Registro de la Reunión ANLA/ Record of Meeting (ANLA)

Mayo 25 de 2018

Nombre de la reunion / Name of Meeting	Reunión de Cierre No. 4 (RC4) / Wap-Up Meeting No.4 (WUM4)			
Fecha de la Reunión / Date of Meeting	25 May 2018		**Hora / Hour**	17:00-18:00
Sitio / Venue	Sala de Conferencias Hotel GHL Collection Hamilton / Conference Room GHL Collection Hamilton Hotel			
Attendance				
ANLA	1	Maria Paula Franco	Contratista Convenios /Project Coordinator	
	2	Fajardo David	Líder del Equipo ANLA / Team Leader	
NK	1	Ichizuru ISHIMOTO	Líder de equipo / Planificador de túneles Team Leader/ Tunnel Planner	
	2	Wako NOTO	Especialista en construcción de túneles Tunnel Construction Specialist	
	4	Hikaru TANAKA	Coordinador / Planificador de túneles Coordinator/ Tunnel Planner	
Material	Appendix-A: Plan de Trabajo (Revisión 5c) / Work Plan (Revision 5c) Appendix-B: Actividades de JICAST en la Visita 4 / JICAST's Activities in Site Visit 4 Appendix-C: Informe de asesoramiento para el Manual Ambiental de ANLA (ANLA-EHB) Revisión 0 / Advisory Report for ANLA Environmental Handbook (ANLA-EHB) Revision 0 Appendix-D: Borrador del plan de acción (Revisión 3) / Draft Action Plan (Revision 3) Appendix-E: Presentación de ACTOS por JICAST / ACTOS Presentation by JICAST			

1. *Objetivos de la Reunión / Objectives of Meeting*

Objectives of this Wrap Up Meeting (WUM) is as follows:

1) Confirmar las actividades realizadas por el Equipo de Estudio de JICA / Confirm the activities performed by the JICA Study Team (JICAST).

2) Actualizar el Alcance de los Servicios, de acuerdo con los resultados de las discusiones, durante la Visita 4 / Update the Scope of Services in accordance with the results of discussions during Site Visit 4.

3) Actualizar el cronograma de Servicios, de acuerdo con los resultados de las discusiones, durante la Visita 4 / Update the Schedule of Services in accordance with the results of discussions during Site Visit 4.

4) Confirmar el cronograma del cierre del final del JICAST / Confirm the schedule of the closing of the JICAST closing.

2. *Actividades realizadas durante la visita 4 / Activities Performed during Site Visit 4*

2.1. *General*

- JICA Study Team (JICAST) se desplazó a Colombia para prestar los servicios a ANLA, entre el 6 de mayo y el 27 de mayo de 2018, durante 22 días, correspondiente a la "Visita 4" / JICA Study Team (JICAST) is mobilized in Colombia to provide the services to ANLA between 6 May and 27 May 2018 for 22 days, said "Site Visit 4".

- Durante esta última asignación de JICAST, el Sr. Kawahara y el Sr. Tsunoda, de la Oficina de Tokio de JICA, visitaron ANLA, entre el 21 y el 25 de mayo de 2018, para confirmar con ANLA el trabajo realizado por JICAST y el plan de cooperación futura con ANLA. / During this last assignment of JICAST, Mr Kawahara and Mr Tsunoda, from JICA Tokyo Office, visited ANLA, between 21-25 May 2018, to confirm with ANLA for the work performed by JICAST and plan of the future cooperation with ANLA.
- ANLA y JICAST confirmaron el cronograma de trabajo durante la Visita 4 el 15/5/2018, según el Plan de trabajo (R5c) (**Apéndice A**) / ANLA and JICAST confirmed the work schedule during Site Visit 4 on 15/5/2018 based on Work Plan (R5c) (**Appendix-A**).
- Las actividades realizadas por JICAST durante la Visita al sitio 4 se resumen en el Apéndice B. / Activities performed by JICAST during Site Visit 4 are summarized in **Appendix-B**.

