovery of fish populations	Conceptual	Quantitative	Balcome et al								
Arthur Rylah Institute	Resilience	Population Resilience	Fish	How can complimentary actions synergistically maximise the benfits of E flows	That E flows cant do ti all	Conceptual	Establish Influence	MDBC 2004	many	many						
Arthur Rylah Institute	Ecosystem function	Process	Fish	How do flows influence Carbon transfer and ecosystem productivity	That rehabilitation of the system may be limited by overall production and that E flows can increase producivity	Conceptual	Establish Influence		dams, ecosytem changes	Carp						
Arthur Rylah Institute	Resilience	Process		What are the adverse risks from Eflows and water management	There will be some adverse risks that need to be quantified and minimised	Established Influence	Quantitative	Mallen-Cooper et al 2008; King et al 2012	WQ, Invasive spp	carp						
Charles Darwin University	Ecosystem function	Species diversity	Macroinvertebrates	Do flows influence macroinvertebrate diversity through their influence on productivity?		Established Influence	Conceptual	Robson et al. 2011	Invasive Species	Carp	Do carp limit recovery of macroinvertebrate communities?		Possible Influence	Established Influence	Miller and Crowl 2006	
Charles Darwin University	Resilience	Species diversity	Fish	How much does flow influence the spawning and recruitment of fish relative to other influences, including spatial variability and other abiotic factors	The influence of flow on spawning and recruitment of fish varies across species and spatially	Likely Influence	Establish Influence	King et al 2009		invasive species, habitat decline	Does habitat decline, invasive fish and interacting biological factors influence fish spawning and recruitment success	other factors such as temperature and habitat characterstics are a greater driver of spawninga nd recruitment strength than flow characteristics	Possible Influence	Interaction		
Charles Sturt University	Biodiversity	Species diversity	Other vertebrates						Water management	Wetland drying	How does the timing and rate of wetland drawdown impact the survival of frogs post metamorphosis?	Rapid drawdown and mid-summer drying of wetlands leads to increased mortality of recently metamorphosed frogs.	Likely Influence	Establish Influence		CSU collaborators: Wassens. OS studies have shown that tadpoles subject to rapid drawdown of wetlands are smaller on metamorphosis and have decreased fitness and survivorship. Poor recruitment rates due to rapdi drying may contribute to declines of summer breeding wetland species
Charles Sturt University	Biodiversity	Ecosystem diversity	Other vertebrates	How does wetland productivity and trophic dynamics influence the growth, fitness and survival of tadpoles?	Tadpole survival to metamorphosis increases with increasing availability and quality of biofilms and microinvertebrate prey species	Conceptual	Interaction									CSU collaborators: Wassens.
Charles Sturt University	Ecosystem function	Process	Secondary Production	How do flow regimes affect the composition, timing, availability and quality of microinvertebrates, and what are the implications of this for the growth and survival of the early life stages of fish?		Likely Influence	Quantitative	Humphries et al. 2013								CSU collaborators: McCasker, Watts, Jenkins, Howitt, Watkins, Humphries. Also fits under the ecological objectives: Biodiversity->Species Biodiversity->Fish/Macroinvertebrates
Charles Sturt University	Ecosystem function	Process	Production	What are the ecological benefits of within channel flow 'pulses'?	Interactions between flow and withint channel geomorphic features will largely determine the type and magnitude of ecolgoical response derived from inchannel environmental flows.	Possible Influence	Quantitative & Interactions									CSU collaborators: McCasker, Watts, Howitt, Watkins. While the ecological benefits of floodplain and wetland inundation and connectivity to the main river has been well documented, little is known about the effect that within channel flows have on stimulating carbon and nutrient cycling, primary production and secondary production (e.g microinvertebrate biomass), and how the ecological outcomes can be maximised from this kind of watering scenario.
Charles Sturt University	Water quality	Chemical WQ	Waterbirds	Does the induced changes to contaminants in water flow (e.g. heavy metals, steroidal hormones from feedlot effluents) alter the decision of waterbirds to breed at a given time or location and their success if they do decide to breed?	Increases in waterflows past areas with runoff from mining, feedlots or pulpmills will increase soluble heavy metals and steroidal hormones in the water. The bioaccumulation of these toxins in waterbirds will cause individuals with high loads to skip breeding attempts or significantly lower survival of eggs and/or hatchlings.	Established Influence	Establish Influence	Williams et al. 2007 and Tartu et al. 2013	Heavy metals or endocrine disrupting chemicals	Alterations in demography of waterbirds (reproduction and survival)	Does the induced changes to trace metals in water flow (e.g. heavy metals, steroidal hormones from feedlot effluents) alter the decision of waterbirds to breed at a given time or location and their success if they do decide to breed?	Increases in waterflows past areas with runoff from mining, feedlots or pulpmills will increase soluble heavy metals and steroidal hormones in the water. The bioaccumulation of these toxins in waterbirds will cause individuals with high loads to skip breeding attempts or significantly lower survival of eggs and/or hatchlings.	Established Influence	Establish Influence	Williams et al. 2007 and Tartu et al. 2013	CSU collaborators: Howitt, Watson. Depending on how the question is worded, it can fall under water flow (how water flow causes the changes in dissolved chemical pollutants) or pressure-stress (how the chemicals stress the higher-order food chain through bioaccumulation). Note that a pilot study on estrogenic compounds in Australian riverine environments (Williams et al 2007) identified this area of research as a priority.
Charles Sturt University	Ecosystem function	Population Resilience	Waterbirds	Do the temporal patterns, timing and volumes of environmental flow disrupt the layering of prey items available for breeding waterbirds and how might flow be managed to prevent these disruptions during key time periods (i.e. early chick rearing).?	Environmental flows (release) may impact on the availability (i.e. Location within the system or size) of small prey items essential for early chick rearing in colonial waterbirds. If waterflow is disruptive to populations of macroinvertebrates and fishes locations within the system, then waterbird breeding success will be heavily impacted.	Possible Influence	Influence	Birt et al. 1987								CSU collaborators: Watson, Howitt.

Submitted by	Environmental outcome related to			Flow-ecology questions					Pressure-stress questions							
Organisation	Level 1	Level 2	Level 3	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Pressure	Stress	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Any comments
Charles Sturt University	Water quality	Chemical WQ	River	Does flow influence the concentrations of pollutants (e.g. herbicides, insecticides, heavy metals), which may act as threats to expected improvements in system productivity?	Connectivity with the floodplain would be expected to introduce carbon and nutrients to river systems with a resulting boost to the productivity of the system, however, a (catchment dependent) input of contaminants may suppress this outcome.	Established Influence	Interaction	McKenzie-Smith, F., Tiller, D., and Allen, D. (1994) Organochlorine pesticide residues in water and sediments from the Ovens and King Rivers, North-East Victoria, Australia. Archives of Environmental Contamination and Toxicology 26, 483-490. Kanzari, F., Syakti, A.D., Asia, L., Malleret, L., Piram, A., Mille, G., and Doumenq, P. (2014) Distributions and sources of persistent organic pollutants (aliphatic hydrocarbons, PAHs, PCBs and pesticides) in surface sediments of an industrialized urban river (Huveaune), France. Science of The Total Environment 478(0), 141-151.	Heavy metals or pesticides	Inhibition of productivity through supression of algal, macrophyte or invertebrate populations	Do flows influence the concentrations of pollutants (e.g. herbicides, insecticides, heavy metals) which may act as threats to expected improvements in system productivity?	Inputs of organic and heavy metal contaminants to riverine and wetland systems during high flows in contaminated catchments may result in contaminant concentrations sufficiently high to cause toxicity to aquatic organisms.	Established Influence	Interaction	see previous	CSU collaborators: Howitt.
