

National Centre for Coastal Research  
(NCCR)

**Gap Analysis for Preparation of  
DPR for Kalpasar Dam**

**Final Gap Analysis Report**

Report Ref: 282702/Kal/Inc/1

Final |29/12/2021

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 282702

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# Document verification



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## List of Abbreviations

|        |  |
|--------|--|
| AASHTO | American Association of State Highway and Transportation Officials |
| ADB    | Asian Development Bank   |
| ALARP  | As Low as Reasonably Practicable                                   |
| ALS    | Accidental Limit State   |
| BIS    | Bureau of Indian Standards   |
| CAPEX  | Capital Expenditure  |
| CBIP   | Central Board of Irrigation and Power                              |
| CFD    | Computational Fluid Dynamics                                       |
| CIfA   | Chartered Institute of Archaeologists                              |
| CIFRI  | Central Inland Fisheries Research Institute                        |
| CIRIA  | Construction Industry Research and Information Association         |
| CWC    | Central Water Commission   |
| DPR    | Detailed Project Report  |
| EIA    | Environmental Impact Assessments                                   |
| EPP    | Emergency Preparedness Plan  |
| ESIA   | Environmental and Social Impact Assessment                         |
| EWS    | Early Warning System   |
| FAO    | Food and Agriculture Organization                                  |
| FEE    | Functional Evaluation Earthquake                                   |
| FHWA   | Federal Highways Administration                                    |
| FSL    | Full Supply Level  |
| GTS    | Great Trigonometric Survey   |
| HAT    | Highest Astronomical Tide  |
| ICOLD  | International Commission on Large Dams                             |
| ICOMOS | International Council on Monuments and Sites                       |
| IFC    | International Finance Corporation                                  |
| GSDMA  | Gujarat State Disaster Management Authority                        |
| IITM   | Indian Institute of Technology Madras                              |
| InSAR  | Interferometric Synthetic Aperture Radar                           |
| INTACH | Indian National Trust for Art and Cultural Heritage                |
| IPCC   | Intergovernmental Panel on Climate Change                          |
| LAT    | Lowest Astronomical Tide   |
| LiDAR  | Light detection and ranging  |
| M&E    | Mechanical and Elec  |
| MASL   | Meters above sea level   |
| MCE    | Maximum Credible Earthquake  |
| MCM    | Million Cubic Meters   |
| MDE    | Maximum Design Earthquake  |

|         |  |
|---------|--|
| MHWN    | Mean High Water Neaps  |
| MHWS    | Mean High Water Springs  |
| MLWN    | Mean Low Water Neaps   |
| MLWS    | Mean Low Water Springs   |
| MSL     | Mean Sea Level   |
| NCCR    | National Centre for Coastal Research                                 |
| NCE     | No Collapse Earthquake   |
| NIOT    | National Institute of Ocean Technology                               |
| NOAA    | National Oceanic and Atmospheric Administration                      |
| Nr      | Number   |
| NWL     | Normal Water Level   |
| O&M     | Operation and Maintenance  |
| OBE     | Operating Basis Earthquake   |
| OPEX    | Operational Expenditure  |
| PMF     | Probable Maximum Flood   |
| PMP     | Probable Maximum Precipitation                                       |
| PPP     | Public Private Partnership   |
| RAP     | Resettlement Action Plan   |
| RCP     | Representative concentration pathways                                |
| RTE     | Reservoir Triggered Earthquake                                       |
| SCADA   | Supervisory control and data acquisition                             |
| SDG     | Sustainable Development Goals  |
| SEE     | Safety Evaluation Earthquake   |
| SLS     | Serviceability Limit State   |
| SPS     | Safeguard Policy Statements  |
| ToR     | Terms of Reference   |
| ULS     | Ultimate Limit State   |
| UNESCO  | The United Nations Educational, Scientific and Cultural Organization |
| USACE   | United States Army Corps of Engineers                                |
| USBR    | United States Bureau of Reclamation                                  |
| USEPA   | U.S Environmental Protection Agency                                  |
| US-FDSC | US Federal Dam Safety Commission                                     |
| WB      | World Bank   |

## Executive Summary

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The Consultant, Arup, teamed up with HR Wallingford, UK, have been commissioned by the National Centre for Coastal Research (NCCR) on 14 June 2021 to perform a review of 31 completed studies and seven studies in progress, for the Kalpasar project and undertake a gap analysis.

The Gap Analysis identified 102 High Risk Gaps, 88 Medium Risks Gaps and 7 Low Risks Gaps, split across six Workstreams, namely Dam Engineering; Estuary Water Management and Quality; Geotechnics, Geology and Seismology; Environmental Review, Socio-Economic Impacts and Transport Cost Benefit. It can be noted that, in the process of undertaking the gap analysis, two workstreams that were previously, in the Inception Report, captured under the stream Dam Engineering, have been now kept separately, as they could have significant impacts on the feasibility of the Kalpasar Scheme. These are:

- Socio-Economic Impact
- Transport

The Kalpasar project feasibility has been studied over the past 40 years, considering various aspects, from the technical solution of the dam to the environmental impacts. Data and knowledge have been developed in different levels of detail. The reports and studies in the scope for this Gap Analysis were reviewed for their relevance and quality, within the framework set out in the Inception Report.

After the completion of the Gap Analysis by Arup, it was concluded that there are several overarching themes across the gaps identified across all workstreams. Those are summarised below.

- There is lack of clarity on the definition on the Project Aims and Needs, Project Design Brief, Design Limit States and Design Standards
- There is not appeared to be any design integration between the different studies to produce a single coherent design. There is lack of continuity between reports, and there is lack of reference to the project objectives.
- There is lack of clarity of how project decisions thus far have been made and different options evaluated
- Many of the studies provided are out of date and would need updating with most up-to-date available data and currently proposed alignment
- There is no one database or an information model collating and comparing the available data (from carried out surveys) for the existing site and the proposed scheme.
- There is little assessment done on the stakeholders and receptors for the scheme. There is no clarity if any engagement with the potential stakeholders have been made.
- There is little information on how the scheme would impact the wider region and how that affects the region development plans and vision

- There is no up to date analysis of the Costs and Benefits of the Project.

Recommendations and mitigations have been made for addressing the identified gaps. While addressing the gaps will reduce the overall project risk, some of the identified issues, even after mitigation, have the potential to lead to significant cost and time impacts on the project and put the feasibility under review.

## 1 Introduction

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The Consultant, Arup, teamed up with HR Wallingford, UK, have been commissioned by the National Centre for Coastal Research (NCCR) on 14 June 2021 to perform a review of 31 completed studies Kalpasar project and undertake a gap analysis.

According to the contract the following deliverables expected:

- 1 Inception Report
- 2 Draft Review Report that will comprise a review of the completed studies, comments and recommendations for going forward with the design, include actions to be taken for areas of concern as well as further investigations and analysis to be carried out,
- 3 Final Review Report following receipt of a single consolidated set of comments from NCCR.

The NCCR shared the completed studies with Arup and HR Wallingford on 23rd June 2021 and then 3 ongoing studies on 3<sup>rd</sup> July 2021. A list of the reports received is presented in Appendix 1.

In order to better manage the review process, we have subdivided the tasks into the following components:

- A) Dam Engineering
- B) Estuary Water Management & Quality
- C) Geotechnics/Geology and Seismology
- D) Environmental Review (*amended from Marine & Estuary Environmental review to include terrestrial elements*)

In the process of undertaking the gap analysis two workstreams that were previously, in the Inception Report, captured under the stream A), have been now kept separately, as they would have key impacts on the feasibility of the Kalpasar Scheme. These are:

- E) Socio-Economic Impact
- F) Transport

The details and criteria for the review of each section has been outlined in the Inception Report from July 2021.

This is the Draft Review Report by the Consultant; the report comprises:

- Section 1: Introduction

- Section 2: Reports Reviewed by Each Workstream
- Section 3: General Overview of the Gap Analysis
- Section 4: Workstream A – Dam Engineering
- Section 5: Workstream B - Estuary Water Management & Quality
- Section 6: Workstream C - Geotechnics/Geology and Seismology
- Section 7: Workstream D - Environmental Review
- Section 8: Workstream E - Socio-economic Impact
- Section 9: Workstream F – Transport Cost Benefit Analysis
- Section 10: Conclusion and Recommendations

## **2 Reports Reviewed by Each Workstream**

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### **2.1 A) Dam Engineering**

- Pre-feasibility volume 1 & 2
- Techno Economic Feasibility Report Kalpasar
- Primary Dam cross sections finalized 2015
- Pre-Feasibility volume 2
- Design of Dam and Spillway cross section
- Primary Dam cross sections finalized 2015
- Water Availability Studies NIH
- Estimation of PMF, Design Flood and Spillway Capacities IIT
- Design of Dam and Spillway cross section; Six Specific Studies Volumes V and VII
- Six Specific Studies Volume V
- Primary Dam Cross Sections finalised 2015

### **2.2 B) Estuary Water Management & Quality**

- Techno economic feasibility report
- Water quality report
- Water availability study
- A study on positive irrigation impact of Kalpasar reservoir project in Saurashtra region of Saurashtra
- Study of taluka-wise Irrigation planning and Agro-economic impact of Kalpasar project in coastal areas of Saurashtra region
- Irrigation facilities

- Scope of Work for EIA & SIA Studies

### 2.3 C) Geotechnics/Geology and Seismology

- Final Report on Marine Geo Technical Investigation works for the Gulf of Khambay Development Project (Kalpasar) Government of Gujarat by COMACOE (reported April 2021)
- GEOPHYSICAL SURVEY FOR REVISED DAM CORRIDOR [Component 1 of 4 of the overall project Seabed Engineering Investigations and Model studies for Gulf of Khambhat Development Project] FOR KALPASAR PRABHAG OF NARMADA WATER RESOURCES WATER SUPPLY & KALPASAR DEPARTMENT GOVERNMENT OF GUJARAT PREPARED BY NATIONAL INSTITUTE OF OCEAN TECHNOLOGY CHENNAI January 2013

### 2.4 D) Marine & Estuary Environmental Review

- Prefeasibility report, Haskoning 1999 Vol 1 and 5, Annex 12.
- Assessment of Baseline Environmental quality and social status of Kalpasar Project, Vol 1 and 2, 2011.
- Hydrodynamic and sediment model studies and related measurements, NIOT, 2018.
- Comprehensive Report on KALPASAR PROJECT Duration of (July-2009 to December-2014), GPCB
- Mangrove Studies, GEC, undated.
- Synopsis of various environmental and socioeconomic studies, GES, 2018
- EIA and SIA studies for Kalpasar Project, NEERI, April 2008. Gov of India, Ministry of Environment and Forests, Meeting Minute 24-Sept-2010.
- Fisheries Report, 2008.
- Assessment of Baseline Environmental quality and social status of Kalpasar Project, Vol 2, 2011.
- Impact of the proposed Kalpasar dam on the ports in the Gulf of Khambhat, Sept 2016.

### 2.5 E) Socio-economic Impact

- Synopsis of the environmental and socioeconomic aspects of the various studies related to Kalpasar project
- Conceptual and Structure Plan and Preparation of Base Map of Kalpasar Project Area, 2014

- Neeri Scoping Study Report (EIA and SIA), 2008
- Traffic Assessment Study
- Impact of Kalpasar Project on the existing and Proposed Ports
- Fisheries Study
- Present Status of Salt Pans and Assessment of Social, Economic and Environmental Impact of the Kalpasar Reservoir Project
- Socio-Economic Appraisal of the Kalpasar Area (Chapter 2) 2011

## **2.6 F) Transport**

- Traffic Assessment Study

## 3 General Overview of the Gap Analysis

### 3.1 Standards and Guides

The Gap analysis was based on National and international Standards, as previously described in the Inception Report. For the complete bibliography used for the analysis refer to Appendix 2.

### 3.2 Risk based approach for undertaking the gap analysis

In the Inception Report, it was outlined that the gap analysis will be undertaken with a risk-based approach. A matrix was prepared based on the inception report to provide a systematic framework for reviewing the provided reports by the client. The matrix subdivision is explained below.

- Review Component – related workstream
- Sub-component – related to the sub-title for each component in the inception report
- Inception Report section – reference to the inception report section
- Topic – topic examined within a subcomponent of the review
- Assigned to – Information reviewers
- Gap/Issue identified – Description of the gap or issues (if) identified for each topic
- Risk/ Importance (High/ Medium/ Low) – Assigned level of risk associated with the gap/issue identified
- Mitigation/ Recommendation – consideration of possible mitigations
- Reference Documents/ Codes/ standards – reference to relevant international standards and documents
- Kalpasar Report(s) reviewed relevant to this issue – reference to Kalpasar reports reviewed on the topic.

The following definitions have been used throughout the gap analysis:

- High- Risks which could jeopardise the feasibility of the scheme or which have the potential to require a large change to the design with associated impact on design and construction cost.
- Medium- Risks which have not been addressed (or fully addressed) through the studies to date which could be carried out at a later stage or are expected to have a lesser impact on the design and are not likely to jeopardise the scheme's feasibility.
- Low- Risks which have been fully addressed at the study level with only design development required

**For conciseness only the key high-risk items have been summarised in the report.**

The full the matrix can be found in Appendix 2.

### 3.3 Overview of Risk Identified

Following the framework set out in the Inception Report and completing the Gap Analysis matrix a number of risks/gaps were identified for each Workstream. The overall number of risks initially directly corresponded to an item stated in the Inception Report. As the review progressed a number of additional gaps/issues were added to the matrix.

Overall, 102 high risk gaps/issues were identified, 88 medium risks and 7 low risk issues were identified. The infographic below shows the split across each workstream.

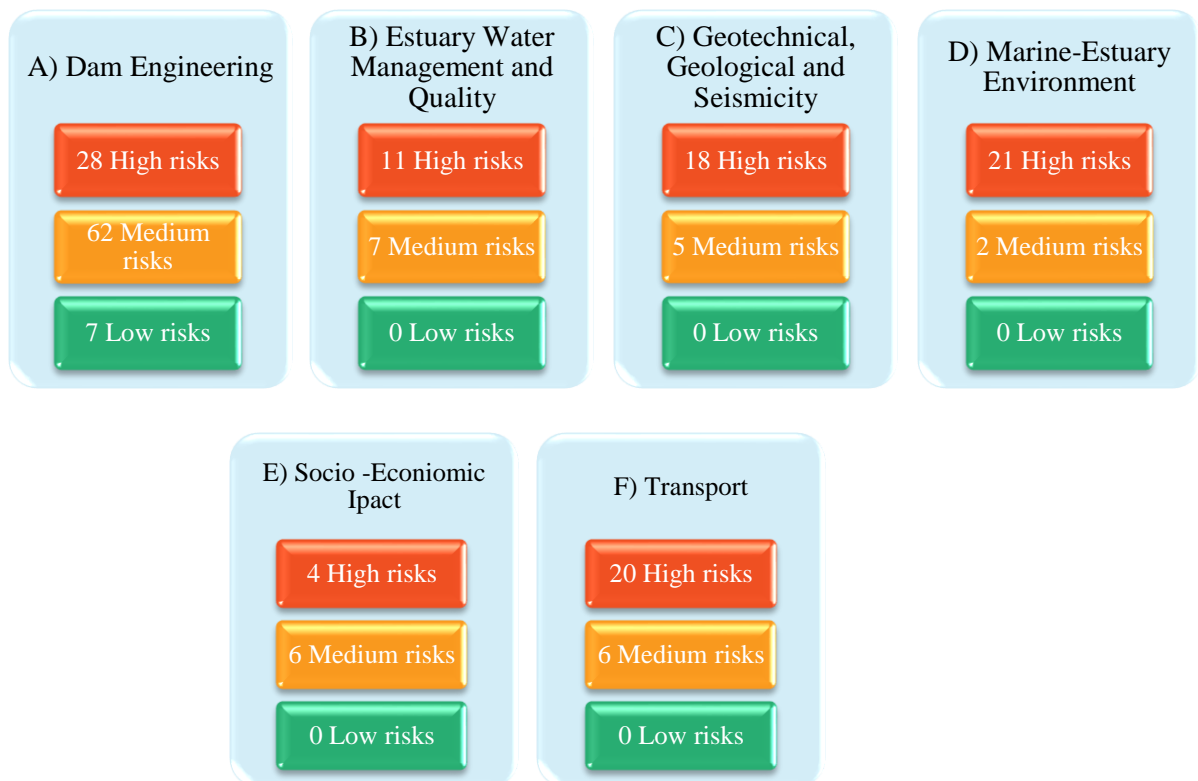


Figure 1. Issues and Gaps Identified Across Workstreams

## 4 A - Dam Engineering

Following the inception review 28 High Risks, 62 Medium Risks and 7 Low Risk gaps/issues were identified.

## 4.1 Key High-Risk Gaps

### 4.1.1 Dam Design Criteria

#### High Risk Gaps/Issues Identified:

There is **no** document outlining the design aspirations and performance targets for the Kalpasar project.

The dam has not been categorised to appropriate standards based on its hazard potential.

There is no one document outlining the standards to be achieved in terms of reliability, design life or operational capacity, for any element of the proposed dam design, appurtenant structures, or related infrastructure, such as the new road.

No design life or standards were referenced in any of the documents outlining the proposed dam design or related infrastructure, such as the new irrigation canal and the Narmada dam and canal, mechanical and electrical component, roads bridges etc.

As there is a direct relationship between dam safety and its lifespan, the design criteria should be stated in the project reports and briefs for each of the design stages.

#### Recommendations:

A Design Brief should be prepared stating the project needs and aspirations, as well as standards to be followed. This will aid the setting of Design Criteria, i.e. the Ultimate Limit State Criteria and Serviceability Limit State Criteria (based on recognised standards), for each of the components of the dam. Freeboard and overtopping limits should also be set.

For example, the design life of the dam structure forms part of the ultimate limit state criteria, while expected wind speed and wave overtopping limits before closing the motorway and railway link for parts of the serviceability criteria.

The Design Brief should cover all aspects of the engineering design. The Design Brief should be prepared in accordance with recognised national and international standards. The design Brief is to be issued to all parties undertaking design studies/work.

#### Residual risk after mitigation:

The Design Brief aim is to provide a framework to which the future design work is conducted. The residual risk is that in meeting all the criteria set out in the Brief, the project becomes unfeasible from technical or cost/benefit perspective.

### 4.1.2 Water Availability

#### High Risk Gaps/Issues Identified

A large proportion of the Kalpasar water is supplied by the Narmada River, which already has a large water supply dam supplying an irrigation canal (Sardar Sarovar Dam). Other supply dams are built on the other tributaries, the operating regime of these reservoirs will affect the available freshwater inflows into Kalpasar reservoir.

The water in the tributary rivers flows varies with season and the release of flows from existing reservoirs, the seasonality is not reflected in the water availability estimates. The data presented in the hydrological assessments and demand forecasts is outdated and does not include future projections of climate change, land use/crops and population growth.

No objective for reliability of water supply has been set.

There has not been a long period model simulation of the water inflows, water demands and losses to determine accurately the availability of the water and reliability of supply. A 1-year model has been simulated (NIOT 2018, Dam Impact Model Studies), along with the use of annual-averaged estimates.

### Recommendations

The target reliability of water supply should be set. A draft Operations and Maintenance Plan (O&M Plan) should be prepared for the expected performance of the Kalpasar Reservoir. The plan should outline the day-to-day management of the reservoir, including proposed strategy on maintaining the reservoir balance for the available water and demand.

The water balance should be modelled in a long-term catchment-based model (such as 50 to 100 years, reference should be made to “Guidelines for Preparation of Detailed Project Reports of Irrigation and Multipurpose Projects”), so that the reliability of the water supply is proven over a representative time period. The model can then be used to inform the design of the reservoir and operating Plan.

The model should be based on available rainfall-runoff records, sensitivity testing should also be undertaken including for different climate change scenarios. The model should also include forecasts for the water releases from the existing and proposed reservoirs on the tributary rivers, that are adjusted for climate change and predicted changes to the water demands from those reservoirs. The model should be able to capture water losses such as evaporation, spillway releases, salinity flushes and leakage estimates. The irrigation demands from Kalpasar should be modelled to include future forecasts for changes due to climate change, and economic and demographic changes to the region.

### Residual risk after mitigation

The results from the updated water balance model may conclude that there is not enough water available for the sustainable long-term utilisation of the dam. There is a high risk that this might affect the cost-benefit analysis and ultimately the feasibility of the project.

## **4.1.3 Constructability – Closure Construction Sequence**

### High Risk Gaps/Issues Identified

The construction sequence and the design of the gulf closure section of the dam is only briefly discussed in the Feasibility reports reviewed. Some further modelling of the current velocities is presented in the Dam Impact Model Studies (NIOT, 2018). However, considerations such as sequencing of the work, scour mitigation due to high current velocities in the closure or the inclusion of deep-water salinity flush sluices, are not reflected in the design of the proposed dam cross sections.

The criticality of the closure design cannot be over emphasised. This tidal closure will present issues of an order of magnitude greater than any tidal closures on previous projects around the world and requires very careful planning and design to ensure that scour near the dam is managed and contained at acceptable levels.

The proposed dam cross-sections feature steep slopes and multiple layers at a great underwater depth. The inclusion of the deep flush sluices will require precision of placement to guarantee watertightness and smooth operation, which should be considered in the construction sequence. The proposed dam design should be developed in consideration of the temporary construction cases.

### Recommendations

A detailed hydrodynamic model including the different stages of construction should be prepared. That would enable the optimisation of a construction sequence for the proposed dam alignment.

A draft Construction Sequence Plan should be prepared detailing the approach to the construction of the different sections of the dam. A careful consideration should be given for the temporary cases during construction, and constructability considerations should be carried forward in the future stages of the design. It is important to engage potential contractors specialising in marine environment construction to fully integrate the constraints of the site in the design.

### Residual risk after mitigation

The Construction Sequence plan should form part of the design process. Early engagement with potential contractors may not be possible. Overlooking constructability issues may lead to substantial project changes late in the project delivery process, leading to unexpected delays and costs.

## **4.1.4 Constructability – Materials Sourcing and Suitability**

### High Risk Gaps/Issues Identified

The proposed dam cross sections show a layered dam construction, with a main body of excavated and dredged material, multiple filter layers and rock armour/concrete armour blocks protection. At its widest the dam will reach over 400m at its base. The preliminary estimates for the required quantities of each material were not provided, nor were preliminary options of where those materials might be sourced or how they are to be transported to site and stockpiled.

Of a particular concern is the sourcing of suitable rock, as it has been stated in the reports that suitable rock for the protection of the dam is not available in the vicinity of the dam.

For the main part of the dam, it is proposed to use dredged material from the area of the spillway channel and the new Narmada canal. However, no assessment of the suitability of the materials found on the spillway and the canal alignment has been provided.

### Recommendations

For a dam of such scale, sourcing materials with the required properties in such large quantities must be considered carefully with respect to source availability and logistics for the material transportation to site. A draft Material Management Strategy should be prepared, considering the quantities, the qualities and the potential strategy for sourcing of the materials. The logistics of transporting and stockpiling materials on site should be considered. A strategy for utilisation or disposal of unsuitable excavated materials should be prepared.

### Residual risk after mitigation

The lack of availability or suitability of materials can pose a risk of design changes late in the design process. That can cause significant increases in the cost of the project and possible project delays. Early engagement with potential material sources and developing understanding of the quantities of required and available resources is key for reducing the project risks further.

## 4.1.5 Cost Benefit Analysis

### High Risk Gaps/Issues Identified

Since the early pre-feasibility studies and the techno-economic appraisal of the project there has **not** been an updated cost benefit analysis.

There have been significant changes to the scheme, including changes of the alignment of the dam, the proposed cross sections and the commissioning of the latest stage of the Sardar Sarovar Dam (which affects the water availability). **No** evidence was found in the provided reports of evaluation of multiple options and optimisation of the proposed dam for the reduction of the project overall capital, operational and maintenance costs.

The benefit assessment has only a very high level of indirect impacts assessment for the region, predominantly considering the impacts of improved irrigation for agriculture. Further, socio economic impacts for the region, such as those resulting from improved transport links, were not considered.

### Recommendations

Prepare an updated Cost-Benefit analysis for the project. The assessment should be used as tool to re-evaluate the feasibility of the scheme, and in line with the requirements of the DPR, should provide costs and benefits for each individual element of the scheme; for example water supply, transport and tidal surge protection. The document can then be developed into an Optioneering Report and Matrix for selecting and optimising the design of the project. The Cost-Benefit analysis should be kept live and updated with the progression of the design.

### Residual risk after mitigation

After re-evaluation of the cost-benefit of the scheme it might be found that the project costs (including risks) are excessive compared to benefits. Alternative options may emerge with a better business case.

#### 4.1.6 Sediment and Salinity Management

##### High Risk Gaps/Issues Identified

A high percentage of sediment and salinity flushing is assumed. Deep water scour and utilising the spillway are the means of sediment and salinity flushing. In addition, the closure of the estuary will reduce the current velocities in the reservoir, reducing mixing and increasing sedimentation. A hydrodynamic model of the sediment and salinity has been prepared, however only limited cases have been considered. A high volume of flushing through scour and the spillway is required to achieve low salinity in the lake and reduce sedimentation. Only annual average salinity and sediment loads are assumed to be carried through the rivers. However, high salinity has been modelled for the south-west section of the reservoir, which is where the irrigation pumps are proposed to be located. It is not clear whether the salinity will be sufficiently low for crop tolerances and it is not clear what timescales have been considered.

The proposed approach channel for the spillway has a no gradient and therefore the approach velocity to the spillways will be minimal. The lack of velocity in the approach channel will encourage sediment settlement and siltation. The location of the spillway to the side of the dam and away from the mixing zones will also reduce the spillway ability to flush sediment and salt.

##### Recommendations

The Sediment Model should be updated to reflect seasonality and estuary topography and dynamics. The long term performance of and alternatives to deep-water scour sluices should be considered. The approach velocities and gradients at the spillway should be reviewed to minimise the chance of silting up the approach channels.

The risk of salinity to crops requires study.

##### Residual Risks

After revising the sediment and salinity to reflect the seasonality and the topography of the estuary, there is a risk that the water may not be of sufficient quality for irrigation, putting the feasibility of the project at risk.

#### 4.1.7 Dam Hazard Categorisation

##### High Risk Gaps/Issues Identified:

Within the provided studies, the dam is not categorised based on its hazard potential. Multiple dam breach scenarios have been considered in the Dam Impact Assessment study, including the risk of a sea breach at high surge tides.

However, there is no assessment of potential consequences should any of the dam breach scenarios occur. Consequences should include:

- Flood impacts
- Loss of life
- Property, asset and infrastructure damage or loss of operation
- Environmental loss
- Wider economic loss (such as loss of transport corridors or irrigation)

#### Recommendations:

The Kalpasar dam should be categorised based on its hazard potential, using the approaches described in ICOLD Bulletin 82 and others with particular use of the USACE dam hazard classification.

A dam breach hazard assessment should be prepared. This will serve a number of purposes:

- Inform the selection of design and construction standards, including the safety check flood and seismic design.
- To provide dam breach inundation mapping for development planning
- To determine the consequences of a dam breach and therefore the selection of the reservoir design and safety check floods
- For emergency planning and development of the Emergency Preparedness Plan (EPP)

#### Residual Risks

A ***prescriptive standards based approach*** where a dam hazard category is assigned based on criteria such as dam height, stored volume, population at risk downstream of breach and economic consequences. Based on the size of the storage capacity and the height of the dam it is highly likely that the dam will be categorised as high risk.

Alternatively, a ***risk-based approach*** may be taken where the incremental losses caused by failures in a range of events are considered along with a comparison of flood damages (not resulting from a dam failure). This aims to achieve a risk that is As Low as Reasonably Practicable (ALARP).

This will impact on the design standards that are to be used in the subsequent design stages, the capital cost of the scheme and the operations and maintenance regime.

## 4.2 Other High Risks Gaps Identified

### 4.2.1 Hydrology and Hydraulic Modelling

The Probable Maximum Flood (PMF) has been estimated, but no other flood events are considered. A range of flood events combined with tidal variation should be considered in the design. The PMF assumes no contribution from Narmada - it is not clear how the contribution from the Narmada will be managed during floods.

The latest hydrological study is dated 2011. The Probable Maximum Precipitation (PMP) estimates do not appear significantly greater than the maximum observed event. There has been little or no evidence presented of model calibration or event testing. The hydrological assessment assumes that the existing dams regulate the catchment contribution to the estuary; we need to ensure that there is supporting legislation in place to ensure this is the current practice.

As there have been several big events in the region in the last decade it is recommended that the hydrological study is updated to include recent data; it is recommended in particular that the use of the radar network is explored to bolster the rainfall analysis which in the previous study was limited to a small number of rainfall gauges. For Further guidelines and recommendations refer to inception report.