2.2. *Alcance de los Servicios / Scope of Services*

Durante la Visita 4, se han llevado a cabo los siguientes alcances de los servicios de consultoría: / During the Site Visit 4, the following scopes of the consulting services have been carried out:

- Alcance 1 / Scope 1: Soporte para preparar el manual técnico para EIA (EHB-EIA) / Support to Prepare Technical Handbook for EIA (EHB-EIA)
- Alcance 2 / Scope 2: Soporte para preparar el Manual técnico para EIA (EHB-DAA) / Support to Prepare Technical Handbook for EIA (EHB-DAA)
- Alcance 3 / Scope 3: Suministro de transferencia de tecnología / Provision of Technology Transfer
- Alcance 4 / Scope 4: Preparación del Seminario Técnico / Preparation of Technical Seminar
- Alcance 5 / Scope 5: Propuesta del Plan de Acción para ANLA / Proposal of ANLA's Action Plan
- Confirmación del cronograma de cierre de las actividades del JICAST. / Confirmation of the closing schedule of the JICAST activities.

3. *Alcance 1 Soporte para preparar el manual técnico para EIA (EHB-EIA) / Support to Prepare Technical Handbook for EIA (EHB-EIA)*

3.1. *Reunión de ANLA y JICAST para EHB-EIA / Meeting of ANLA and JICAST for EHB-EIA*

Las siguientes reuniones para la discusión sobre EHB-EIA se llevaron a cabo durante la Visita 4 / Following meetings for the discussion on the EHB-EIA were held during Site Visit 4.

Table 3.2-1 List of Meeting of ANLA and JICAST for EHB-EIA

No.	Date & Time	Venue	Agenda
1	16/5/2018 9:30-11:30	Gavilan	Hidrogeología / Hydrogeology
2	16/5/2018 14:00-15:30	Gavilan	Geología / Geology
3	17/5/2018 10:00-12:00	Gavilan	Hidrología y Calidad del Agua / Hydrology and Water Quality
4	17/5//2018 14:00-15:30	Gavilan	Geotecnia / Geotechnics

3.2. *Informe de la Asesoría para el Manual Ambiental de ANLA (ANLA-EHB) / Advisory Report for ANLA Environmental Handbook (ANLA-EHB)*

El "Informe de asesoramiento para el Manual Ambiental de ANLA (ANLA-EHB) Revisión 0" se envió a

ANLA el 25/5/2018 para su revisión y comentario, como se muestra en el **Apéndice-C.** / "Advisory Report for ANLA Environmental Handbook (ANLA-EHB) Revision 0" was submitted to ANLA on 25/5/2018 for review and comment as shown in **Appendix-C**.

3.3. *Cronograma de cierre para EHB-EIA / Closing Schedule for EHB-EIA*

Se confirma de la siguiente manera: / It is confirmed as follows:

- ANLA enviará sus comentarios sobre "Revisión 0" a JICAST antes del 20/6/2018. / ANLA will send their comments on "Revision 0" to JICAST not later than 20/6/2018.
- JICAST actualizará el informe a "Revisión 1" como la versión final y lo enviará a ANLA antes del 10/7/2018. / JICAST will update the report to "Revision 1" as the final version and submit to ANLA not later than 10/7/2018.

4. *Scope 2: Apoyo para preparar el Manual Técnico para EIA (EHB-DAA) / Support to Prepare Technical Handbook for DAA (TOR-DAA)*

4.1. *Presentación del Informe de Revisión por JICAST / Submission of Review Report by JICAST*

JICAST presentó el informe de revisión para el último borrador de TdR de DAA el 8/4/2018. ANLA había revisado el informe para la actualización del borrador de TdR-DAA. / JICAST submitted the review report for the latest draft TOR of DAA on 8/4/2018. ANLA had reviewed the report for the updating the draft of TOR-DAA.

4.2. *Reunión de ANLA, INVIAS, ANI y JICAST para TdR-DAA el 23/5/2018 / Meeting of ANLA, INVIAS, ANI and JICAST for TOR-DAA on 23/5/2018*

MADS, ANLA, INVIAS, ANI y JICAST discutieron sobre comentarios al borrador de TdR de DAA el 23/5/2018, incluida la discusión sobre los comentarios de JICAST. / MADS, ANLA, INVIAS, ANI and JICAST discussed the comments to the draft of TOR of DAA on 23/5/2018, including the discussion on comments of JICAST.

No hubo una conclusión de la reunión y se acordó continuar la discusión en la segunda semana de junio (pendiente por confirmación por parte de MADS). There was agreement on the suggestions in the meeting and it was agreed to continue the discussion on the 2nd week of June (to be confirmed by MADS).