Charles Sturt University	Ecosystem function	Chemical WQ	Wetland	What effect does flow have on carbon cycling in freshwater ecosystems (especially wetland and floodplain systems)?	Variations in management of water regemes in wetlands and other floodplain habitats may result in them acting as a carbon source (net export of carbon from the system) or carbon sink (overall storage of carbon in the biota and sediments) affecting both the ecosytem function and greenhouse impacts of the system.	Likely Influence	Establish Influence	Kayranli, B., Scholz, M., Mustafa, A., and Hedmark, Å. (2010) Carbon Storage and Fluxes within Freshwater Wetlands: a Critical Review. Wetlands 30(1), 111-124. Kayranli, B., Scholz, M., Mustafa, A., and Hedmark, Å. (2010) Carbon Storage and Fluxes within Freshwater Wetlands: a Critical Review. Wetlands 30(1), 111-124. Kayranli, B., Scholz, M., Mustafa, A., and Hedmark, Å. (2010) Carbon Storage and Fluxes within Freshwater Wetlands: a Critical Review. Wetlands 30(1), 111-124.								CSU collaborators: Howitt.
Charles Sturt University	Water quality	Chemical WQ	Wetland	Does the method of water delivery (e.g. small, targetted delivery, which may include use of EWM vs. higher flushing flows) change the water quality outcomes, and are there risks of long-term changes to water and sediment chemistry in terminal wetlands?	Delivery of minimal volumes of water to floodplain wetlands with limited system flushing may result in accumulation of nutrients, salinity and greater risk of blackwater events and acid sulfate soils in the long term, and the associated deprivation of the riverine system of the returned nutrients.	Likely Influence	Interaction	Pittock, Finlayson, Howitt (2013)								CSU collaborators: Howitt.
Charles Sturt University	Biodiversity	Ecosystem diversity	Other vertebrates	Can inundation extent in the previous year predict the recruitment levels/sucess in freshwater turtles, particularly the long-necked turtle (*Chelodina longicollis*)?	Long-necked turtle breeding demonstrates a lagged response to inundation size. Large floods are likely to positivly influence the breeding condition of long-necked turtles due to the abundance of prey species such as tadpoles and small aquatic invertebrates, which translates into increased breeding success the following year.	Likely Influence	influence	Chessman 2011 Declines of freshwater turtles associated with climatic drying in Australia Wildlife Research. 2011 38(8). p.664								CSU collaborators: O'Cock.
Charles Sturt University	Ecosystem function	Ecosystem resilience	Wetland	Can antecedent conditions across floodplains be quantified using remote sensing data validated with atmospheric flux towers?	H1. Wetland evapotranspiration and metabolism rates are indicators of antecedent condition and ecosystem function during dry phases. H2. Remote sensing data validated with atmospheric flux towers provides a robust cost-effective tool to assess antecedent conditions over large spatial scales.	Likely Influence	Establish Influence	Coletti, J. Z., Hinz, C., Vogwill, R., & Hipsey, M. R. (2013). Hydrological controls on carbon metabolism in wetlands. Ecological Modelling, 249: 3-18. doi: http://dx.doi.org/10.1016/j.ecolmodel.2012.07.010								CSU collaborators: Hall, Horta, Wassens, Wolfenden Soil moisture status and vegetation growth and phenological stage determine the antecedent metabolic condition of wetlands prior to environmental watering events. Low-cost monitoring techniques could be employed to characterise antecedent conditions, in terms of evapotranspiration and respiration, which can be important in predicting outcomes of watering actions.
Charles Sturt University	Ecosystem function	Biological WQ	River	What is the metabolic effect (distance downstream and intensity) of in-river carbon from return flows at various levels of wetland inundation?	Large scale assessment of carbon accumulation, using validated remote sensing, across a floodplain provides a useful tool for determining ideal water volumes in managed return flows.	Conceptual	Quantitative	Tamooh, F., Meysman, F. J. R., Borges, A. V., Marwick, T. R., Van Den Meersche, K., Dehairs, F., . . . Bouillon, S. (2014). Sediment and carbon fluxes along a longitudinal gradient in the lower Tana River (Kenya). Journal of Geophysical Research: Biogeosciences, 119(7): 1340-1353. doi: http://dx.doi.org/10.1002/2013JG002358								CSU collaborators:Wolfenden, Wassens, Horta, Hall Return flows mobilise carbon that has accumulated within wetlands into river channels. Quantifying the accumulation and therefore availability of carbon for mobilisation as well as the downstream concentration of mobilised carbon following return flow events will help predict their impact.
Charles Sturt University	Ecosystem function	Process	Fish	How does flow affect dispersal, settlement and recruitment of riverine fishes?	Flow will influence dispersal, settlement and recruitment differently for fish with contrasting life history strategies.	Likely Influence	Establish Influence	Schludermann et al. 2012								CSU collaborators: Humphries, McCasker, Kopf. Dispersal and settlement are key processes affecting the distribution and population dynamics, and ultimately, the persistence of riverine fishes.
Charles Sturt University	Biodiversity	Process	Fish	What are the swimming capabilities of the larvae of Murray-Darling Basin fishes and how does this relate to hydraulic habitat?	The rank of swimming capability for the different life history strategies of fishes will be: equilibrium>opportunistic>periodic.	Established Influence	Quantitative	Kopf et al. 2014								CSU collaborators: Humphries, McCasker, Kopf, Watts. A comprehensive list of the tolerances of swimming capabilities of the larvae of all MDB fishes would allow modelling with known hydraulic habitat of river reaches and so provide information on the effects of river regulation on dispersal potential and survival.
Charles Sturt University	Resilience	Population Resilience	Fish						Invasive Species	Competition	How do invasive species influence restoration targets set for MDB fish community biomass?	Flow alteration and invasive species interact to limit native fish community biomass.	Likely Influence	Quantitative	Kopf et al. In-progress (email rkopf@csu.edu.au)	CSU collaborators: Kopf, Humphries, McCasker. Provide quantitative estimates for fish community biomass restoration targets not presently available for the MDB
Charles Sturt University	Biodiversity	Population Resilience	Fish	What proportion of fish recruitment following environmental flows can be attributed to natural spawning versus hatchery releases?	Fish recruitment following environmental flows, in certain locations, may be confounded by on-going hatchery releases	Likely Influence	Quantitative									CSU collaborators: Kopf, Watts, McCasker Fisheries releases of hatchery reared fish throughout the MDB may be affecting recruitment responses following environmental watering actions
Charles Sturt University	Biodiversity	Species diversity							Loss of keystone species		How does the loss of keystone species (e.g. mussels, Murray cod) limit the recovery of river ecosystems, despite flow restoration.	The loss of keystone species limits the recovery of river ecosystems, despite flow restoration.	Likely Influence	Establish Influence	Humphries and Winemiller, 2009	CSU collaborators: Humphries, McCasker, Kopf, O'Cock. Keystone species are known to have disproportionate effects - both top-down and bottom-up - on ecological processes, populations and communities.