A joint probability analysis should be performed considering combinations of fluvial and coastal storms.

## 4.2.2 Climate Change Impact

Climate change is already leading to changes in the intensity and frequency of events which can impact dam infrastructure, these impacts are anticipated to continue increasing and intensifying in future climate conditions. A comprehensive report on the potential climate change impacts was not found in the available studies. Understanding the long-term effect of climate change is key to ensuring that dam and the related infrastructure is resilient and sustainable. For key considerations please refer to the inception report.

The whole life cost of the dam should be assessed considering the need for future climate change adaptations, either providing additional capacity where appropriate or allowing for ease of future modification with the decisions based on lowest whole life cost.

## 4.2.3 Proposed Dam Cross Section

The detailed design of the cross section of the dam body is complicated and it is not clear how it could be constructed in the prevailing depths and tidal conditions. The cross section, which will vary along the length of the dam with varying depth, exposure and geotechnical conditions, will need further optimisation but in addition this optimisation will need to focus on constructability as described in Sections 4.1.1, 4.1.3, and 4.1.4.

There was no design report accompanying the cross sections, and therefore there was a lack of clarity on how the sections were developed. The following key considerations need to be outlined and consistent throughout all documentation and reporting, and were not found in the available reports:

- Standard design units and reference datum
- Design life for dam and for replaceable elements (see section **Error! Reference source not found.**)
- Geometry

- Stability analysis
- Seepage analysis
- Topographical and bathymetric data
- Metocean data for various return periods
  - Significant wave height and period (reservoir-side and gulf-side)
  - Current data (including river outflow effects, variation with depth)
  - Wind speed & direction (monthly, seasonally, annually)
  - Temperature
- Tidal data – Obtained from ESSO - Indian National Centre for Ocean Information Services or similar recognised body
  - Highest astronomical tide (HAT)
  - Mean high water springs (MHWS)
  - Mean high water neaps (MHWN)
  - Mean sea level (MSL)
  - Mean low water neaps (MLWN)
  - Mean low water springs (MLWS)
  - Lowest astronomical tide (LAT)
- Water levels
  - Highest combined tide + storm surge level
  - Lowest combined tide and negative surge level
  - Sea-level rise allowance due to global warming
  - Reservoir water level range including Normal Water Level (NWL)/Full Supply Level (FSL), Peak Stillwater level (design and safety check), minimum level
  - Gauge data for upstream catchments for upstream fluvial analysis
  - Discharge rates for dams in the upper catchments
- Design return periods need to be specified
- The appropriate levels of risk should ultimately be decided by a combination of:
  - Industry standards (including those listed above) and national regulations
  - Cost-benefit analysis to determine as-low-as-reasonably-practicable outcomes (ALARP)
  - Acceptable degree of damage – balance of CAPEX with OPEX (including maintenance/repair and impact of downtime).
  - What funding agencies or insurance companies will accept
- Materials
  - Proposed material properties
  - Source of material

#### 4.2.4 Geometry

It has not been demonstrated clearly how the proposed dam geometry meets all design considerations and project needs. Refer to Section 4.1.1 for the need of

preparing a Design Brief. The design geometry should balance the different design objectives and requirements set out in the Design Brief.

The key parameters are:

- Crest width
- Crest height
- Road/rail vertical and horizontal alignments (see sections 4.2.11 and 0)
- Downstream (Dredged material) slope
- Upstream (Rock core) slope
- Rock/block armour layer thickness
- Rock/block armour diameter
- Settlement Allowance
- Freeboard allowance

The required crest width and width of the various berms will follow from stability analysis and ensuring any shallow failures do not jeopardise the safety of the dam but also operational requirements such as maintenance access. The width of the crest, berms and therefore overall dam footprint is expected to be heavily influenced by the width of the road and rail corridors. The width of the dam will also influence the seepage analysis where a narrower dam will be more prone to seepage and therefore the resulting risk of internal erosion and saline intrusion. This variation in seepage path length will also influence the appropriate choice of material with lower permeability material and more significant seepage cut-offs for narrower (and/or higher) dams.

The height of the dam will need to be sufficient to manage:

- The required reservoir water storage volume needed to meet the demand including any loss due to saline stratification and sediment dead storage
- The modelled design and safety check flood rise, this is therefore related to the spillway design, gate operating philosophy and flood modelling
- The freeboard allowance required to prevent reservoir wave overtopping
- Operation requirements for the road and railway such as remaining operational (spray/overtopping) in specified return period events
- Reservoir impoundment and reservoir rim flood risk
- The tidal range and storm surge
- The freeboard allowance required to limit wave overtopping from the sea
- Allow for settlement of the dam whilst still maintaining all of the above

The height of the dam also strongly influences the dam hazard categorisation, with higher dams generally resulting in greater consequences of failure and therefore posing a higher hazard.

## 4.2.5 Loading

In the provided reporting it was **not** clear Design return periods for the dam and structures need to be specified for ALS, ULS and SLS design scenarios. Refer to Inception report for examples of standards/code guidance that can be used to define the loading limit states. Those should be defined in the Design Basis/ Brief Report.

### Ship impact

All safety critical structures such as spillways, locks and sluices should be designed for dynamic forces arising from ship impact and impact of large debris. An assessment should be made of the likely type and size of ship and likely debris as well as the design impact velocity and deflection.

Methods for assessing the loading due to ship impact are given in EN 1991-1-7, Accidental Actions, or AASHTO Bridge Design Specifications.

## 4.2.6 Stability Analysis

Although the stability of the completed dam has been assessed, there has been no assessment of the dam stability during the construction process, As well as the geotechnical stability of the dam and its foundations, there are many other factors to be considered, such as wave action, seismic events, floods, and impacts of climate change. Risks of damage are also affected by the duration of the construction process and an understanding of the proposed construction method should be an integral part of the design process. Refer to Section 4.1.3 and Section 6 for recommendations.

## 4.2.7 Rock armour design

The downstream (seaward) slope, with a vertical height of up to about 44m, is planned to be protected by a layer of concrete Xbloc armour units of 8t to 48t weight, on a base layer of rock of 1.3 to 2.4m thickness. The unit weight of the armour units appears to be appropriate in relation to possible design wave heights although smaller armour units could be used in those parts of the dam in shallower water with depth-limited waves. The presence of berms at several levels on the armoured slope will affect the amount of overtopping.

The design of the protection of the upstream face of the dam also requires consideration.

No information has been seen regarding the selection of the type of armour unit, which will be affected by construction conditions and overall cost. The method of construction is not clear, and construction of relatively thin base layers in conditions exposed to waves and variations in tide height, in depths of more than 20m, might not be practicable with the accuracy implied by the complex cross-section.

## 4.2.8 Scour protection

The seabed and the dam will be vulnerable to scour damage from tidal flows as construction progresses along the length of the dam and particularly in those areas

affected by the closure. Scour protection along the length of the dam and upstream and downstream of the closure section and the spillway will be required in advance of the main dam construction. Some of this will have a permanent function while other parts may become buried as construction proceeds. Refer to Section 4.1.3 for recommendations and the Inception report for relevant guidance and standards.

#### **4.2.9 Freeboard and Overtopping**

It is not clear how the freeboard allowance has been determined and incorporated in the dam design crest level. Only seaside wave run up has been considered and not reservoir wave run-up. Given the openness of the reservoir and the length of the wind fetch, significant waves can develop in the reservoir side.

Overtopping of the dam both from the sea and reservoir will need to be assessed to ensure the design minimises the risk of damage to the dam. It is not clear whether settlement has been considered.

The rate of safe overtopping tolerable to a dam will usually be extremely limited and based on the duration of the overtopping flow and velocity of the flow on the downstream face. In addition, limits should be placed on overtopping for the safety of operation of the highway and rail corridors as well as safe access of inspection, maintenance and emergency response. This should be based on limiting overtopping flows or spray to those safe for pedestrians and vehicles. The extreme floods under which the road and railway are closed to traffic should be agreed with the client and respective authorities.

An analysis of short-term settlement should be made to inform the phasing of the works and management of differential settlement between structures and earthworks. Long-term settlement monitoring should be carried out to ensure the minimum required dam crest level and height of any seepage cut-off is maintained throughout the design life of the dam.

An additional consideration for embankment dams is that the peak still water level remains below any impermeable core or barrier within the dam with an allowance made for settlement and desiccation.

#### **4.2.10 Dam Access for inspection and maintenance**

There are currently no proposals for surveillance operation and maintenance of the dam structures. No access route designs have been provided.

Access to the dam site is important both for construction and for ongoing surveillance and maintenance of the dam. Access roads for inspection and maintenance need to be accessible in a reservoir emergency and so need a good standard of protection from flooding and from other hazards such as rockfalls and landslides. The roads need designing with sufficient width and turning space for the largest vehicles envisaged as being needed during inspection, operation, maintenance, or emergency response. This could take the form of access of the main highway with turning areas to access dam infrastructure. Vehicle bridges are therefore typically required over obstructions and structures such as the spillway.

### 4.2.11 Highway and Railway Design

No details on the proposed road and railway alignment were provided. The design of the transport corridors would impact on the dam design criteria, constructability and material availability. Proposed criteria for operation, such as wind velocity and flood levels at which the road and the railway must remain operational should be included in the Operations and Maintenance Plan. The future stages of the design should also consider details of the bridges and the connecting infrastructure.

### 4.2.12 Mechanical equipment

No design life or standards are referenced within the feasibility or the proposed M&E structures components, such as spillway gates, draw off pipes or pumps for lifting irrigation of water. There is a direct relationship between dam safety and its life-span, i.e. if the dam is unsafe its life-span has expired.

A design life for the M&E equipment is to be agreed on project leadership scale and requirements included in the brief for the subsequent design phases of the project. Where mechanical and electrical components with a shorter design life are used the design must consider how they may be safely refurbished or replaced. Where a range of options for equipment with differing design life exists the whole life cycle cost should be assessed including differing maintenance and replacement/refurbishment intervals. The design life for replaceable M&E components should be at least 25years.

The selection of appropriate options (e.g. pumping vs sluices) and appropriate gate choices should be reviewed in an option selection exercise. Where either gates or pumping is utilised to remove the saline water at lower levels, careful consideration needs to be given to sedimentation and the impacts this will have upon the operation and longevity of the equipment.

The reservoir water level and inflow will require monitoring to inform gate and sluice operation and flood warnings and emergency response. Such monitoring will also inform water resource planning. Similarly, sea levels will need to be monitored to inform gate and sluice operation and to provide warning in case of emergency.

All gate options will require instrumentation to be integrated into a SCADA system for control and health and condition monitoring. Due to the criticality of the system, the security of it will need to be considered. As well as security of access and control the reliability of the system should be considered. Redundancy of power and operation of safety critical systems such as spillway gates will be required. Control systems will need to link to early warning and flood warning systems.

### 4.2.13 Instrumentation Plan

The operation and regulation of the water levels of Kalpasar Reservoir is a complex system including gates on the new Narmada Canal and barrage, spillway gates, scour sluices, irrigation pumps, etc. All management operation options will require an integrated approach of instrumentation and monitoring.

At present no Operation and Management Plan has been provided, as discussed in Section 4.1.2, and no instrumentation and monitoring plan has been provided.

All instrumentation should be integrated into a SCADA system for control and health and condition monitoring. Due to the criticality of the system, the security of it will need to be considered. As well as security of access and control the reliability of the system should be considered. Redundancy of power and operation of safety critical systems such as spillway gates will be required. Control systems will need to link to early warning and flood warning systems.

#### **4.2.14 Emergency Preparedness Plan (EPP)**

No outline EPP has been provided. This should be prepared and discussed with stakeholders before construction begins. No stakeholders have been identified. Refer to Section 4.1.7 for recommendation and Inception Report for typical contents of an EPP.

#### **4.2.15 Narmada Canal**

No proposed alignment or design details are provided for the Narmada Canal and the Barrage. There are limited details on the flows the canal is expected to carry, and they are critical for the water availability for the Kalpasar dam. The design should be developed further in subsequent design stages and its management included in the O&M Plan.

## **5 B - Estuary water management and quality**

### **5.1 Key High-Risk Gaps**

#### **5.1.1 Integrated approach for delivery information**

##### Issue Description

Multiple reports were made available for review, however, there was no integrated and consistent method of presentation for the information. The studies are often presented in a standalone format and there is a lack of continuity and little cross-referencing between previous findings and reports.

Three different hydraulic models for the project were made available for this gap analysis, with different domains and different purposes. There is no over-arching model or reporting structure for the models.

There is no georeferenced or time reference database for the information available. Key stakeholders and receptors were not identified, such as Nirma Chemical plant built within the proposed reservoir basin.

##### Recommendations

Prepare an integrated Desk Study Report on conducted studies and models; compare findings to project aims. Identify key stakeholders and receptors both

upstream, and downstream of Kalpasar, to enable evaluation of the project impact on the estuary, such as impacts on flooding and water quality.

Prepare a georeferenced and time referenced database of the available studies and findings to enable better understanding of the localised and catchment-wide influences and impacts on the estuary and water quality.

#### Residual risk after mitigation:

An overarching study on the estuary will enable early engagement and design influence to mitigate the risks posed to and by the project. It can identify the need for implementing mitigations, such as protection from floods. There is a risk of increased design and construction time, and increased costs in implementing any mitigations.

### **5.1.2 Water availability – seasonality**

#### Issue Description:

There is no recent information on water availability in the catchment or analysis that considers seasonality of the inflow.

One specific report relating to the techno-economic feasibility states that the calculations to deduct the water availability in the catchment area are using the monthly inflow series for the period from 1901 to 2006 which is not recent enough to estimate the current water availability.

Another study referenced in this report has refined the assessment of the water availability which was done by the Central Designs Organisation (C.D.O.) in 2009 considering a greater number of rain gauge stations, establishing modified rainfall runoff relationship for each of the river basins, future planning in the basin up to 2025 and demand assessment in the study area.

Other specific issues relating to water availability have been described in section 4.1.2. of this report. Again, more recent data is required as well as water availability forecasts based on the latest climate change projections.

#### Recommendations

Understanding the current and future water availability is crucial to the feasibility of this project. The mitigation actions listed out in Section 4.1.2. are recommended for action.

We also propose to obtain recent monthly rainfall data and revise water availability projections taking into account the latest climate change predictions.

#### Residual risk after mitigation

The results from the updated water balance model may conclude that there is not enough water available for the sustainable long-term utilisation of the dam. There is a high risk that this might affect the cost-benefit analysis and ultimately the feasibility of the project.

### 5.1.3 Water demand

#### Issue Description

The water demand highlighted in the studies relates to drinking water consumption, crop irrigation use and industrial use. The main concerns reside in the outdated, or lack of data reported in the studies. These are broken down below by usage.

*Drinking water:* Data from the reports [1 – Prefeasibility vol.1&3], which were written in 1998, is outdated and include future projections of population growth (2010, 2035 and 2060, assuming the dam would be in service by 2010). It is necessary to update the projected population growth and water demand forecasts as these are likely to have changed over time.

*Irrigation use:* Data from the reports is outdated and does not include future projections of land use/crops. Climate change forecasts are not taken into account either.

In Report 22 [- Study of taluka-wise Irrigation planning and Agro-economic impact of Kalpasar project.], the land use pattern used to assess water needs for irrigation purposes dates back to 2003-4. The land use and crop patterns are likely to have changed since this study was carried out. More recent data is needed to understand current and future irrigation water consumption.

*Industrial use:* No information available in the reports provided about the current and future water demand for industrial and other commercial purposes in the region.

#### Recommendations

*Drinking water:* Obtain the latest population information expected to have access to water for drinking purposes, as well as and robust population growth figures for the next 30-50 years.

*Irrigation use:* The latest available data on the crop type, surface area of each crop type, associated water usage and future forecasts of agricultural land use in the next 30-50 years should be obtained.

*Industrial use:* We propose the collation of the latest information available on the industrial and other commercial current water demands and future forecasts (30-50 years horizon).

#### Residual risk after mitigation

The results from the updated water balance model may conclude that there is not enough water available for the sustainable long-term utilisation of the dam. There is a high risk that this might affect the cost-benefit analysis and ultimately the feasibility of the project.

### 5.1.4 Identification of flood receptors and consequences

#### Issue description

There has been no assessment on the possible flood receptors and flood consequences in the reservoir basin area (low lying reclaimed lands), low-lying

reaches of the rivers discharging directly in the basin, or the downstream coastal areas. In the dam impact assessment model, the domain extents have been limited and do not include a representation of those reaches.

Only dam breach scenarios and resulting extreme tides scenarios have been assessed, without mapping the flood extents in the estuary. Fluvial flooding of different return periods, seasonality and combined probability events have not been assessed to determine the pre and post construction risk of flooding in the estuary.

There has been no assessment of potential environmental impacts in and around the reservoir and the estuary, as a result of changes to the risk of flooding. For example, there has been no assessment of potential sources of pollution, such as Nirma Point chemical plant; changes to the water levels upstream of the dam could impact on water levels in tributaries, potentially increasing them. Without tidal flushing, pollutants released in flood events would impact on the reservoir water quality.

### Recommendations

Multiple flood scenarios with a range of return probabilities from different sources (fluvial, tidal, tsunami, storm surges, etc) should be simulated and mapped for both pre-dam and post-dam cases to establish the overall impacts on flood risk in the estuary from the project. Assessment should be made of consequences of all flood scenarios to establish the associated flood receptors and consequences. Carry out an assessment on the risk for economic and environmental damages, such as triggering water pollution incidents or closure of vital local infrastructure.

### Residual risk after mitigation

The results of the consequence modelling will inform the dam hazard classification, which may have design, maintenance and cost implications. There may also be a need for mitigation against flood risks in the downstream area particularly, but also in the tributaries feeding the reservoir; this would also have cost implications.

## **5.1.5 Extreme tidal range impacts**

### Issue description

The most recent analysis on extreme tidal range identifies a 1.8m increase downstream with the dam in place. This is a major increase in levels which could require significant mitigation to prevent additional flood risk to receptors downstream of the dam.

Noting the processes that generate the macro tide range, there is low confidence that the model domain can encapsulate the whole of the effect of the dam. It may also lead to overprediction of the magnitude of effect on tide at the barrage line, creating high increases in tide levels within the estuary downstream of the dam.

### Recommendations

Sensitivity testing of a larger model domains should be carried out to check for the effects on tidal level changes. The model domain size should be extended to a point where further widening does not lead to significant water level changes in the

predicted tidal ranges. The cyclone model area used elsewhere is an example of a larger model domain.

#### Residual risk after mitigation

The sensitivity testing should confirm if the tidal level increases are real or a factor of the model domain. If the levels are real, significant mitigation will be required and cost will be incurred. Larger model domains may also identify previously unknown affects further downstream.

### **5.1.6 Pollution risks, sources and receptors**

#### Issue Description:

The water quality data provided in the reports is not recent enough to determine the current status of the water quality in the estuary. Also, obtaining, seasonal analysis of water quality trends would be beneficial to determine the variation in water quality during the year.

In Report 8 [- Water quality report] the water quality data is displayed as an annual average over 5 years (July 2009 – December 2014). The data is outdated to fully assess the most recent status of the water quality in the catchment.

Salinity related considerations are set out in section 4.1.2.

#### Possible mitigation:

Obtaining water quality data at a finer resolution (e.g. monthly) would allow to monitor the trends of the parameters during different seasons. The collation and analysis of more recent water quality data in the estuary is recommended including turbidity, BOD, COD, TSS, Nitrogen, Phosphorus and heavy metals.

We recommend the production of a Pollution Prevention and Management Strategy which tackles both the diffuse pollution and point source pollution issues and proposes appropriate measures to prevent and control discharges into the rivers feeding into the estuary.

#### Residual risk after mitigation:

There is a medium risk that the water quality of the estuary will be poor which could result in environmental and human health issues.

## **5.2 Remaining high risk gaps**

### **5.2.1 Strategy for management/adaptation for protection of the dam and surrounding area.**

There is no return period attached to the extreme water level study based on cyclones. It targets a probable maximum storm surge based on the historical record. This is then added to the highest astronomical tide level and modelling of wind waves. The validation of the model or tide alone or surges is vague. The best is that

the predicted surge was 2.2 m compared to an observation of 2 m. A 10% difference is quite large in this context.

## 5.2.2 Salinity

Impact of salinity on crops is not fully considered, only seems to consider a short time period rather than long-term effects. Study required into long-term risk of salinity to crops. Refer to Section 4.1.6.

# 6 C – Geotechnics and Seismicity

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## 6.1 Key High-Risk Gaps

### 6.1.1 Integrated Approach for Delivery of Information

#### Issue Description

Whilst various investigations have taken place and have been made available for this gap analysis, these have not been reviewed together to provide a combined ground model. There is no georeferenced model that recognises the transient nature of seabed levels. Changes through time, i.e. between studies, have not been investigated.

#### Recommendations

Prepare an overarching Desk Study bringing together the already available information for the existing ground conditions, from previous geophysical studies of the site. The Desk Study is to identify the ground issues and risks. The report is also to identify any gaps of the knowledge. The desk study report is to compare findings to project aims.

Along with the Desk Study, prepare a georeferenced (using common zones) and time-referenced ground model, to investigate the movement of the seabed levels and the fault lines that run across the proposed location of the dam.

#### Residual risk after mitigation

The geotechnical and seismic findings are likely to have a significant impact on the design geometry and cross sections of the dam. Capturing those constraints early will reduce the residual risk to the project to low. However, designs dealing with these issues could increase costs and impact the benefit cost of the project.

### 6.1.2 Design Standards

#### Issue Description

Local design standards need to be enhanced based on best international practice. It is important for a project of such scale to meet best practice internationally.

#### Recommendations

Appropriate local and international design standards related to seismic design need to be confirmed in the Design Basis. Refer to Section 4.1.1, and the Inception Report for relevant design standards. Further work will need to be undertaken to develop the applicable codes based on the agreed classification of the structure.

#### Residual risk after mitigation

The Design Brief aim is to provide a framework to which the future design work is conducted. There is a low residual risk that in meeting all the criteria set out in the Brief, the project becomes unfeasible from technical or cost/benefit perspective.

### **6.1.3 Dynamic Seabed**

#### Issue Description

From the surveys provided it is clear that the bed of the inner and outer gulf is a very active environment with constantly changing levels. Differences of up to 30m in levels appear to have developed over the few years between successive bathymetry and borehole location surveys. This means that geotechnical investigation of the soils within 30m of mean sea level provides only a ‘snapshot in time’.

Sand ridge and bar migration will result in variable bed level, density, and strength development in the shallow foundation soils until the dam construction is complete. The proposed earthfill dam will have large volume of material below MSL. The shifting nature of the seafloor will add complexity in the calculation of dam material volumes and reduce their certainty. Consequently, dam construction cost and programme are going to unpredictable

#### Recommendations

A study of seafloor morphology and scour should be undertaken to understand how the seabed changes with time. This may include on site monitoring work over a period, to develop an understanding of the rate of change and typical patterns.

#### Residual risk after mitigation

With improved understanding of the material migration and scour, there will be residual uncertainty about the exact floor state at the time of construction. As the construction commences, the scour patterns will change with the estuary closure narrowing.

### **6.1.4 Site -specific study on Seismic Hazards**

#### Issue Description

No site-specific seismic hazard assessment has been carried out to define the design criteria. It is expected that this should be a site specific probabilistic seismic hazard assessment (PSHA). This should define the Safety Evaluation Earthquake (SEE), the Operating Basis Earthquake (OBE) and an earthquake to be considered during the construction phase (CLE). The potential of Reservoir Triggered Earthquakes (RTE) should also be considered.

### Recommendations

A site-specific seismic hazard assessment should be prepared. This seismic hazard study must be consistent with the performance requirements set out in the Design Brief and in accordance with the design standards for the relevant hazard classification for the dam.

### Residual risk after mitigation

The updated seismic study would influence the design of the dam.

## **6.1.5 Liquefaction**

### Issue Description

The current liquefaction assessment is not based on a site-specific seismic risk assessment. There are thick deposits of silty sand at the base of the estuary, and dredged material from the estuary base is proposed to make up the majority of the dam embankment. Silty sand materials are highly susceptible to liquefaction in a saturated environment.

### Recommendations

The liquefaction assessment should be updated once the site-specific seismic hazard assessment has been completed, for SSE, OBE, CLE and RTE.

### Residual risk after mitigation

The liquefaction assessment will impact on dam geometry and cross sections as well as the material selection. There is a medium residual risk that the engineering solution to mitigate the liquefaction risk are going to add cost and complexity to the design and construction of the dam.

## **6.1.6 Tsunami**

### Issue description

The tsunami hazard assessment report by NGRI does not consider other tsunami sources (volcanoes, landslides, meteorological etc.). Furthermore, based on an initial review, the proposed model does not appear to match observed events such as the 1945 Makran tsunami which had a maximum water height of 17m at Pasni, Pakistan. Additionally, the NOAA tsunami database indicates 2m water height in Mumbai for the 1945 event, which is much higher than the values calculated for Scenario 1 in the NGRI report.

### Recommendations

The tsunami hazard assessment should be updated to include a range of possible sources. The model should be verified and calibrated against previous known events in the region.

### Residual risk after mitigation

Once the tsunami hazard is understood, the required design modifications to prevent serious damage to the dam could increase costs and significantly decrease the benefit cost ratio.

### 6.1.7 Unknown Faulting

#### Issue description

It is not clear if all regional and local faults, and the evidence of their seismic activity, have been identified. Existing records of faults may not be sufficient to identify all faults, with some faults not yet identified.

#### Recommendations

A regional and local fault mapping exercise should be undertaken. This should feed into the site specific seismic hazard assessment, collating evidence for fault activity. New geophysical studies should examine whether there are any unknown faults under the proposed alignment.

#### Residual risk after mitigation

New faults discovered by the fault mapping and new information about existing faults with relevance to the dam will have an impact on the design which will need to mitigate against the potential hazards. This has the potential to increase costs and reduce the benefit cost ratio.

## 6.2 Remaining High Risk Gaps

### 6.2.1 COMACOE zones and data

The COMACOE Geo-Technical Investigation Report (Reported April 2021) although called final appears to require further review. For example, the report is divided into 7 Zones but appears to be missing all of the borehole and in-situ test data (Appendix B and C have information from a different zone) from Zone 1. The report should be finalised, and all data included.

### 6.2.2 Variance in ground investigation zones

The report by COMACOE is divided into 7 Zones, however the IITM assessment of the data reduces this to 6 Zones. A consistent referencing system needs to be established to avoid confusion.

### 6.2.3 Rim stability/Landslides

The potential for mass movement hazard needs to be assessed in relation to the reservoir basin. Risks of mass movements in the reservoir rim area must be evaluated and mitigation measures may be needed. The stability and structural integrity of the reservoir rim upstream of the structure must be evaluated for all potential loading conditions whether hydrologic, earthquake, or other hazards, man-made or natural. Reservoir rim instability may lead to poor water quality, blockage of channels and structures and waves which may threaten reservoir users and the

dam structure. Risks of mass movements in the reservoir rim area must be evaluated and mitigation measures may be needed.

#### **6.2.4 Basin leakage**

Basin leakage during impoundment occurs when infiltration of reservoir water is occurring through the surrounding and underlying soils, which is problematic if seepage occurs beneath the dam retention structures and can cause other erosional issues for the reservoir area. The permeability, hydraulic conductivity, and porosity of the soils supporting the reservoir volume should be evaluated. Erosion potential and corrosivity of the foundation soils should be evaluated.

#### **6.2.5 A study of alternative construction options**

Alternative construction methods (other than mass filling) for part of the structure should be considered. For example the use of caissons of known geometry that can be floated out and ballasted into position on a seafloor prepared by suction dredger or similar. Such options could significantly reduce the quantity of mass fill required.

#### **6.2.6 Seismic performance criteria**

No seismic performance criteria have been defined relating to the operational and safety requirements of the Kalpasar dam and the linear infrastructure (rail, highway, communication, etc) that it will carry. The seismic security and the operational resilience of the various installations require evaluation and stakeholder agreement. It should be noted that due to the nature of the project, there are no current Indian or international codes which adequately define these requirements. The performance criteria should be both qualitative and quantitative (e.g. acceptable settlement and/or displacement limits). This should define performance requirements for both operational (serviceability) and safety (ultimate) requirements which must consider the multi-functional aspects of the project. See Tables 3-1 & 3-2 in the Inception report for some suggested high level seismic criteria.

#### **6.2.7 Site response analyses**

No site-specific site response analyses have been carried out. These studies model the influence of the near-surface layers on earthquake ground motions. The near-surface layers act as a filter that amplify/de-amplify the seismic waves coming from the earthquake source. The site response studies should account for the variation in geology along the length of the dam, the impact of scour, the presence of mobile soils and the impact of the dam on the in-situ stresses. A series of site response analyses should be carried out along the length of the dam at regular intervals. Intervals should be selected based on the variation of the underlying geology.