4.3. *Cronograma de cierre para TdR-DAA / Closing Schedule for TOR-DAA*

Se acordó que "Informe de Revisión para TdR-DAA", por parte de JICAST, se mantiene en su Parte B del "Informe de Asesoramiento para el Manual Ambiental de ANLA (ANLA-EHB) Revisión 0" tal como está. Este es el producto de este alcance. / It was agreed that "Review Report for TOR-DAA" by JICAST is kept in its Part B of "Advisory Report for ANLA Environmental Handbook (ANLA-EHB) Revision 0" as it is. This is considered the product of the scope.

5. *Scope 3: Suministro de transferencia de tecnología / Provision of the Technology Transfer*

(1) *Estado actualizado de QAS / Updated status of QAS*

Durante la Visita 4, se llevaron a cabo discusiones continuas sobre el QAS, y todos los problemas se cerraron, como se muestra en la Tabla 5-1. / During Site Visit 4, continuous discussions on the QAS had been conducted, and all issues were closed as shown as Table 5-1.

Table 5-1 Estado de QAS en la visita / Status of QAS in Site Visit 4

No.	Topic	Estado / Status
100s	Numerical Modeling of Groundwater Flow	Cerrado / Closed
200s	Various Issues Related to Actual Projects	
210	Toyo Tunnel	Cerrado / Closed
220	Manso River	Cerrado / Closed
230	Energy piedra sol	Cerrado / Closed
240	Mining soto norte	Cerrado / Closed
250	Chingaza Park	Cerrado / Closed
260	Toyo Tunnel 2	Cerrado / Closed
270	Rio Cauca Hydropower Project	Cerrado / Closed
300s	EHB-DAA-->Progress_Scope2	Cerrado / Closed
400s	EHB-EIA-->Progress_Scope1	
410	EHB Geology (C2.2)	Cerrado / Closed
420	EHB Hydrology (C2.6)	Cerrado / Closed
430	EHB Water Quality (C2.7)	Cerrado / Closed
440	EHB Hydrogeology (C2.9)	Cerrado / Closed
450	EHB Geotechnics (C2.10)	Cerrado / Closed
460	EHB Vibration (C2.12)	Cerrado / Closed
500s	Inquiries from Contractor's Perspective (INVIAS)	Cerrado / Closed
600s	Mini-Seminar	
610	Environmental Management in Operation Phase	Cerrado / Closed
620	Fundamentals of Groundwater	Cerrado / Closed
630	Ground Subsidence	Cerrado / Closed
640	Water Contamination in Tunnel Construction Works	Cerrado / Closed
700s	Technical Seminar	Cerrado / Closed

6. Scope 4: Preparación del Seminario Técnico / Preparation of Technical Seminar

6.1. Seminario ACTOS Mayo 25 de 2018 / ACTOS Seminar on 25/5/2018

El viernes 25/5/2018, se realizó el Seminario de ACTOS, con 85 asistentes, como se muestra en la Tabla 6-1. / On Friday 25/5/2018, ACTOS Seminar was held, with 85 attendants, as shown in Table 6-1.

Table 6-1 Agenda del Seminario de ACTOS el 25/5/2018 / Agenda of ACTOS Seminar on 25/5/2018

No.	*Time*	*Item*	*Presenter*
		Friday 25 May, 2018	
Session 1: Keynote Speech			
1	0800-0815	Discurso por el Presidente de la ACTOS	ACTOS
2	0815-0830	Discurso por Director General o delegado del INVÍAS	INVÍAS
3	0830-0845	Discurso por Presidente o delegado de la ANI	ANI
4	0845-0900	Discurso por Delegado de la ANLA	ANLA
5	0900-0915	Discurso por Delegado de JICA	Mr. Tsunoda/ *JICA Tokyo*
Session 2: Basic Concepts of Planning, Design, Construction and Maintenance of Road Tunnels in Japan			
6	0915-1000	Tunnel Planning and Design Methods in Japan	Prof. Isago/ Tokyo Metropolitan Univ.
7	1000-1045	Tunnel Construction Technologies in Japan	Prof. Isago/ Tokyo Metropolitan Univ.
		<<Coffee Break 15 min.>>	
8	1100-1145	Tunnel Operation and Maintenance Practice in Japan	Prof. Isago/ Tokyo Metropolitan Univ.
9	1145-1215	New Tunnel Construction Technlogies in Japan	Mr. Kawabe/ Hazama Ando Co., Ltd.
10	1215-1225	Summary Comments by ANLA	Mr. Guillermo/ Depty GD, ANLA
11	1225-1255	Report of Performed Service by JICA Study Team	Mr. Ishimoto/ JICA Study Team
12	1255-1330	FORUM AND SESSION OF QUESTIONS	

