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Dear Ms Scott

INLAND RAIL – NORTH STAR TO BORDER (NS2B)
PREFERRED INFRASTRUCTURE REPORT (PIR)
INDEPENDENT REVIEW OF HYDROLOGY AND FLOODING ISSUES
FINAL REVIEW REPORT

Following the receipt of a State Significant Infrastructure (**SSI**) application for the NS2B Project the Department recognised that hydrology and flooding were key environmental issues that required careful assessment.

Subsequent to the preparation of the Secretary's Environmental Assessment Requirements (**SEARs**) for the Project in August 2018, our firm was engaged to provide independent advice to the Department on the following aspects of the Project:

(i) the technical adequacy of the Proponent's assessment of hydrology and flooding impacts;
(ii) the appropriateness and effectiveness of flood management and mitigation measures; and
(iii) recommendations for conditions for the construction and operation of the project should the Department recommend approval.

Review Activities

Our review activities have comprised:

(a) provision of on-going technical advice to the Department on hydrology and flooding issues throughout the Department's evaluation of the Project;
(b) assessment of the Environmental Impact Statement (**EIS**) which was exhibited from 26 August 2020 until 6 October 2020. Our initial review of the hydrology and flooding components of the EIS were provided to the Department on 20 October 2020;
(c) attendance at 14 Hydrology Working Group (**HWG**) meetings with the Proponent and their technical advisers between November 2020 and March 2022. Various technical aspects of the hydrology and flooding issues associated with the Project were discussed at these meetings including hydrologic and hydraulic modelling;
(d) assessment of the Preferred Infrastructure Report (**PIR**) – Hydrology and Flooding assessment report which was submitted in May 2021;
(e) advice on the subsequent Requests for Information (**RFI**s) relating to further modelling and assessment of velocities through culverts for which responses were received from the Proponent on 5 November 2021 and 10 December 2021;

(f) advice of conditions that to address outstanding concerns relating to hydrology and flooding issues, should the Department decide to grant approval to the Project.

This report focuses on our review of the PIR and the subsequent RFI responses, i.e. items (d) and (e), above.

Advice on draft conditions, i.e. item (f), has been separately provided to the Department.

Documents Relevant to this Review Report

The specific documents which are covered by this current review report comprise:

(a) Inland Rail – North Star to NSW/Queensland Border – Preferred Infrastructure Report (Future Freight Joint Venture, May 2021);

(b) Response to DPIE RFI regarding further modelling and assessment of velocities through culverts Technical Note (Future Freight Joint Venture, 5 November 2021); and

(c) Response to DPIE RFI regarding further modelling and assessment of velocities through culverts Technical Note (Future Freight Joint Venture, 10 December 2021).

REVIEW COMMENTS

1. Flood Immunity

1.1. There are very limited details provided about the flood immunity to which the Project is to be designed. The SEARs for the Project which were issued in March 2020 require that the Proponent "*describe and justify the proposed flood planning level (FPL) for the project including the AEP of the flood which will overtop the formation and rail*".

1.2. It appears that much of the rail height is determined by factors other than flooding and in respect of the Macintyre River floodplain, and possibly other sections, the crest of the formation is at least 0.3m above the 1% AEP flood level.

1.3. Justification of the adopted flood immunity has not been provided. The reviewer notes that other sectors of the project within NSW and Queensland have utilised different flood immunities and a rational basis for these differing immunities has never been provided. Lowering the flood immunity may have benefits including reduced flood impacts, reduced risk of sudden collapse of formation, reduced visual impacts, reduced noise impacts, reduced construction costs, etc., provided the potential increased disruption to rail services due to flooding is acceptable.

2. Updated Hydrologic and Hydraulic Modelling

2.1. There were a number of deficiencies in the EIS modelling that were identified in various submissions. However these deficiencies have been largely addressed in the updated modelling within the PIR, particularly in regard to the improved hydrological modelling.