## 7 D –Environmental Review

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### 7.1 Introduction

This part of the gap analysis has considered the treatment of marine and estuary environment issues and wider terrestrial biodiversity issues in the documents provided, in the context of best practice Environmental and Social Impact Assessment (ESIA) processes. The review has focussed on a gap analysis of risks associated with the main environmental assessment topic areas, and the interaction of these risks with the overall project business case.

The gap analysis has therefore assessed whether the main environmental risks from the project are being appropriately considered and managed. The analysis also considers whether the environmental impact studies conducted to date will provide the required evidence and quality of assessment in accordance with national and international standards and good practice.

### 7.2 Context for the review of marine, estuary and wider environmental issues

The development and operation of the Kalpasar barrage has the potential for significant impacts on the local estuarine environment and beyond. To comply with national and international practice in ESIA, it is essential therefore that all major environmental impacts and costs are scoped and assessed and that alternative options that may satisfy the project aims are fully considered.

The review and gap analysis has therefore considered whether the existing assessment materials encompass the major risks posed by an estuarine barrage. Examples of the likely main issues can be found in the HR Wallingford publication ‘Guidelines for the Assessment and Planning of Estuarine Barrages’ (Burt and Rees, 2001). That said, the issues and assessment of marine and estuary impacts for the Kalpasar project also need to be grounded in the local and regional environmental conditions at the site. These include:

- Effects on river and estuary hydrodynamics, morphology and flood risk;
- Biodiversity (including terrestrial habitats) effects from the footprint of the barrage structures and associated infrastructure, the water impoundment and water level, quality changes inside and outside the barrage and potential dredging areas required for dam material fill;
- Climate implications from resource usage and energy consumption during construction and operation, as well as the potential to be affected by, and/or act in combination with, climatic changes associated with climate change (e.g. extreme weather events or increased tidal ranges);
- Direct and indirect displacement of people with estuary-based livelihoods within and outside the barrage area (see also Workstream E);

- The development of practical and effective measures to mitigate and compensate for adverse physical, natural and human effects.

In addition, this component of the gap analysis has considered the potential acceptability of the assessment information (with regard to marine and estuary effects) and the residual risks with respect to international institutions such as the Asian Development Bank (ADB). This has been done by reference to the ADB's Safeguard Policy Statement (SPS).

The SPS aims to promote sustainability of project outcomes by protecting the environment and people from a project's potential adverse impacts by avoiding adverse impacts of projects on the environment and affected people, where possible; minimising, mitigating, and/or compensating for adverse project impacts on the environment and affected people when avoidance is not possible.

## 7.3 Key High-Risk Gaps

### 7.3.1 Scoping and integration of approach for delivery of environmental information

#### Issue Description:

The reports prepared to date demonstrate evidence of the technical ability to deliver the information required for the ESIA and business case, but are presently neither systematic in coverage (both spatially and temporally) nor well-integrated with other technical areas such as water quality.

Typically, this issue is addressed through the preparation of an ESIA scoping report. Whilst there is a scoping report already, it is not comprehensive across all topic areas and being issued in 2008 is not reflective of the scheme as currently proposed and is unlikely to adequately consider the current environmental conditions. In addition, apparent omissions within the scope of the ESIA studies to date include:

- The 2008 scoping report rightly identifies the impacts on flora, especially mangroves, as a key area of investigation. The scope should also consider the loss of other habitats such as saltmarsh and dunes, the conversion to sub-tidal (outside the barrage) as a result of sea level changes, and the impact of saltmarsh loss due to the implementation of compensatory mangrove habitat.
- The impacts arising from the secondary developments associated with the barrage are omitted, such as the effect of large increases in population density stimulated by the presence of the barrage on water quality and ecological receptors. This includes largescale plans of land cover change and intensification of agriculture, leading to increases in run-off and eutrophication.
- The 2008 scoping report also identifies the impacts on a wide range of fauna as a key area of investigation and resolution. Whilst detailed scoping recommendations are made for some areas, in others the analysis is very

superficial. This scoping needs to be updated with the latest project design, including all associated facilities and infrastructure. The required studies must include receptors such as marine mammals, sea turtles, avifauna, and intertidal benthos, as well as terrestrial species and habitats.

- The effects of displacement of people engaged in sectors linked to the marine environment including the saltpan, agriculture and fishery need to be properly scoped and displacement effects fully assessed and resolved (See also workstream E).

As well as the incomplete scoping of topics to be considered in the ESIA, there is an absence of clear integration of studies that must link to each other. Principally these are the assessments of changes to water levels, water quality and morphology that fit in workstream B, and their interaction with marine and estuary environment receptors in this workstream. There are then knock-on implications for Workstream E where resources utilised by people may be affected, e.g. fisheries, or freshwater resources outside the dam area.

#### Possible mitigation:

The ESIA studies should be systemically scoped across all relevant receptors in accordance with the EIA Notification, 2006; taking into account the studies that have been undertaken since 2008. The scoping should include the interaction of secondary effects between different receptors. For example, the effect of water quality on ecology, and then to assess the effects at the population level, and address them.

Furthermore, the scoping must be related to the latest project concept, and encompass cumulative effects from other planned and consented projects in the area, and any secondary effects from, for example, the population growth stimulated by this and other largescale schemes.

The scoping should address the need for a substantial increase in baseline data acquisition. This will include updating the datasets from previous surveys and extending it to include, for example, marine sediment sampling within and outside the barrage, and ecological survey of areas within associated developments for the scheme such as quarries and/or dredging areas.

The scoping process must include sufficient consultation with external stakeholders and be responsive to their requests for amendments to the assessment approach.

#### Residual risk after mitigation:

Scoping the terms of reference of ESIA studies is a widely adopted practice including in India. It should therefore be possible to undertake a satisfactory scoping exercise to address the risks identified above. Therefore, whilst the presently identified risks in this area are high, the residual risk can be feasibly reduced to a low level by an updated programme of scoping.

## **7.3.2 Technical gaps in baseline understanding**

### Issue Description:

The general deficiencies of the scoping process that has been conducted for the ESIA studies are presented in Section 7.3.1 above. This section of the gap analysis focusses on the technical limitations in baseline understanding that are of greatest importance to marine and estuary environmental risks.

There is limited baseline understanding of the soil conditions in the terrestrial and sub-tidal areas. Sampling has concentrated in a few areas and will need to extend to all relevant land/intertidal areas, with more focus on likely impact areas. This will inform the assessment of the interactions with water quality following barrage enclosure, especially salinisation and eutrophication effects. Work to address this issue will require an updated definition of the areas to be affected by the project.

There is also insufficient baseline understanding of the water quality conditions and inputs from feeder rivers. Sampling data for input rivers is available for 2009-2014, but seemingly limited to one year for the Gulf beyond some physical parameter measurements. Addressing this is essential to inform the assessment of the water quality changes arising from barrage enclosure, and the subsequent effect on ecological and social receptors. There is an indication that dredging will be required within the project. However, details are required on the dredging location in order to define the sampling programme of potentially contaminated sediments to be dredged for dam construction or land reclamation.

The present and future status of mangrove forests is one of the most important environmental risks arising from the scheme. There are a number of reasonably comprehensive reports describing mangrove forests in the project area and beyond. However, there are apparent inconsistencies. For example, there is reportedly an increase in mangrove cover over time, which is partially attributed to agencies efforts in reforestation. Satellite images used in the mapping do not seem to tally with the ground-truth assessment of mangrove forest density. This has a very important bearing on the impact assessment and compensation requirement. Updated survey and subsequent analysis will need to be conducted with up-to-date satellite images.

The reports note the presence of areas of halo-tolerant and saline plants such as *Salicornia brachiata*, which is a saltmarsh species. Saltmarsh is typically of high ecological value and delivers many ecosystem services. Assessment should therefore be made of the presence and density of saltmarsh, as well as the presence of mangrove. The reports mention the presence of dunes and associated dune flora, however this is also not surveyed or mapped.

Whilst the baseline information relating to mangrove forests has been studied in some detail, the descriptions of the terrestrial and aquatic fauna (animals) is largely lacking. The exception being a high-level review of the fisheries of the Gulf of Khambhat but even this is insufficient for a sufficient assessment.

A more detailed assessment of the fisheries and aquatic ecology baseline, in terms of its biodiversity value (as opposed to a social resource), is required to understand the conservation value of the estuary itself and its importance as a migration route for species such as hilsa. It is recommended that the value of faunal species / assemblages (terrestrial and aquatic) and habitats are assessed according international Lenders standards for biodiversity (i.e. the determination of potential Critical/Natural Habitat, as part of a formal Critical Habitat Assessment). This

baseline analysis will inform the Project mitigation requirements (i.e. “no net loss” or “net gain” requirements for natural and critical habitat respectively).

There is very limited information on avifauna which is mostly derived from secondary data and some bird data from a few survey sites, which will not represent the majority of the impacted area. There is only limited sampling of intertidal and marine benthos, which will provide a food resource for avifauna. Without mitigation this alone is considered high risk because the intertidal areas are understood to be foraging and stop-over areas for internationally important bird species. An assessment of the intertidal areas as a feeding resource will be required and assessment of increased flight times for migratory birds, as a result of the intertidal area loss following dam closure.

There is a lack of information on marine turtle nesting areas and the use of the Gulf and surrounding area for marine mammals.

Overall, there is insufficient baseline for a full assessment of likely change in faunal community composition following the closure of the barrage and the resulting alterations to communities present.

#### Possible mitigation:

The mitigation of this risk is linked to the scoping recommendations above, as the required baseline studies can be addressed within a renewed scoping process. However, with respect to the technical robustness of the baseline, the following main recommendations are made.

A comprehensive sampling programme of the Gulf of Khambat, feeder rivers and adjacent land areas is essential. This should consider physical and chemical quality of the water and soils and take into account seasonal variability of the former. The existing sampling can be used to guide the developed of a suitable sampling programme.

Detailed habitats survey is also needed for all potentially affected areas (including areas outside the barrage affected by sea level changes), covering the type, condition and extent of habitats. It is recommended that data is collected in such a way that the value of baseline habitats (terrestrial and aquatic) can be assessed according to international standards for biodiversity (i.e., the determination of modified, natural or critical habitat, as defined by ADB / IFC biodiversity standards, as part of formal Critical Habitat Assessment). This should include an assessment of whether the estuary qualifies as Critical Habitat for hilsa and/or other migratory fish species.

This baseline habitat analysis will inform the mitigation requirements (i.e., “no net loss” or “net gain” requirement), as well as the impact assessment. This will require updated satellite images, and additional ground-based surveys and ground truthing of the remote sensing land-cover assessment.

Updating the mangrove data should include mapping and assessment of saltmarsh and dunes (and associated fauna) in the direct and indirect impact zones. Given the

importance of mangrove planting as mitigation, the project also needs a review of previous attempts to reforest mangroves in areas close to the project site.

A wide range of detailed faunal surveys (and complementary desk study research) are needed for all potentially affected areas, including assessment of the abundance and diversity of fauna present and consideration of seasonal variability. These will need to include seasonal avifauna survey of intertidal areas within the barrage area, and use of intertidal outside of the barrage closure and further afield that will be affected by tidal amplitude increases, predicted as a result of the closure. This should link in with assessment of the intertidal area as a food resource for birds, both inside and outside of the closure area. There is also a need to include baseline surveys of turtle nesting areas as well as use of the Gulf of Khambhat by marine mammals.

#### Residual risk after mitigation:

The baseline studies outlined here, which will need to be confirmed during the updated scoping stage, should not present any major technical obstacles provided they are scoped, planned and resourced properly. Owing to the need for surveys across multiple seasons and possibly years, these surveys will have an impact on the production times for the ESIA. Nonetheless, the residual risk to the project overall is considered low.

### **7.3.3 Limitations in the Impact Assessments**

#### Issue Description:

Many of the limitations to the impact assessments that have been conducted to date can be linked back to the absence of a systematic scoping exercise and the issues identified above regarding the baseline requirement. Indeed, it is not clear from the available reports how the recommendations of the Scoping Report (2008) have been taken forward since then, noting the reservations of the MoEF, expressed in 2010.

The mangrove study quantifies the areas at risk, and is updated in the GES synopsis report. This appears to be based on the scheme as foreseen in c. 2010, and needs to be updated. As noted above, there is no consideration of saltmarsh or dune system effects.

The fisheries impact analysis is high-level and needs to be comprehensively updated and expanded based on detailed surveys and desk study screening. It needs to consider the latest proposed scheme, including the implications of the Narmada River diversion for hilsa (and other migratory fish/invertebrates) and their migration routes. It should be noted that there is the potential for significant impacts/loss of estuarine habitats used by these species, which likely qualify as natural/critical habitat under international biodiversity criteria. Typically, mitigation is required to demonstrate “no net loss” or “net gain” for natural and critical habitats respectively in order to secure international finance.

Likewise, other faunal effects such as upon marine mammals, avifauna and marine benthos are still not fully assessed, taking into account the (as yet not completely addressed) effects on the estuary physical regime.

A study in 2016 on the impacts of the project on water levels at nearby ports identifies effects on water levels, currents and bedload sediment. However, these are not evaluated in terms of impacts for the port operations. A separate study in 2018 appears to reach contradictory findings that need to be reconciled. Neither report considers the water quality effects within the barrage (except for salinity), with respect to eutrophication, accumulation of contaminants and related ecological effects for example. Contaminant accumulation may pose risks to the food chain if the impoundment is used for fish production.

There is a residual risk concerning the likely increased salinity of water sources to the south of the barrage as a result of alterations in flow and increases in tidal amplitude. This may affect the coastal habitat through submergence or salinity ingress in coastal aquifers, with subsequent human and ecological implications. There will also need to be further assessment of this knock-on increase in water levels and potential decrease in water quality outside the barrage area. Conversely, the reduction in salinity inside the barrage area may lead to an increase in waterborne disease vectors that will need to be assessed and mitigated.

The impacts assessments are focussed mainly on the physical footprint of the scheme but need to be integrated with the effects on parameters such as water quality and levels, and take into account secondary, indirect and cumulative effects.

#### Possible mitigation:

Full examination is needed of the direct, indirect, secondary and cumulative effects, informed by a comprehensive baseline, and supported by validated modelling of the effects on estuary water levels and morphology in and outside the barrage. It is critical that the assessment of ecological effects, for example, is informed by a sufficient assessment of effects on water quality. The assessment must consider the scheme as presently proposed, rather than previous iterations.

The assessment approach must be validated through scoping consultations with the regulatory authorities.

#### Residual risk after mitigation:

The delivery of a comprehensive technical assessment, which will need to be confirmed during the updated scoping stage, will be a major undertaking but should not present any technical obstacles provided it is resourced properly. However, once the assessment is updated, there remains the risk that effects on Critical Habitats for mangrove forest, migratory fish and birds, may remain significant unless adequate mitigation and compensation measures can be found. For this reason, the residual risk to the project overall is considered medium.

### **7.3.4 Environmental Mitigation and Compensation Strategy**

#### Issue Description:

A project of this scale will lead to adverse effects requiring mitigation or compensation. Reaching consensus on the mitigation and compensation requirements relies on a robust and evidence-based assessment, using the steps outlined in the sections above. As this is presently lacking, there are substantial

gaps in the understanding of what level of mitigation and compensation measures are required. For example, the measures that will be required to mitigate the likely significant impacts on fisheries, avifauna, coastal habitats (other than mangrove) and marine benthos are largely omitted at this point.

Thought is given to mangrove restoration and compensation, given the importance of this issue. These plans need to be updated in view of the latest proposed scheme. The potential areas for mitigation of mangrove loss will need to be assessed against a climate change model and assessed against alterations to coastal processes as a result of having the barrage in-place. This could alter conditions outside the barrage closure area (e.g., water levels) that may indirectly affect further areas of existing mangrove, and areas identified for potential mangrove mitigation.

All of the preferred mitigation approaches will need to be substantiated by evidence on their effectiveness, and for this reason a review of previous mangrove restoration programmes is recommended. The mangrove restoration areas will need to be selected so as to be sustainable in the long term and the impacts of the restoration programme may themselves have impacts that may require mitigation.

Notwithstanding the potential habitat losses, it is likely that the Project will need to implement mitigation to facilitate the free passage of migratory fish and invertebrate species if it is to demonstrate “no net loss” or “net gain” for these migratory species. The adverse effect of the barrage on fish/invertebrate passage is noted in the documentation, but mitigation to enable fish passage, such as a fish bypass channel is not discussed. It is noted that such mitigation will need to be informed by water availability and quality and currently it is uncertain if such a measure could be effective.

Detailed quantification of the type and extent of habitats that will be lost is essential to inform the mitigation requirement. It is therefore reiterated that new data is collected to ensure the value of baseline habitats (terrestrial and aquatic) can be assessed according to international standards for biodiversity.

The effects on water quality within the barrage have been an issue of concern from the outset of the project development. It is critical that plans are in place to improve the river water discharges behind the barrage, to mitigate these water quality effects. However, there is no clear evidence of any steps planned in this regard other than relocation of water waste discharges seaward of the barrage. This will have consequential impact upon the marine environment and further mitigation will be needed.

#### Possible mitigation:

A robust mitigation and compensation plan should be prepared, based on:

- Quantified and delineated descriptions of the impacts upon all relevant receptors (natural/critical habitat areas, faunal populations etc)
- Identification of the available mitigation approaches, adopting the mitigation hierarchy (avoid, minimise, reduce, compensate)
- Evaluation of the practicality and effectiveness of the available mitigation approaches, in the long term (e.g., mangrove restoration / fish passage)

- Consultation with regulatory authorities on the adequacy of these measures
- Incorporation of the technical and cost requirements of the preferred measures within the overall business case for the scheme.

#### Residual risk after mitigation:

The barrage will likely have large and wide-ranging impacts. The development of practical and effective long term mitigation measures is therefore an essential activity. However, the scale and nature of these likely effects have so far only been partially defined with respect to mangrove forests, and largely undefined in most other areas and habitats.

The development and agreement of these measures can only be progressed hand-in-hand with the preceding steps of the ESIA, and as outlined above there are significant gaps in these areas. There remains considerable uncertainty about the scale of the mitigation and compensation measures required, and their practicality and effectiveness. The full financial cost of these measures is therefore not fully identified.

In principle, the approaches outlined in this chapter to investigate these uncertainties are quite feasible, albeit time consuming and requiring adequate resources and expertise. These studies may however conclude that adequate measures to mitigate or compensate for effects upon natural/critical habitats cannot be delivered with certainty or are technically unfeasible. As the ability to deliver effective mitigation and compensation has cost and feasibility implications for the overall business case, but is presently not evidenced, this issue is considered a medium to high residual risk to the project.

### **7.3.5 Compliance with international funding requirements**

#### Issue Description:

International funders have policies that require the protection of the environment and people from a project's potential adverse impacts by avoiding adverse impacts where possible; and otherwise minimising, mitigating, and/or compensating for adverse project impacts on the environment and affected people when avoidance is not possible. Regardless of whether international funding will be needed, these policies provide a useful benchmark for the project.

By reference to the ADB's safeguard policies for example, as outlined above, many of the major impacts of the project still need to be fully assessed and addressed, including estuary physical regime, water quality, many ecological impacts (mangrove, fisheries etc), and waterborne disease vectors.

As there may be effects on marine and estuary resources and attributes utilised by the ports sector, agriculture, salt production and marine fishing, there is also a knock-on issue for direct and economic displacement of people - refer to Workstream E.

Once these effects have been properly quantified, measures also need to be put in place to address them. In terms of ecological effects, this will mean achieving a net gain in biodiversity.

Possible mitigation:

A comprehensive ESIA should be developed to international standards e.g. of the ADB, addressing all of the areas mentioned in the preceding sections of this chapter.

Residual risk after mitigation:

The production of the complete ESIA to a standard acceptable by international funders should, in principle, be possible. The expectation of funders will be that the mitigation and compensation measures are built into the business case, such as net gain for biodiversity.

However, at present and for the reasons stated in previous sections, there is presently low certainty that steps can be taken to address all of these requirements, especially with regard to the delivery of satisfactory mitigation and compensation. Therefore, this issue is considered a medium to high residual risk to the project.

### 7.3.6 Sustainable solution

Issue Description:

Looking at the project as a whole and its implications for the marine and estuary environment, there is no evidence that an evaluation has been made of the available options; and whether the currently proposed project is the most sustainable solution, in any respect other than the capacity to deliver a sufficient amount of water from the feeder-river systems.

To reach a degree of national and international acceptance, it is therefore recommended that an appraisal of the available options is made, by reference to the UN Sustainable Development Goals (SDGs). The SDGs are a comprehensive list of global goals integrating social, economic and environmental dimensions of development. These goals have been widely adopted as the benchmark for project legitimacy and appropriateness for financing.

Possible mitigation:

Conduct an objective 'fair basis' evaluation of whether this project represents the most sustainable approach to delivering project aims, by reference to the SDGs.

It is stressed that the alternative options considered should be capable of delivering the currently envisaged project aims.

Residual risk after mitigation:

There is no reason in principle why such an option evaluation cannot be conducted. However, in the absence of such a review there is high uncertainty that the outcome would be that this project represents the most sustainable approach. This issue is therefore considered high risk.

## 7.4 Remaining high risk gaps

There are no other high-risk gaps that are not already described in this chapter.

## 8 E - Socio-Economic Impacts

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### 8.1 Key High-Risk Gaps

#### 8.1.1 Comprehensive Integrated Social Impact Assessment (SIA)

##### Issue Description:

A comprehensive integrated Social Impact Assessment (SIA) has not been carried out. Although several studies assess different social aspects of the project, an integrated assessment with a common objective is lacking. Being a complex project, it has many (sub) components that may lead to changes in people's livelihoods and living conditions. These potential negative and positive impacts and mitigation measures according to the mitigation hierarchy are not in place.

##### Possible mitigation:

SIA should be performed. Past, present and future impacts and risks should be identified. The risks and impacts should be presented for each phase of the project (construction, transition, operation). As a minimum, the following items should be included in SIA:

- Direct or indirect impacts occurring at the project site or in the wider area of influence. Indirect impacts include the side effects of the project given the complexity of the social processes and the interrelationships between the social components.
- Analysis of alternatives.
- Immediate triggered adverse impacts as well as longer term impacts.
- Cumulative effects that occur through interaction with other developments at the project site (as well as in the wider influence area).
- Stakeholder mapping

In addition, the assessment should consider the principles of social sustainability and the Sustainable Development Goals.

##### Residual risk after mitigation:

If the possible mitigation measures were successfully implemented, most of the risks and impacts could be avoided and mitigated. However, in the short and medium term, impacts on the livelihoods of certain groups (e.g. salt collectors, simple fishermen) may be unavoidable. Therefore, the project should identify livelihood sources and highlight basic living conditions. Consistent social monitoring is critical to track changes. The complexity of the project may lead to indirect impoverishment risks, which should be mitigated by introducing livelihood restoration programs and supporting adaptation to the new socio-ecological environment.

## 8.1.2 Receptors Identification and Engagement

### Issue Description:

Potential sensitive social receptors haven't been identified or weakly presented. Particularly, the reports are silent on assessment of impacts on indigenous people, nearby businesses, vulnerable groups, cultural facilities.

### Possible mitigation:

In general, it is necessary to map out the stakeholders and create a plan for engaging them at different stages of the project. The views and preferences of stakeholders (especially key stakeholders) should be incorporated into project planning and sub-component preparation.

An Indigenous Peoples Assessment, which should identify potential impacts and risks, needs to be undertaken. Perceived risks and preferred mitigation measures should be assessed.

### Residual risk after mitigation:

Generally, it is necessary to map the stakeholders and create a plan to involve them in the various stages of the project. The views and preferences of stakeholders (especially key stakeholders) should inform project planning and sub-component preparation, and an Indigenous Peoples Assessment needs to be undertaken that identifies potential impacts and risks. Perceived risks and preferred mitigation measures should be assessed.

Indigenous peoples and marginalized groups should be monitored and the project must be prepared to take appropriate corrective actions.

## 8.1.3 No Gender Assessment

### Issue description

No gender assessment has been carried out. Potential negative impacts of the project from a gender perspective and ways to incorporate gender benefits were not discussed. Beyond avoiding negative effects, a gender impact assessment can also be used in a more transformative way as a tool for defining gender equality objectives and formulating the policy to proactively promote gender equality.

### Possible mitigation

A gender assessment should be conducted, and a Gender Action Plan (GAP) should be prepared. Specific gender elements should also be included in the project for better project implementation.

The objectives of the GAP are:

- Promoting women's participation in the project;
- Maximizing women's access to project benefits;
- Minimizing social vulnerability of women arising due to the project activities like securing land, security concerns during construction

### Residual risk after mitigation

Due to the role of women in society or other socio-structural barriers, women may not be able to reap the benefits of the project if they are not encouraged or included in targeted assistance. Women's voices should be heard at all stages of the project through focus group discussions, individual interviews, confidential grievance mechanisms, etc.

## **8.1.4 No Labour Assessment**

### Issue description

No assessment of labour impacts has been undertaken (e.g. risks of labour influx, measures to avoid child labour, forced labour, possible loss of jobs), etc. The nature of the project may lead to labour migration and structural changes in the labour market, as well as influence the supply and demand situation.

### Possible mitigation

To meet international donor requirements and align with good international practise, a work assessment and specific action plan are critical. Such a plan should also include a work- specific (occupational related) grievance mechanism.

### Residual risk after mitigation:

Risks can be mitigated if appropriate plans are made and implemented. However, continuous monitoring is required throughout the project. During the construction phase, occupational health and safety should be the focus. During the transition and operational phase, residual impacts could occur in the form of structural changes in the labour market and transition to a new employment situation in the project area.

## **8.1.5 Archaeology and Cultural Heritage Impact assessment**

### Issue description

The Reports are silent about the risks & impacts on archaeology and cultural heritage.

### Possible mitigation

SIA should include baseline, potential impacts and risks to archaeology and cultural heritage. Relevant mitigation measures to be identified.

### Residual risk after mitigation:

A significant portion of the risks can be avoided through alternative project designs/elements. However, the remaining risks, such as restricting access to cultural heritage sites can be mitigated by working closely with the relevant key stakeholders. Impacts to culturally and architecturally significant sites may delay project activities by facing opposition groups and/or regulatory requirements.

## 8.1.6 International Standards

### Issue description

Impacts and risks of land acquisition and resettlement, potential loss of access to natural resources, associated monitoring and reporting requirements are lacking. International standards and performance requirements should be followed in identifying risks and preparing appropriate plans.

### Possible mitigation

Impacts and risks of land acquisition and resettlement, potential loss of access to natural resources, associated monitoring and reporting requirements are not present. International standards and performance requirements should be followed in identifying risks and preparing appropriate plans.

### Residual risk after mitigation:

Land acquisition and loss of access to natural resources (fishing sites, salt collection points, access to the open sea) can have a negative impact on livelihoods and lead to impoverishment risks. Continuous monitoring is essential. In addition, the project should make use of external monitoring (preferably after 1 and 3 years) to assess the impact of such plans and determine the necessary corrective measures.

## 9 F - Transport cost benefit analysis

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### 9.1 Key High Risk Gaps

#### 9.1.1 Transport Report

##### Issue Description:

A Traffic Assessment has been provided, focusing on road traffic only. No analysis of a multi-modal transport baseline, forecast flows, opportunities and impacts has been undertaken.

##### Possible mitigation:

Develop a comprehensive multi-modal Transport Assessment and baseline.

A Transport Business Case for Investment Report should also be produced, containing the following information:

- Strategic Case:
  - Strategic context
  - Organisational overview
  - Business strategy and aims
  - Other relevant strategies
  - The Case for Change

- Spending objectives
  - Existing arrangements
  - Business needs – current and future
  - Potential scope and service requirements
  - Main benefits and risks
  - Constraints and dependencies
- Economic Case:
    - Critical Success factors
    - Long-listed options
    - Preferred Way Forward
    - Shortlisted options (including the “Business As Usual (BAU)” and ‘do minimum’)
    - NPSC/NPSV findings
    - Benefits appraisal
    - Risk assessment
    - Sensitivity analysis

The above should be integrated into the wider Financial, Commercial and Management for the scheme.

Residual risk after mitigation:

By developing a more in-depth understanding of the regional transport needs and impacts and opportunities that Kalpasar would bring to the region, it is possible to strengthen the benefits ration in the Cost-Benefit Assessment for the overall project.

## 9.1.2 Outdated Traffic Assessment

Issue Description:

The Traffic Assessment was undertaken in October 2013. Any data, references and guidance documents detailed within the report may no longer be pertinent. The traffic assessment only refers to vehicle users but there is no assessment of rail use.