7. Scope 5: Propuesta del Plan de Acción para ANLA / Proposal of ANLA's Action Plan

El Plan de Acción (R3) fue discutido entre ANLA, JICA-Tokio, JICA-Colombia y JICAST el 5/24/2018, adjunto como **Apéndice-D** / Action Plan (R3) was discussed between ANLA, JICA-Tokyo, JICA-Colombia and JICAST on 24/5/2018, attached as **Appendix-D**

Se acordó que el plan de acción será discutido más a fondo entre las partes interesadas, y los resultados de esas discusiones se compartirán con JICA-Tokio a través de JICA-Colombia. / It was agreed that the action plan will be further discussed among the stakeholders, and the results of those discussion will be shared with JICA-Tokyo though JICA-Colombia.

8. Plan de cierre para las actividades de JICAST / Closing Plan for JICAST's Activities

8.1. Scope 1: Soporte para preparar el manual técnico para EIA (EHB-EIA) / Support to Prepare Technical Handbook for EIA (EHB-EIA)

- ANLA enviará sus comentarios sobre "Revisión 0" a JICAST antes del 20/6/2018. / ANLA will send their comments on "Revision 0" to JICAST not later than 20/6/2018.
- JICAST actualizará el informe a "Revisión 1" como la versión final y lo enviará a ANLA antes del 10/7/2018. / JICAST will update the report to "Revision 1" as the final version and submit to ANLA not later than 10/7/2018.

8.2. Scope 2: Apoyo para preparar el Manual Técnico para EIA (EHB-DAA) / Support to Prepare TOR for DAA (TOR-DAA)

- Cerrado / Closed.

8.3. Scope 3: Suministro de transferencia de tecnología / Provision of Technology Transfer

- Cerrado / Closed.

8.4. Scope 4: Preparación del Seminario Técnico / Preparation of Technical Seminar

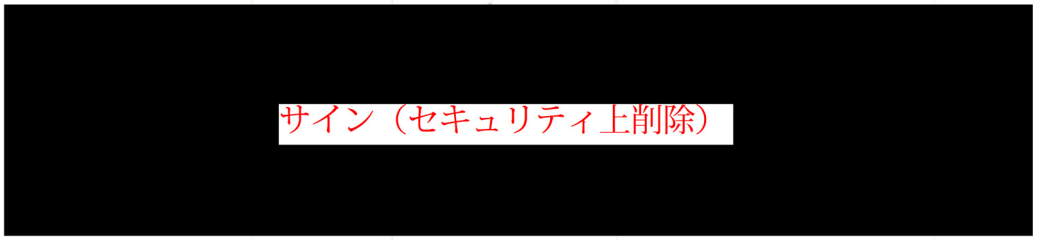
- Cerrado / Closed.

8.5. Scope 5: Propuesta del Plan de Acción para ANLA / Proposal of ANLA's Action Plan

- Cerrado / Closed.

8.6. Servicios Generales / Overall Services

- El período contractual de JICAST con JICA Tokyo vencerá el 20/7/2018. / The contract period of the JICAST with JICA Tokyo will be expired on 20/7/2018.
- JICAST preparará el informe final y lo enviará a JICA Tokyo oportunamente en el período del contrato. / JICAST will prepare the final report and submit it to JICA Tokyo timely in the contract period.



(2)邦文報告書

コロンビア国トンネル分野 ANLA 組織強化アドバイザー業務
第１回　現地業務結果報告書

１概要

1 - 1 調査団員名簿

表－１　調査団員名簿

No	氏名	担当	組織	現地期間
1	石本　一鶴 Ichizuru Ishimoto	総括／トンネル計画 Team Leader/ Tunnel Planner	日本工営	7/21－8/5
2	野末　康博 Yasuhiro Nozue	地質評価 Geological Specialist	日本工営	7/24-8/5
3	能登　和幸 Wako Noto	トンネル施工 Tunnel Construction Specialist	日本ｼﾋﾞｯｸｺﾝｻﾙﾀﾝﾄ	7/21－8/5
4	寺本　雅子 Masako Teramoto	水理評価分析 Geohydrology Specialist	日本工営	7/21－8/5
5	田中　真治 Shinji Tanaka	環境社会配慮 Environmental (Natural&Social) Specialist	日本工営	7/24-8/5
6	宮市　哲 Satoshi Miyaichi	地下水・地表面水変動予測（水質） Environmental (Water Quality) Specialist	日本工営	7/24-8/5
7	田中　光 Hikaru Tanka	業務調整／トンネル計画 Coordinator/ Tunnel Planner	日本工営	7/21－8/5