2.2. Because the PIR's hydraulic modelling was of insufficient spatial resolution and accuracy to allow erosion velocities to be properly assessed, the Department issued two RFIs to provide finer grid modelling. These RFIs were issued on 11 June 2021 and 20 August 2021, and the Proponent responded to these on 5 November 2021 and 10 December 2021, respectively.

2.3. In our opinion the updated modelling meets current industry standards and is potentially fit for purpose for the detail design and for the accurate assessment of flood mitigation of impacts. The updated modelling however did not examine all the scenarios

necessary to assess the Project's flood impacts, with the outstanding assessments being deferred to detailed design.

2.4. The updated modelling has been endorsed by an independent peer review conducted by BMT Commercial Australia Pty Ltd. In relation to the 1976 flood event, BMT noted that the "*latest calibration is more robust than previous model calibrations and is more defendable in terms of its accuracy, and its basis using current best practice methods*".

2.5. Nevertheless on the southern catchments distant from the Macintyre River such as the Mobbindry Creek, Back Creek, Forest Creek and Strayleaves Creek catchments, there is no calibration data. Further investigation and justification of model parameters using regional hydrological approaches is required in order to provide confidence in the predicted design discharges on these small watercourses.

2.6. There is limited documentation of the updated modelling, limited assessment of flood impacts and there are no model sensitivity runs. If the Project receives approval, these matters will need to be addressed prior to detailed design.

2.7. Finally whilst the PIR assesses flood impacts against the 1976 flood in the Macintyre River, it repeatedly states that it is unreasonable for the Project's flood impacts to be tested against this event given the Proponent's assessment of the annual exceedance probability (**AEP**) of this event as 1 in 200. The reviewer disagrees for two reasons:

(a) use of the 1976 flood to assess a project's impacts is consistent with the established practice for all floodplain developments in the Valley; and

(b) there is significant uncertainty regarding the AEP of the 1976 flood event and the PIR's AEP estimate and other available estimates vary widely.

2.8. Further comments on the use of the 1976 flood to assess the flood impacts of the Project within the Macintyre River floodplains is provided in section 4 below.

3. Quantitative Design Limits (QDLs) and Flood Mitigation Objectives (FMOs)

3.1. Quantitative Design Limits (**QDL**s) are important because they define the maximum acceptable changes in relevant flood parameters such as velocity, duration, water levels, etc.

3.2. QDLs are also important because if approval is eventually given to the Project, the QDLs will likely be used to trigger design modifications, special mitigation measures for affected landowners, acquisition of additional corridor land, payment of compensation, etc.

3.3. Consequently the QDLs need to be carefully formulated, justified and documented. This requirement was listed in Item 8.1(e) of the SEARs. The EIS did not contain QDLs per se but rather proposed Flood Impact Objectives (**FIO**s) against which the flood impacts of the Project have been assessed. However many of the FIOs were not quantitative and the choice of FIOs had not been justified, or not adequately justified. Therefore the use of those FIOs cannot be supported.

3.4. The derivation, justification and use of QDLs have been a major issue for discussion between DPE and the Proponent at numerous NS2B HWG meetings over the last three years. Various versions of the draft QDLs have been discussed based on minor updates and improvements to the QDLs which were conditioned within the 13 August 2020 approval of Phase 1 of the Narrabri to North Star (**N2NS Phase 1**) project.

3.5. The PIR proposed Flood Management Objectives (**FMO**s) rather than FIOs. The FMOs were more closely related to the Department's QDLs but with some significant differences including lower FMO limits for the 1976 flood, which are not supported.

3.6. Should the Department decide to approve the NS2B Project, we recommend use of the draft QDLs referred to in paragraph 3.4 and applied to all events up to the larger of the 1976 and 1% AEP floods,. Separate to the current review we have provided advice to the Department on potential conditions of approval utilising these QDLs.

4. 1976 and 1% AEP Design Floods

4.1. The Border Rivers Valley differs from most valleys in NSW in that floodplain management planning is based on the historical flood of record, i.e. the 1976 flood, rather than a nominated AEP design flood such as the 1% AEP event.