CSIRO	Biodiversity	Species diversity	Vegetation	How viable are River Red Gum communities over extended timeframes given flows at site, catchment and Basin scales?	Basin flow regimes are insufficient to support resilient poplations of Red Gums at the Basin scale - specific targeting of environmental water and prioritisation is needed across scales	Conceptual	Quantitative	Doody, T.M., Benger, S.N., Pritchard, J.L., Overton, I.C., 2014. Ecological response of Eucalyptus camaldulensis (river red gum) to extended drought and flooding along the River Murray, South Australia (1997–2011) and implications for environmental flow management. Marine and Freshwater Research, -.	Climate change, water use	Connectivity, floodplain habitat, soil moisture, life stages, seed dispersal	What long term management strategy is going to increase resilient red gum communities given stressors	Critical flow thresholds for Red Gums cannot be met across the basin	Conceptual	Quantitative		

Submitted by	Environmental outcome related to			Flow-ecology questions					Pressure-stress questions							
Organisation	Level 1	Level 2	Level 3	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Pressure	Stress	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Any comments
CSIRO	Biodiversity	Species diversity	Vegetation	How viable are Black Box Eucalyt communities over extended timeframes given flows at site, catchment and Basin scales?	Annual watering and 4 year monitoring periods are insufficient to capture the dynamic nature of change of Black Box communities	Conceptual	Quantitative	Overton, I.C., Jolly, I.D., Slavich, P.G., Lewis, M.M., Walker, G.R., 2006. Modelling vegetation health from the interaction of saline groundwater and flooding on the Chowilla floodplain, South Australia. Australian Journal of Botany 54, 207-220.	Climate change, water use	Connectivity, floodplain habitat, soil moisture, life stages, seed dispersal	What is the long term management strategy of environmental water to support resilient Black Box communities in the face of water use and climate change where critical flood events occur at frequencies outside the annual monitoring and water planning cycles; What are the appropriate indicators given the prolonged/lagged periods in response	Black Box require inundation that extent beyond water planning periods - indicators of health cannot be detected on an annual basis	Conceptual	Quantitative		
CSIRO	Resilience	Ecosystem resilience	Ecosystem function	What ecosystem function threshold effects exist as a function of flow, and what are the interactions/tradeoffs between these threshold effects?	As flow hydrological characteristics vary, ecological responses are nonlinear and exhibit threshold effects. Knowledge of such thresholds is useful for identifying critical levels of the flow attributes, and for examining the consequences of tradeoffs between different watering options in the outcomes for various objectives.	Likely Influence	Interaction	Gordon, L.J., Peterson, G.D., Bennett, E.M., 2008. Agricultural modifications of hydrological flows create ecological surprises. Trends in Ecology & Evolution 23, 211-219; Folke, C., Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L., Holling, C.S., 2004. Regime Shifts, Resilience, and Biodiversity in Ecosystem Management. Annual Review of Ecology, Evolution, and Systematics 35, 557-581.	All	All	What factors other than flow attributes affect the location of these thresholds?	Given a threshold in a non-linear flow-ecosystem relationship, the location of that threshold will be influenced by other factors such as nutrient concentrations, weeds and other invasive species, climate change.	Likely Influence	Interaction		
CSIRO	Biodiversity	Ecosystem diversity	River, wetland, floodplain	How is hydrological diversity influencing habitat dynamics and biodiversity across scales?	Changes in flow regime are changing the diversity and amount of hydrological habitats (flow regimes, duration, frequency, depth, etc) which is leading to a loss of biodiversity	Likely Influence	Establish Influence	Ganf, G., White, S., Oliver, R., 2010. Allocating water to the wetlands of the Murray Valley to maximise aquatic plant species diversity. In: Saintilan, N., Overton, I.C. (Eds.), Ecosystem Response Modelling in the Murray-Darling Basin. CSIRO Publishing.	Climate change, water use	Connectivity, diversity of hydrological habitats	Water use is leading to less hydrological habitat diversity and this is then leading to a reduction in biodiversity	Can environmental water be used to increase the hydrological habitat diversity to then increase biodiversity	Likely Influence	Establish Influence		
CSIRO	Ecosystem function	Process	Foodweb	How do flows influence aquatic foodweb complexity	Habitats experiencing the most variable flow rates will exhibit higher biodiversity	Likely Influence	Influence	Hardy et al. 2010. Carbon source accounting for fish using combined DNA and stable isotope analyses in a regulated lowland river weir pool. Mol Ecol 19:197-212; Bradford et al 2013. Micro-eukaryote community composition assessed by pyrosequencing is associated with light availability and phytoplankton primary production along a lowland river. Freshw Biol 58: 2401-2413.	Flow regime	Changes in water and nutrient avaiability	How does water availability relate to biodiversity across different envirinments	The biodiversity in habitats that experience greater physical variation will be more resilient to water and nutrient stresses	Likely Influence	Interaction	Baldwin et al. 2013. . Impacts of inundation and drought on eukaryote diversity in semi-arid floodplain soils. Mol Ecol 22:1746-1758	
CSIRO	Ecosystem function	Species diversity	Other vertebrates	Do flows influence bird diversity and density through their influence on water availability and vegetation? Do floodplain/riparian areas receiving flows act as refuges and/or source populations for maintenance of bird diversity?	1. Floodplain/riparian woodlands will have a higher average diversity and density of birds compared with adjacent non-floodplain/riparian woodlands (outside their foraging range). 2. Floodplain/riparian woodlands provide source populations for non-floodplain/riparian woodlands. See also more detailed hypotheses in next worksheet.	Likely Influence	Quantitative	McGinness H. M., Arthur A. D. & Reid J. R. W. (2010) Woodland bird declines in the Murray-Darling Basin: are there links with floodplain change? The Rangeland Journal 32, 315-27. Also McGinness H. M., Arthur A. D. & Davies M. (2014 In Press) Floodplain woodland bird abundance and landscape water availability. Ecohydrology.	Fragmentation and landuse	Changes in hydrological and vegetative connectivity	How do changes in flow regime and vegetative connectivity through flow regulation and vegetation clearing affect bird diversity and density?	1. Floodplain/riparian woodlands that have received natural or near natural flooding regimes will have a higher average diversity and density of resident woodland birds compared with floodplain woodlands with greatly altered flood regimes. 2. Differences in bird diversity and density between floodplain/riparian woodlands and adjacent non-floodplain/riparian woodlands will be greater during droughts and/or in areas that have been heavily cleared and/or have suffered significant changes in flow regime.	Established Influence	Quantitative	McGinness H. M., Arthur A. D. & Reid J. R. W. (2010) Woodland bird declines in the Murray-Darling Basin: are there links with floodplain change? The Rangeland Journal 32, 315-27. Also McGinness H. M., Arthur A. D. & Davies M. (2014 In Press) Floodplain woodland bird abundance and landscape water availability. Ecohydrology.	
CSIRO	Ecosystem function	Species diversity	Other vertebrates	Do flows influence native and/or feral mammal diversity through their influence on water availability, vegetation and/or prey, and subsequent species interactions?	1. Floodplain/riparian zones that have received natural or near natural flooding regimes or recent environmental water will have a higher average diversity and activity/relative abundance of resident native and feral mammals compared with floodplain/riparian zones with greatly altered flood regimes or no recent flooding. 2. Floodplain/riparian zones will have a higher average diversity and activity/relative abundance of resident native and feral mammals compared with nearby non-floodplain/riparian zones (outside their foraging range). 3. The effects of flows on water availability, vegetation and/or prey will be associated with changes in native and/or feral mammal activity/relative abundance.	Likely Influence	Interaction	McGinness H. M., Doerr V. A. J., Stol J., Davies M. J. & Robinson F. H. (2014) Restoration of Paika Lake and associated wetlands: Floodplain biomass and biodiversity responses to managed flooding. CSIRO vegetation monitoring progress report 2. CSIRO, Canberra.	Invasive species	Predation by ferals, e.g. foxes, cats, or pigs	Do feral predators preferentially hunt in/around sites receiving flows, and does this affect recovery, diversity, activity/relative abundance or behaviour of native fauna? If so, in what way?	Feral predators preferentially hunt in/around sites receiving flows, and this restricts recovery, diversity, activity/relative abundance and behaviour of native fauna. Understanding the spatial and temporal patterns and interactions of predator and prey behaviour in such situations will inform better management and support restoration.	Likely Influence	Interaction	McGinness H. M., Doerr V. A. J., Stol J., Davies M. J. & Robinson F. H. (2014) Restoration of Paika Lake and associated wetlands: Floodplain biomass and biodiversity responses to managed flooding. CSIRO vegetation monitoring progress report 2. CSIRO, Canberra.	