1 - 2 調査工程

表－２　調査工程

Date		Activities	Outline
7/21	Fri	Arrival (Mr.Ishimoto, Mr.Noto, Ms.Teramoto, Mr. H.Tanaka）	
7/22	Sat	Internal meeting, Information collection	➢ Familiarization with road conditions in Colombia
7/23	Sun	Site visit to Givavdot City （Passing El Boqueron Tunnel）	
7/24	Mon	9:00-10:00 EOJ Meeting	➢ Courtesy & Explanation of workplan
		11:30-12:30 JICA Colombia office	➢ Ditto
		Arrival (Mr. Nozue, Mr.S.Tanaka, Mr. Miyaichi)	
7/25	Tue	8:30-9:30 ANLA Meeting	➢ Introduction of ANLA

Date		Activities	Outline
		14:00-15:00 JICA Colombia office	➢ Lecture on safety stay during the study period
7/26	Wed	10:00-12:00 ANLA Kick off meeting and Workshop	➢ Explanation of workplan ➢ Introduction and discussion on the projects including Toyo Tunnel in evaluation process
7/27	Thu	Internal meeting, Information collection, Document arrangement and preparation	➢ Confirmation on the contents of documents provided by ANLA, including TOR[*1] of EIA. ➢ Preparing the draft of TOC[*2] for technical handbook.
7/28	Fri	6:35 Flight from Bogota to Armenia 16:00 Flight from Armenia to Medellin	➢ Site visit survey, La Linea Tunnel
7/29	Sat	Site visit survey	➢ Site visit survey, Occidente Tunnel, Toyo Tunnel, Oriente Tunnel
7/30	Sun	Site visit survey 17:00 Flight from Medellin to Bogota	➢ Site visit survey, Rio Negro Tunnel
7/31	Mon	08:00-10:00 ANLA Workshop	➢ Numerical analysis and evaluation for water quality
		16:30-17:30 ANLA Workshop	➢ Ditto
8/1	Tue	09:00-12:30 ANLA Workshop	➢ Discussion on the Toyo tunnel project
		14:30-16:30 ANLA Workshop	➢ Discussion on TOR[*1] of EIA and DAA[*3]
8/2	Wed	Preparing the draft report on the activities of JICAST in the 1st Survey	
		14:00-15:00 ANLA Meeting	➢ Pre-meeting for Wrap up meeting
8/3	Thu	08:30-12:30 ANLA Workshop	➢ Discussion on Rio Manso Project
		14:00-15:00 ANLA Meeting	➢ Director Meeting ➢ Wrap up for 1st survey of JICAST
8/4	Fri	14:00 JICA Colombia office	
8/5	Sat	00:15 Flight from Bogota to Tokyo via Houston	
8/6	Sun	Arrival date at Tokyo	

*1 TOR: Terms of Reference

*2 TOC: Table of Contents

*3 DAA: Diagnostico Ambiental de Alternativia (Environmental Diagnosis of Alternatives)

*表中、現地調査については別添２トンネル現地調査報告を参照

２業務の具体的内容

２-１業務全般に係る作業

ワークプランの説明のため、ANLA に説明と協議を行いワークプランを更新した。また、第

２回現地調査時までの調査団ならびに ANLA のワークプランについて協議・合意した（別添１議事録参照)。

２-２【活動１】既存資料の情報収集

ANLA との協議、ワークショップを通して、コロンビア国のトンネル事業の実施にあたって関連する環境影響評価に係る資料、トンネル計画・設計に係る資料、事業の実例等を含む以下の資料の提供を受けた。これらの資料により、コロンビア国のトンネル事業の現状、EIA の評価プロセスならびに現状について概ね把握することができた。