4.2. The use of the 1976 flood is described in the Border Rivers Valley Floodplain Management Plan (**FMP**). This FMP has formed the basis for floodplain development planning in the Border for many years. Although unusual, an historical flood is used in some other NSW valleys, and its use is entirely consistent with the NSW Flood Prone Land Policy and the NSW Floodplain Development Manual.

4.3. The AEP of the 1976 flood remains uncertain and is variable in different parts of the catchment. Whilst its magnitude exceeds the 1% AEP flood at the rail alignment, it is smaller than the 1% AEP event under climate change conditions.

4.4. The 1976 flood is not applied in the southern catchments which are not directly impacted by breakout flows from the Macintyre and Dumaresq Rivers. In these catchments the 1% AEP event is used for floodplain development planning.

4.5. In their letter to the Proponent on 10 December 2020 the Department directed that "*the greater of, the large design flood as defined in the Border Rivers Valley Floodplain Management Plan (1976 flood event), or the 1% AEP flood*" should be used to assess the flooding impacts of the Project.

4.6. This approach is supported. Its application means that the 1976 flood is to be used for the sections of the rail alignment on the Macintyre River floodplain whereas the 1% AEP flood is to be used for the portions of the alignment within the southern catchment floodplains e.g. Mobbindry Creek, Back Creek, Strayleaves Creek and Forest Creek.

5. Levee Heights

5.1. The construction of levees around agricultural development in the Border Rivers floodplains requires approval under the NSW Water Management Act. Numerous levees have been approved and constructed consistent with the requirements of the Border Rivers FMP.

5.2. In some cases these levees have been approved with unlimited height restrictions. This means that existing levees which have such approvals can be raised in the future without additional approvals.

5.3. This has created some complexity when assessing the flood impacts of the Project as provision needs to be made for the future raising of these levees. Consequently the Project impacts need to be assessed for both:

(a) current levee heights (i.e. as identified by the 2019 LIDAR survey or other recent surveys); and

(b) future raised levees which may ultimately be at heights which prevent any overtopping even in extreme floods.

5.4. During the first quarter of 2020, the Department directed the Proponent to assess the Project's impacts using both levee scenarios described in the previous paragraph. This

approach is supported and if the Project is ultimately approved, it will be important that the same approach is utilised during detailed design.

6. Proposed 'Mitigation Framework'

6.1. The PIR describes the Proponent's 'mitigation framework' which it proposes to implement when it is not possible or practical to meet the flood impact QDLs.

6.2. Whilst the modification of the design of the Project to eliminate impacts should always be the primary objective, there will likely be situations where it is not practical or economic to make such modifications, and other mitigation options may need to be considered to reduce the impacts to acceptable levels. These options might include, for example, house raising or construction of levees within affected private land, acquisition of land or an easement, construction or relocation of buildings, etc.

6.3. The PIR describes a framework involving consultation with the affected landowner, within which these mitigation options might be pursued. Should the Project be approved, such proposals are supported subject to the following matters (which are presented for further discussion and consideration by the Department):

(a) carefully worded approval conditions being provided which ensure that the rights of all impacted landowners are preserved;

(b) where arrangements are made with affected landowners or infrastructure owners, these arrangements are formalised in a written agreement;

(c) as much as is possible, the Proponent is protected from lengthy delays and unjustified and unreasonable compensation claims that could possibly be levied by recalcitrant landowners;

(d) a mechanism be provided for an independent third party to assist with dispute resolution including provision of technical advice;

(e) where road safety or road traffic ability is adversely impacted, formal approval from the road authority is obtained;

(f) where appropriate, agreements be tied to the land via an easement or covenant or other suitable mechanism to ensure future owners of the land are also bound by the agreement;

(g) decisions about the non-materiality of a QDL exceedance are not made by the Proponent in the absence of the agreement of the landowner or the Department.

7. Risk to Life and Embankment Collapse Issues

7.1. The potential collapse of sections of the rail embankment during extreme flood events has not been assessed with the updated modelling provided with the PIR.