CSIRO	Ecosystem function	Connectivity	Other vertebrates	At broad landscape scales, how do flows influence movements of riparian/floodplain vertebrate fauna such as waterbirds or woodland birds? Is it more through connecting habitats, or through altering habitats, or through providing new habitats? Do responses vary according to species or functional group?	1. Flows connecting habitats will result in more movements and greater movement distances of riparian/floodplain vertebrate fauna than in the absence of flows, and hence greater population connectivity and gene flow. 2. Movement responses to flows will vary spatially and temporally according to fauna species, functional group, and whether flows are connecting existing habitats, altering existing habitats, or providing new habitat.	Likely Influence	Conceptual	McGinness H. M., Doerr V. A. J., Doerr E. D. & Davies M. J. (2014) Connecting land and water: Understanding and managing vertebrate fauna diversity in river floodplains and riparian zones. In: The role of hydrological and riparian connectivity in maintaining biodiversity of river-floodplain ecosystems. Final report prepared by the Murray-Darling Freshwater Research Centre and the Commonwealth Scientific and Industrial Research Organisation for the Department of Environment's National Environmental Research Program. Murray-Darling Freshwater Research Centre Wodonga, Victoria.	Fragmentation and landuse	Changes in hydrological and vegetative connectivity through flow regulation and vegetation clearing	How do changes in hydrological and vegetative connectivity through flow regulation and vegetation clearing affect broad scale movements of riparian/floodplain vertebrate fauna such as woodland birds or waterbirds?	Spatial and temporal differences in hydrological and vegetative connectivity are associated with spatial and temporal differences in vertebrate fauna movements and hence gene flow, population sustainability and diversity at broad scales.	Likely Influence	Interaction	McGinness H. M., Doerr V. A. J., Doerr E. D. & Davies M. J. (2014) Connecting land and water: Understanding and managing vertebrate fauna diversity in river floodplains and riparian zones. In: The role of hydrological and riparian connectivity in maintaining biodiversity of river-floodplain ecosystems. Final report prepared by the Murray-Darling Freshwater Research Centre and the Commonwealth Scientific and Industrial Research Organisation for the Department of Environment's National Environmental Research Program. Murray-Darling Freshwater Research Centre Wodonga, Victoria.	
CSIRO	Ecosystem function	Process	Vegetation	How much carbon is sequestered by understorey growth, eucalypt seedling regeneration, and adult tree growth triggered by flows? How does this change over time? How is it affected by follow-up flow regimes post-germination?	1. Carbon sequestration triggered by flows will be significantly faster and greater than that without flows, particularly at sites undergoing flow restoration from a dry beginning. Relative rates of sequestration will be rapid within the first 3 years of flow restoration, then will decline.	Established Influence	Quantitative	McGinness H. M., Doerr V. A. J., Stol J., Davies M. J. & Robinson F. H. (2014) Restoration of Paika Lake and associated wetlands: Floodplain biomass and biodiversity responses to managed flooding. CSIRO vegetation monitoring progress report 2. CSIRO, Canberra.	Fragmentation	Changes in hydrological regime; lack of follow-up flows	How do changes in hydrological regime or insuffficient/inappropriate follow-up flows influence carbon sequestration via vegetation growth and regeneration over time?	Changes in hydrological regime will alter which components of the floodplain/riparian vegetation community sequester the most carbon in the short-term and the long-term. Inappropriate flow regimes or insufficient flows will halt or reduce carbon sequestration.	Possible Influence	Establish Influence	McGinness H. M., Doerr V. A. J., Stol J., Davies M. J. & Robinson F. H. (2014) Restoration of Paika Lake and associated wetlands: Floodplain biomass and biodiversity responses to managed flooding. CSIRO vegetation monitoring progress report 2. CSIRO, Canberra.	

Submitted by	Environmental outcome related to			Flow-ecology questions					Pressure-stress questions							
Organisation	Level 1	Level 2	Level 3	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Pressure	Stress	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Any comments
CSIRO	Ecosystem function	Process	Vegetation	Do particular wetland plant species or groups require planting intervention or special management in degraded / relatively isolated areas undergoing restoration using managed flows, compared to areas in relatively good condition? How do different water delivery methods affect which species require planting intervention or special management? Which dispersal mechanisms and functional traits dominate at different stages of flow restoration, and which mechanisms or traits are not represented?	1. Some wetland plant species or groups will require planting or special management at degraded / relatively isolated sites undergoing flow restoration. 2. Different water delivery methods will result in different species requiring planting or special management. 3. These will be determined by plant dispersal mechanisms and functional traits.	Established Influence	Conceptual	Brock et al., Nielsen et al. Also McGinness H. M., Doerr V. A. J., Stol J., Davies M. J. & Robinson F. H. (2014) Restoration of Paika Lake and associated wetlands: Floodplain biomass and biodiversity responses to managed flooding. CSIRO vegetation monitoring progress report 2. CSIRO, Canberra.	Fragmentation and landuse	Connectivity; dispersal; changes in hydrological regime; grazing intensity	How do different water delivery methods affect which species require planting intervention or special management in isolated/degraded areas vs. areas in good condition?	1. Some wetland plant species or groups will require planting or special management at degraded / relatively isolated sites undergoing flow restoration. 2. Different water delivery methods will result in different species requiring planting or special management. 3. These will be determined by plant dispersal mechanisms and functional traits.	Established Influence	Conceptual	Brock et al., Nielsen et al. Also McGinness H. M., Doerr V. A. J., Stol J., Davies M. J. & Robinson F. H. (2014) Restoration of Paika Lake and associated wetlands: Floodplain biomass and biodiversity responses to managed flooding. CSIRO vegetation monitoring progress report 2. CSIRO, Canberra.	
CSIRO	Ecosystem function	Process	River, Floodplain	Do flows influence micro-primary producer diversity, function and biomass by altering connectivity and water quality and does this improve food resources for aquatic foodwebs?	Enhanced connectivity increases primary production via more conducive water quality and larger areas of suitable conditions, improving the food supply to aquatic foodwebs	Established Influence	Quantitative	Oliver, R. L., & Lorenz, Z. (2010). Flow and metabolic activity in the channel of the Murray River. Ecosystem Response Modelling in the Murray-Darling Basin. CSIRO Publishing, 267-280.	Overexploitation	Land use, connectivity, Water quality	Do changes in land use, connectivity and water quality influence primary production and alter the food resources for aquatic food webs	Land use changes and altered connectivity decrease water quality reducing primary production and limiting food resources for aquatic foodwebs	Established Influence	Quantitative	Oliver, R. L., & Lorenz, Z. (2010). Flow and metabolic activity in the channel of the Murray River. Ecosystem Response Modelling in the Murray-Darling Basin. CSIRO Publishing, 267-280.	Traditional, biochemical and molecular techniques will be employed to address the questions
CSIRO	Ecosystem function	Process	River, Floodplain	Do flows influence decomposer diversity, function and biomass by altering connectivity and sources and supplies of organic materials and does this improve food resources for aquatic foodwebs?	Enhanced connectivity increases decomposer populations by increasing the quantity and variety of organic material supplies, improving the food supply to aquatic foodwebs	Likely Influence	Interaction	Bradford, T. M.et al (2013). Microeukaryote community composition assessed by pyrosequencing is associated with light availability and phytoplankton primary production along a lowland river. Freshwater Biology, 58(11), 2401-2413.	Overexploitation	Land use, connectivity, organic material supplies	Do changes in land use, connectivity and organic material supplies influence decomposer populations and alter the food resources for aquatic food webs	Land use changes and altered connectivity decrease supplies of organic materials reducing decomposer populations and limiting food resources for aquatic foodwebs	Likely Influence	Interaction	Bradford, T. M.et al (2013). Microeukaryote community composition assessed by pyrosequencing is associated with light availability and phytoplankton primary production along a lowland river. Freshwater Biology, 58(11), 2401-2413.	Traditional, biochemical and molecular techniques will be employed to address the questions
CSIRO	Ecosystem function	Ecosystem resilience	Floodplain	Are we achieving a good outcome for floodplain ecosystem function at a basin scale?	Focussing on individual sites or spreading the water thinly across the basin, or something in between is a realisation of limited environmental water but does this lead to the best outcomes at a basin scale for resilient populations and ecosystems?	Conceptual	Quantitative		Climate change, water use	Connectivity, floodplain habitat, ecosystem function, resilience	What is the long term outloook for floodplain ecosystem function in the MDB under climate change and water use and how can environmental water be used at a basin scale to support resilient floodplain ecosystems?	Strategic planning needs to occur for the distribution of environmental water at a basin scale to support resilient floodplain ecosystems	Conceptual	Quantitative		Requires basin scale remote sensing supported by the 4 sites