表－３　主な収集資料

No.	資料名	言語	概要
1	ANLA BASICS	英	ANLA の概要説明のためのパワーポイント資料
2	TOR for EIA of road and tunnel project (Resolution751)	西 英訳済	ANLA が発行している EIA 図書の作成要件
3	EIA ならびに代替案検討（DAA）の TOR の比較資料	西	DAA の TOR の更新にあたって、EIA の TOR との比較資料
4	トンネルマニュアル Invias 2016	西	Invias のトンネル設計・施工に関するマニュアル（355P）
5	Cacao トンネル事業の EIA 資料	西	事業者より ANLA に提出された Cacao トンネル事業の EIA 申請
6	Cacao トンネル事業に対する環境ライセンス	西	ANLA より事業者に対して出状された環境ライセンス
7	Toyo トンネル事業の EIA 資料	西	事業者より ANLA に提出された Toyo トンネル事業の EIA 申請
8	EL Manso 事業の概要資料	西 英訳済	導水路トンネルである El Manso 事業の課題点に係る資料
9	その他	西	首記プロジェクト等に対するその他詳細なデータ他

２-３【活動２】現状と課題の確認

(1)トンネル事業の現状と課題

収集した EIA 資料から、トンネル事業の実施にあたり、地質調査・評価に係るプロセス、水理検討に係るプロセスについては今日一般的に実施される標準的なプロセスに沿った検討が行われていることが伺われる。また環境影響低減対策についても比較案とされている工法は一般的な工法が網羅され、ジェットグラウトも事業において適用されている現状にあり、特段の課題は認められない。ラ・リネア・トンネルの現地踏査結果から、工事の後半に INVIAS 主導

で導入された濁水処理施設は十分な濁水浄化能力が確認され、施設の維持管理も適切に行われており良好な状況であることを確認した。

上述の通り、個別の検討・技術については一定の水準にあることが確認されたが、事業実施におけるトンネル計画・設計における課題として、いずれのトンネル事業においても路線選定のプロセスが明確ではなく、施工性・経済性・社会環境影響の低減を主眼とした最適な路線選定が行われているとは言えない状況にあり、路線計画能力の向上が課題の一つとして挙げられる。ラ・リネア・トンネルの事業は、メイントンネル（8.6km）を始めとしてその他多くのトンネル・橋梁・接続道路からなる大プロジェクトである。個別の工事は一定の水準で実施されていることが伺われたが、環境問題で 2 年遅れて 2018 年完成の予定とされた工程に対し、現時点で既に 1 年以上の遅れが見込まれているなど、工程管理を始めとする工事監理が十分に実施されていないことが課題として挙げられる。

(2)トンネル事業の環境影響評価プロセスの現状

コロンビア国のトンネルを含む道路事業の環境影響評価のプロセスは、初めに代替案検討（DAA）が事業者によって実施され、ANLA が提案内容を評価した後、ルートの選定を行う。その後、調査・計画を含む事業の EIA が事業者によって実施され、申請に基づき ANLA が EIA を確認し、問題がないと判断された場合に、環境承認ライセンスを発行する。ANLA からのライセンスの交付を受け、事業者は工事を開始する。

(3)トンネル事業の環境影響評価プロセスの課題

トンネル事業の環境影響評価プロセスの課題として以下の 6 点が挙げられる。

① トンネル事業の路線選定は調査が十分ではない DAA 段階で実施され、合理的な判断の根拠がない段階で確定し、調査結果を踏まえた柔軟な変更ができない。
② 路線選定は ANLA が決定することとなっているが、十分な路線選定の能力がない。その結果、事例として挙げられた事業では非合理的な路線案が選定されている。
③ EIA 資料において、環境影響に係るスコーピング、各環境項目の優先度付けがされておらず、主要な課題が不明確である。
④ EIA 資料において、事業の基礎的な情報（平面図・縦断図・横断図）がなく、事業の全体像が把握できない状況である。
⑤ EIA 資料は③にも係り、全ての調査結果が網羅的に記載され膨大であることから、ANLA はその確認・評価に時間を要している。
⑥ ANLA 職員はトンネル事業に係る基礎的な技術力・知見が不足しており、場合によっては必ずしも適正な評価が行われていない。

2-4【活動３】技術便覧（案）の作成支援

技術便覧（案）の作成支援にあたって、調査団は ANLA より提供された DAA ならびに EIA の TOR に準拠して技術便覧の目次案を作成し、ANLA と協議を行った。今後の作業スケジュールとして目次案は 8 月中に ANLA により確定、調査団がコンテンツ案を作成し、9 月中にドラフ