7.2. Should the Project be approved, this matter will need to be addressed together with accompanying risks to life in downstream areas.

8. Erosion and Scour Risks near Cross Drainage Structures

Background

8.1. The potential for the Project to initiate or exacerbate erosion along watercourses and overland flowpaths is one of the major risks of the Project.

8.2. Within the brownfield sections of the alignment, flood flows overtop the rail during relatively frequent floods. This overtopping is dispersed over long lengths of the alignment. However except in extreme floods, the construction of the Project with much higher rail levels will confine these flows to discrete locations where culverts and bridges are provided to convey water through the rail formation rather than over it.

8.3. A necessary consequence of this confinement of flows will be increased velocities both at the entrances and the exits to these cross drainage structures.

8.4. As the distance from the formation increases both upstream and downstream, flows will be dispersed and velocities will return to their current levels. However because the rail corridor is typically very narrow (e.g. 40m) there is generally insufficient space for this dispersion to occur within the rail corridor. Consequently increased velocities occur within the adjacent private land beyond the corridor.

Accuracy of Velocity Modelling

8.5. The EIS flood modelling was based on grid sizes of 30m for the Macintyre River and 10m for the southern tributaries. During the initial review of the EIS, concerns were raised that these models were of insufficient spatial resolution to determine the velocity changes that would likely occur at the entrances and exits to cross drainage structures, particularly at the corridor boundary where the greatest velocity changes were likely to occur on the adjacent private land.

8.6. Because of these deficiencies in the modelling of velocities the Department issued two RFIs which required the Proponent to provide finer grid modelling that predicted velocities at a resolution of 2m or less, in the vicinity of the drainage structure entrances and exits.

8.7. The Proponent provided their responses to these RFIs on 5 November 2021 and 10 December 2021 utilising finer grid modelling at a resolution of 3.75m. Whilst this finer grid modelling was a significant improvement over the EIS modelling, the responses did not fully address the RFIs and a number of concerns remain. These matters, which are listed below, will need to be addressed through conditions of consent if the Department decides to approve the Project:

(a) in the case of culverts, as the distance between the extremity of the culverts and the corridor boundary is typically about 10m, modelling using grids no larger than 2m are required. Velocity modelling using 3.75m grids will be underestimating peak velocities to some extent;

(b) the Proponent has justified their choice of larger grid sizes based on an incorrect interpretation of the user manual for the flood modelling software;

(c) separate advice received by the Department from floodplain management staff with more than three decades of experience in this Valley has confirmed the need for the finer grid modelling;

(d) the tests for erosion initiation used by the Proponent were based on their proposed velocity FMO not the QDL referred to in the RFI. Consequently the findings were misleading. If the Department's nominated QDL had been used, an additional culvert cluster and five additional bridges would have been identified as non-compliant;

(e) the modelling was only undertaken for the large design flood (i.e. either 1976 or 1% AEP) with DPE approved levees in place. Use of different floods e.g. those with lower downstream tailwater levels or in conjunction with the existing (i.e. 2019) levees may have resulted in some additional exceedances of the QDL, but probably not many. The absence of this information further detracts from the completeness of the Proponent's response to the RFI.

8.8. The failure of the Proponent to use the nominated velocity QDL and, to a lesser extent, the finer grid modelling requested in the RFI, mean that the necessary amendments to many bridges and some culvert clusters in the Reference Design are still uncertain and the extent of residual impacts on adjoining lands have not been fully clarified.

Determination of the Erosion Threshold Velocity (ETV)

8.9. The initiation of erosion is related to a limiting flow velocity referred to as the erosion threshold velocity (**ETV**). When velocities exceed the erosion threshold, erosion risk significantly increases.

8.10. Erosion is an inherently unstable process. Once it starts significant further erosion can develop. Because of this instability, if velocities already exceed the ETV, any increase in velocity, however small, may exacerbate the erosion risk.