Deakin University	Ecosystem function	Process	Wetland	How do flows interact with other stressors to influence ecological function at individual sites within the MDB?	1. There is a range of values within which functions operate normally. 2. Stressors (including changes to flow regimes) will affect these functions. 3. Environmental flows will restore the functions to their normal trajectories. 4. There will be measureable drivers of those functions (i.e. indicators) that will be able to be modelled to predict responses in ecological function through time and under differing watering regimes.	Conceptual	Quantitative	Maltby (2009)								
Deakin University	Biodiversity	Ecosystem diversity	Wetland	What synergies and trade-offs exist for different watering strategies when considering multiple hydrologic assets?	1. Optimal watering decisions for the Basin as a whole will differ from optimal watering decisions for individual hydrologic assets. 2. Optimising watering decisions based on ecological data from individual hydrologic assets will compromise whole-of-Basin ecological condition compared with basing those decisions on an integrated Basin-wide tool	Conceptual	Quantitative	Lester and Fairweather (2011), Lester et al. (2013)								
Deakin University	Resilience	Connectivity	Waterbirds	Do flows influence connectivity of waterbirds?	Manage flows profoundly influence foraging sites, breeding sites, movements, and timing of these events	Likely Influence	Establish Influence		Climate change, fragmentation, landuse	disturbance regime, Connectivity, habitat	What is the connectivity of waterbirds between different parts of the MD basin, and how can we map it?	In response to disturbance regime (particularly managed flows) waterbirds move long distances to forage and breed	Established Influence	Established Influence		Understanding of animal movement and connectivity and resilence is being transformed by satellite based technologies which allow animals to be tracked at hourly or minute intervals. As well as movement, these data rich methods also allow fundamental aspects of behaviour to be inferred (eg breeding, mating, flight) and their spatial and temporal location. Using techniques we have applied on the Lake Eyre basin over the last 4 years, we will satellite tracked waterbirds to obtain hourly GPS fixes on birds. Movement of birds can be analysed in relations to (1) ecological opportunity and (2) managed flows. The work will also reveal new breeding areas, and allow other groups to sample habitats, that the animals tell us, they travel vast distances to exploit. The proposed work has the potential to transform understanding of connectivity and resilence in the MDB.
Deakin University	Biodiversity	Ecosystem diversity	Waterbirds	Do flows influence waterbird diversity through their influence on breeding success?	Manage flows profoundly influence foraging sites, breeding sites, movements, and timing of these events, and thereby diversity	Likely Influence	Establish Influence		Climate change, fragmentation, landuse	disturbance regime, Connectivity, habitat	What is the connectivity of waterbirds between different parts of the MD basin, and how can we map it?	In response to disturbance regime (particularly managed flows) waterbirds move long distances to forage and breed	Established Influence	Established Influence		Understanding of animal movement and connectivity and resilence is being transformed by satellite based technologies which allow animals to be tracked at hourly or minute intervals. As well as movement, these data rich methods also allow fundamental aspects of behaviour to be inferred (eg breeding, mating, flight) and their spatial and temporal location. Using techniques we have applied on the Lake Eyre basin over the last 4 years, we will satellite tracked waterbirds to obtain hourly GPS fixes on birds. Movement of birds can be analysed in relations to (1) ecological opportunity and (2) managed flows. The work will also reveal new breeding areas, and allow other groups to sample habitats, that the animals tell us, they travel vast distances to exploit. The proposed work has the potential to transform understanding of connectivity and resilence in the MDB.
Deakin University	Resilience	Ecosystem resilience	Macroinvertebrates	Do environmental flows affect dormant aquatic crustacean egg bank resilience through their influence on ephemeral river / stream channel, floodplain and wetland sedimentology?	In ephemeral river / stream, floodplain and wetland settings, the different hydrological regimes of artifical environmental flows, compared to natural flood waters, impact on dormant crustacean egg bank sediment profiles and resilience.	Possible Influence	Conceptual	Nielsen et al. 2003								
Deakin University	Resilience	Ecosystem resilience	Vegetation	What is the capacity of floodplain vegetation to recovery from extended droughts?	If sufficient flows are not provided to floodplain during and after drought, they may not recover and over repeated cycles become more terrestrialised	Established Influence	Quantitative	Horner et al 2010, Slavich et al 1999	drought	physiological and reproductive	How can flows be applied to maximise the recovery of floodplain vegetation following extended drought?	Without adequate flows, floodplain species will become locally extinct following droughts.	Likely Influence	Conceptual	Horner et al 2012	
Deakin University	Biodiversity	Ecosystem diversity	Vegetation	What flows are needed to restore and then maintain existing floodplain trees in good condition?	The water regimes (frequency, season, duration) required to restore floodplain forests to good condition will differ depending on the initial level of dieback and water availability (rainfall, inundation and groundwater) at a location. These vegetation responses to flooding differ among forest types and floodplains of the Basin.	Established Influence	Quantitative	Cunningham et al 2009, Cunningham et al 2014	drought	physiological	How does drought reduce the effectiveness of flows to improve forest condition?	Droughts will increase the physiological stress on trees between flows and reduce their capacity to recover in condition.	Established Influence	Quantitative	Slavich et al 1999	

Submitted by	Environmental outcome related to			Flow-ecology questions					Pressure-stress questions							
Organisation	Level 1	Level 2	Level 3	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Pressure	Stress	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Any comments
Deakin University	Biodiversity	Ecosystem diversity	Vegetation	What flows promote successful recruitment of new floodplain trees?	Flows are necessary for recruitment of trees but successful recruitment will be constrained by other environmental conditions: water availability, soil conditions and geomorphology.	Likely Influence	Quantitative		land use	grazing and nutrification	How do other land uses (e.g. grazing) determine the recruitment success of floodplain trees?	Successful tree recruitment after flows will be impeded by grazing by exotic and native herbivores, and altered soil nutrients due to adjacent agriculture.	Established Influence	Quantitative	Horner et al (in prep)	
Deakin University	Biodiversity	Ecosystem diversity	Vegetation	What flows promote native plants over weeds in floodplian ecosystems?	Native species are likely be favoured by flows that mimic historical flows whereas flows to disadvantage exotic species are little understood.	Established Influence	Quantitative	Horner et al 2012, Lunt et al 2012	land use	grazing and nutrification	How do other land uses (grazing and cropping) effect the ability of flows to restore native plant understories and wetlands?	Restoration of native plant diversity and removal of exotics will be hindered by land uses surrounding the native floodplains.	Established Influence	Quantitative		
Deakin University	Ecosystem Function	Process	Vegetation	Can flows be used to increase the carbon storage capacity of floodplains?	Restoring flows to floodplain forests will not only increase carbon cycling between land and water but will also increase carbon storage in biomass and soil.	Established Influence	Quantitative		drought	physiological	Can flows be used to improve growth and carbon storage of floodplain forests during droughts?	Inadequate flows to floodplain forests will substantially reduce productivity and consequently terrestrial carbon storage.	Likely Influence	Quantitative		
Griffith University	Ecosystem function	Process	multiple trophic levels, but fish as higher order consumer	What are the primary sources of energy driving production and supporting food webs and hence higher trophic levels in regulated rivers of the MDB?	the contribution of allocthonous carbon to the food web will vary with the extent of floodplain inundation	Likely Influence	Quantitative		habitat	habitat	Has reduced in-channel production due to desnagging reduced energy production in ways that cannot be compensated for with eflows alone?		Conceptual	Quantitative		we see this as an integrated question linking modelling of inundation patterns of floodplain and in-channel features with upscaling of basal production linked to quantification of primary energy sources supporting higher trophic levels. The question lends itself ot an integrated and collaborative appraoch
Griffith University	Ecosystem function	Process	multiple trophic levels, but fish as higher order consumer	Does limited energy production limit eflows outcomes for higher trophic levels, especially for in-channel flows?	floodplain inundation will be required to support signficant increases in fish biomass.	Conceptual	Quantitative	Jardine, T. D., B. J. Pusey, S. K. Hamilton, N. E. Pettit, P. M. Davies, M. M. Douglas, V. Sinnamon, I. A. Halliday, and S. Bunn. 2012. Fish mediate high food web connectivity in the lower reaches of a tropical floodplain river. Oecologia 168:829–838.	invasive species	carp	Do carp reduce the potential benefits of eflows to native fish populations?		Possible Influence	Interaction		
Griffith University	Ecosystem function	Connectivity	multiple trophic levels, but fish as higher order consumer	How can floodplain infrastructure be managed to protect important connnections between the floodplain and the river channel, and what are all those connections?	floodplain infrastructure has the potential to isolate riverine and floodplain ecosystems if not carefully managed.	Established Influence	Quantitative	Bond, N. R., J. Costelloe, A. J. King, D. Warfe, P. Reich, and S. Balcombe. 2014. Ecological risks and opportunities from engineered artificial flooding as a means of achieving environmental flow objectives. Frontiers in Ecology and the Environment 12:386–394.								