ト（英）を ANLA に送付、第 2 回現地調査時に協議することとした。

2 - 5 【活動 5 】知見移転

⑴全般

知見移転は ANLA との協議の結果、ANLA が評価を実施した、もしくは実施中のプロジェクトを題材としたケーススタディとしてワークショップを通じた議論を行うとともに、質問回答票の交換を通じた活動によって実施することとして ANLA と合意した。

⑵現地セミナー

現地セミナーは ANLA との協議の結果、関係機関・関係者も含め、第三回渡航時（2018 年 2 月予定）に開催することとして合意した。第二回協議時にその内容について ANLA と協議し、確定する。

⑶ワークショップ

ワークショップは下記の通り、5 回開催した。

表－３　ワークショップ

No.	日時	課題	出席者
1	7/26 10:00-12:00	調査団のワークプラン説明・Toyo トンネル他トンネル事業の課題	ANLA　EIA 評価チーム 調査団
2	7/31 8:00-10:00 16:30-17:30	水理解析・評価、水質評価について	ANLA　EIA 評価チーム 調査団
3	8/1 9:00-12:30	Toyo トンネルに関する議論	ANLA　EIA 評価チーム 調査団
4	8/1 14:30-16:30	EIA ならびに DAA の TOR に関する議論	ANLA　文書検討チーム 調査団
5	8/3 8:30-12:30	Rio Manso プロジェクトに関する議論	ANLA　EIA 評価チーム 調査団

３業務の達成状況

⑴資料収集

本調査を通じて、業務の実施・全体並びに各派遣時のワークプランの更新にあたり、必要となる ANLA ならびにコロンビアのトンネル事業に関する一通りの情報収集ができた。今後、収集資料の分析を進め、ANLA 職員の能力開発に有効なワークショップの計画を行う。

⑵課題特定及び分析

上述の通り、現地調査を通じて一通りの課題を特定した。今後、資料の分析に基づき第 2 回現地調査まで引き続き課題の抽出・分析を行う。

(3)トンネル事業に係る技術助言

ワークショップを通じて、技術的な助言を行った。引き続き実事業の事例を通じたワークショップならびに質問回答票の活動を行うとともに、技術便覧（案）の作成を通じた技術助言を実施する。

(4)推奨行動計画案の作成

課題抽出後、第３回現地調査より協議を行ことで ANLA と合意した。

(5)現地セミナー

上述の通り、第３回現地調査時に開催する。

以上

別添１　協議議事録
別添２　トンネル現地調査結果

別添２－道路トンネル現地調査結果

調査期間中にコロンビアの主要な道路トンネル現場４ヶ所を視察、2 か所のトンネルを通過した。視察した道路トンネルの名称と概要を表- 1 に示す。

表-1　視察したトンネル現場の概要

No.	トンネル名	諸　　元	開通時期
1	La Linea （山岳トンネル）	延長: 8.6km、片側1車線･2方向 設計速度:60km、最急縦断勾配:0.96%	2018 年予定
2	Oriente （山岳トンネル）	延長: 8.2km、片側2車線×2本 設計速度:60km、最急縦断勾配:2.5%	2018 年予定
3	Toyo （山岳トンネル）	延長: 9.8km、片側2車線×2本 設計速度:60km、最急縦断勾配:3.0%	2022 年予定
4	Occidente （山岳トンネル）	延長: 4.6km、片側1車線･2方向 設計速度:50km、最急縦断勾配:4.6%	2006 年完成
5	Rio Negro （山岳トンネル）	片側1車線･2方向	確認中
6	Sumapaz （山岳トンネル）	延長 4.2km、片側1車線･2方向	2010 年完成

1.　La Linea トンネル

La Linea トンネルはアルメニア市の東で現在建設途中の道路トンネルである。現場視察の際は、現場の管理を行っている国営道路の実施機関 INVIAS が同行した。