Section 3.6 considers the potential impacts of several major infrastructure projects on the proposed Kalpasar Dam. Since the production of the 2013 transport report, a number of these projects (or phases of these projects) have become operational. These projects may also have changed in scale, detail etc. since production of the transport report.

Possible mitigation:

Update the Traffic Assessment, ideally to a 2019 baseline to represent the latest pre-COVID-19 travel patterns. Include assessment of present and potential rail users. If no directly applicable data is available ( as there is currently limited rail connectivity in the region, include an assessment of similar regions and impacts of similar connectivity projects.

#### Residual risk after mitigation:

The impact of COVID-19 on long-term travel behaviour is currently unknown. Any future forecasts undertaken at this time may therefore not be representative of future travel patterns post-pandemic. It is recommended that multiple future scenarios are considered in order to fully assess different potential levels of travel demand and subsequent impacts.

Due to the Traffic Assessment being undertaken in 2013, a number of datasets, references and guidance documents detailed within the report are outdated, including the following:

- Traffic surveys;
- Industry trip generation surveys;
- Toll revenue data;
- Willingness to pay surveys;
- Socio-economic data; and
- Traffic growth rates.

Similarly, the report considers potential cumulative impacts of several major infrastructure projects. The status of these projects will have changed since the original report was produced, and additional major projects may have arisen. The subsequent impacts of these changes will need to be considered.

### **9.1.3 Economic Viability & Strategic Case**

#### Issue Description

The transport crossing has been assessed in terms of economic costs and benefits over a 40 year horizon, discounted back to give an Expected Investment Rate of Return (EIRR), which at the time of analysis needed to be 12% to pass the Government of India and World Bank criteria for investment. The 2013 study, with a price base of 2010, concluded that the transport crossing is a viable investment with the lowest EIRR of all scenarios tested being 59.84%.

However, the economic viability of the new transport corridors created by Kalpasar was not assessed for the full project life. The costs included capital construction estimates, assuming a 5 year construction duration after completion of the dam, with a 20% spend each year to completion. Transport forecasts were projected 40 years into the future and capacity requirements checked against the proposed 8 lanes. However, no projections or checks on capacity past 40years were reported.

The capital costs included are for the road surfacing only on top of the existing dam. This most likely underestimates the costs since the dam cross section and crest

height will have to be increased due to safety requirements for the road; these costs were not included.

Similarly the O&M costs include for maintenance of the road surface and operation of the toll plaza only; no provision is made for the maintenance of the dam in terms of transport links.

### Recommendations

Develop a Transport Business Case for Investment Report – as described in Section 9.1.1

Integrate the above into the wider scheme Financial, Commercial and Management for the scheme as a whole.

### Residual Risk after Mitigation

The economic case for the transport link may not be sufficient to support the construction of the dam itself, but it can act to support the overall Cost-Benefit Analysis and Project Business Case.

## **9.1.4 Risk Assessment**

### Issue Description

No risk analysis has been undertaken on the traffic data analysis or the economic value assessment. The project risk, including data and modelling uncertainties in the predicted demand and costs, should be identified and quantified. A proposed mitigation strategy should be developed following the eliminate-reduce-mitigate hierarchy approach.

### Recommendation

Undertake a full Risk Assessment - covering Transport, rather than just traffic, and propose mitigation strategies.

### Residual Risk After Mitigation

The uncertainty around the business case will be reduced but there is no guarantee that the business case will still be viable.

## **9.1.5 Construction Traffic**

### Issue Description:

At present there is no construction development plan or finalised estimates for the quantities of materials required. No assessment has been undertaken of the forecast construction traffic. The impact on local infrastructure during the construction duration has not been assessed. A project of the scale of Kalpasar can considerably increase the strain on local infrastructure.

### Recommendation:

Develop a Construction Traffic Management Plan. Assess local existing infrastructure and consider developing new capacity where required.

### Residual risk after mitigation:

Potential significant adverse impacts arising from construction traffic. However, these would be expected to be sufficiently mitigated through the implementation of the Construction Traffic Management Plan.

## 10 Conclusion on gaps

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The Kalpasar project feasibility has been studied over the past 40 years from various perspectives, such as the technical solution of the dam to the environmental impacts. Data and knowledge have been developed in different levels of detail. The reports and studies in the scope for this Gap Analysis were reviewed by each work stream for their relevance and quality, within the framework set out in the Inception Report.

After the completion of the Gap Analysis by Arup, it was concluded that there are several overarching themes across the gaps identified across all workstreams. Those are summarised below.

- There is lack of clarity on the definition on the Project Aims and Needs, Project Design Brief, Design Limit States and Design Standards
- There is not appeared to be any design integration between the different studies to produce a single coherent design. There is lack of continuity between reports, and there is lack of reference to the project objectives.
- There is lack of clarity of how project decisions thus far have been made and different options evaluated
- Many of the studies provided are out of date and would need updating with most up-to-date available data and currently proposed alignment
- There is no one database or an information model collating and comparing the available data (from carried out surveys) for the existing site and the proposed scheme.
- There is little assessment done on the stakeholders and receptors for the scheme. There is no clarity if any engagement with the potential stakeholders have been made.
- There is little information on how the scheme would impact the wider region and how that affects the region development plans and vision
- There is no up to date analysis of the Costs and Benefits of the Project.

Recommendations and mitigations have been made for addressing the identified gaps. While addressing the gaps will reduce the overall project risk, some of the identified issues, even after mitigation, have the potential to lead to significant cost and time impacts on the project and put the feasibility under review.

## 11 Timelines for gap closure

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The Gap Analysis identified 102 High Risk Gaps, 88 Medium Risks Gaps and 7 Low Risks Gaps, split across six Workstreams, namely Dam Engineering; Estuary Water Management and Quality; Geotechnics, Geology and Seismology; Environmental Review, Socio-Economic Impacts and Transport Cost Benefit.

The client has asked for guidance on the timelines to close the gaps, and specifically if the gaps need to be closed prior to the submission of the Detailed Project Report (DPR).

It should be noted that to reduce the uncertainty with investment decisions taken at DPR stage, and reduce the associated risks (which include costs), all gaps should be closed prior to DPR submission. However, noting that this may not be practical, we have treated the gaps in two ways:

- Key gaps that are fundamental and can jeopardise the feasibility of the scheme; referred to as “Feasibility Key Gaps” in the risk matrix
- Key gaps that significantly increase the uncertainty and carry a risk of increased costs, complexity or programme if not closed at DPR stage; referred to as “Increased Risk Key Gaps” in the risk matrix

In this section, we have reported on the feasibility key gaps. We have grouped together sections A (Dam Engineering), B (Estuary Water Management & Quality) and C (Geotechnics/Geology and Seismology) as “Technical”. We have reported on D (Environmental) and E (Social) separately.

The gap analysis matrix has been updated for the feasibility key gaps and some of the increased risk key gaps to confirm the timeline for addressing the gaps.

### 11.1 Technical (sections A, B, and C)

The following feasibility key gaps are fundamental and can jeopardise the feasibility of the scheme if not addressed. They should therefore be closed before submission of the DPR.

#### 11.1.1 Water Availability and Integrated Operations Plan

Throughout the document provided to Arup for review, not enough evidence was found to demonstrate the reliability of the water supply for the Kalpasar Reservoir. Impacts of seasonality, climate change and operations of other dams in the Kalpasar catchment have not been investigated in detail. There have not been updated forecasts for the future demands for the supply from Kalpasar. An integrated catchment operation plan and long term (20 years+) simulation of the scheme is needed to establish the reliability of the dam according to the DPR

guidance. In Addition, very few details have been provided on the Narmada diversion canal which will provide the main source of water for the dam.

### 11.1.2 Constructability

Not enough detail was provided for methodology and construction sequence to evidence the feasibility of the scheme. No outline proposals were found for some of the key technical challenges for the scheme such as, but not limited to, the closure construction, the deep-water-flushing sluices, for stability of the dam, the interfaces between the different sections of the dam in both the permanent and temporary cases. The technical solutions need to be quantified and costed and associated constructability risks analysed to prove that scheme is technically feasible prior to submitting DPR. No updated estimates on material quantities and required qualities have been provided, neither potential material sources have been identified.

### 11.1.3 Cost Benefit Analysis

No outline masterplan showing the scheme in its entirety has been provided, making the assessment of the associated capital costs and risks unclear. An integrated assessment on the consequences from the scheme construction was also not provided. The receptors of both benefits and negative impacts from the scheme need to be identified and mapped before the completion of DPR, as well as any potential mitigation measures outlined and costed. For this baseline risk assessment to be made, the impact of water levels on receptors upstream and downstream of the dam needs to be fully understood. Once the impacts to receptors are understood, mitigations will need to be considered and costs to implement them estimated and included in the cost benefit analysis.. Receptors include and are not limited to, local population, infrastructure, existing businesses, and environmental assets This is essential to provide a complete cost-benefit assessment and to prove the business case for national and international investors.

## 11.2 Environmental (section D)

### 11.2.1 Requirement For Up to Date Data

The updated Guidelines For Submission, Appraisal And Acceptance Of Irrigation And Multipurpose Projects (CWC, 2017), set out what environmental considerations and evaluations are required for projects such as the Kalpasar dam. The guidelines provide details of the process to follow from project proposal, to creation of the DPR and associated approvals.

Section 1.2 of CWC (2017) states that ... The project proposal is examined and if found acceptable, CWC conveys 'In-Principle' consent to the State Government for preparation of Detailed Project Report (DPR). Thereafter, DPR is prepared with up-to-date cost and simultaneously the Project Authorities process and obtain

necessary clearances of the Ministry of Environment & Forests in respect of Environment Impact Assessment and Forest area being diverted.

As such, there is a requirement for the DPR to be prepared with up-to-date information and have the associated clearances, supported by an EIA, in place.

Although there is no definition of what up-to-date is, from an ecological perspective, this in our view is expected to include data collected within the last 3 years.

## 11.2.2 Requirement for Comprehensive Information on Ecological Impacts

### The guidance

The updated guidance (CWC, 2017) goes on to state regarding the DPR in section 4.4 that ... Detailed Project Report (DPR) shall be prepared in accordance with applicable Indian Standards and as per the latest "Guidelines for preparation of Detailed Project Reports of Irrigation and Multipurpose Projects" issued by Govt. of India, Ministry of Water Resources, RD & GR (MoWR, 2010), after detailed surveys and investigations. It must be ensured that duly completed check-list, salient features and all relevant details as well as location map, Index map showing command area and canal network, annexures etc. as required by the aforesaid MoWR, RD & GR Guidelines are contained in the report and estimates are comprehensive as well as up-to-date in accordance with the existing Guidelines.

In the 2010 report (MoWR, 2010), Section XXIII (page 16) 134 states that there is a requirement, with respect to the ecological aspects, that a DRP is produced that includes information to satisfy:

- (a) Is the area likely to have any of the following environmental and ecological problems due to the altered surface water pattern? If yes, whether preventive measures have been discussed?
  - (i) Excessive sedimentation of the reservoir and the upper reaches of the river its tributaries tailing into reservoir
  - (ii) water logging, salinity/alkalinity
  - (iii) Quality of surface and ground water
  - (iv) Ground water recharge
  - (v) Health hazards, water borne diseases, industrial pollutants, etc
  - (vi) Submergence of important mineral deposits
  - (vii) Submergence of monuments/archaeological sites
  - (viii) Fish culture and aquatic life
  - (ix) Plant life (flora)
  - (x) Wild life

- (xi) Migratory birds
- (xii) National parks and sanctuaries
- (xiii) Seismicity due to filling of reservoir
- (xiv) Likely change in the regime of the river
- (xv) Any other

(b) Have the environmental and forest clearances from MOE&F been obtained? If not, what is status thereof?

### **The available ecological data**

From a review of the current ecological data that is available, there is the potential for environmental and ecological problems that may arise due to the Kalpasar dam project for most of the categories listed above. Whilst there is some evidence to inform an assessment in many of the categories listed above, it is our view that in only a few cases, can the evidence be considered comprehensive as well as up-to-date. These deficiencies are summarised within our gap analysis report.

### **Preventative measures**

In addition, whilst preventative measures have been discussed for some categories, such as an indication of the compensation required for mangrove habitats (for example), the data used to make these judgements are not up-to-date. For other areas, such as: (viii) fish culture; (ix) plant life (apart from mangrove); (x) wild life; and (xi) migratory birds, baseline data is not comprehensive in coverage or recent enough to describe the baseline, or form the basis of environmental impact assessment and to determine suitable preventative measures.

### **11.2.3 Requirement to append clearances in respect of the EIA**

Whilst it is not explicitly detailed within the Ministry of Water Resources (2010) report what level of detail is required for the above (i) to (xv) categories for the DPR itself, the CWC guidance (2017), section 4.5 states that “The clearances obtained in respect of Environment Impact Assessment, Forest, R&R Plans, etc. shall also be appended with DPRs and implied costs shall be duly accounted in the estimate.”

As such, whether the full requirements to consider the environmental problems that may arise from the Kalpasar dam project are fully contained within the DPR itself, or within the documentation that is required to obtain the other approvals (including an EIA), these approvals and associated documentation, which will include an EIA, must be appended to the DPR.

In order to suitably satisfy the requirements for EIA that are likely to be required to obtain the clearance certificates, that are required to be submitted alongside the DPR, the red environmental risk gaps in our gap analysis will need to be comprehensively addressed with up-to-date information.

### 11.2.4 Cost Benefit

Both the CWC (2017) and the MoWR (2010) guidance documents also require consideration of the cost benefit of a project. In order to do this effectively, full consideration of the cost to avoid and mitigate environmental impacts will need to be calculated. As explained in the gap analysis report, at present there is insufficiently comprehensive and up-to-date assessment data to understand the current baseline, assess the likely effects of the project or calculate the required mitigation or compensation requirements.

### 11.2.5 References

Ministry of Water Resources, RD & GR (2010), Guidelines for preparation of Detailed Project Reports of Irrigation and Multipurpose Projects. Government of India.

Central Water Commission (2017) Guidelines For Submission, Appraisal And Acceptance Of Irrigation And Multipurpose Projects. Ministry Of Water Resources, River Development & Ganga Rejuvenation New Delhi. Available online at:

<http://cwc.gov.in/sites/default/files/reviseacceptanceguidelinesdpr2017.pdf>

## 11.3 Social (section E)

### 11.3.1 The Importance of a Social Impact Assessment (SIA)

International Financial Institutions and Multilateral Development Organizations have comprehensive policies and standards on assessing and managing social impacts in projects. Some of these activities must be started at the early stages of the project (project identification and preparation stage); they cannot be postponed to later stages.

The identification and management of social impacts and risks, is crucial to predict and mitigate adverse effects and identify opportunities to increase benefits for local communities and society at large. The international requirements highlight the need for a social impact assessment (SIA). Without this assessment, projects are not typically financed.

The assessment is also required to support decision-making in the design and planning of development projects. Although assessing, managing, and monitoring the environmental and social risks and impacts are requirements for the project throughout its life cycle, several tasks need to be completed before a project investment decision is made. The rationale for this requirement is that the Project may lead to serious, long-term, and costly social and impoverishment risks such as (i) land and homelessness, (ii) marginalization, (iii) food insecurity, (iv) increased morbidity, (v) social segregation, (vi) increased livelihood risks for

marginalized and vulnerable groups, (vii) gender negative impacts, (viii) adverse impacts on cultural heritage and indigenous peoples.

### 11.3.2 Other requirements for international financing

In addition to the general social impact assessment, the following aspects are mandatory to attract international financing:

#### **Land acquisition and resettlement (LAR)**

Land Acquisition and Resettlement impacts and risks must be identified and proper mitigation measures must be incorporated in the project formulation.

International lenders require the Client to prove that the Project doesn't have significant LAR impacts from an economic point of view and human rights, social inclusion, gender, and indigenous perspectives.

Physical and economic displacement, if not mitigated, can lead to serious economic and social risks which cannot be managed after the project investment decision.

#### **Stakeholder involvement**

This is another vital topic which is required by International Donors/Investors to be started at the earliest stages. Early stakeholder engagement means identifying supportive and rebellious groups and managing their expectations. In many cases, a project can address concerns through design and project elements if they are identified in the early stages of project identification and preparation. Project preparation without proper stakeholder engagement is considered risky Project by international lenders/investors.

#### **Impacts and risks for indigenous peoples**

They are distinct from mainstream populations and, in many cases, are among the most economically marginalized and vulnerable segments of the population. That is why International lenders/investors require project proponents to consult with indigenous peoples and allow them to actively participate in project design and in determining project implementation modalities. The assessment of anticipated direct and indirect economic, social and cultural impacts should be carried out in close collaboration with indigenous peoples. There may be circumstances that require free, prior and informed consent (FPIC) or/and broad community support. Without proper assessment, the extent of impacts and risks cannot be understood and appropriate remediation strategies cannot be formulated. If these studies are not conducted during the initial phases, it may result in significant delays in project implementation and unforeseen costs. Moreover, international donors/investors don't typically finance a project if the Client can't ensure meaningful participation of indigenous people and local ethnic minorities.

## 11.4 Transport (section F)

The transport gaps can not really be considered a risk to the overall feasibility of the project; the gaps if closed would increase the certainty in the business case for the project. Therefore, if these gaps are not closed during the DPR, there will be a risk of making decisions with a business case which is not fully developed. This could lead to sub-optimum option selection or poorly informed benefit cost conclusions. It should be noted that there are believed to be some positive impacts from a fully evaluated and updated transport assessment, with the potential to find significant regional benefits from a major new transport link, so if the gaps were closed during the DPR, there could be benefits to the project in the long term.

## Appendix 1 Kalpasar Report Check List

The following table shows the reports for studies complete, ongoing and to be carried out. It highlights whether these have been received yet at the time of this review.

| No. | Package Name  | Status   | Received | Included in the original 38 Reports |
|-----|---|----------|----------|-------------------------------------|
| 1   | Techno Economical Feasibility Report Including Haskoning Report                           | Complete | Yes      | Yes                                 |
| 2   | Conceptual and Structure Plan and Preparation of Base Map of Kalpasar Project Area        | Complete | Yes      | Yes                                 |
| 3   | Legal Opinion   | Complete | Yes      | Yes                                 |
| 4   | Topography Survey 0 to 10 m contour along peripheral area of reservoir.                   | Complete | Yes      | Yes                                 |
| 5   | Bathymetry Survey for entire GoK  | Complete | Yes      | Yes                                 |
| 6   | Traffic_Assesment_Study_GoK   | Complete | Yes      | Yes                                 |
| 7   | Geo physical survey for revised dam corridor 2010 & 2014                                  | Complete | Yes      | Yes                                 |
| 8   | Water Sampling and Water Quality Monitoring Program                                       | Complete | Yes      | Yes                                 |
| 9   | Estimation of PMF, Design flood including determining spillway capacities                 | Complete | Yes      | Yes                                 |
| 10  | Groundwater conditions in Kalpasar Command area in Saurashtra                             | Complete | Yes      | Yes                                 |
| 11  | Water availability study for Kalpasar project main report                                 | Complete | Yes      | Yes                                 |
| 12  | Vetting of Water Availability Studies for Gulf of Khambhat Development Project (Kalpasar) | Complete | Yes      | Yes                                 |
| 13  | Study on sea-level changes, global warming and regional climate                           | Complete | Yes      | Yes                                 |
| 14  | Impact of Kalpasar Project on the existing and Proposed Ports                             | Complete | Yes      | Yes                                 |
| 15  | Impact of Tsunami   | Complete | Yes      | Yes                                 |
| 16  | Impact of Storm surges, wind waves and seiches  | Complete | Yes      | Yes                                 |
| 17  | Design of spillway report 2018  | Complete | Yes      | Yes                                 |
| 18  | Primary and alternate locations of Spillway 2 DT 2014                                     | Complete | Yes      | Yes                                 |
| 19  | Primary Dam cross sections were finalized during 3 DT 2015                                | Complete | Yes      | Yes                                 |

|    |   |          |     |     |
|----|---|----------|-----|-----|
| 20 | Hydrodynamic and sediment model studies and related measurements  | Complete | Yes | Yes |
| 21 | Fisheries Study   | Complete | Yes | Yes |
| 22 | Study of taluka-wise Irrigation planning and Agro-economic impact of Kalpasar project in coastal areas of Saurashtra region | Complete | Yes | Yes |
| 23 | A study on positive irrigation impact of Kalpasar reservoir project in Saurashtra region of Saurashtra                      | Complete | Yes | Yes |
| 24 | A study of agronomical constraints in agriculture in the command area of semi-arid and arid region of Saurashtra            | Complete | Yes | Yes |
| 25 | Irrigation facilities   | Complete | Yes | Yes |
| 26 | Assessment of Baseline Environmental quality and social status of Kalpasar Project  | Complete | Yes | Yes |
| 27 | Present Status of Salt Pans and Assessment of Social, Economic and Environmental Impact of the Kalpasar Reservoir Project   | Complete | Yes | Yes |
| 28 | Impact on mangroves consequential to creation of Kalpasar reservoir and mitigation strategy                                 | Complete | Yes | Yes |
| 29 | Scope of Work for EIA & SIA Studies   | Complete | Yes | Yes |
| 30 | Synopsis of the environmental and socioeconomic aspects of the various studies related to Kalpasar project                  | Complete | Yes | Yes |
| 31 | Reclaimable land plan GIS data base   | Complete | No  | Yes |
|    | Renewable Energy  | Complete | Yes | No  |
|    | Reference_Report_CWC_Guidelines_for_Preparation_of_DPR_for_Irrigation_And_Multipurpose_Projects                             | Complete | Yes | No  |
|    | Reference_Report_Six Speific Studies Kalpasar   | Complete | Yes | No  |
| 1  | Establishment & Monitoring of Seismological Observatories   | Ongoing  | No  | Yes |
| 2  | Geotechnical Investigation and Survey along Dam Alignment   | Ongoing  | Yes | Yes |
| 3  | Water Quality Monitoring and diversion effluent studies   | Ongoing  | Yes | Yes |
| 4  | Desk wave flume studies for design c/s  | Ongoing  | Yes | Yes |

|    |   |                 |    |     |
|----|---|-----------------|----|-----|
| 5  | Physical model study break water alignment.   | Ongoing         | No | Yes |
| 6  | Mathematical model studies for wave tranquility   | Ongoing         | No | Yes |
| 7  | Hydraulic model studies   | Ongoing         | No | Yes |
|    |   |                 |    |     |
| 1  | Design of Dam, spillway, sluices, gates, breakwater structures and any other allied structures, stability of dam.                         | To be completed | No | No  |
| 2  | Foundation compressibility studies for estimating the extra quantities of dam construction materials                                      | To be completed | No | No  |
| 3  | Detailed Construction Material Survey and transport facilities  | To be completed | No | No  |
| 4  | Survey investigation and design of Narmada Diversion Canal  | To be completed | No | No  |
| 5  | Survey investigation and design of Irrigation Canal, Pumping Stations & Allied Structures   | To be completed | No | No  |
| 6  | Detailed Studies on Wind Solar Power Plant  | To be completed | No | No  |
| 7  | Existing proposed Drinking Water supply scheme  | To be completed | No | No  |
| 8  | Existing proposed Industrial Water supply scheme discuss Kalpasar   | To be completed | No | No  |
| 9  | Hydrological, Meteorological & Hydro Geological   | To be completed | No | No  |
| 10 | Arrangements for offtake of reservoir water (by canals/ lift schemes) locations, capacities and main canal alignments                     | To be completed | No | No  |
| 11 | Closure Techniques for construction of dam  | To be completed | No | No  |
| 12 | Inundation area on downstream of Kalpasar dam and Effect on sub soil water table in the adjoining area particularly downstream of the dam | To be completed | No | No  |
| 13 | EIA/SIA study   | To be completed | No | No  |
| 14 | Flood Control   | To be completed | No | No  |
| 15 | CRZ Clearance proposal  | To be completed | No | No  |

## Appendix 2

### Gap Analysis Matrix with References

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## A) Dam Engineering

| Sub-component   | Inception Report section | Topic                       | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes   |
|-----------------|--------------------------|-----------------------------|--|--------------------------------------|---|--|--|---|
| Dam design life | 3.2.1                    | Civil structure/fixed items | No design life or standards referenced within the feasibility or the proposed cross sections. There is a direct relationship between dam safety and its lifespan, i.e., if the dam is unsafe its lifespan has expired  | High                                 | The service life of a major asset like Kalpasar dam the design life should be at least 100 years. All fixed, cast-in, or non-replaceable components should be capable of service for the full dam design life. A design life is to be agreed on project leadership scale and requirements included in the brief for the subsequent design phases of the project.  | Cost Benefit Analysis  | Close Gap                                | Design Life of the Project Needs to be Stated in the DPR, and reflected in the cost -benefit assessment |
| Dam design life | 3.2.1                    | M&E structures/components   | No design life or standards referenced within the feasibility or the proposed M&E structures components, such as spillway gates draw off pipes or pumps for lifting irrigation of water. There is a direct relationship between dam safety and its lifespan, i.e., if the dam is unsafe its lifespan has expired | High                                 | A design life for the M&E equipment is to be agreed on project leadership scale and requirements included in the brief for the subsequent design phases of the project. Where mechanical and electrical components with a shorter design life are used the design must consider how they may be safely refurbished or replaced. Where a range of options for equipment with differing design life exists the whole life cycle cost should be assessed including differing maintenance and replacement/refurbishment intervals. The design life for replaceable M&E components should be at least 25years. | Cost Benefit Analysis  | Close Gap                                | Design Life of the Project Needs to be Stated in the DPR, and reflected in the cost -benefit assessment |

| Sub-component             | Inception Report section | Topic                             | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes   |
|---------------------------|--------------------------|-----------------------------------|---|--------------------------------------|--|--|--|---|
| Dam design life           | 3.2.1                    | Operations Plan                   | Instruction manuals describing operation and maintenance should be provided for all equipment and included in the Operations Plan. Emphasis should be drawn on the tidal regime effect on O&M to ensure minimal saline water intrusion in the reservoir.  | High                                 | To follow as design develops though needs consideration with spillway operations (feeds into reservoir flood study) and regular consultation with stakeholders   | Water Availability and Integrated Operations Plan                    | Close Gap                                | A draft dam operation regime including water balance needs to be provided to prove the viability and reliability of the scheme. Plan has to include inflow regimes from Narmada and trigger levels for operation of the spillway and deep-water sluices |
| Dam design life           |                          | Operations and Maintenance Manual |   | Medium                               |  |  |  | A skeleton operations and maintenance manual should be provided at the outline design stage and filled in as design progresses. A complete operations and maintenance manual should be provided to the operator at completion of the scheme.            |
| Dam Hazard Categorisation | 3.2.2                    | Hazard categorisation             | The currently proposed dam geometry would classify as a large dam in accordance with ICOLD (Bulletin 157). The dam should be categorised based on its hazard potential. While the dam is constructed in an open estuary, there are coastal communities and infrastructure both upstream and downstream of the dam, and therefore the risk of loss of life, economic losses and environmental impact should be considered should the dam fail. | High                                 | Conduct a dam breach study on the proposed dam alignment and construction, identifying potential failure modes including breaches from sea and reservoir, risk of occurrence and inundation potential. Assess the potential loss of life, economic damages from the inundation and environmental impacts. Classify the dam in accordance with USACE dam hazard classification. | Cost Benefit Analysis  | Close Gap                                | This can be a provisional categorisation, based on accounting the number of flood receptors pre-and post-scheme completion. Existing flood modelling can be used.   |
| Dam Hazard Categorisation | 3.2.2                    | Dam Breach assessment             | Breach analysis carried out but not representative of worst-case water levels and no hazard analysis carried out. See dam hazard categorisation. Considered medium risk as dam appears to   | Medium                               | See dam hazard categorisation.   | Cost Benefit Analysis  | Close Gap                                | Needs to be mapped for dam hazard categorisation  |