Griffith University	Biodiversity	Ecosystem resilience	Wetland and floodplain	What is the resistance and resilience of wetland and floodplain vegetation to extended periods of wetting and drying?			Conceptual		Land use							
Griffith University	Biodiversity	Ecosystem resilience	Wetland and floodplain	How does the resistance and resilience of floodplain and wetland vegetation to alternate wetting/drying regimes affect potential responses to different watering options?			Conceptual		Land use	grazing/cropping	How does land use (e.g. grazing) influence recovery potential and trajectories of change in response to eflows	grazing and cropping reduce the response of wetland and floodplain vegetation to eflows delivery	Established Influence	Quantitative		
Griffith University	Biodiversity	Ecosystem diversity	Wetland and floodplain	What are the Indigenous values associated healthy river floodplain systems and how are they affected by current water management regimes?			Conceptual	Jackson, S., Finn, M and P. Featherston 2012. Aquatic resource use by Indigenous Australians in two tropical river catchments: the Fitzroy River and Daly River, Human Ecology 40(6): 893-908 DOI 10.1007/s10745-012-9518-z.	land use	grazing/cropping	How does land-use influence the ability for water management to effectively support Indigenous use of floodplain resources?					
Griffith University	Biodiversity	Ecosystem diversity	Wetland and floodplain	How can Indigenous ecological knowledge contribute to refining environmental water management in the MDB?			Quantitative	Woodward, E., S. Jackson, M. Finn, and P. M. McTaggart. 2012. Utilising Indigenous seasonal knowledge to understand aquatic resource use and inform water resource management in northern Australia. Ecological Management and Restoration 13:58–64.								
Griffith University	Ecosystem function	Process	Macroinvertebrates	Are algae and allocthonous sources both important contributors to zooplankton production?		Established Influence	Quantitative									
Griffith University	Biodiversity	Population Resilience	Macroinvertebrates	Do environmental flows contribute to increased abundance of fauna such as mussels and macro-crustaceans (e.g. macrobrachium, crayfish) which historically were highly abundant in rivers and floodplain wetlands	Wetland areas receiving environmental flows will have higher abundances of crayfish and mussels	conceptual	Quantitative	Rogers, K., and T. J. Ralph. 2011. Floodplain Wetland Biota in the Murray-Darling Basin. CSIRO PUBLISHING.	Water quality	hypoxia/blackwater	blackwater events will reduce the habitat suitability of both lentic and lotic environments	improved understanding of the hydrologic regimes required to sustain healthy populations of crustaceans and molluscs	Quantitative	Quantitative		
MDFRC	Ecosystem function	Process		How does river-floodplain connectivity affect carbon-nutrient cycling, and in-turn how does cycling affect riverine productivity, foodweb dynamics and biodiversity	Floodplain inundation and the associated carbon and nutrients mobilised to the river channel have a strong infleunce on riverine productivity, food webs and the success of processes such as fish recruitment		Conceptual		Fragmentation (barriers, hydrological, seasonal flow reversal, habitat - desnagging) Climate change (extreme events) Invasive species (carp)							
MDFRC	Ecosystem function	Connectivity		How does spatial and temporal habitat heterogeneity affect biodiversity and resilience	Spatially and temporally diverse habitats promote biodiversity and resilience of plant and animal populations				Fragmentation (barriers, habitat - desnagging) Climate change (extreme events) WQ - Salinity							
MDFRC	Ecosystem function	Connectivity		What is the long term significance of movement/dispersal supported by eflow delivery	Movement and dispersal is critical to the long term sustainability of populations through processes such as contribution to resilience (eg recolonisation), supporting key life history stages, and exchange of genetic material				Fragmentation (barriers) Landscape change (space between sites, size of sites) WQ Distribution of existing populations (source/sink)							
MDFRC	Biodiversity	Species diversity		We know that flows affect individual processes (movement, recruitment, germination, spawing etc) but how do those processes come together to drive population viability across spatial and temporal scales	Environmental watering often targets specific processes at small spatial and temporal scales (eg spawning) but integrated actions across larger scales and multiple processes will be required to achieve environmental objectives				Many potential pressures and stressors - they are process and context specific							
MDFRC	Biodiversity	Species diversity		What is the influence of the river and floodplain environments on the adjacent terrestrial landscape, particularly during/shortly after floods and during drought	The river and floodplain environments have a significant influence on supporting biodiversity of adjacent/overlapping terrestrial species (eg woodland birds)											

Submitted by	Environmental outcome related to			Flow-ecology questions					Pressure-stress questions							
Organisation	Level 1	Level 2	Level 3	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Pressure	Stress	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Any comments
SARDI Aquatic Sciences	Resilience	Ecosystem resilience	Vegetation	Does artificial floodplain inundation promote resilience in aquatic and floodplain ecosystems of the southern MDB	The use of floodplain regulators will result in changes to the understorey floodplain plant community by increasing the abundance of flood dependent species and reduce the abundance of terrestrial species. The use of floodplain regulators will result in changed age class stucture of floodplain overstorey and shrubs and result in a larger number of seedlings and saplings. The use of floodplain regulators will result in a larger seedbank of flood dependent species.	Likely Influence	Establish Influence	Holland, K.L., Turnadge, C.J., Nicol, J.M., Gehrig, S.L. and Strawbridge, A.D. (2013). Floodplain response and recovery: comparison between natural and artificial floods. Goyder Institute for Water Research, Technical Report Series No. 13/5, Adelaide, South Australia.	many							
SARDI Aquatic Sciences	Resilience	Ecosystem resilience	Fish	Does artificial floodplain inundation promote resilience in aquatic and floodplain ecosystems of the southern MDB	The use of floodplain regulators will result in changes in site fish assemblage structure and will not promote resilience in native large-bodied fish species	Likely Influence	Establish Influence		many							
SARDI Aquatic Sciences	Biodiversity	Process	Fish	Does artificial floodplain inundation promote recruitment of non-native species which contribute to broad-scale populations	The use of floodplain regulators will enhance recruitment of non-native species which will contribute to broad-scale populations	Likely Influence	Establish Influence	Bice and Zampatti 2011	Invasive species	carp						
SARDI Aquatic Sciences	Resilience	Ecosystem resilience	River	How do complementary actions (e.g. e-water delivery, regulator operation, weir pool manipulations) interact and benefit/impact broader ecosystem resilience in the lower River Murray	Certain combinations of actions will be beneficial but some will be counterproductive	Likely Influence	Establish Influence		many	many						
SARDI Aquatic Sciences	Ecosystem function	Process	River	How does water source and delivery influence ecosystem productivity and resilience in the lower River Murray	The recruitment and population dynamics of flow-cued spawning species (golden perch and silver perch) will be influenced by the source and delivery method of environmental water	Likely Influence	Interaction	Zampatti et al. in press	many	regulated flows						