8.11. The determination of an ETV in a specific location is a complicated and specialised task. The key physical parameters that influence erosion include the water velocity, water depth, soil type, vegetation cover and land use practices.

8.12. A default erosion threshold velocity of 0.5m/s has been established for all Inland Rail sectors in western and northern NSW. This has been based on various FMPs, soil conservation service advice and the experience of NSW and Queensland soil conservation specialists with many decades of experience in these floodplains.

8.13. The Department has consistently advised that the 0.5m/s limit is to be applied in the absence of expert site-specific geotechnical/soils advice that establishes a different ETV for a particular area. We support this advice.

8.14. A review of literature including overseas literature provides various general recommendations to set ETVs based on soil classifications and/or vegetation densities. Whilst the Proponent has suggested that ETVs be determined for the Project using this procedure, there are concerns that the resultant ETVs may not be appropriate in many western and northern floodplains.

8.15. The accuracy and applicability of this procedure to the determination of ETVs for the Project and other Inland Rail projects in western and northern NSW has been discussed with the Proponent at numerous HWG meetings. Following on from these discussions it is our opinion that when determining ETVs for the Project:

(a) *Indirect determination* methods which involve assignment of an ETV based on a soil classification are unlikely to be accurate particularly when the method has not had specific regard to the erodability characteristics of soils in western and northern NSW, including the black cracking clays. Whilst the Proponent has proposed such ETV methods on some Inland Rail sectors, advice received by the Department from geomorphologists has identified concerns with these methods, particularly those developed overseas;

(b) *Direct determination* methods which involve testing of undisturbed soil samples in a hydraulic flume are likely to be the most accurate procedure from which to determine ETVs. Such tests on representative samples can be used to infer reliable ETV values across a rail sector based on soil characteristics identified on site at each cross drainage structure;

(c) *Vegetation assumptions* are critically important. Well maintained vegetation cover can significantly increase the ETV. Nevertheless the advice of soil conservation specialists that have been consulted in relation to the Inland Rail projects in western and northern NSW, and in south-east Queensland, confirm that bare soil conditions should be assumed when setting ETVs for use in design. This is because of the loss of vegetation which occurs during drought periods and the variable land management practices adopted by landowners.

(d) *Need for specialised and experienced advice*. Discussions with current and past employees of the Soil Conservation Service both in NSW and in Queensland have emphasised the importance of obtaining advice from experienced soil scientists with extensive local experience in the floodplains through which the Project is to be constructed. Given the numerous floodplains through which the Project passes, it is essential that the ETVs selected for design are validated by reference to the Soil Conservation Service personnel in NSW and Queensland, and the erosion guidelines published by these organisations.

(e) *Existing erosion* requires special consideration. Where the proposed alignment passes through an area of active erosion the Proponent will need to rectify the existing erosion problem as part of the design of the Project. This may likely require restoration works being constructed beyond the rail corridor.

9. Cross Drainage Structures near Macintyre River

9.1. Between Whalan Creek and the Macintyre River there is a large section of the alignment with little cross drainage as the flood model has flow running parallel to the rail alignment and not through it. With different spatial distributions of rainfall in the upstream catchments, the proportion of flows arriving on each side of the alignment may alter.

9.2. These altered flow conditions may then require additional cross drainage to equalise conditions on each side of the alignment and prevent an accumulation of flow on one side of the alignment.

9.3. Should the Department decide to approve the Project, it is recommended that during detailed design, the spatial variation in historical rainfalls be examined together with the underlying meteorological conditions, and these be used to infer the likely maximum extent of alternative flow distributions that may potentially occur in the future. Whilst such an approach has been briefly investigated and reported by the Proponent in their responses to the PIR RFIs, the reviewer considers that a further assessment, including additional justification and documentation of the adopted rainfall adjustments, are required.

9.4. The adequacy of the proposed cross drainage infrastructure should then be checked during detailed design to ensure the QDLs are satisfied under the alternative flow distributions.

Yours sincerely

Drew Bewsher
Director