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|--------------------------------|--------------------------|--------------------|---|--------------------------------------|--|--|--|---|
|                                |                          |                    | have been designed as high hazard   |                                      |  |  |  |   |
| Design and Safety Check Floods | 3.2.3                    | Safety check flood | PMF selected as Safety check flood however a simplification of the coincidence of peaks has been made. Earlier pre-feasibility study (1998) suggested not enough data for statistical analysis and following feasibility partly utilised the earlier study. Suggest update to new dam alignment and update to include additional 20 years of data, statistically analysis of coincidence of storm peaks from different catchments may now be possible. Check if 2018 report does this | Medium                               |  | Cost Benefit Analysis  | Close Gap                                | Safety Check flood determined as PMF and used for design; however current estimates are very closed to observed events in the last 100 years. Verify estimate post DPR, as it will influence spillway design. |
| Design and Safety Check Floods | 3.2.3                    | Design flood       | Unclear about the return period of the design flood. PMF used for design of the spillway. Consideration could be given to use of both a design and safety check flood.  | Low                                  | Provide return periods for storms. Considered low risk as PMF used for design. |  |  | PMF used for design.  |

| Sub-component | Inception Report section | Topic      | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes   |
|---------------|--------------------------|------------|---|--------------------------------------|--|--|--|---|
| Surveys       | 3.2.4                    | Topography | Topographical survey provided in scanned paper format and in tiles. It is difficult to assess completeness without joining the pieces together. Survey origin 2003 to 2004. Survey scale is 1:15,000, and contour spacing is 0.5m. No detailed levels provided along the proposed level of the embankment. No survey report provided and so methods, coordinates system and benchmarks used are unclear. Scale is too coarse for detailed design. | Medium                               | Provide a digital copy of the terrain information for subsequent design stages to enable detailed evaluation of the terrain and flood inundation levels. If no up-to-date survey is available, conduct a new survey of the estuary, including the dam footprint, estuary rim, Narmada dam and Narmada canal. Benchmarks should be established and retained to ensure consistency for following surveys and construction work. Due to the large area of survey needed, it is possible to deploy LIDAR scanner for the wider basin and limit the extents of the conventional topographical survey close to the footprint of the proposed embankment and dam associated structures. If LIDAR survey is used, it is recommended that a high frequency (high resolution) scanner is used to improve the accuracy of the survey. Ground stations should be established to ground truth the LiDAR survey and relate the survey to permanent benchmarks retained for conventional surveys and construction setting out. Survey needs to be consistent benchmark and coordinate system with the bathymetric survey. | Cost Benefit Analysis  | Close Gap                                | Digital copy of the topography will enable analysis on flood receptors and other desk studies recommended in Sections B and D |

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|-----------------------------------|--------------------------|------------|--|------------------------------------|---|--|--|---|
| Surveys                           | 3.2.4                    | Bathymetry | Only bathymetry survey report provided, not the survey data itself. Not possible to assess completeness and suitability for design. Only a single survey was reported (2018).  | Medium                             | Provide a digital copy of the bathymetric information for subsequent design stages to enable detailed evaluation of the terrain, construction foundation details. Bathymetry and topography should have the same spatial reference point and datum, so a complete terrain surface is generated for the subsequent design stages. Consideration should be given to water level at time of survey for both bathymetry and bank in topographic survey to ensure no gaps in coverage. Multiple surveys should be carried out, spread over time or older surveys referenced to allow variation of bed levels over time to be assessed. | Cost Benefit Analysis  | Close Gap                                | Digital copy of the bathymetry will enable analysis on sea floor and dam alignment.   |
| Hydrology and Hydraulic Modelling | 3.2.5                    | Hydrology  | PMF estimated but no other flood events, a range of flood events combined with tidal variation should be considered. PMF assumes no contribution from Narmada - it is not clear how the contribution from the Narmada will be managed during floods. Hydrological study is dated 2011; PMP estimated does not appear significantly greater than max observed event; no/little evidence of model calibration or event testing. Hydrological assessment assumes that the existing dams regulate the catchment contribution to the estuary- we need to ensure that there are supporting legislation in place to ensure this is practice. No allowances made for climate change. | High                               | As there have been several big events in the region in the last decade it is recommended that the hydrological study is updated to include recent data; it is recommended that the use of the radar network is explored to bolster the rainfall analysis which in the previous study was limited to a small number of rainfall gauges.  | Water Availability and Integrated Operations Plan                    | Close Gap                                | Safety Check flood determined as PMF and used for design; however current estimates are very closed to observed events in the last 100 years. Verify estimate post DPR, as it will influence spillway design. |

| Sub-component                       | Inception Report section | Topic                     | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|-------------------------------------|--------------------------|---------------------------|---|--------------------------------------|---|--|--|--|
| Hydrology and Hydraulic Modelling   | 3.2.5                    | Hydraulic modelling       | Reservoir routing analysis has been carried out however consideration of different storm durations and patterns could be made. Study will require update for new dam alignment and to reflect any changes to gate operation philosophy. | Low                                  | Carrying out flood study with flood routing considering different storm events, hydrograph shapes and storm durations |  | Understand and cost the risk of not filling the gaps | Study already completed, but it will need updating with hydrology and gate philosophy  |
| Water Demand and Supply Reliability | 3.2.6                    | Flow requirements         | Refer to Water Availability in Section B of this matrix.  | High                                 |   | Water Availability and Integrated Operations Plan                    | Close Gap  | Water supply and demand projections and reliability need to be provided in DPR to prove scheme viability.                        |
| Water Demand and Supply Reliability | 3.2.6                    | Reliability               | Unclear where reliability targets have been set and agreed with client  | High                                 | Reliability targets to be agreed  | Water Availability and Integrated Operations Plan                    | Close Gap  | Water supply and demand projections and reliability need to be provided in DPR to prove scheme viability.                        |
| Climate change impact               | 3.2.7                    | Extreme heat and drought  |   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Conduct a sensitivity analysis on the impacts of climate change to demonstrate the scheme viability for its design life for DPR. |
| Climate change impact               | 3.2.7                    | Future flow capacity      |   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Conduct a sensitivity analysis on the impacts of climate change to demonstrate the scheme viability for its design life for DPR. |
| Climate change impact               | 3.2.7                    | Sea Level Rise - spillway | This does not appear as a consideration in the hydrological assessment  | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Conduct a sensitivity analysis on the impacts of climate change to demonstrate the scheme viability for its design life for DPR. |

| Sub-component                 | Inception Report section | Topic   | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|-------------------------------|--------------------------|---|--|--------------------------------------|---|--|--|--|
| Climate change impact         | 3.2.7                    | Sea Level Rise - saline seepage                 | This does not appear as a consideration in the hydrological/climate assessment   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Conduct a sensitivity analysis on the impacts of climate change to demonstrate the scheme viability for its design life for DPR.   |
| Climate change impact         | 3.2.7                    | Sea Level Rise - freeboard and overtopping      | This does not appear as a consideration in the hydrological assessment   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Conduct a sensitivity analysis on the impacts of climate change to demonstrate the scheme viability for its design life for DPR.   |
| Climate change impact         | 3.2.7                    | Sea Level Rise - soil erosion and sedimentation | This does not appear as a consideration in the hydrological assessment   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Conduct a sensitivity analysis on the impacts of climate change to demonstrate the scheme viability for its design life for DPR.   |
| Climate change impact         | 3.2.7                    | Sea Level Rise - extreme winds                  | This does not appear as a consideration in the hydrological assessment   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Conduct a sensitivity analysis on the impacts of climate change to demonstrate the scheme viability for its design life for DPR.   |
| Climate change impact         | 3.2.7                    | Sea Level Rise - rainfall induced landslides    | This does not appear as a consideration in the hydrological assessment   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Conduct a sensitivity analysis on the impacts of climate change to demonstrate the scheme viability for its design life for DPR.   |
| Dam key design considerations | 3.2.8.1                  | Choice of Dam Type                              | The dam will have three sections: Dam body, closure section and spillway. These were discussed in the 1998 Pre-feasibility Report and further discussed in the Feasibility Report from 2009. More recent documents do not appear to refer to the design of the closure section, which will be a large and critical part of the project. The dam body is planned to be an embankment, which is to | High                                 | Mitigation discussed separately for each section of the dam; below. | Cost Benefit Analysis  | Close Gap  | Choice of dam selection has large cost and constructability implications for the scheme. A year projection on material requirements and plan for deliveries is required in DPR |

| Sub-component                      | Inception Report section | Topic  | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|------------------------------------|--------------------------|--|--|--------------------------------------|---|--|--|--|
|                                    |                          |  | be expected. The closure section and the spillway section are distinct sections and are each discussed separately.   |                                      |   |  |  |  |
| Dam key design considerations      | 3.2.8.2                  | Selection of dam alignment   | The revised alignment of the Kalpasar dam, following the deletion of tidal power and navigation locks is appropriate for design at this stage. The diversion of flows from the Narmada River and the related separate dam alignment is broadly outlined, but there is a considerable lack of detail regarding the preferred alignment and construction type. Refer to Narmada Dam and Canal Sections below.  | Medium                               | Amendments might be required at the detailed design stage, for example when more detailed geotechnical data is available. |  | Understand and cost the risk of not filling the gaps | The dam alignment has been selected, however future amendments may lead to time and cost implications for the project. A nominal cost for future design alterations should be included in the DPR. |
| Dam Body key design considerations | 3.2.8.3                  | Standard design units and reference datum                            | All designs are in metric units. Horizontal datums are not critical at this early planning stage of the project but need confirmation before detailed design. Vertical datums are a frequent source of confusion, particularly on large maritime projects where Chart Datum might vary across the project area, but the Kalpasar project is using the Indian National Datum which approximates to Mean Sea level and will be constant across the area. | Low                                  | Ensure any future surveys make consistent use of datums.  |  |  | Verify all surveys use the same standardised units.  |
| Dam Body key design considerations | 3.2.8.3                  | Design life for dam and for replaceable elements (see section 3.1.4) | See earlier comment on design life   | High                                 |   | Cost Benefit Analysis  | Close Gap  | See earlier comment on design life   |

| Sub-component                      | Inception Report section | Topic              | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes  |
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| Dam Body key design considerations | 3.2.8.4                  | Design geometry    | The detailed design of the cross section of the dam body is complicated and it is not clear how it could be constructed in the prevailing depths and tidal conditions. The cross section, which will vary along the length of the dam with varying depth, exposure, and geotechnical conditions, will need further optimisation but in addition this will optimisation need to focus on constructability. There was no design report accompanying the cross sections, lacking clarity on how the sections were developed. | High                                 | Simplify the cross-section design as far as possible. Provide a design report stating the standards and the governing criteria for the design. | Constructability   | Close Gap                                | Constructability and needs to be assessed as it will have direct implications on the CAPEX of the scheme   |
| Dam Body key design considerations | 3.2.8.6                  | Stability analysis | As well as the geotechnical stability of the dam and its foundations, there are many other factors to be considered, such as wave action, seismic events, floods, and impacts of climate change. Although the stability of the completed dam has been assessed, it will be vulnerable to damage during the construction process. Risks of damage are also affected by the duration of the construction process and an understanding of the proposed construction method should be an integral part of the design process. | High                                 | Review stability at all stages of construction.  | Constructability   | Close Gap                                | Stability analysis of the completed scheme and construction stages need to be assessed to prove the viability and constructability of the proposed dam geometry for DPR. |

| Sub-component                         | Inception Report section | Topic           | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes  |
|---------------------------------------|--------------------------|-----------------|---|--------------------------------------|---|--|--|--|
| Closure section design considerations |                          | Design geometry | The closure method and the design of the closure sections are discussed in the 1998 Pre-feasibility Study and Six Specific Reports Volume V which refer to the earlier project plan with a larger impounded area, and in the Techno Economic Feasibility Report (2009?). In the earlier reports a closure section 10km long is suggested. This would comprise caissons (for sudden closure) or a rock embankment placed from a bridge (for gradual vertical closure) At that time it was estimated that these two options had very similar costs. For the revised alignment a shorter closure section is proposed but it would still be a substantial proportion of the total length of the dam. In the 2009 report a gradual closure (horizontal and then vertical embankment construction, without caissons) is described. This is based on a simplified calculation showing that currents would be about 4.37 m/s, i.e., within the limit of 6 m/s considered as the practical limit for gradual closure. However, this calculation appears to consider only average velocities in the closure gap, and more rigorous calculations are presented in the Dam Impact Model Studies report (2018). These show currents of at least 5.84m/s during closure, which would require very substantial scour prevention measures that are close to the limits of practicable construction. | high                                 | This will need a detailed approach to the design, including a focus on constructability, taking into consideration the rates at which construction materials can be placed. | Constructability   | Close Gap                                | The closure has the potential of being one of the most technically challenging part of the construction. A clear understanding of the methods and materials used would be required to prove the viability of the scheme for DPR. |

| Sub-component | Inception Report section | Topic | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes |
|---------------|--------------------------|-------|--|--------------------------------------|----------------------------|--|--|-------|
|               |                          |       | <p>No further details of designs or modelling were provided for the closure section in the subsequent drawings of the proposed dam cross-sections. The criticality of the closure design cannot be over emphasised. This tidal closure will present issues of an order of magnitude greater than any tidal closures on previous projects around the world and requires very careful planning and design to ensure that scour near the dam is managed and contained at acceptable levels.</p> |                                      |                            |  |  |       |

| Sub-component                          | Inception Report section | Topic            | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|--|--------------------------|------------------|--|--------------------------------------|--|--|--|--|
| Spillway section design considerations | 3.2.12                   | Design geometry  | Includes large vertical lift gates. These would need to be designed to be capable of opening and closing with a head of water in either direction. Construction of the concrete spillway structures will need to be done in the dry, and cofferdam works to achieve this will be very substantial. If a construction method involving the use of float-in caissons was to be adopted, issues would include selection of a suitable construction site, feasibility of towing caissons in the existing tidal flow conditions, and preparation of adequate foundations. Access for lifting (or removing?) the gates for maintenance will also be needed. There is very little detail regarding constructability of the slipway and gates. In 1999 it was reported that low level sluices (-14 to -19m MSL) would be required to discharge saline water and allow degradable and non-degradable pollutants that tend to settle to the bottom of the reservoir to be flushed out. These low-level sluices do not appear to be part of the present design. | high                                 | The constructability of the spillway section will have a major impact on the selection of the optimum design and the design should be reviewed taking this into consideration, if such a review has not already been done. The cost of temporary works such as cofferdams will be a significant part of the total cost of the spillway. The impact of the spillway design on water quality in the reservoir requires careful study, also including the impact of the closure method and the design of the closure section. | Constructability and Cost Benefit Analysis                           | Close Gap  | Optioneering and some outline optimisation for the confirmed design case flows and dam hazard category will have big CAPEX implication for the scheme. The costs of materials usage and selection will have to be reported as part of the DPR. |
| Dam Body key design considerations     | 3.2.8.7                  | Seepage analysis | See comment on Basin Leakage in C Geotechnics. Risk of seepage through dam, foundation, abutment and at interfaces with structures requires consideration. Risks include internal erosion, negative impact of seepage on stability, loss of fresh water and potential for saline intrusion. Seepage analysis needs to be   | Medium                               | Seepage analysis needs to be undertaken considering all potential impacts of seepage   |  | Understand and cost the risk of not filling the gaps | See comment on Basin Leakage in C Geotechnics.   |

| Sub-component                      | Inception Report section | Topic                                    | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes   |
|------------------------------------|--------------------------|--|--|--------------------------------------|---|--|--|---|
|                                    |                          |  | integrated to wider design of embankment geometry and materials  |                                      |   |  |  |   |
| Dam Body key design considerations | 3.2.8.3                  | Topographical and bathymetric data       | See earlier comment on surveys. It should be noted that the bathymetry of the area constantly changes as a result of erosion and deposition. Reports on the bathymetric survey have been provided but not the actual bathymetric survey charts.  | Medium                               | Provide copies of the actual bathymetric survey charts.   | Cost Benefit Analysis  | Close Gap  | Digital copy of the bathymetry will enable analysis on sea floor and dam alignment.   |
| Dam key design considerations      | 3.2.8.3                  | Metocean data for various return periods | It appears that extreme events with a return period of 50 years have commonly been adopted for design, but the probability of these values being exceeded during the design life of the project is very high. The design life of the project is considerably longer than the length of time for which metocean data is available, and extrapolation is therefore necessary to evaluate extreme events, and in addition allowance for the effects of climate change is necessary. | Medium                               | For the permanent structure design, the return periods of typical events adopted for design should substantially exceed the design life of the structure. Designers should identify and use responses for a range of events including conditions above any nominal design level, and not simply use a single design event. Designs for temporary conditions during the construction period can be based on less extreme events because the shorter duration of the construction period leads to a lower risk of failure. See comments elsewhere on effects of climate change. |  | Understand and cost the risk of not filling the gaps | Sensitivity analysis needs to be undertaken to understand and cost the risks of increasing return periods in excess of the design life of the structure |
| Dam key design considerations      | 3.2.8.3                  | Tidal Data                               | See Section B on consideration on extreme tides and tidal surges and associated comments on freeboard and overtopping.   | High                                 | Need to consider combination of fluvial and tidal events.   |  | Understand and cost the risk of not filling the gaps | See Section B   |

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| Dam key design considerations | 3.2.8.3                  | Water Levels          | A key objective of the project is to fill the reservoir with fresh water by storing river flows. By August and September, the reservoir levels will be high, but river flood flows can occur in these months with the potential of causing flooding. The 1998 and 1999 studies considered the impact of fluvial flows, dominated by the effect of the Narmada River. It appears that similar studies have not been carried out in detail for the revised layout which is upstream of the Narmada River. It is expected to be necessary to lower the reservoir level in advance of forecast floods, but unnecessary lowering will result in not achieving a full reservoir for the following dry season. Water levels adopted for design of the reservoir side of the dam are based on the intended operating policy for water levels in the reservoir, with an allowance for the effects of fluvial floods affecting the level in an already partly full reservoir. Water levels on the sea side include allowance for extreme tides, storm surges and future sea level rise. | High                                 | A decision support system will be needed, making use of forecast fluvial flows and with a knowledge of the response of the water levels in the reservoir to the inflows and the spillway management response times. The reliability of such systems, as well as the reliability of the mechanical and electrical systems controlling the spillway gates, will be critical to the safe operation of the reservoir and the avoidance of flooding. [See comments on spillway design.] Water levels adopted for dam design should be updated to allow for the effects of climate change on sea level, river flows, and frequency and intensity of cyclones. | Water Availability and Integrated Operations Plan                    | Close Gap                                | Flood impact assessment is a requirement for the DPR in accordance with Guidelines |
| Dam key design considerations | 3.2.8.3                  | Design Return Periods | See comments above on Metocean data for various return periods  |                                      |   |  |  |  |
| Dam key design considerations | 3.2.8.3                  | Risk levels           | See comments above on Metocean data for various return periods  |                                      |   |  |  |  |

| Sub-component                 | Inception Report section | Topic        | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes   |
|-------------------------------|--------------------------|--------------|--|--------------------------------------|--|--|--|---|
| Dam key design considerations | 3.2.8.3                  | Materials    | Sources of the required large quantities of materials have not been described. For example, 8 quarries each producing 25,000 tonnes/week are proposed. The logistics of transporting and placing such quantities requires study. Placing scour protection cannot take place during spring tides or during the monsoon season, and towing caissons will have similar constraints.   | High                                 | Identifying the sources of construction materials and the locations of any offsite construction locations will be necessary to plan the construction method and duration.  | Constructability   | Close Gap  | Material quantities and one year plan of supply required for DPR, as per guidelines   |
| Geometry                      | 3.2.8.4                  | Crest width  | Newest dam cross-sections (2015) show 6 lane road on berm with 18m wide crest, earlier studies recommended 8+2 lanes on crest. Unclear how latest berm and crest widths have been determined   | High                                 | Dam width including crest and berm should consider all of the contributing factors such as transport corridor requirements (traffic forecasts), seepage (internal erosion and saline intrusion risks) and stability and demonstrate that the most economic solution has been selected. An optioneering report should be carried out identifying the optimum solution.  |  | Understand and cost the risk of not filling the gaps | Understanding the sensitivity of the overall project cost to varying the crest width as the design progresses will help understand the project feasibility and areas of future optimisation |
| Geometry                      | 3.2.8.4                  | Crest Height | The crest height of the dam should take into consideration overtopping in extreme wave and sea level conditions, allowance for sea level rise, and settlement. Overtopping will impact upon the stability of the dam and operational conditions for road and rail traffic along the dam, and also have an effect on the salinity of the freshwater reservoir. Waves from the north should be evaluated and allowed for in design. The level of the road is shown as 2m above the reservoir flood level and the possibility that wave action could affect traffic using the road should be checked. | High                                 | Check the frequency and significance of overtopping from north and south affecting the road and railway. Evaluation of overtopping on this large and complex structure will require numerical and physical modelling at the detailed design stage. All of the factors which influence the crest height should be considered and the dam crest height determined, including tidal range, sea level rise, reservoir water level range and flood rise, settlement, wave run-up/overtopping limits (operational and safety to both reservoir and sea sides), potential for tsunami action. |  | Understand and cost the risk of not filling the gaps | Understanding the sensitivity of the overall project cost to varying the crest heights the design progresses will help understand the project feasibility and areas of future optimisation  |

| Sub-component | Inception Report section | Topic                  | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|---------------|--------------------------|------------------------|--|--------------------------------------|---|--|--|--|
|               |                          |                        | We have not seen any overtopping calculations carried out to date. |                                      |   |  |  |  |
| Geometry      | 3.2.8.4                  | Road/Railway alignment | Road and spillway bridge design not provided.                      | Medium                               | Develop the design of the road alignment, details of the bridges and connecting infrastructure in the future design stages. |  | Understand and cost the risk of not filling the gaps | Outline dings of road will be required to assess the cost of the project vs the benefits of the new transport links created. |

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|---------------|--------------------------|------------------|--|--------------------------------------|---|--|--|--|
| Geometry      | 3.2.8.4                  | Downstream slope | The downstream (seaward) slope, with a vertical height of up to about 44m, is planned to be protected by a layer of concrete Xbloc armour units of 8t to 48t weight, on a base layer of rock of 1.3 to 2.4m thickness. The unit weight of the armour units appears to be appropriate in relation to possible design wave heights although smaller armour units could be used in those parts of the dam in shallower water with depth-limited waves. The presence of berms at several levels on the armoured slope will affect the amount of overtopping. No information has been seen regarding the selection of the type of armour unit, which will be affected by construction conditions and overall cost. The method of construction is not clear, and construction of relatively thin base layers in conditions exposed to waves and variations in tide height, in depths of more than 20m, might not be practicable with the accuracy implied by the complex cross-section. The dam will be vulnerable to damage from waves until the protection is in place. The seabed and the dam will be vulnerable to scour damage from tidal flows as construction progresses along the length of the dam and scour protection along the length of the dam will be required in advance of the main dam construction. | High                                 | Planning the method and sequence of construction, including the number of fronts along which dam construction will proceed, requires assessment at different stages of construction to confirm stability. | Constructability   | Close Gap                                | Planning of the construction sequence and presentation of material quantities and sources will be needed to confirm the project feasibility and assessment of CAPEX for DPR. |

| Sub-component | Inception Report section | Topic                          | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes   |
|---------------|--------------------------|--------------------------------|--|--------------------------------------|---|--|--|---|
| Geometry      | 3.2.8.4                  | Upstream slope                 | The upstream slope is shown as a riprap layer 60cm thick overlying a 30cm inverse filter and a geotextile fabric layer. The fetch to the north of the dam is about 50km. No information has been seen regarding extreme winds and waves that could occur from the north, but cyclones could cause substantial wave action. The basis for selecting the riprap layer has not been seen, but a layer of the described size is suitable only for very small waves. Construction of the described layers and geotextiles will be very difficult in the prevailing depths and tidal conditions. | High                                 | The design of the upstream slope needs to be clarified, considering appropriate design wave heights from the north. Planning the method and sequence of construction, including the number of fronts along which dam construction will proceed, requires assessment at different stages of construction to confirm stability. | Constructability   | Close Gap  | Planning of the construction sequence and presentation of material quantities and sources will be needed to confirm the project feasibility and assessment of CAPEX for DPR.                  |
| Geometry      | 8.2.8.4                  | Rock armour thickness/diameter | See comments above on downstream and upstream slopes.  |                                      |   |  |  |   |
| Geometry      | 3.2.8.4                  | Settlement allowance           | Settlement of the foundations can be expected, and allowance must be made for this. Settlement of the material in the dam cross section should be relatively rapid and can be expected to occur during the construction period.  | Low                                  | Settlement allowances should be checked during the detailed design of the project.  |  |  | Design can be developed further in stages   |
| Geometry      | 3.2.8.4                  | Freeboard allowance            | See comments above on crest height   | High                                 |   |  | Understand and cost the risk of not filling the gaps | See comments above on crest height  |
| Loading       | 3.3.7.5                  | Wave loading                   | Wave loading on structures requires consideration  | Medium                               | Assessment of wave loading and structural response  |  | Understand and cost the risk of not filling the gaps | Wave loading and design can be made in future design changes. However, a provision for the cost associated wave mitigations such as wave wall needs to be included in the CAPEX of the scheme |

| Sub-component      | Inception Report section | Topic   | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|--------------------|--------------------------|---|---|--------------------------------------|---|--|--|--|
| Loading            | 3.2.8.5                  | Ship Impact   | No consideration of debris and ship impacts has been identified, these should be considered in the design of the dam and appurtenant structures.  | Medium                               | Provision of aids to navigation, and availability of a tugs should a vessel be drifting towards the spillway gates, should be considered. Design of structures for debris and ship impact.                                |  |  | Design can be developed in future project stages |
| Stability Analysis | 3.2.8.6                  | Critical Failure modes - End of Construction, Rapid Draw down, Steady state seepage, Earthquake   | No stability analysis has been identified and these issues listed should be considered in the analysis: Critical Failure modes - End of Construction, Rapid Draw down, Steady state seepage, Earthquake   | Medium                               | Stability analysis to be undertaken including these considerations: Critical Failure modes - End of Construction, Rapid Draw down, Steady state seepage, Earthquake   |  | Understand and cost the risk of not filling the gaps | See section C                                    |
| Stability Analysis | 3.2.8.6                  | Static and dynamic analysis - 2D and 3D finite element, soil structure interaction, stresses in structural elements                                   | No stability analysis has been identified and these issues listed should be considered in the analysis: Static and dynamic analysis - 2D and 3D finite element, soil structure interaction, stresses in structural elements                                   | Medium                               | Stability analysis to be undertaken including these considerations: Static and dynamic analysis - 2D and 3D finite element, soil structure interaction, stresses in structural elements                                   |  | Understand and cost the risk of not filling the gaps | See section C                                    |
| Stability Analysis | 3.2.8.6                  | Loads - dead loads, water load (reservoir and tail water), silt, earth, earthquake, traffic surcharge   | No stability analysis has been identified and these issues listed should be considered in the analysis: Loads - dead loads, water load (reservoir and tail water), silt, earth, earthquake, traffic surcharge   | Medium                               | Stability analysis to be undertaken including these considerations: Loads - dead loads, water load (reservoir and tail water), silt, earth, earthquake, traffic surcharge   |  | Understand and cost the risk of not filling the gaps | See section C                                    |
| Seepage Analysis   | 3.2.8.7                  | Safety, flooding, and saline contamination  | No stability analysis has been identified and these issues listed should be considered in the analysis: Safety, flooding, and saline contamination  | Medium                               | Stability analysis to be undertaken including these considerations: Safety, flooding, and saline contamination  |  | Understand and cost the risk of not filling the gaps | See section C                                    |
| Rock armour design | 3.2.8.8                  | Failure methods: Slope instability, Sliding of structure, Movement of rock cover, Migration of sub-layers, Piping, Liquefaction, Erosion of foreshore | No stability analysis has been identified and these issues listed should be considered in the analysis: Failure methods: Slope instability, Sliding of structure, Movement of rock cover, Migration of sub-layers, Piping, Liquefaction, Erosion of foreshore | Medium                               | Stability analysis to be undertaken including these considerations: Failure methods: Slope instability, Sliding of structure, Movement of rock cover, Migration of sub-layers, Piping, Liquefaction, Erosion of foreshore |  | Understand and cost the risk of not filling the gaps | See section C                                    |

| Sub-component             | Inception Report section | Topic                           | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|---------------------------|--------------------------|---------------------------------|---|--------------------------------------|---|--|--|--|
| Scour protection          | 3.2.8.9                  | Analysis and modelling          | The seabed and the dam will be vulnerable to scour damage from tidal flows as construction progresses along the length of the dam and particularly in those areas affected by the closure. Scour protection along the length of the dam and upstream and downstream of the closure section and the spillway will be required in advance of the main dam construction. Some of this will have a permanent function while other parts may become buried as construction proceeds. | High                                 | Adequate planning of the sequence of construction to mitigate excessive scour | Constructability   | Close Gap  | Planning of the construction sequence and presentation of material quantities and sources will be needed to confirm the project feasibility and assessment of CAPEX for DPR.               |
| Freeboard and overtopping | 3.2.9                    | Protection of vehicles          | See comment on crest height above, acceptable serviceability limits should be set, and the berm (reservoir waves) and crest heights (sea waves) set accordingly   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Understanding the sensitivity of the overall project cost to varying the crest heights the design progresses will help understand the project feasibility and areas of future optimisation |
| Freeboard and overtopping | 3.2.9                    | Protection of railway           | See comment on crest height above, acceptable serviceability limits should be set, and the berm (reservoir waves) and crest heights (sea waves) set accordingly   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Understanding the sensitivity of the overall project cost to varying the crest heights the design progresses will help understand the project feasibility and areas of future optimisation |
| Freeboard and overtopping | 3.2.9                    | Pedestrian access during storms | See comment on crest height above, acceptable serviceability limits should be set, and the berm (reservoir waves) and crest heights (sea waves) set accordingly   | Medium                               |   |  | Understand and cost the risk of not filling the gaps | Understanding the sensitivity of the overall project cost to varying the crest heights the design progresses will help understand the project feasibility and areas of future optimisation |