SARDI Aquatic Sciences	Ecosystem function	Process	River	How does water source and delivery influence ecosystem productivity and resilience in the lower River Murray	Carbon transfer and productivity will be influenced by the source and delivery method of environmental water	Likely Influence	Interaction		many	regulated flows						
SARDI Aquatic Sciences	Resilience	Process		What are the adverse risks from Eflows and water management and how to manage them to optimise the ecological outcomes	There will be some adverse risks that need to be quantified and minimised (e.g. invasive species, black water events)	Established Influence	Quantitative	McNeil and Closs 2007; McNeil 2004; Mallen-Cooper et al 2008; King et al 2012;	WQ, Invasive spp	carp, WQ						
SARDI Aquatic Sciences	Resilience	Ecosystem resilience		Can we develop better understanding of eco-hydrological relationships through analysing existing long-term data (e.g. fish and vegetation data for the River Murray)	Yes to the question. Ecological hypothesis: eflows can improve resillience of the fish and vegetation popualtions	Likely Influence	Quantitative	King et al. 2009; Ye et al. 2014; Nicol et al. 2014; Gehrig et al. 2013; Wilson et al. 2012; Bice et al. in press	Many	many						
University of New England	Ecosystem function	Ecosystem diversity	Wetland	Can empirical response curves relate environmental water to physical and biotic responses in floodplain wetlands?	There are predictable relationships between inundation dynamics and biota/process responses in floodplain wetlands.	Conceptual	Quantitative	Shafroth, P. B., Wilcox, A. C., Lytle, D. A., Hickey, J. T., Andersen, D. C., Beauchamp, V. B., ... & Warner, A. (2010). Ecosystem effects of environmental flows: modelling and experimental floods in a dryland river. Freshwater Biology, 55(1), 68-85.								The development of hydro-ecological models in floodplain wetlands (eg Gwydir, Lachlan, Lowbidgee) are essential to identify key biotic threshold responses and levels of hydrologic alteration acceptable for particular diversity/function or, conversely, the quantity and quality of flow required to restore and sustain desirable system attributes. Conceptual models for individual taxa/process exist, but are poorly linked to generate an ecosystemn level response. Poff and Zimmerman 2010 FB review stated this approach was required for successfull E-flow outcomes.
University of New England	Resilience	Ecosystem diversity	River	Are the environmental flow requirements (timing, magnitude, frequency) to sustain Basin-scale biodiversity the same in the northen and southern MDB	River systems in the northern and southern Basin require different environmental watering regimes to maintain and improve biodiversity.	Conceptual	Quantitative	Pittock, J., & Finlayson, C. M. (2011). Australia's Murray–Darling Basin: freshwater ecosystem conservation options in an era of climate change. Marine and Freshwater Research, 62(3), 232-243.								A big question, but pivotal to Basin-scale resilience and biodiversity. Quantifying and acknowledging differences in drivers of ecological rsponses to E-flows was a priority question emerging from UNE group discussions.
University of New England	Water quality	Species diversity	Wetland	Does the timing, magnitude and duration of environmental water generate water chemistry that affects species diversity and reporoduction?	Environmental flows can generate water chemistry (e.g., stoichiometric ratios of C:N:P, hypoxia) that directly affect ecosystem processes, species diversity and reproduction.	Established Influence	Quantitative	Glibert, P. M., Fullerton, D., Burkholder, J. M., Cornwell, J. C., & Kana, T. M. (2011). Ecological stoichiometry, biogeochemical cycling, invasive species, and aquatic food webs: San Francisco Estuary and comparative systems. Reviews in Fisheries Science, 19(4), 358-417.								Relationships between stoichiometry, biogeochemical cycles and food webs have been established (e.g., nutrient ratios affecting zooplankton food resources for larval fish survival). Literature demonstrates the influence of environmental water delivery regime on water quality. The potential link between environmental flow-produced water chemistry and foodweb (diversity, richness) consequences is clear but untested anywhere in the world.
University of New England	Ecosystem function	Connectivity	River	How does hydrologic connectivity affect ecosystem service provision; which services are most influenced by connectivity; and how connectivity influences how humans access and benefit from ecosystem services?	Increased hydrologic connectivity will increase biodiversity and ecosystem function leading to increased provision of ecosystem services	Conceptual	Quantitative	Mitchell, M. G., Bennett, E. M., & Gonzalez, A. (2013). Linking landscape connectivity and ecosystem service provision: current knowledge and research gaps. Ecosystems, 16(5), 894-908.								This question is truly integrative and applicable to river, wetland and floodplain systems across the Basin. Conceptual models exist for links between biodiversity, function and ecosystem services leading to hydrological connectivity as a driver of all 3 levels. Testing hypotheses developed from conceptual models will provide empirical evidence for the importance of connectivty to all water users (env and human).
University of New England	Biodiversity	Species diversity	Vegetation						Invasive Species	Lippia	Does environmental water promote the spread of Lippia and reduce floodplain wetland vegetation diversity?	The delivery of environmental water to prolong summer inundation will increase the spatial cover of Lippia and reduce the vegetation diversity of floodplain wetlands.	Conceptual	Quantitative	Price, J. N., Berney, P. J., Ryder, D., Whalley, R. D. B., & Gross, C. L. (2011). Disturbance governs dominance of an invasive forb in a temporary wetland. Oecologia, 167(3), 759-769.	Conceptual models have been developed from glasshouse experiment for the depth and duration of inundation that will promote Lippia over native vegetation (e.g. water couch) in the northern MDB (Macquarie.Gwydir marshes). Field validation is frequired to provide empirical evidence for conceptiual models.
University of New England	Biodiversity	Species diversity	Fish						Invasive Species	Carp	Does environmental water promote an increase in the abundance/reproduction and spatial distribution of Carp, leading to a reduction in native fish biodiversity?	The delivery of environmental water will provide hydrologic connectivity to habitat and resources to increase the abundance, reproduction and and distribution diversity of Carp and decrease the diversity of native fish.	Conceptual	Interaction	Conallin, A. J., Smith, B. B., Thwaites, L. A., Walker, K. F., & Gillanders, B. M. (2012). Environmental Water Allocations in regulated lowland rivers may encourage offstream movements and spawning by common carp, Cyprinus carpio: implications for wetland rehabilitation. Marine and Freshwater Research, 63(10), 865-877.	E-flows can benefit exotic species, with timing of water delivery identified as a driver for increased Capr spawning. However, the drivers that provide a competitive advantage of Carp post-spawning (habitat, food resources, connectivity etc) over natives are not known.
University of New England	Resilience	Connectivity	Fish	What hydrologic connectivity is required for sustainable native fish populations?	Increased hydrologic connectivty in floodplain wetlands will improve native fish abundance, diversity and fecundity.			Koehn, J. D., King, A. J., Beesley, L., Copeland, C., Zampatti, B. P., & Mallen-Cooper, M. (2014). Flows for native fish in the Murray-Darling Basin: lessons and considerations for future management. Ecological Management & Restoration, 15(s1), 40-50.								Hydrologic conenctivity is acknowledged as the driver of fish diversity and recruitment. We do not know the resources (habitats, food etc) that are required to be conencted and at what temporal scales. Understanding small-scale patterns in fish movement will contribute to understanding these relationships.