| Sub-component                             | Inception Report section | Topic   | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|---|--------------------------|---|--|--------------------------------------|--|--|--|--|
| Freeboard and overtopping                 | 3.2.9                    | Maintenance access during storms                  | See comment on crest height above, acceptable serviceability limits should be set, and the berm (reservoir waves) and crest heights (sea waves) set accordingly  | Medium                               |  |  | Understand and cost the risk of not filling the gaps | Understanding the sensitivity of the overall project cost to varying the crest heights the design progresses will help understand the project feasibility and areas of future optimisation |
| Freeboard and overtopping                 | 3.2.9                    | Salinity of the reservoir                         | See comment on crest height above  | Low                                  |  |  | Understand and cost the risk of not filling the gaps | Understanding the sensitivity of the overall project cost to varying the crest heights the design progresses will help understand the project feasibility and areas of future optimisation |
| Sedimentation                             | 3.2.10.1                 | Catchment Sedimentation load                      | Sediment yields have been estimated however additional sediment gauging would be beneficial  | Medium                               | Additional sediment gauging at a range of flows to inform estimates  |  |  | Details can be developed after DPR   |
| Sedimentation                             | 3.2.10.2                 | Sediment management                               | A high proportion of sediment flushing is assumed. Additional consideration of distribution of siltation is required particularly around offtakes, draw offs and spillways.  | Medium                               | Consider risk of sedimentation in design of hydraulic structures. Assess movement of silt within reservoir at differing stages of operation  |  |  | Details can be developed after DPR   |
| Dam Access for inspection and maintenance | 3.2.11                   | Construction, maintenance and surveillance access | The proposed draw off facility is at -4mSL. The dam embankment is to extend to the maximum depth of the estuary at approximately -25mSL. The remainder of the lake side dam will only be exposed at low lake levels (about once a year) with no option to dewater reservoir below low tide and the sea side of the dam will be exposed in a pattern related to the estuary tides. There are currently no proposals for surveillance, operation and maintenance of the dam structures and the O&M | Medium                               | A manual for the operation, surveillance and maintenance is to be prepared during the design process. Provisions for executing the plan without compromising the health and safety of the operatives are to be incorporated in the detailed design of the project. Design for access routes to be developed. |  |  | An outline design for the access provision needs to be considered and costed for DPR   |

| Sub-component       | Inception Report section | Topic                                   | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|---------------------|--------------------------|---|--|--------------------------------------|--|--|--|--|
|                     |                          |   | plans need to be developed. No access route designs have been provided and need to provide sufficient maintenance and inspection access to the dam and structures.   |                                      |  |  |  |  |
| Spillway structures | 3.2.12                   | Modelling of discharge with tide levels | Current design of spillway only considers discharges during PMF in combination with tides. No other return periods considered.   | Medium                               | The design of the spillway is to consider normal operational conditions and lower return periods other than PMF conditions combined with varying tide levels |  |  | Details can be developed after DPR   |
| Spillway structures | 3.2.12                   | Freeboard requirements                  | It is not clear how the freeboard allowance has been determined and incorporated in the dam design crest level, only sea side wave run up has been considered not reservoir wave run-up, unclear how the different studies have been used and whether settlement has been considered | High                                 | Determine minimum freeboard requirements and assess performance of design  |  | Understand and cost the risk of not filling the gaps | See comments on dam height   |
| Spillway structures | 3.2.12                   | Form and design of spillways            | The proposed spillway is of gross width of 2086m, having 115 spans of 18m wide gates and 4m thick piers.   | Medium                               | Consider range of flow and tide cases  |  |  | Details can be developed at a further stage of the project   |
| Spillway structures | 3.2.12                   | Location of spillways                   | The location of the spillway has been considered but will require review for the new alignment   | Medium                               | Study to review location to ensure still valid with new alignment  |  | Understand and cost the risk of not filling the gaps | Provide an estimate for the cost and time implications of changes to the size and location of the spillway |
| Spillway structures | 3.2.12                   | Gates and controls                      | Spillway option of gated or uncontrolled spillways has not been determined. Physical or mathematical modelling would be required to determine which options are feasible and then cost   | Medium                               | CFD or physical modelling to be carried out when design sufficiently developed   |  |  | Details can be developed at a later stage of the project   |

| Sub-component       | Inception Report section | Topic   | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|---------------------|--------------------------|---|---|--------------------------------------|--|--|--|--|
|                     |                          |   | analysis would be required to refine options.   |                                      |  |  |  |  |
| Spillway structures | 3.2.12                   | Load cases with tides   | Load cases not provided   | Medium                               | To be provided   |  |  | Details can be developed at a later stage of the project |
| Spillway structures | 3.2.12                   | Crest level   | It is not clear how the freeboard allowance has been determined and incorporated in the dam design crest level, see freeboard above   | High                                 |  |  | Understand and cost the risk of not filling the gaps | See comment of dam height requirements                   |
| Spillway structures | 3.2.12                   | Performance modelling (physical/CFD)                                | No physical or CFD modelling carried out for spillway structures, should be undertaken  | Medium                               | CFD or physical modelling to be carried out when design sufficiently developed |  |  | Details can be developed at a later stage of the project |
| Spillway structures | 3.2.12                   | Discharge rating curve  | Provided  | Low                                  |  |  |  | Details can be developed at a later stage of the project |
| Spillway structures | 3.2.12                   | Flow velocity and depth profile                                     | Only tentative design of the spillway and stilling basin provided. The design of spillway report suggests further model studies upon finalising location and design flows for the spillway.               | Medium                               | CFD or physical modelling to be carried out when design sufficiently developed |  |  | Details can be developed at a later stage of the project |
| Spillway structures | 3.2.12                   | Stilling basin  | Consideration has been given to a range of flows and tidal conditions however confirmation of design through model studies is required  | Medium                               |  |  |  | Details can be developed at a later stage of the project |
| Spillway structures | 3.2.12                   | Structural details  | Not yet provided  | Medium                               | To be developed  |  |  | Details can be developed at a later stage of the project |
| Highway Design      | 3.2.13                   | Indian Road standards, links to overtopping limits, traffic loading | The road design and standards applied is not clear (alignment, road construction). Similarly, permissible overtopping limits (sea or reservoir) related to road remaining safe for use have not been set. | Medium                               | Standards to be proposed and design developed                                  | Cost Benefit Analysis  | Close Gap  | A statement on Standards to be used for the design       |

| Sub-component                     | Inception Report section | Topic  | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|-----------------------------------|--------------------------|--|--|--------------------------------------|---|--|--|--|
| Railway Design                    | 3.2.14                   | Indian rail standards, links to overtopping limits, railway loading, routing of utilities with regard to waterproof dam elements | The railway design and standards applied is not clear (alignment, track construction). Similarly, permissible overtopping limits (sea or reservoir) related to remaining safe for use have not been set.           | Medium                               | Standards to be proposed and design developed   | Cost Benefit Analysis  | Close Gap  | A statement on Standards to be used for the design   |
| Access for fishing and shipping   | 3.2.15                   | Fish passage, locks  | As noted in Section D fish passage and impact on fish has not been properly addressed  | High                                 | Refer to Section D. Design of mitigation measures will need to follow the recommended studies.  | Cost Benefit Analysis  | Close Gap  | Refer to section D   |
| Mechanical equipment              | 3.2.16                   | Gates  | There are two proposed designs for gate layout identified which comprise 115no 18m x 7.5m or 95 18m x 5m vertical lift gates. Mathematical and physical modelling required to determine preferred arrangement.     | Medium                               | CFD or physical modelling to be carried out when design sufficiently developed  |  |  | Details can be developed at a later stage of the project   |
| Mechanical equipment              | 3.2.16                   | Sluices/pumps  | Selection of sluicing or pumping has not been identified for optimum operation. Durations required for removal of saline water need to be refined, currently estimated at 1-2 years by using the freshwater pumps. | High                                 | Modelling to determine if sluices are suitable for removal of saline water. Establish required timescales for removing saline water to inform requirements.         | Water availability   | Close Gap  | Outline design and constructability review for estimating CAPEX for the DPR required                 |
| Mechanical equipment              | 3.2.16                   | Monitoring, instrumentation, and controls  | There are little proposals on the instrumentation and controls required.   | Medium                               | Once design layout and initial control philosophy are determined, Layer of Protection Analysis (LOPA), and Hazard & operability study (HazOp) should be undertaken. |  | Understand and cost the risk of not filling the gaps | CAPEX and OPEX cost need to be included for a comprehensive cost - benefit analysis for a DPR.       |
| Construction sequence and methods | 3.2.17                   | During construction, closure, emergency access   | For closure works and construction sequence see comment above, no up-to-date construction sequence or methods available  | Medium                               | To be developed for latest design cross-sections and alignment  | Constructability   | Close Gap  | Construction sequence and materials availability need to be assessed for CAPEX estimates for the DPR |

| Sub-component                     | Inception Report section | Topic                                     | Gap/Issue identified                   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Notes  |
|-----------------------------------|--------------------------|---|--|--------------------------------------|--|--|--|--|
| Instrumentation plan              | 3.2.18                   | Water levels                              | No dam instrumentation plan identified | Medium                               | A draft document should be prepared and developed as the design progresses |  | Understand and cost the risk of not filling the gaps | A cost estimate for required equipment and operations costs needs to be included in the CAPEX and OPEX estimates for DPR and cost-benefit assessment |
| Instrumentation plan              | 3.2.18                   | Seepage and leakage                       | No dam instrumentation plan identified | Medium                               | A draft document should be prepared and developed as the design progresses |  | Understand and cost the risk of not filling the gaps | A cost estimate for required equipment and operations costs needs to be included in the CAPEX and OPEX estimates for DPR and cost-benefit assessment |
| Instrumentation plan              | 3.2.18                   | Water pressure in embankment/ foundations | No dam instrumentation plan identified | Medium                               | A draft document should be prepared and developed as the design progresses |  | Understand and cost the risk of not filling the gaps | A cost estimate for required equipment and operations costs needs to be included in the CAPEX and OPEX estimates for DPR and cost-benefit assessment |
| Instrumentation plan              | 3.2.18                   | Deformation monitoring                    | No dam instrumentation plan identified | Medium                               | A draft document should be prepared and developed as the design progresses |  | Understand and cost the risk of not filling the gaps | A cost estimate for required equipment and operations costs needs to be included in the CAPEX and OPEX estimates for DPR and cost-benefit assessment |
| Instrumentation plan              | 3.2.18                   | Seismic monitoring                        | No dam instrumentation plan identified | Medium                               | A draft document should be prepared and developed as the design progresses |  | Understand and cost the risk of not filling the gaps | A cost estimate for required equipment and operations costs needs to be included in the CAPEX and OPEX estimates for DPR and cost-benefit assessment |
| Operations and maintenance manual | 3.2.19                   | Operations and instrumentation            | No draft O&M identified                | Medium                               | A draft document should be prepared and developed as the design progresses |  | Understand and cost the risk of not filling the gaps | A cost estimate for required equipment and operations costs needs to be included in the CAPEX and OPEX estimates for DPR and cost-benefit assessment |

| Sub-component                     | Inception Report section | Topic  | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project)     | Recommended Action Before DPR Submission             | Notes   |
|-----------------------------------|--------------------------|--|---|--------------------------------------|---|--|--|---|
| Operations and maintenance manual | 3.2.19                   | Surveillance/inspections   | No draft O&M identified   | Medium                               | A draft document should be prepared and developed as the design progresses  |  | Understand and cost the risk of not filling the gaps | A cost estimate for required equipment and operations costs needs to be included in the CAPEX and OPEX estimates for DPR and cost-benefit assessment          |
| Emergency preparedness plan       | 3.2.20                   | Prepared prior to construction and agreed with stakeholders. Contents as per best practice, such as US Federal Dam Safety Commission | No EPP identified   | Medium                               | A draft document should be prepared and developed as the design progresses, stakeholders should be continuously involved in development   |  |  | This item should be developed as part of the design   |
| Narmada Dam                       |                          | Alignment  | Only preliminary concept design on barrage alignment with approximate location has been presented in the Feasibility Report. The design has not been developed further, there is no optioneering report/statement or constraints plan considering the possible alignments for the proposed barrage.<br>The preliminary concept design suggest 1.3km river barrage, with connected to 7km embankment for tidal protection of low lying land, and 18km of flood protection embankment. It is unclear where the flood protection embankment is located.<br>It is unclear the extents of the lake formed by the barrage in normal operation and flood conditions. | High                                 | Develop an optioneering report assessing the possible locations for the Narmada barrage, including constructability, environmental and socio-economic impact of the construction of the barrage. Consider the water availability impact on Kalpasar with and without the water from Narmada River | Water Availability and Integrated Operations Plan; Cost benefit analysis | Close Gap  | Understanding of how the Narmada dam will be operated and constructed is needed to demonstrate the water resources availability and reliability of the scheme |

| Sub-component | Inception Report section | Topic          | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes   |
|---------------|--------------------------|----------------|--|--------------------------------------|--|--|--|---|
| Narmada Dam   |                          | Crest Height   | The preliminary design alignment suggests that the barrage will be located in the tidal zone of the Narmada River and that the approach embankment will serve as a protection of low-lying land from saline intrusion. Therefore, the embankment of the dam will be subject to the same tidal and wave actions from the estuary experienced by the Kalpasar dam. There is no analysis on tide and wave action from both estuary and lake side, settlement, tsunami and mean sea level rise to determine the required dam crest elevation. Nominally the dam crest is set at +10mSL, however this is lower than Kalpasar Dam. | Medium                               | Check the frequency and significance of overtopping from the river and from the sea affecting the road proposed on the crest of the dam. Evaluation of overtopping on this large and complex structure will require numerical and physical modelling at the detailed design stage. All of the factors which influence the crest height should be considered and the dam crest height determined, including tidal range, sea level rise, reservoir water level range and flood rise, settlement, wave run-up/overtopping limits (operational and safety to both reservoir and sea sides), potential for tsunami action. |  |  | Not part of Kalpasar scheme, however, the feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme |
| Narmada Dam   |                          | Crest Width    | The preliminary design in the Feasibility Report suggests crest width of 30m to accommodate 6 lane road.   | Medium                               | Provide updated traffic survey and forecast for the need of the new coastal path including the latest local infrastructure in development (e.g. New Narmada bridge), coupled with a cost benefit analysis for the proposed barrage and embankment cross sections.  |  |  | See Section F   |
| Narmada Dam   |                          | Cross Sections | Not provided   | Medium                               | Cross sections to be developed.  |  |  | Not part of Kalpasar scheme, however, the feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme |
| Narmada Dam   |                          | Surveys        | Not provided. A list of proposed surveys to be undertaken listed in feasibility report.  | Medium                               | Surveys to be carried out as proposal enable further refinement of options for the Narmada dam design.   |  |  | Not part of Kalpasar scheme, however, the feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme |

| Sub-component | Inception Report section | Topic                          | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project)     | Recommended Action Before DPR Submission | Notes   |
|---------------|--------------------------|--------------------------------|--|--------------------------------------|---|--|--|---|
| Narmada Dam   |                          | Water Availability             | The Narmada dam project is at an earlier stage e of development compared to Kalpasar dam. Kalpasar water security heavily depends on the flows from the Narmada barrage. No assessment of the Kalpasar project viability was provided without the Narmada Dam.   | High                                 | Water availability analysis to be carried out evaluating the viability of the Kalpasar project in case of delays of the Narmada dam and canal project.                                    | Water Availability and Integrated Operations Plan                        | Close Gap                                | Not part of Kalpasar scheme, however, the feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme   |
| Narmada Dam   |                          | Operations and instrumentation | No dam instrumentation plan identified, no draft Operations Plan Provided  | Medium                               | A draft document should be prepared and developed as the design progresses  | Water Availability and Integrated Operations Plan                        | Close Gap                                | A draft dam operation regime including water balance needs to be provided to prove the viability and reliability of the scheme. Plan has to include inflow regimes from Narmada and trigger levels for operation of the spillway and deep-water sluices |
| Narmada Dam   |                          | Spillway                       | Spillway capacity required 100,000m <sup>3</sup> /s. Brief description of how it can work presented in Feasibility Report. Spillway width required is wider than the river at that location. No analysis provided on operation of the spillway working with the tidal range. As there is no storage curve for the Narmada reservoir, it is unclear if the reservoir will have enough storage capacity for the part time operation of the spillway. | Medium                               | Design to be developed further to prove the viability of the dam.   | Cost Benefit Analysis  | Close Gap                                | Not part of Kalpasar scheme, however, the feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme   |
| Narmada Canal |                          | Alignment                      | No alignment provided, only a preliminary possible route proposal described in the Feasibility Report. Route and alignment description demonstrates that the canal will be operating under minimum   | High                                 | Possible routes options and impact assessment to be considered as design progresses. Consideration to be given to the possibility of the benefits of widening the existing Narmada Canal. | Water Availability and Integrated Operations Plan; Cost benefit analysis | Close Gap                                | The feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme   |

| Sub-component | Inception Report section | Topic                          | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project)     | Recommended Action Before DPR Submission | Notes   |
|---------------|--------------------------|--------------------------------|--|--------------------------------------|--|--|--|---|
|               |                          |                                | available head, increasing the risk of siltation for the canal.  |                                      |  |  |  |   |
| Narmada Canal |                          | Dimensions                     | Minimal consideration for the proposed canal dimensions provided. No proposed cross sections provided. | Medium                               | As design develops, consideration to be given to the relationship between the water availability and flood storage capacity in the proposed new Narmada Dam, which is to govern the dimensions required for the canal. | Water Availability and Integrated Operations Plan; Cost benefit analysis | Close Gap                                | The feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme |
| Narmada Canal |                          | Operations and instrumentation | No canal instrumentation plan identified; no draft O&M plan provided.                                  | Medium                               | As design is developed further, a detail instrumentational and O&M plan to be developed. The canal O&M plan has to be linked with the O&M for the proposed Narmada Dam, Existing Narmada Dam, and Kalpasar Dam.        | Water Availability and Integrated Operations Plan                        | Close Gap                                | The feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme |
| Narmada Canal |                          | Surveys                        | No accompanying studies provided to support alignment  | High                                 | Conduct topographical and GI surveys, conduct socio-economic and environmental impact studies to enable the further development of the Narmada canal.  | Constructability and Cost Benefit Analysis                               | Close Gap                                | The feasibility of the Narmada Barrage and Canal need to be demonstrated for the feasibility of Kalpasar scheme |

## B) Estuary Water Management & Quality

| Sub-component    | Inception Report section | Topic  | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards |
|------------------|--------------------------|--|--|--------------------------------------|--|--|--|---------------------------------------|
| Tidal Flood Risk | 3.4.2                    | Tidal model including proposed dam   | Extent of model. Noting the processes that generate the macro tide range it is not clear that the model domain can encapsulate the whole of the effect of the barrage. It may also lead to overprediction of the magnitude of effect on tide at the barrage line. The cyclone model area used elsewhere is close to what I would expect.   | High                                 | Sensitivity testing for larger model domains   | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |                                       |
| Tidal Flood Risk | 3.4.2                    | Extreme tidal surges, sea level rise (consideration of RCPs), strategy for management/adaptation for protection of the dam and surrounding area. | There is no return period attached to the extreme water level study based on cyclones. It targets a probable maximum storm surge based on the historical record. This is then added to the highest astronomical tide level and modelling of wind waves. The validation of the model or tide alone or surges is vague. The best is that the predicted surge was 2.2 m compared to an observation of 2 m. A 10% difference is quite large in this context. | High                                 | Improved statement on model validation. Sensitivity testing to investigate uncertainties. Intercomparison of various models reported | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |                                       |
| Tidal Flood Risk | 3.3.2                    | Dam breach scenarios   | Dam breach scenarios have been considered from both reservoir side and sea side in the hydrodynamic and sedimentation report. However, the loss of life, damages of the breach wave on flood risk are not developed. This is tightly linked to the Dam Hazard Categorisation. See also A Dam Engineering   | Medium                               | Map flood risk receptors within the estuary, assess risk to life and property and prepare a draft Emergency Preparedness Plan.       | Cost Benefit Analysis  | Close Gap  |                                       |

| Sub-component      | Inception Report section | Topic  | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project)      | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards |
|--------------------|--------------------------|--|---|--------------------------------------|---|---|--|---------------------------------------|
| Fluvial Flood Risk | 3.3.3                    | Baseline hydraulic model including upstream catchment, seasonal aspects, use of gauged data, 2D modelling, survey data, link to tidal model, calibration       | The Dam Impact Study hydrodynamic model's extents stop at the confluences of the rivers. Only annual averages considered. No long term interaction between the reservoir and the rivers considered.   | Medium                               | Review model domain and extend to include the low river reaches that would be impacted by the tidal range and Kalpasar reservoir.   | Cost Benefit Analysis   | Understand and cost the risk of not filling the gaps |                                       |
| Fluvial Flood Risk | 3.3.3                    | Upstream fluvial impact of removing the tidal influence and implementing the Kalpasar Dam scheme   | In the Six Specific Studies it is advised to consider the effect of the reservoir to the low lying lands near the confluences of the river. The Dam Impact Study extents stop at the confluences of the rivers. The reservoir will have a high tailwater effect on the rivers directly discharging in the reservoir basin, reducing the discharge capacity of the rivers and increasing the probability of flooding to those lands. There has not been a study looking at the Kalpasar's impact on the fluvial flood risks in the upstream catchment. | Medium                               | Prepare a study on the impacts of fluvial flood risk as a result of the dam. Identify flood receptors and potential consequences such as loss of life and property damages  | Cost Benefit Analysis   | Close Gap  |                                       |
| Fluvial Flood Risk | 3.3.3                    | Flood risk to reclaimed land due to lower water levels on the reservoir side, assessed for monsoon flooding and potential breach scenarios of the Kalpasar Dam | No model of storms of different return periods was found of the Kalpasar reservoir. Different flood scenarios need to be considered to establish the impact on flood risk (positive or negative) by the construction and operation of Kalpasar study needs to review both the upstream and the downstream flood risks, assess the combined probability of flood scenarios happening simultaneously (such as a monsoon flooding and spring tide and a storm surges, high waves etc)  | High                                 | After revising the extents of the dam impact model, establish and run sufficient scenarios to determine the impact on flood risk at the reservoir rim, upstream catchment reaches and the downstream coastal areas. Determine the flood extents and identify the flood receptors. | Cost Benefit Analysis & Water Availability and Integrated Operations Plan | Close Gap  |                                       |

| Sub-component                               | Inception Report section | Topic                        | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project)      | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards   |
|---|--------------------------|------------------------------|---|--------------------------------------|---|---|--|---|
| Fluvial Flood Risk                          | 3.4.3                    | Climate change consideration | The assessment for sea level change is dated 2011 and needs to be updated in line with present predictions.   | Medium                               | Update sea level change predictions   | Cost Benefit Analysis   | Understand and cost the risk of not filling the gaps |   |
| Fluvial Flood Risk                          | 3.4.3                    | Environmental Damages        | There has been no assessment of potential environmental impacts reservoir and the estuary, as a result of increased risk of flooding. For example, there has been no assessment of potential sources of pollution, such as Nirma Point chemical plant, and how increased risk of fluvial flooding and lack of tidal flushing would impact on the reservoir water quality. | High                                 | Carry out an assessment on the risk for economic and environmental damages, such as triggering water pollution incidents or closure of vital local infrastructure due to changes of the risk of flooding. | Cost Benefit Analysis   | Close Gap  |   |
| Catchment water management (quality/supply) | 3.3.4                    | Drinking water               | Data from the reports [1 – Prefeasibility vol.1&3], which were written in 1998, is outdated and include future projections of population growth (2010, 2035 and 2060, assuming the dam would be in service by 2010). It is necessary to update the projected population growth and water demand forecasts as these are likely to have changed over time.                  | High                                 | Obtain latest information on the population expected to have access to water for drinking purposes and future prediction of population growth in the next 30-50 years.                                    | Cost Benefit Analysis & Water Availability and Integrated Operations Plan | Understand and cost the risk of not filling the gaps | <ul style="list-style-type: none"> <li>World Health Organisation, Guidelines for drinking water quality, Fourth edition incorporating the first addendum</li> <li>EU Directives relating to the quality of water intended for human consumption (80/778/EEC) and Council Directive 98/83/EC.</li> <li>USEPA standard — National Primary Drinking Water Standard. EPA 816-F-02-013.</li> </ul> |

| Sub-component                               | Inception Report section | Topic            | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project)      | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards  |
|---|--------------------------|------------------|---|--------------------------------------|---|---|--|--|
| Catchment water management (quality/supply) | 3.3.4                    | Irrigation water | Data from the reports is outdated and does not include future projections of land use/crops. Climate change forecasts are not taken into account either. Report: 22. - Study of taluka-wise Irrigation planning and Agro-economic impact of Kalpasar project. In this report, the land use pattern described dates back from 2003-4 to assess water needs for irrigation purposes. The land use and crop patterns are likely to have changed since this study was carried out. More recent data is needed to understand water usage requirements for irrigation purposes. | High                                 | Obtain the latest information on the crop type, surface area of each crop type, associated water usage and future prediction of agricultural land use in the next 30-50 years | Cost Benefit Analysis & Water Availability and Integrated Operations Plan | Understand and cost the risk of not filling the gaps | <ul style="list-style-type: none"> <li>• FAO irrigation and drainage paper 29 Rev 1, Water quality for agriculture</li> <li>• Central Water Commission tolerance limits for inland surface waters for the various classes of water use</li> <li>• IS 11624 (1986): Guidelines for the quality of irrigation water [FAD 17: Farm Irrigation and Drainage Systems]</li> <li>• IS 4251 (1967): Quality tolerances for water for processed food industry [FAD 25: Drinking Water]</li> </ul> |
| Catchment water management (quality/supply) | 3.3.4                    | Industrial water | No information available in the reports provided about the current and future water demand for industrial and other commercial purposes in the region.  | High                                 | Obtain the latest information available on the industrial and other commercial current water demand and future forecasts (30-50 years horizon)                                | Cost Benefit Analysis & Water Availability and Integrated Operations Plan | Understand and cost the risk of not filling the gaps |  |

| Sub-component                               | Inception Report section | Topic     | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards   |
|---|--------------------------|-----------|---|--------------------------------------|--|--|--|---|
| Catchment water management (quality/supply) | 3.3.4                    | Pollution | The water quality data provided in the reports is not very recent; seasonal analysis of water quality trends would be beneficial. Report 8 - Water quality report. The water quality data is displayed as a annual average over 5 years (July 2009-December 2014). The data is outdated to fully understand the most recent status of the water quality in the catchment. Obtaining water quality data at a finer resolution (e.g. monthly) would allow to monitor the trends of the parameters during different seasons. | High                                 | Obtain more recent water quality data in the estuary (e.g. turbidity, BOD, COD, TSS, Nitrogen, Phosphorus, heavy metals) | Water Availability and Integrated Operations Plan                    | Understand and cost the risk of not filling the gaps | <ul style="list-style-type: none"> <li>• Indian Standard for Drinking Water as per BIS specifications (IS 10500-2012) (second revision)</li> <li>• Manual on Water Supply and Treatment, third edition, Ministry of Urban Development, New Delhi</li> <li>• Central Water Commission tolerance limits for inland surface waters for the various classes of water use</li> <li>• Surface Water Quality Standards (ISI-IS 2296-1982)</li> <li>• Model Bill to regulate and control the development and management of ground water, 2005</li> <li>• The Water (Prevention and Control of Pollution) Amendment Bill by Ministry of Water Resources (2012)</li> <li>• IS 11624 (1986): Guidelines for the quality of irrigation water [FAD 17: Farm Irrigation and Drainage Systems]</li> <li>• IS 4251 (1967): Quality tolerances for water for processed food industry [FAD 25: Drinking Water]</li> </ul> |

| Sub-component                               | Inception Report section | Topic              | Gap/Issue identified   | Risk/ Importance (High/Medium/Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Reference Documents/ Codes/ standards |
|---|--------------------------|--------------------|--|------------------------------------|--|--|--|---------------------------------------|
| Catchment water management (quality/supply) | 3.3.4                    | Water availability | There is no recent information on water availability in the catchment or analysis that takes into account seasonality of the inflow.<br>Report: 1 - Techno economic feasibility report states calculations making use of the monthly inflow series for the period from 1901 to 2006 to deduct the water availability in the catchment area. Another study in this report has refined the assessment of the water availability which was done by the C.D.O. (2009) considering more number of rain gauge stations, establishing modified rainfall runoff relationship for each of the river basins, future planning in the basin up to 2025, and demand assessment as per pattern in the command area. Again, more recent data is required as well as water availability forecasts based on climate change projections. | High                               | Obtain recent monthly rainfall data and revise water availability projections taking into account climate change predictions   | Water Availability and Integrated Operations Plan                    | Close Gap                                |                                       |
| Catchment water management (quality/supply) | 3.3.4                    | Water availability | Target water supply reliability and how this has informed design are unclear. Short record period used to determine availability and so may not be representative of long term performance.  | High                               | Target availability should be agreed and design set to achieve this. Study should be carried out using longer record period should be used in simulation of reservoir water level including inflows, outflows (spills, various supplies), losses (e.g. seepage, evaporations). Sensitivity and climate change impacts should also be assessed. | Water Availability and Integrated Operations Plan                    | Close Gap                                |                                       |
| Catchment water management (quality/supply) | 4.1.2                    | Salinity           | Impact of salinity on crops is not fully considered, only seems to consider a short time period rather than long-term effects  | High                               | Study required into long-term risk of salinity to crops  | Water Availability and Integrated Operations Plan                    | Close Gap                                |                                       |

## C) Geotechnics/Geology and Seismology

| Sub-component  | Inception Report section | Topic  | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Reference Documents/ Codes/ standards |
|--|--------------------------|--|---|--------------------------------------|--|--|--|---------------------------------------|
| Geotechnical - Ground Investigation, dam site and construction materials | 3.4.1.1                  | COMACOE zones and data   | The COMACOE Geo Technical Investigation Report (Reported April 2021) although called final appears to require further review. For example, the report is divided into 7 Zones but appears to be missing all of the borehole and insitu test data (Appendix B and C have information from a different zone) from Zone 1. | High                                 | COMACOE reports to be finalised  | Constructability   | Close Gap                                |                                       |
| Referencing system to be used by all parties                             | 3.4.1.1                  | The site seems to be split into different zones by different authors which could cause confusion | The report by COMACOE is divided into 7 Zones. We would note that IITM's assessment of the data reduces this to 6 Zones.  | High                                 | Suggest that a clear referencing system needs to be put in place to avoid confusion. | Constructability   | Close Gap                                |                                       |

| Sub-component  | Inception Report section | Topic                           | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Reference Documents/ Codes/ standards |
|--|--------------------------|---------------------------------|--|--------------------------------------|---|--|--|---------------------------------------|
| Geotechnical - Ground Investigation, dam site and construction materials | 3.4.1.1                  | Dynamic nature of seabed levels | It is clear from the 'as built' levels of investigation locations in the COMACOE investigation that the bed of the inner as well as the outer gulf is a very active environment with constantly changing levels and differences over a few years of up to 30m appear to be a characteristic result from successive bathymetry and borehole location surveys. This means that geotechnical investigation of the soils within 30m of mean sea level provides only a 'snapshot in time'. Sand ridge and bar migration will result in variable bed level, density and strength development in the shallow foundation soils until construction is complete. The proposed earthfill dam will have a potentially huge volume of material below MSL. This means that the normally simple calculation of dam material volumes is going to be difficult to predict with certainty, due to the shifting nature of the seafloor. Consequently, dam construction cost and programme are going to be unpredictable. Further study of this aspect is likely to be required. | High                                 | A study of seafloor morphology /scour study to understand how the seabed changes with time. This may well include on site monitoring work | Constructability   | Close Gap                                |                                       |

| Sub-component  | Inception Report section | Topic  | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Reference Documents/ Codes/ standards   |
|--|--------------------------|--|--|--------------------------------------|--|--|--|---|
| Geotechnical - Ground Investigation, dam site and construction materials | 3.4.1.1                  | Desk study to place geotechnical data in a coherent soil model recognising the transient seabed levels | Whilst various investigations have taken place these have not been reviewed together to provide a combined soil model recognising the transient seabed levels. NIOT (Jan 2013) have noted for example that the 'Area has been investigated by several reputed organizations who have also identified some active faults in the area. The earlier work carried out by NIOT in 1999 and 2004 in the GoK to the south, picked up possible neo tectonically active faults which have affected the seabed itself. ' | High                                 | An overarching Desk Study is required to bring together all the available information regarding the existing ground conditions and to identify ground issues and risks. The development of the Geodatabase should facilitate this. | Constructability   | Close Gap                                | IS6955 (2008) Subsurface exploration for earth and rockfill dams - Code of Practice (WRD5: Geological Investigation and Subsurface Exploration) also<br>IS4651-1 (1974) Code of Practice for planning and design of ports and harbours, Part 1 : Site Investigation (CED47:Ports and Harbours) International<br>'industry good practice '<br>CIRIA C731 - The International Levee Handbook (Chapter 7 Site characterisation and data requirements)<br>CIRIA C683 Rock in Hydraulic Engineering BS EN 1997 (Eurocode 7 :Geotechnical Design Parts 1 and 2) |

| Sub-component  | Inception Report section | Topic   | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Reference Documents/ Codes/ standards  |
|--|--------------------------|---|--|--------------------------------------|--|--|--|--|
| Geotechnical - Ground Investigation, dam site and construction materials | 3.4.1.1                  | ground model based on all the available information | We understand that the Client body propose to develop an project Geodatabase which would be available to all collaborators. This is regarded as being the essential first step in enabling a conceptual 'ground model' for the dam site to be prepared. This would, amongst other things, include the ground levels and seal levels (various tides) and potentially the variation of these - i.e. including bathymetry data, and interpretation of the superficial deposits and geological sequence beneath the site (as partly identified in the Camocoe reports), and an interpretation of the structural geology as interpreted from the geophysical survey works undertaken. | High                                 | Based on the desk study a conceptual ground model/geological model should be prepared so that the various findings to date can be collated and interpreted | Constructability   | Close Gap                                |  |
| Geotechnical - Ground Investigation, dam site and construction materials | 3.4.1.1                  | material sources                                    | Currently it is envisaged that the dam structure will be constructed largely of rock fill and sands (potentially dredged) but there are no further details of the sources of such material, the means of transport to site or of the environmental impact of such activities. It is understood that such work is to be instructed shortly but at this point we have no further information.  | High                                 | A preliminary sources study should be undertaken to identify sources of material for use in construction.  | Constructability   | Close Gap                                | Industry good practice'<br>' CIRIA C731 - The International Levee Handbook (Chapter 7 Site characterisation and data requirements)<br>CIRIA C683 Rock in Hydraulic Engineering<br>BS EN 1997 (Eurocode 7: Geotechnical Design Parts 1 and 2) |

| Sub-component                  | Inception Report section | Topic                    | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards |
|--------------------------------|--------------------------|--------------------------|--|--------------------------------------|---|--|--|---------------------------------------|
| Geotechnical - Reservoir Basin | 3.4.1.2                  | Rim stability/Landslides | The potential for mass movement hazard needs to be assessed in relation to the reservoir basin. Risks of mass movements in the reservoir rim area must be evaluated and mitigation measures may be needed. The stability and structural integrity of the reservoir rim upstream of the structure must be evaluated for all potential loading conditions whether hydrologic, earthquake, or other hazards, man-made or natural. Reservoir rim instability may lead to poor water quality, blockage of channels and structures and waves which may threaten reservoir users and the dam structure. | High                                 | Risks of mass movements in the reservoir rim area must be evaluated and mitigation measures may be needed.<br><br>The stability and structural integrity of the reservoir rim upstream of the structure must be evaluated for all potential loading conditions whether hydrologic, earthquake, or other hazards, man-made or natura | Constructability   | Close Gap  |                                       |
| Geotechnical - Reservoir Basin | 3.4.1.2                  | Basin Leakage            | Basin leakage during impoundment occurs when infiltration of reservoir water is occurring through the surrounding and underlying soils, which is problematic if seepage occurs beneath the dam retention structures and can cause other erosional issues for the reservoir area. The permeability, hydraulic conductivity, and porosity of the soils supporting the reservoir volume should be evaluated. Erosion potential and corrosivity of the foundation soils should be evaluated.   | High                                 | The permeability, hydraulic conductivity, and porosity of the soils supporting the reservoir volume should be evaluated. Erosion potential and corrosivity of the foundation soils should be evaluated.   | Constructability   | Understand and cost the risk of not filling the gaps |                                       |

| Sub-component            | Inception Report section | Topic   | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards |
|--------------------------|--------------------------|---|---|--------------------------------------|---|--|--|---------------------------------------|
| Construction assumptions | 4.4.1                    | A study of alternative construction options should be undertaken and compared to the currently identified method of mass filling. | Alternative construction methods (other than mass filling) for part of the structure may well be appropriate, for example the use caissons of known geometry that can be floated out and ballasted into position on a seafloor prepared by suction dredger or similar. Such options could significantly reduce the quantity of mass fill required and will no doubt be considered as the design develops. | High                                 | Review alternative construction options - these could significantly reduce the quantity of mass fill required and will no doubt be considered as the design develops. | Cost Benefit Analysis<br>Constructability                            | Understand and cost the risk of not filling the gaps |                                       |
| Design basis             | 4.4.1                    | Design Basis  | A Design Basis Report should be established at the earliest opportunity and agreed by all stakeholders to inform all designers going forward. We note that development of this has now been initiated.  | High                                 | A Design Basis Report should be established at the earliest opportunity and agreed by all stakeholders to inform all designers going forward.                         | Cost Benefit Analysis<br>Constructability                            | Close Gap  |                                       |

| Sub-component                 | Inception Report section | Topic                            | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Reference Documents/ Codes/ standards |
|-------------------------------|--------------------------|----------------------------------|--|--------------------------------------|---|--|--|---------------------------------------|
| Seismic Design Considerations | 3.4.2.2                  | Performance criteria             | No seismic performance criteria have been defined relating to the operational and safety requirements of the Kalpasar dam and the linear infrastructure (rail, highway, communication, etc) that it will carry. The seismic security and the operational resilience of the various installations require evaluation and stakeholder agreement. Please note that due to the nature of the project, there is no current Indian or international codes which adequately define these requirements. The performance criteria should be both qualitative and quantitative (e.g. acceptable settlement and/or displacement limits). See Tables 3-1 & 3-2 in the Inception report for some suggested high level seismic criteria. | High                                 | Define Performance requirements for both operational (serviceability) and safety (ultimate) requirements which must consider the multi-functional aspects of the project. | Cost Benefit Analysis<br>Constructability                            | Close Gap                                |                                       |
| Seismic Design Considerations | 3.4.2.2                  | Site specific seismic assessment | No site-specific seismic hazard assessment has been carried out to define the design criteria. It is expected that this should be a site specific probabilistic seismic hazard assessment (PSHA). This should define the Safety Evaluation Earthquake (SEE), the Operating Basis Earthquake (OBE) and an earthquake to be considered during the construction phase (CLE). The potential of Reservoir Triggered Earthquakes (RTE) should also be considered.  | High                                 | A site-specific seismic hazard assessment is required. This seismic hazard study must be consistent with the performance requirements.                                    | Constructability   | Close Gap                                |                                       |

| Sub-component                 | Inception Report section | Topic                  | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards |
|-------------------------------|--------------------------|------------------------|---|--------------------------------------|---|--|--|---------------------------------------|
| Seismic Design Considerations | 3.4.2.2                  | Site response analyses | No site-specific site response analyses have been carried out. These studies model the influence of the near-surface layers on earthquake ground motions. The near-surface layers act as a filter that amplify/de-amplify the seismic waves coming from the earthquake source. The site responses studies should account for the variation in geology along the length of the dam, the impact of scour, the presence of mobile soils and the impact of the dam on the in-situ stresses. | High                                 | A series of site response analyses should be carried out along the length of the dam at regular intervals. Intervals should be selected based on the variation of the underlying geology.   | Constructability   | Close Gap  |                                       |
| Seismic Design Considerations | 3.4.2.3 & 3.4.2.4        | Design Basis           | Local seismic design standards need to be enhanced based on best international practice.  | High                                 | Appropriate local and international design standards related to seismic design need to be confirmed in the Design Basis.  | Cost Benefit Analysis<br>Constructability                            | Understand and cost the risk of not filling the gaps |                                       |
| Seismic Design Considerations | 3.4.2.2 & 3.4.2.5        | Liquefaction           | The current liquefaction assessment should be repeated once the site-specific seismic hazard assessment has been completed.   | High                                 | Update the liquefaction assessment for SSE, OBE, CLE and RTE.   | Cost Benefit Analysis<br>Constructability                            | Close Gap  |                                       |
| Seismic Design Considerations | 3.4.2                    | Faulting               | All regional and local faults and the evidence of their seismic activity identified.  | High                                 | Undertake regional and local fault mapping exercise to feed into seismic hazard assessment collating evidence for fault activity. New geophysical studies should examine whether there are any unknown faults under the proposed alignment. | Constructability   | Understand and cost the risk of not filling the gaps |                                       |

| Sub-component                 | Inception Report section | Topic       | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards |
|-------------------------------|--------------------------|-------------|--|--------------------------------------|---|--|--|---------------------------------------|
| Seismic Design Considerations | 3.4.2                    | Overtopping | Risk of overtopping of the dam due to seismic effects has not been considered  | High                                 | An assessment should be made of seismic displacement of the dam, liquefaction, seismically induced waves in the reservoir (in addition to Tsunami listed elsewhere) and earthquake induced landslides into reservoir resulting in overtopping of the dam with the design including an allowance for these effects | Cost Benefit Analysis<br>Constructability                            | Understand and cost the risk of not filling the gaps |                                       |
| Tsunami Hazard Assessment     |                          | Tsunami     | The tsunami hazard assessment report by NGRI must be updated to consider other tsunami sources (volcanoes, landslides, meteorological etc.). Furthermore, the proposed model should be verified. Based on an initial review it does not appear to match observed events such as the 1945 Makran tsunami which had a maximum water height of 17m at Pasni, Pakistan. Additionally, the NOAA tsunami database indicates 2m water height in Mumbai for the 1945 event, which is much higher than the values calculated for Scenario 1 in the NGRI report. | High                                 | Update the tsunami hazard assessment.   | Cost Benefit Analysis<br>Constructability                            | Close Gap  |                                       |

| Sub-component  | Inception Report section | Topic                              | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards  |
|--|--------------------------|------------------------------------|---|--------------------------------------|--|--|--|--|
| Geotechnical - Ground Investigation, dam site and construction materials | 3.5.1.1                  | Spacing of investigation locations | The current coverage of the favoured alignment will need supplementing by further phases of ground investigation and should be informed by a detailed desk study and the development of a preliminary ground model. Currently perhaps only some 10% to 15% of the required detail has been undertaken and the subsequent work is likely to include amongst other things: 1. Line of route geophysics to characterise the superficial geology along the route; 2. CPTU/SCPT to provide detail (CPT and Seismic cone); 3. Boreholes for correlation with the above indirect methods; The above will be supplemented by detailed laboratory testing on the samples recovered. Supplementary information is also required including periodical monitoring of changes in the bed level (regular bathymetric survey or other monitoring). | Medium                               | Assuming the viability of the project and alignment is confirmed and as the design stages develop there will quickly become a need for more detailed ground investigation. This is likely to be undertaken in stages and the very hostile environment of much of the alignment means that significant forward planning will be required to facilitate this work and is likely to include: Line of route geophysics to characterise CPTU/SCPT to provide detail (CPT and Seismic cone) Boreholes for correlation with the above indirect methods Later investigation of sources of materials will be required | Cost Benefit Analysis<br>Constructability                            | Understand and cost the risk of not filling the gaps | IS6955 (2008) Subsurface exploration for earth and rockfill dams - Code of Practice (WRD5: Geological Investigation and Subsurface Exploration) also IS4651-1 (1974) Code of Practice for planning and design of ports and harbours, Part 1 : Site Investigation (CED47: Ports and Harbours) International 'industry good practice 'CIRIA C731 - The International Levee Handbook (Chapter 7 Site characterisation and data requirements) CIRIA C683 Rock in Hydraulic Engineering BS EN 1997 (Eurocode 7 : Geotechnical Design Parts 1 and 2) |

| Sub-component  | Inception Report section | Topic  | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards |
|--|--------------------------|--|---|--------------------------------------|--|--|--|---------------------------------------|
| Geotechnical - Ground Investigation, dam site and construction materials | 3.5.1.1                  | Lack of comment on high to very high carbonate content of many of the underlying soils | One aspect of the COMACOE investigation that does not appear to have been commented on by other is the apparent high to very high carbonate content of many of the underlying soils. These results need some clarification as it is not clear whether this is expected in this area as it does not appear to have been noted by published information for the geology of the area. However, if confirmed, this may have a positive effect in relation to liquefaction potential (see Seismic Assessment Section). | Medium                               | Suggest to be confirmed by COMACOE in the finalisation of their draft report   | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |                                       |
| Geotechnical - Ground Investigation, dam site and construction materials | 3.5.1.1                  | Developing geotechnical design   | Further details of the developing geotechnical design will need to be reviewed as information becomes available. It is apparent that some preliminary work is underway including in the following areas:<br><br>Development of a Geological Model for the site<br><br>Assessment of Geohazards<br><br>Seismic engineering including liquefaction assessment<br><br>Soil structure interaction aspects<br><br>Study of construction options  | Medium                               | It is suggested that a comprehensive geotechnical scope is developed to ensure all relevant are aspects are covered going forward including the issues mentioned | Cost Benefit Analysis<br>Constructability                            | Understand and cost the risk of not filling the gaps |                                       |
| Seismic Design Considerations  | 3.5.2 & 4.4.2            | Seiche   | No assessment of the reservoir seiches has been undertaken.   | Medium                               | A study of seiche potential and impact within the newly impounded area must be carried out.  | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |                                       |

| Sub-component                 | Inception Report section | Topic       | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards |
|-------------------------------|--------------------------|-------------|---|--------------------------------------|--|--|--|---------------------------------------|
| Seismic Design Considerations | 3.4.2                    | Overtopping | Consequence of earthquakes on condition, safety and operation of road and railway has not been considered | Medium                               | Effect of earthquakes on multi-functional installations should be considered in design | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |                                       |

## D) Environmental Review

| Sub-component                             | Inception Report section | Topic                        | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards |
|---|--------------------------|------------------------------|--|--------------------------------------|--|--|--|-------|---------------------------------------|
| Technical coverage of environmental risks | 3.5.2                    | Baseline and evidence - Land | There is limited baseline understanding of the soil conditions both in the terrestrial and sub-tidal areas. Limited sampling data for the terrestrial and marine soils has been undertaken that will need to be enhanced to give a full dataset. Sampling has concentrated at a number of built-up areas and will need to also look at other land/intertidal areas to determine likely impact during and following the dam works. This is needed to inform the assessment of the interactions with water quality following barrage enclosure, especially salinisation and eutrophication effects. Will need a good delineation of what areas are going to be 'reclaimed' or if areas are going to undergo land use alteration. | Medium                               | Comprehensive sampling programme of the Gulf of Khambhat and adjacent land areas. This should consider physical and chemical quality of the soils. Can use sampling to date to guide new sampling programme. |  |  |       |                                       |

| Sub-component                             | Inception Report section | Topic                         | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards  |
|---|--------------------------|-------------------------------|---|--------------------------------------|---|--|--|-------|--|
| Technical coverage of environmental risks | 3.5.2                    | Baseline and evidence - Water | There is insufficient baseline understanding of the water quality conditions and inputs from feeder rivers. Sampling data for input rivers is available for 2009-2014, but seemingly limited to one year for the Gulf beyond some physical parameter measurements. This is essential to inform the assessment of the water quality changes arising from barrage enclosure. There is mention of the use of dredging within the project however there is no indication of where this dredging is to occur. Detailed sampling of sediments to be dredged and used in either dam construction or land reclamation will be required as there is a high probability of the resuspension of contained contaminants within any dredged sediments. | Medium                               | Comprehensive sampling programme of the Gulf of Khambhat and, to a lesser extent, feeder rivers is needed. This should consider physical and chemical quality and take into account seasonal variability. |  |  |       | See Section 4.3 'Study Methods' of 'Guidelines for the assessment and planning of barrages', Burt and Rees, 2001 |

|  |              |   |  |             |   |   |                  |  |  |
|--|--------------|---|--|-------------|---|---|------------------|--|--|
| <p>Technical coverage of environmental risks</p> | <p>3.5.2</p> | <p>Baseline and evidence - Vegetation</p> | <p>The prefeasibility reports suggest that the areas of mangrove affected by the barrage are already substantially degraded. However subsequent survey report that appears reasonably comprehensive does not support this assertion. There seems to have been an increase in mangrove cover over time, and this is at least partially due to agencies efforts in reforestation. Satellite images used in mapping do not seem to tally with the ground-truth assessment of density assessment. This has a very important bearing on the impact assessment and compensation requirement and so inconsistencies need to be addressed. The reports note the presence of areas of halo-tolerant and saline plants such as <i>Salicornia brachiata</i>, which is a saltmarsh species. Assessment should be made of the presence and density of saltmarsh, as well as the presence of mangrove.</p> | <p>high</p> | <p>Detailed habitats survey is needed for all potentially affected areas (including areas outside the barrage affected by sea level changes), including assessment of the type, condition and extent of habitats. It is recommended that data is collected in such a way that the value of baseline habitats (terrestrial and aquatic) can be assessed according international Lenders standards for biodiversity (i.e. the determination of modified, natural or critical habitat, as defined by ADB / IFC biodiversity standards, as part of formal Critical Habitat Assessment). This baseline habitat analysis will inform the mitigation requirements (i.e. “no net loss” or “net gain” requirement). Surveys can build on previous surveys. Will require most recent satellite images with a repeat of some of the more detailed ground-based surveys and QA of the remote sensing land-cover assessment. There is some assessment of the potential areas for mangrove planting as mitigation. However the project needs full analysis of how successful attempts have been to reforest mangroves in areas close to the project site. Updating the mangrove data should also include mapping and assessment of saltmarsh in the direct and indirect impact zones.</p> | <p>Requirement for up to date data; Requirement for comprehensive information on ecological impacts</p> | <p>Close Gap</p> | <p>Requirement for the DPR submission, Can be done using surveys already completed</p> | <p>See Section 3.3 'Study Methods' of 'Guidelines for the assessment and planning of barrages', Burt and Rees, 2001</p> <p>Asian Development Bank’s (ADB) 2009 Safeguard Policy Statement (SPS) - Chapter 5 Biodiversity Conservation and Sustainable Natural Resource Management.</p> |
|--|--------------|---|--|-------------|---|---|------------------|--|--|

| Sub-component                             | Inception Report section | Topic                         | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes   | Reference Documents/ Codes/ standards   |
|---|--------------------------|-------------------------------|--|--------------------------------------|--|--|--|---|---|
| Technical coverage of environmental risks | 3.5.2                    | Baseline and evidence - Fauna | A detailed description of the terrestrial and aquatic fauna is largely lacking, other than a high-level review of the fisheries of the Gulf. There is for example only cursory information on avifauna which is mostly derived from secondary data and some bird data form around the 11 survey sites, which will not represent the majority of the impacted area. There is some but limited sampling of marine benthos. There is some survey data on classes of fauna found in rivers as well as information on planktonic species. However there is insufficient baseline for a full assessment of likely change in community composition following the closure of the dam and the resulting alterations to communities present. Impacts on marine fauna will be a pivotal issue for the project and needs a detailed baseline. Reason for high risk status is the driven mostly by the use of the intertidal areas as foraging and stop-over areas for internationally important bird species. Some assessment of the intertidal areas as a feeding resource will be required and assessment of increased flight times for some migratory birds. There is a lack of information on marine turtle nesting areas and the use of the gulf area and surrounding area for marine mammals. The reports mention the presence of dunes and associated dune flora, however this is not surveyed or mapped. | High                                 | Detailed faunal surveys are needed for all potentially affected areas, including assessment of the abundance and diversity of fauna present. This should include consideration of seasonal variability. Surveys will need to include seasonal avifauna survey of intertidal areas within closed dam area, and use of intertidal in adjacent and further afield areas that will be affected by sea level changes post dam closure. This should link in with assessment of the intertidal area as a food resource for birds. There is a need to show baseline for turtle nesting areas as well as use of the gulf for marine mammals. Survey and mapping of dune systems and associated fauna. It is recommended that faunal surveys are undertaken in such a way that allows the value of faunal species / assemblages (terrestrial and aquatic) to be assessed according international Lenders standards for biodiversity (i.e. the determination of potential Critical Habitat trigger species and subsequent assessment, as part of a formal Critical Habitat Assessment). This baseline analysis will inform the mitigation requirements (i.e. "no net loss" or "net gain" requirements). | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                | Unfeasible in timing available. Cost surveys and programme delays | See Section 3.3 'Study Methods' of 'Guidelines for the assessment and planning of barrages', Burt and Rees, 2001<br><br>Asian Development Bank's (ADB) 2009 Safeguard Policy Statement (SPS) - Chapter 5 Biodiversity Conservation and Sustainable Natural Resource Management. |

| Sub-component                             | Inception Report section | Topic           | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes  | Reference Documents/ Codes/ standards   |
|---|--------------------------|-----------------|--|--------------------------------------|--|--|--|--|---|
| Technical coverage of environmental risks | 3.5.2                    | Scoping - Land  | The effects of displacement of people engaged in the saltpan, agriculture and fishery sectors need to be properly scoped and displacement effects fully assessed and resolved. Other than for the saltpan sector, these effects are only discussed in general terms. The work will need to include an assessment of the effect of land alteration, and/or conversion from what is described as 'wasteland' into either agricultural, industrial, housing or other and its knock-on effect on sedimentation, water quality issues as well as human use. This should also include assessment of the effect of large increases in human population as a result of the dam closure and associated works.           | High                                 | Confirm what studies have been undertaken since 2008. Update the scoping for the latest project design, and ensure that effects on directly and indirectly affected people are fully considered and addressed. Also address the secondary effects of population growth stimulated by the barrage.  | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                | Key for supporting cost-benefit analysis for the project and gaining support from project donors | Involuntary Resettlement Safeguards: A Planning and Implementation Good Practice Sourcebook (Draft Working Document), ADB, November 2012. Addressing project impacts on fishing-based livelihoods a good practice handbook: Baseline Assessment and Development of a Fisheries Livelihood Restoration Plan, IFC, 2015   |
| Technical coverage of environmental risks | 3.5.2                    | Scoping - Water | The scoping report identifies the water quality impacts as a key area of investigation and resolution. Detailed scoping recommendations are made. This scoping needs to be updated with the latest project design and the required studies confirmed. The work will need to include assessment of the impact of land-cover change as well as population increases and associated growth/development/construction that is predicted to happen as a result of the dam closure. Current calculations of land cover (including water) seem to massively underrepresent areas of open sea. This is possibly due to the satellite tiles that were used for the analysis which do not cover the full open water area. | High                                 | Confirm what studies have been undertaken since 2008. Update the scoping of water issues with the latest project design, including sea level changes outside the dam. There will be a requirement to obtain sediment sample results from any areas that are identified for dredging. This will include sampling throughout the dredge depth. Re-check the current land use (including water) from satellite images analysis. Will need to obtain up-to-date satellite images as current sets are not suitable. Scoping should encompass cumulative effects from other projects in the area, and also secondary effects from the population growth stimulated by this scheme. | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |  | See Section 3.3 'Study Methods' of 'Guidelines for the assessment and planning of barrages', Burt and Rees, 2001. For dredge sampling see 'OSPAR Guidelines for the Management of Dredged Material', available at <a href="https://dredging.org/documents/ceda/downloads/environment-ospar-dmguidelines.pdf">https://dredging.org/documents/ceda/downloads/environment-ospar-dmguidelines.pdf</a> |