University of New England	Biodiversity	Species diversity	Waterbirds	What are the physical, chemical and biological characteristics that determine nesting sites for waterbirds in floodplain wetlands?	Nesting sites for colonial nesting waterbirds is driven by the availability of trophic resources.	Established Influence	Conceptual	Arthur, A. D., Reid, J. R., Kingsford, R. T., McGinness, H. M., Ward, K. A., & Harper, M. J. (2012). Breeding flow thresholds of colonial breeding waterbirds in the Murray-Darling Basin, Australia. Wetlands, 32(2), 257-265.								Waterbirds are highly mobile and connect the landscape. Breeding events are large and spatially-focussed linked to wetland inundation. But why do waterbirds choose to nest at a particular wetland when physically they appear similar? Is it the trophic resources for a breeding cycle that drives selection? Understanding these dynamics will allow priority E-flow delivery to promote and sustain successful waterbird breeding.

Submitted by	Environmental outcome related to			Flow-ecology questions					Pressure-stress questions							
Organisation	Level 1	Level 2	Level 3	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Pressure	Stress	Question	Hypothesis	Current knowledge status	EWKR status objective	Reference	Any comments
University of New England	Resilience	Ecosystem resilience	Wetland	Is there an gradient of ecological resposnes associated with land-use (cleared, grazed, reserved) and inundation from environmental water?	There are increased ecological benefits from the inundation and connectivity of multiple land-uses in floodplain wetlands.	Established Influence	Quantitative	Berney, P., Ryder, D, Wilson, G & Whalley, W (In Press) Divergent responses to long-term grazing exclusion among three plant communities in a flood pulsing wetland in eastern Australia, Pacific Conservation Biology.								There is potential resilience in aquatic communities that hydrologically connecting altered land-uses may provide (or increase) biodiversity and ecosystem functions for local and basin scale outcomes. We do not know where resilience lies in these landscapes and therefore the potential to value add to ecological outcomes through inundation on non-reserve property is currently unknown. The lower Gwydir has a knowledge base for this question and adjacent land uses available to test these hypotheses.
UNSW	Ecosystem function	Ecosystem diversity	Waterbirds	How does the diversity of waterbirds respond to different environmental flows	Different functional groups will have variable responses, reflecting their food and habitat requirements	Likely Influence		Kingsford et al. 2010								Also affected by wetland availability at broader scales but clear that there are also local responses. May also be invasive species affects - fish (direct and indirect)
UNSW	Biodiversity	Species diversity	Waterbirds	How much does flow affect breeding of colonial waterbirds and environmental flows and food availability?	Flow thresholds that trigger breeding and support recruitment exist for different species, varying with wetlands	Quantitative	Quantitative	Bino et al. (2013), Kingsford and Auld (2005), Arthur et al. 2012	Land use, invasive species (pigs, foxes, cats)	Connectivity and nesting habitat	Is there a confounding impact of land use (levees) and clearing of vegetation (waterbird nesting habitat) which affects colonial waterbird breeding?	Vegetation conditions impacts on waterbird breeding	Likely Influence	Interaction		
UNSW	Resilience	Ecosystem resilience	Vegetation	Do flows drive emergent macrophyte wetland vegetation (e.g. common reed) health through variable flooding regimes?	Different macrophyte groups require particular inundation regimes for maintaining populations	Established Influence	Conceptual		Grazing, salinity, fire	Invasive species, fragmentation	Does grazing, fire and salinity affect maintenance of aquatic macrophytes	Additional pressures impact on populations of aquatic macrophytes	Likely Influence	Establish Influence		
UNSW	Ecosystem function	Process	Vegetation	How do altered flow regimes affect key plant species (lignum and typha)required for waterbird breeding?	Flow and flooding regimes are critical for maintenance of breeding sites for colonial waterbirds	Conceptual	Conceptual		Grazing, salinity, fire	Invasive species, fragmentation	As above	As above	Likely Influence	Establish Influence		
UNSW	Resilience	Ecosystem resilience	Vegetation	How much is condition, germination and recruitment of river red gum dependent on different flooding regimes?	Flooding every two years is essential for self-maintaining populations of river red gum	Established Influence	Establish Influence	Roberts and Marston, Jensen	Grazing, salinity, fire	Invasive species, fragmentation	As above	As above	Likely Influence	Establish Influence		
UNSW	Biodiversity	Process	Vegetation	How will climate change and flow regime affect seed banks aquatic plants?	Climate change will increasing drying periods affecting seed bank size and viability	Possible Influence	Influence		grazing, salinity, fire	Invasive species, fragmentation	As above	As above	Likely Influence	Influence		
UNSW	Biodiversity	Process	Floodplain	What is the relationship between flooding and flow for particular river systems?	Inundation regimes for different biotic communities in wetlands are highly dependent on flooding regimes	Quantitative	Establish Influence	Papers - Kingsford/ Ren/ Thomas for Macquarie Marshes	Land use,	Levee banks	How much do levee banks and structures alter flooding regimes	Levee banks affect connectivity of floodplains	Established Influence	Influence	Steinfeld and Kingsford 2012	
UNSW	Biodiversity	Species diversity	Other vertebrates	How much are reptiles (snakes, turtles) dependent on flow regimes of rivers and inundation of wetlands?	Reptiles are highly dependent on refugia (turtles) and flooding regimes (snakes) which coincide with prey abundance.	Conceptual	Influence		Invasive species		How important are the effects of invasive species on populations of turtles (e.g. foxes)?	Nesting sites and their eggs are severely depleted by foxes.	Likely Influence	Interaction		
UNSW	Biodiversity	Species diversity	Other vertebrates	How important are different flooding regimes for maintaining populations of frogs within wetlands and does this vary between species?	Flooding regimes are critically important for different functional groups of frogs.	Established Influence	Conceptual		Invasive species (fish)		Do mosquito fish and carp may prey on tadpoles, affecting frog populations	Mosquito fish and carp impact on frog populations by preying on them.	Conceptual	Interaction		
UNSW	Resilience	Population Resilience	Vegetation	Are river red gums able to survive using groundwater resources instead of flooding regimes?	River red gums predominantly use floodwaters but occasionally rely on groundwater systems in some wetlands for survival	Quantitative	Interaction		High salinity		Does high salinity groundwater affect condition of river red gums?	Increased salinity in groundwater decreases condition of river red gums accessing groundwater	Established Influence	Interaction		
UNSW	Biodiversity	Species diversity	Other vertebrates	Are platypus vulnerable to altered flow regimes, particularly decreased resilience of refugia?	Platypus populations are highly dependent on river flows and refugia areas	Conceptual	Establish Influence		Pollution, land use		Does land use and pollution affect platypus populations more than flow?	Pollution and land use impacts are greater threats to platypus populations than flow.				
UNSW	Resilience	Connectivity	Waterbirds	Do waterbirds travel less in high flow years, compared to low flow years when there is available habitat?	Waterbird communities remain reasonably stable (diversity, abundance) in high flow/ inundation years.	Likely Influence	Establish Influence									
UNSW	Ecosystem function	Connectivity	Other vertebrates	Are there differences in population or source-sink dynamics in less mobile species (e.g. frogs, turtles), where flooding connectivity is critical	Turtle and frog populations are highly dependent on local source-sink dynamics for population viability in a wetland	Likely Influence	Establish Influence									
UNSW	Ecosystem function	Ecosystem resilience	Wetland	How important are different regulating abiotic variables (flooding regime, temperature, water quality) to biological processes (food webs, breeding, recruitment, colonisation)	Critical life processes are differentially influenced by temperature, water quality and flooding regimes	Likely Influence	Establish Influence									
UNSW	Ecosystem function	Process	Wetland	What are the impacts of environmental watering on the carbon balance of wetlands?	Optimal flooding will result in a net carbon store	Likely Influence	Establish Influence		Lack or poor timing of water delivery resulting in tree death		What is the relationship between water stress and tree health?	Stress intensity is more important then stress duration.	Likely Influence	Establish Influence		