| Sub-component                             | Inception Report section | Topic                | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards  |
|---|--------------------------|----------------------|---|--------------------------------------|--|--|--|-------|--|
| Technical coverage of environmental risks | 3.5.2                    | Scoping - Vegetation | The scoping report also identifies the impacts on flora, especially mangroves, as a key area of investigation and resolution. Further work on mangrove extent is summarised in the GES Synopsis report. Nonetheless, detailed scoping recommendations are made. This scoping needs to be updated with the latest project design and the required studies confirmed, including the impacts of water level changes outside the dam. The scope should include an assessment of the recent efforts to reforest mangrove areas by agencies with a view to determining the uncertainties associated with the planned mangrove mitigation. This includes an assessment of use by humans (fodder for cattle, building material, heating/cooking) as a result of increases in populations as a result of the project. Vegetation scope should consider also the loss of saltmarsh, and the impact of potentially changing what is currently likely to be saltmarsh into compensatory mangrove habitat, and conversion to sub-tidal as a result of sea level changes. | High                                 | Confirm what studies have been undertaken since 2008, especially the recommended estimates of type, quantity and quality of mangrove areas affected. Update the scoping of flora issues with the latest project design, and consider other key receptors such as saltmarsh. Assessment of any land/fauna/flora clearance that may be required for the quarrying of rock that will be required for the project. Scoping should encompass cumulative effects from other projects in the area, and also secondary effects from the population growth stimulated by this scheme. | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       | See Section 3.3 'Study Methods' of 'Guidelines for the assessment and planning of barrages', Burt and Rees, 2001 |
| Technical coverage of environmental risks | 3.5.2                    | Scoping - Fauna      | The scoping report also identifies the impacts on a wide range of fauna as a key area of investigation and resolution. Detailed scoping recommendations are made. This scoping needs to be updated with the latest project design and the required studies confirmed, and must include receptors such as sea mammals, turtles, avifauna, and intertidal benthos.  | High                                 | Confirm what studies have been undertaken since 2008. Update the scoping of fauna issues with the latest project design. Scoping should encompass cumulative effects from other projects in the area, and also secondary effects from the population growth stimulated by this scheme.   | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       | See Section 3.3 'Study Methods' of 'Guidelines for the assessment and planning of barrages', Burt and Rees, 2001 |

| Sub-component                             | Inception Report section | Topic                 | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards |
|---|--------------------------|-----------------------|---|--------------------------------------|--|--|--|-------|---------------------------------------|
| Technical coverage of environmental risks | 3.5.2                    | Analysis - Land       | It is not clear how the recommendations of the Scoping Report (2008) have been taken forward since 2008, noting the reservations of the MoEF expressed in 2010. Full examination is needed, supported by validated modelling of the effects on estuary water levels and morphology outside the barrage.   | High                                 | See scoping issues above.  | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |
| Technical coverage of environmental risks | 3.5.2                    | Analysis - Water      | It is not clear how the recommendations of the Scoping Report (2008) have been taken forward since 2008, noting the reservations of the MoEF expressed in 2010. The GES report indicates that baseline survey has continued but detailed examination of effects and mitigation planning is lacking. Current calculations of land cover (including water) seem to massively underrepresent areas of open sea. This is possibly due to the satellite tiles that were used for the analysis which do not cover the full open water area. | High                                 | See scoping issues above.  | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |
| Technical coverage of environmental risks | 3.5.2                    | Analysis - Vegetation | The mangrove study quantifies the areas at risk, and is updated in the GES synopsis report. This appears to be based on the scheme as foreseen in c. 2010, and needs to be updated. There is no consideration of saltmarsh effects.   | High                                 | Full update of mangrove and other flora impact studies to quantify the area and quality of habitat lost. | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |

| Sub-component                             | Inception Report section | Topic                              | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards |
|---|--------------------------|------------------------------------|---|--------------------------------------|--|--|--|-------|---------------------------------------|
| Technical coverage of environmental risks | 3.5.2                    | Analysis - Fauna                   | The fisheries impact analysis is high-level and needs to be comprehensively updated and expanded. It needs to consider the latest proposed scheme, including the implications of the Narmada River diversion for Hilsa (and other migratory fish/invertebrates) and their migration routes. Likewise, other faunal effects such as upon marine mammals, avifauna and marine benthos are still not fully assessed, taking into account the (as yet not completed) effects on the estuary physical regime.  | High                                 | Full assessment needed using the latest baseline of the faunal impacts including fish but also avifauna, marine benthos etc. | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |
| Technical coverage of environmental risks | 3.5.2                    | Mitigation and Compensation - Land | It is not clear how the recommendations of the Scoping Report (2008) have been taken forward since 2008, noting the reservations of the MoEF expressed in 2010. The GES Synopsis report indicates that baseline survey has continued but detailed examination of effects and mitigation planning is lacking. There is the need for detailed delineation of areas that are expected to change. This includes areas that are currently denoted as 'wasteland' and the areas that are going to be 'reclaimed' or where there is identified land-use alteration. There is a need to develop better mitigation for the likely effects on the Asiatic lion, which would also need to consider effects of land use change and increased population expected as a result of the project. See cells H4 and H5 which cover baseline habitat and species assessment requirements to meet international biodiversity standards for Lenders. | High                                 | See scoping issues above.  | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |

| Sub-component                             | Inception Report section | Topic                               | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation                                    | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards |
|---|--------------------------|-------------------------------------|---|--------------------------------------|---|--|--|-------|---------------------------------------|
| Technical coverage of environmental risks | 3.5.2                    | Mitigation and Compensation - Water | It is critical that plans are in place to improve the river water discharges behind the barrage, to mitigate the water quality effects. There is no clear evidence of this. In addition where it is indicated that water/waste discharge will just be moved seaward of the dam, there will need to be other assessment of this impact 'at sea' and further mitigation put in place. Mitigation will need to consider the effects of increased population as a result of the project, as well as increases in project and post-project construction and its knock-on effect on water quality. Mitigation will be required to address increasing demand for waste water/materials. GES synopsis report does not indicate any progress on mitigation planning. | High                                 | Full mitigation plans for water quality effects are required. | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |

| Sub-component                             | Inception Report section | Topic                                    | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards |
|---|--------------------------|--|--|--------------------------------------|---|--|--|-------|---------------------------------------|
| Technical coverage of environmental risks | 3.5.2                    | Mitigation and Compensation - Vegetation | Thought has already been given to mangrove restoration and compensation. These plans need to be updated in view of the latest proposed project. The potential areas for mitigation of mangrove will need to be assessed against a climate change model and assessed against alterations to coastal processes as a result of having the dam in-place. This could alter conditions outside the dam closure area (e.g. water levels) that may indirectly affect further areas on mangrove. Mitigation areas will need to ensure areas are suitable at present, and for the medium-term future. Vegetation impacts should consider also the loss of saltmarsh, and the impact of potentially changing what is currently likely to be saltmarsh into compensatory mangrove habitat. | High                                 | Updated mangrove restoration plan required, including more evidence of effectiveness, and including assessment of indirect impacts on mangroves and possible mitigation areas from project as well as project and climate change effects on sea level rise. There will also need to be mitigation for the increased need for wood (building material and fuel) as a result of the increased populations that are expected as a result of the project. | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |
| Technical coverage of environmental risks | 3.5.2                    | Mitigation and Compensation - Fauna      | The measures to mitigate the impacts on fisheries, avifauna, marine benthos etc are largely missing. This will need to include the increased pressure on these resources (especially those used as food or fuel) as a result of the increased populations as a result of the project.  | High                                 | Full fish resources and fishing activity mitigation plans are needed. Likewise for other ecological effects. This will need to include mitigation as a result of increased demand following population increases as a result of the project and other cumulative effects.   | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |
| Technical coverage of environmental risks | 3.5.2                    | Residual risk - Land                     | It is not clear how the recommendations of the Scoping Report (2008) have been taken forward since 2008, noting the reservations of the MoEF expressed in 2010.  | High                                 | See scoping issues above.   | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |

| Sub-component                             | Inception Report section | Topic                 | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation                         | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards |
|---|--------------------------|-----------------------|---|--------------------------------------|--|--|--|-------|---------------------------------------|
| Technical coverage of environmental risks | 3.5.2                    | Residual risk - Water | The 2016 study on the impacts of the project on water levels at nearby ports identifies effects on water levels, currents and bedload sediment. However these are not evaluated in terms of impacts for the port operations. A separate study in 2018 appears to reach contradictory findings that need to be reconciled. Neither report considers the water quality effects within the barrage (except for salinity), with respect to eutrophication effects for example. There is a residual risk concerning the likely increased salinity of water sources to the south of the dam as a result to alterations in flow and sea level height. There will need to be further assessment of this knock-on water levels and water quality issue for those outside the dam area. The cumulative impact assessment will need to consider the in combination effect of the project on water, alongside a number of other large-scale projects that are in the planning process and within the same likely impact area. | High                                 | As above, full impact and mitigation study needed. | Requirement for up to date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |

| Sub-component   | Inception Report section | Topic                                   | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation                         | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards |
|---|--------------------------|---|---|--------------------------------------|--|--|--|-------|---------------------------------------|
| Technical coverage of environmental risks                 | 3.5.2                    | Residual risk - Vegetation              | Whilst work has already been done to develop a mitigation plan for mangrove loss, this needs to be much more developed and detailed in order for the residual impact assessment to be credible, which will need to consider indirect project impacts as well as sea level increase and increased storminess. The cumulative impact assessment will need to consider the in combination effect of the project on vegetation, alongside a number of other large-scale projects that are in the planning process and within the same likely impact area. | High                                 | As above, full impact and mitigation study needed. | Requirement for up-to-date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |
| Technical coverage of environmental risks                 | 3.5.2                    | Residual risk - Fauna                   | The impact analysis for fisheries and other fauna is high level and not based on comprehensive survey data. There is one year of marine benthos sampling. It is also not clear that it relates to the latest project option. The cumulative impact assessment will need to consider the in combination effect of the project on fauna, alongside a number of other large-scale projects that are in the planning process and within the same likely impact area.  | High                                 | As above, full impact and mitigation study needed. | Requirement for up-to-date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       |                                       |
| Compliance with international standards and good practice | 3.5.3                    | ADB Environmental Safeguards Objectives | The major impacts of the project need to be assessed and addressed, including estuary physical regime, water quality, ecological impacts, waterborne disease and loss of livelihoods.   | High                                 | Comprehensive assessment to be undertaken.         | Requirement for up-to-date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       | refer to ADB guidance                 |

| Sub-component   | Inception Report section | Topic  | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation                                   | Feasibility Key Gaps (gaps that risk the feasibility of the project)                             | Recommended Action Before DPR Submission | Notes | Reference Documents/ Codes/ standards |
|---|--------------------------|--|--|--------------------------------------|--|--|--|-------|---------------------------------------|
| Compliance with international standards and good practice | 3.5.3                    | ADB Involuntary Resettlement Safeguards Objectives | There are major potential resettlement issues related to direct and economic displacement of people currently engaged in the ports sector, agriculture, salt production and marine fishing. There is insufficient evidence that this is being addressed, even if in the case of fishing it is recognised as an issue for the affected communities. | High                                 | Comprehensive assessment to be undertaken and RAP developed. | Requirement for up-to-date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       | Refer to ADB guidance                 |
| Compliance with international standards and good practice | 3.5.3                    | ADB Indigenous Peoples Safeguards Objectives       | The GES Synopsis report refers to the scheduled tribes in the study area, especially Bharuch District. However, these effects are not assessed so significance is unknown.   | High                                 | Comprehensive assessment to be undertaken.                   | Requirement for up-to-date data; Requirement for comprehensive information on ecological impacts | Close Gap                                |       | Refer to ADB guidance                 |

## E) Socio-economic Impact

| Sub-component                                  | Inception Report section | Topic                    | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Reference Documents/ Codes/ standards   |
|--|--------------------------|--------------------------|--|--------------------------------------|--|--|--|---|
| Technical Coverage of Social Risks and Impacts | 3.5.                     | Social Impact Assessment | Comprehensive Social Impact Assessment (SIA) hasn't been carried out. The available information related to baseline data and risks is scattered throughout many reports and not aligned to the common goal. Impoverishment risks & impacts and livelihood restoration measures are not available in the reports, though some indications of loss of employment for salt workers. | High                                 | SIA should be conducted. Past, present and future impacts & risks should be identified. Risks and impacts should be correspondent to the Project phases (construction, transition, operation). Temporary and permanent impacts should be differentiated. | Social Impact Assessment   | Close Gap                                | Handbook on Poverty and Social Analysis, A Working Document, ADB, 2012; World Bank Environmental and Social Framework, 2016;  |
| Technical Coverage of Social Risks and Impacts | 3.5.                     | Mitigation hierarchy     | The Reports are silent on what measures have been taken (or will be taken) to avoid, minimize and mitigate (also compensate) adverse social impacts  | Medium                               | Social Impact Assessment should specify what measures have been taken into account to avoid adverse social impacts, similarly minimization, mitigation, compensation/offset efforts should be explained.   | Social Impact Assessment   | Close Gap                                | Safeguard Policy Statement, ADB, 2009; Handbook on Poverty and Social Analysis, A Working Document, ADB, 2012; World Bank Environmental and Social Framework, 2016; |
| Technical Coverage of Social Risks and Impacts | 3.5.                     | Gender Assessment        | Gender assessment hasn't been carried out. Potential adverse impacts of the Project on gender issues, as well as the opportunities to mainstream gender benefits haven't been discussed. Moreover, there is no indication of gender involvement in the public consultations held so far.   | Medium                               | Gender assessment should be carried out. Depending on the results of the assessment, probably there might be a need for the preparation of Gender Action Plan.   | Social Impact Assessment   | Close Gap                                | Safeguard Policy Statement, ADB, 2009; World Bank Environmental and Social Framework, 2016;   |

| Sub-component                                  | Inception Report section | Topic             | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission | Reference Documents/ Codes/ standards   |
|--|--------------------------|-------------------|---|--------------------------------------|--|--|--|---|
| Technical Coverage of Social Risks and Impacts | 3.5.                     | Labour Impacts    | Assessment of labour impacts hasn't been done. For example, impacts of forecasted labour influx due to Project activities, mitigation measures to avoid use of child labour, forced labour, measures to be implemented to restore potential loss of employment (such as salt workers, fishermen) etc. | High                                 | Labour Assessment should be conducted, and appropriate mitigation measures should be defined as per mitigation hierarchy. Key risks on expected direct employees, key suppliers should be assessed. Also, major risks (child labour, forced labour, minimum working conditions) for Contracted workers and Community workers should be investigated.   | Social Impact Assessment   | Close Gap                                | World Bank Environmental and Social Framework, (Especially ESS2) 2016; IFC Performance Standards, 2012; |
| Technical Coverage of Social Risks and Impacts | 3.2.22                   | Cultural Heritage | The Reports are silent about the risks & impacts on cultural heritage.  | Medium                               | Potential impacts on cultural heritage should be carefully assessed and relevant measures should be taken into account. Good international practice recognizes that cultural heritage provides continuity in tangible and intangible forms between the past, present and future.   | Social Impact Assessment   | Close Gap                                | World Bank Environmental and Social Framework, (Especially ESS8) 2016; IFC Performance Standards, 2012; |
| Technical Coverage of Social Risks and Impacts | 3.5.                     | Indigenous People | The Reports are silent about the risks & impacts on indigenous people.  | High                                 | Potential impacts on Indigenous People should be assessed. If any impact will be identified, Indigenous People Action Plan (or Development Plan) would be necessary.<br>If the project proposes to use the cultural heritage including knowledge, innovations, or practices of Indigenous Peoples for commercial purposes, the Client has to inform the Affected Communities of Indigenous Peoples of (i) their rights under national law; (ii) the scope and nature of the proposed commercial development; (iii) the potential consequences of such development; and (iv) obtain their FPIC ( Free, Prior, | Requirement for International Financing                              | Close Gap                                | World Bank Environmental and Social Framework, (Especially ESS7) 2016; IFC Performance Standards, 2012; |

| Sub-component                                  | Inception Report section | Topic  | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Recommended Action Before DPR Submission             | Reference Documents/ Codes/ standards  |
|--|--------------------------|--|---|--------------------------------------|---|--|--|--|
|  |                          |  |   |                                      | and Informed Consent).  |  |  |  |
| Technical Coverage of Social Risks and Impacts | 3.2.22                   | Loss of access to natural resources and Impoverishment risks | The impact of loss of access to natural resources and livelihood sources are not discussed comprehensively. Impoverishment risks on fishermen and fishing industry, especially during construction stage and transition stages are not discussed. Although some reports mention this issue, but doesn't provide the scale and magnitude of the potential impact. On the contrary benefits of the Project is presented widely. | Medium                               | SIA should also consider loss of access to natural resources and income sources. Consequent action plan(s) should include appropriate measures relevant to the significance of potential risks. | Social Impact Assessment   | Close Gap  | Safeguard Policy Statement, ADB, 2009; World Bank Environmental and Social Framework, 2016; IFC Performance Standards, 2012;   |
| Technical Coverage of Social Risks and Impacts | 3.5.                     | Stakeholder Engagement                                       | The reports do not include necessary Stakeholder Engagement activities which should be implemented during various phases of the Project   | Medium                               | Stakeholder mapping should be conducted and appropriate measures to be defined to deal with Primary and Secondary Stakeholders throughout the Project.  | Requirement for International Financing                              | Close Gap  | Safeguard Policy Statement, ADB, 2009; World Bank Environmental and Social Framework (especially ESS10), 2016;   |
| Technical Coverage of Social Risks and Impacts | 3.2.21                   | Land Acquisition & Resettlement                              | Land Acquisition and Resettlement Plan is missing.  | High                                 | Land Acquisition and Resettlement Plan (and/or Livelihood Restoration Plan, depending on the results of SIA) should be prepared.  | Requirement for International Financing                              | Understand and cost the risk of not filling the gaps | Safeguard Policy Statement, ADB, 2009; World Bank Environmental and Social Framework, 2016; Involuntary Resettlement Safeguards: A Planning and Implementation Good Practice Sourcebook (Draft Working Document), ADB, November 2012 |
| Technical Coverage of Social Risks and Impacts | 3.5.                     | Social Monitoring and Reporting                              | As the Project is complex, its adverse impacts may arise during different phases, therefore continuous (semi-annual for some aspects, annual for some issues) monitoring will be necessary.   | Medium                               | Monitoring arrangements (nature, frequency, coverage, responsibilities, timeframe, indicators) to be identified and included in each relevant action plan (such as LARP, IPDP, GAP etc).        |  |  | Safeguard Policy Statement, ADB, 2009; World Bank Environmental and Social Framework, 2016;  |

## F) Transport

| Sub-component    | Inception Report section | Topic   | Gap/Issue identified  | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Complete Before or After DPR                         |
|------------------|--------------------------|---|---|--------------------------------------|---|--|--|
| Transport report | 6.2.1                    | No Transport Report has been put forward. Only a Traffic Assessment.<br><br>A comprehensive Multi Modal Transport Assessment is required to set out the baseline and Transport Business Case for Investment | No analysis of multi-modal transport baseline, forecast flows, opportunities and impacts  | High                                 | Develop a Comprehensive Multi Modal Transport Assessment and baseline   | Cost Benefit Analysis  | Close Gap  |
| Transport Costs  | 6.2.2                    |   | Develop a Transport Business Case for Investment Report - utilising the following headings:<br><br>Strategic Case:<br>Strategic Context; Organisational overview; Business strategy and aims; Other relevant strategies; The Case for Change; Spending objectives; Existing arrangements<br>Business needs – current and future; Potential scope and service requirements; Main benefits and risks; Constraints and dependencies<br><br>Economic Case:<br>Critical Success factors; Long-listed options; Preferred Way Forward; Shortlisted options (including the “Business As Usual (BAU)” and ‘do minimum’); NPSC/NPSV findings; Benefits appraisal; Risk assessment; Sensitivity analysis<br><br>Integrate the above into the wider scheme Financial, Commercial and Management for the scheme as a whole | High                                 | Cost Benefit Analysis   | Close Gap  |  |
| Transport report |                          | Traffic Assessment was undertaken in October 2013. Data, references, and guidance used may no longer be relevant.   | Outdated Datasets   | High                                 | Traffic Assessment to be updated, ideally to a 2019 baseline - representing the latest pre COVID 19 travel patterns | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |

| Sub-component           | Inception Report section | Topic  | Gap/Issue identified                                      | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Complete Before or After DPR                         |
|-------------------------|--------------------------|--|---|--------------------------------------|--|--|--|
| Transport report        |                          | The Traffic Assessment does not refer to the proposed rail corridor and any potential associated impacts.  | Transport Assessment not comprehensive as not multi-modal | High                                 | Comprehensive Transport Multi Modal Assessment to be undertaken to a 2019 baseline - representing the latest pre COVID 19 travel patterns  | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Traffic survey data     |                          | Traffic surveys used to inform the TA were undertaken in 2010. Traffic surveys >3 years old are typically considered to be outdated. The changes in travel patterns due to Covid-19 have not been considered.<br><br>This will need to be revised and brought up to date | Outdated Datasets   | High                                 | Undertake new traffic surveys (albeit may not be representative until pre-covid movement patterns return). Alternatively, use of appropriate growth factors could be considered. | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Trip generation surveys |                          | Surveys have been carried out at 50 industrial units to understand trip generation rates of various industries. The number of sites surveyed for each type of industry is considered to be relatively small.   | Outdated Datasets   | Medium                               | Suggest undertaking additional trip generation surveys or supplementing with data from another source to validate.   | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |

| Sub-component             | Inception Report section | Topic  | Gap/Issue identified | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Complete Before or After DPR                         |
|---------------------------|--------------------------|--|----------------------|--------------------------------------|--|--|--|
| Traffic survey data       |                          | Average daily traffic for surveyed roads has been considered for roads where 7-day and 3-day surveys were undertaken. It is unclear whether the 3-day surveys were undertaken on weekdays or across a weekend. The potential differences in travel behaviour on weekdays / weekends does not seem to have been considered. | Outdated Datasets    | Medium                               | Examine if any significant differences in weekday / weekend traffic is observed. Consider use of factors to apply to 3-day surveys, to align with 7-day surveys                        | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Toll revenue data         |                          | Toll revenue data collected in 2008/09 has been used to derive seasonal correction factors.  | Outdated Datasets    | Medium                               | More recent toll revenue data should be analysed to understand any notable changes to seasonal patterns. This would ideally be 2019 data, representing the latest pre-covid trip rates | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Willingness to pay survey |                          | Willingness to pay survey undertaken in 2010 based on proposed toll rates at time. Multiple factors could have altered people's willingness to pay, as well as the proposed toll rate, since the original survey was undertaken.<br><br>This will need to be revised and brought up to date                                | Outdated Datasets    | High                                 | Consider impact of any significant changes in proposed toll rates and people's willingness to pay on viability of project. E.g., Scenario testing?                                     | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |

| Sub-component   | Inception Report section | Topic  | Gap/Issue identified | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation  | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Complete Before or After DPR                         |
|---|--------------------------|--|----------------------|--------------------------------------|---|--|--|
| Toll rate   |                          | Toll rates have been derived based on NHAI Toll Policy 2008, amended in 2011.<br><br>This will need to be revised and brought up to date   | Outdated Datasets    | High                                 | Check if policy has been amended / superseded since 2011. If so, update toll rates and consider impact on willingness to pay, revenue etc.            | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Socio-Economic Profile and Estimation of Growth Rates |                          | Chapter 3 considers a range of data including demography, net state domestic product, per capita income, industrial output, agricultural output, tourism and examines growth trends. Most of this data covers 2000-2009. More recent growth trends have not been considered, in particular any adverse growth impacts arising from the Covid-19 pandemic.<br><br>This will need to be revised and brought up to date | Outdated Datasets    | High                                 | Examine growth trends using more recent data and consider adverse impacts of pandemic.<br><br>Produce a comprehensive baseline and forecasting report | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |

| Sub-component                                       | Inception Report section | Topic  | Gap/Issue identified | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Complete Before or After DPR                         |
|---|--------------------------|--|----------------------|--------------------------------------|--|--|--|
| Major Infrastructure Projects in the influence Area |                          | Section 3.6 considers the potential impacts of several major infrastructure projects on the proposed Kalpasar Dam. Since the production of the 2013 transport report, a number of these projects (or phases of these projects) have become operational. These projects may also have changed in scale, detail etc. since production of the transport report. This will need to be revised and brought up to date | Outdated Datasets    |                                      | Consider ongoing impacts of major infrastructure projects and identify any additional major infrastructure projects that have emerged since production of 2013 transport report. This should be a chapter of a comprehensive baseline and forecasting report | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Estimation of traffic growth rates                  |                          | 'Past Traffic Data' method uses traffic data from 1996-2010. This is considered to be outdated and not representative of present-day traffic patterns.   | Outdated Datasets    |                                      | Undertake new surveys (once post-Covid 19 traffic levels return) to validate findings.<br><br>Would be delivered as a chapter of a comprehensive baseline and forecasting report   | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Estimation of traffic growth rates                  |                          | Growth trends of registered vehicles in Gujarat - data from 1996-2010 considered.  | Outdated Datasets    | High                                 | Obtain and analyse more recent registered vehicles data, as well as comparing growth rates against other regions, to see whether Gujarat is representative of wider society trends across the country  | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Estimation of traffic growth rates                  |                          | Recommended growth rates.  |                      | Medium                               | Revise growth rates based on any changes to above items.   | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |

| Sub-component                            | Inception Report section | Topic  | Gap/Issue identified   | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Complete Before or After DPR                         |
|--|--------------------------|--|--|--------------------------------------|--|--|--|
| Review of Feasibility Study for Kalpasar |                          | Section 4.1 reviews a feasibility study undertaken in 1998 based on traffic survey data collected in 1996.<br><br>This will need to be revised and brought up to date  | Outdated Datasets  | High                                 | Undertake updated feasibility study.   | Cost Benefit Analysis  | Close Gap  |
| Chapter 4                                | 4                        | Unclear if whole of section 4 is a review of the feasibility study, or new analysis  |  | High                                 |  |  |  |
| Chapter 4                                | 4                        | No assessment undertaken of construction traffic, its impacts or mitigating travel plans   | No Construction Traffic and Impact Assessment undertaken                   | High                                 | Develop a Construction Transport Impacts Assessment and associated   | Cost Benefit Analysis  | Close Gap  |
| Chapter 4                                | 4                        | No analysis undertaken on the traffic generated / emissions released by the linked schemes, such as the ports development etc.   | No assessment of impacts of linked developments, facilitated by the scheme | High                                 | As part of the recommended Comprehensive Transport Multi Modal Assessment - a full environmental baseline analysis should be undertaken to explore the direct and indirect impacts of the scheme and linked ventures | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Chapter 5 - Economic Viability Analysis  |                          | No benefit analysis undertaken on wider society benefits, such as increases attributed to access to labour / employment, skills / training, healthcare environment etc | No wider benefit or societal benefit analysis undertaken                   | High                                 | Full Transport Economic Baseline and Assessment required, as set out above   | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Chapter 5 - Economic Viability Analysis  |                          | No Economic analysis undertaken on toll free scheme  |  | High                                 | Full Transport Economic Baseline and Assessment required, as set out above   | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |

| Sub-component                           | Inception Report section | Topic  | Gap/Issue identified | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation   | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Complete Before or After DPR                         |
|---|--------------------------|--|----------------------|--------------------------------------|--|--|--|
| Chapter 5 - Economic Viability Analysis |                          | No Economic analysis undertaken on changes to growth factors such as population, car ownership, policy drivers   |                      | High                                 | Full Transport Economic Baseline and Assessment required, as set out above                         | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Chapter 5 - Economic Viability Analysis |                          | No scenario tests undertaken on environmental grounds - including incentives towards zero-emission vehicles  |                      | High                                 | Full Transport Economic Baseline and Assessment required, as set out above                         | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Chapter 5 - Economic Viability Analysis |                          | No strategic alternative case examined, such as a do nothing, or development of strategic alternatives (i.e., a bridge etc)                                      |                      | Medium                               | Full Transport Economic Baseline and Assessment required, as set out above                         | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Chapter 5 - Economic Viability Analysis |                          | No Value for Money statement provided best on transport impact   |                      | Medium                               | Full Transport Economic Baseline and Assessment required, as set out above                         | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| Appendices                              |                          | Appendices referenced in report have not been provided, so cannot be reviewed  |                      | High                                 |  |  |  |
| MISSING COMPONENTS                      |                          | No risk analysis undertaken - across traffic data analysis or economic value   |                      | High                                 | Undertake a full Risk Assessment - covering Transport, rather than just traffic                    | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |
| MISSING COMPONENTS                      |                          | As titled, the report is a Traffic, rather than a Transport Assessment, and as such does not pick up on the full connectivity benefits, impacts and risks a full |                      | High                                 | Undertake a comprehensive Transport Baseline, Impacts, Risks and Benefits Assessment be undertaken | Cost Benefit Analysis  | Understand and cost the risk of not filling the gaps |

| Sub-component | Inception Report section | Topic                            | Gap/Issue identified | Risk/ Importance (High/ Medium/ Low) | Mitigation/ Recommendation | Feasibility Key Gaps (gaps that risk the feasibility of the project) | Complete Before or After DPR |
|---------------|--------------------------|----------------------------------|----------------------|--------------------------------------|----------------------------|--|------------------------------|
|               |                          | Transport Assessment would cover |                      |                                      |                            |  |                              |

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