以下、視察の様子を示す。

写真- 1.1　パイロットトンネル坑口

↳ パイロットトンネルの坑口では排水は濁っていた。

写真- 1.2　工事排水処理施設

↳ 工事の排水は、現場に併設された処理施設で処理されていた。

写真- 1.3　脱水ケーキ

- 濁水中の固形分は処理施設で分離、脱水されていた。

写真- 1.4　パイロットトンネル排水の検査

- パイロットトンネル排水の EC、pH を、簡易計測器等を用いて測定した。

写真- 1.5　INVIAS から説明を受ける

- La Linea トンネル関連資料をもとに説明を受け、質疑応答を行った。

写真- 1.6　メイントンネル排水の検査

- メイントンネル視察後、パイロットトンネルと同様の測定を行った。

2.　Occidente トンネル

Occidente トンネルはメデジン市の西に位置する道路トンネルであり、既に供用を開始している。以下、視察の様子を示す。

写真- 2.1　料金所

- トンネル入口手前に料金所があり、車両が列を成していた。

写真-2.2　トンネル入口側面

- 側面にはトンネル内換気のための排気筒のようなものが見られた。

写真-2.3　トンネル入口

- トンネル入口には管理施設のようなものが併設されており、出口も同様であった。

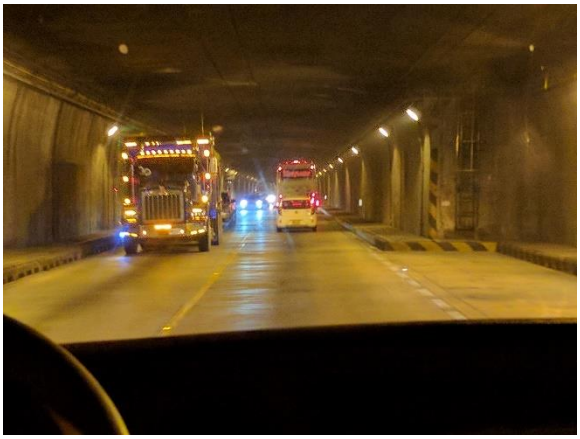


写真-2.4　トンネル内部

- 天井には横流式の換気のためと思われる通風孔が 50m 程度の間隔で存在した。

3.　Toyo トンネル

Toyo トンネルはメデジン市の西に施工を予定されている道路トンネルであり、トンネルの線形は既に決定している。以下、視察の様子を示す。

写真- 3.1　計画線形の検証

- 計画線形と地図を参考に複数のポイントからトンネルの線形を確認、検証した。

写真- 3.2　沢水を引くホース

- 周辺の集落では沢から水を引いて利用していると思われる。

4. Oriente トンネル

Oriente トンネルはメデジン市の東に施工中の道路トンネルである。に示すように、トンネルより下流側に住居が存在するため水質汚濁や騒音といった環境面で考慮すべき点が多くある。

写真- 4.1　坑口と周辺の様子

5. その他（Sumapaz、Rio Negro の道路トンネル）

写真- 5.1　Sumapaz トンネル

（Bogota-Girardot 間）

↳ 壁面に反射板、出入口の暫定照明対応が必要と思われる。道路自体の管理は良い。

写真- 5.2　Rio Negro トンネル

（Medellin-Rio Negro 間）

↳ 落石の片づけや道路の補修などのメンテナンスは非常に良く行われていた。

コロンビア国トンネル分野 ANLA 組織強化アドバイザー業務
第 2 回　現地業務結果報告書（2017.11.8 報告分）

1 概要

1 - 1 調査団員名簿

表－１　調査団員名簿

No	氏名	担当	組織	現地期間
1	石本　一鶴 Ichizuru Ishimoto	総括／トンネル計画 Team Leader/ Tunnel Planner	日本工営	10/22－ 11/4
2	野末　康博 Yasuhiro Nozue	地質評価 Geological Specialist	日本工営	10/22－ 11/4
3	能登　和幸 Wako Noto	トンネル施工 Tunnel Construction Specialist	日本ｼﾋﾞｯｸｺﾝｻﾙﾀﾝﾄ	－
4	寺本　雅子 Masako Teramoto	水理評価分析 Geohydrology Specialist	日本工営	10/22－ 11/4
5	田中　真治 Shinji Tanaka	環境社会配慮 Environmental (Natural&Social) Specialist	日本工営	10/22－ 11/4
6	宮市　哲 Satoshi Miyaichi	地下水・地表面水変動予測（水質） Environmental (Water Quality) Specialist	日本工営	10/22－ 11/4
7	田中　光 Hikaru Tanaka	業務調整／トンネル計画 Coordinator/ Tunnel Planner	日本工営	10/22－ 11/4

1 - 2 調査工程

表－２　調査工程

Day	Date		Activities	Outline
1	10/22	Sun	21:40 Arrival in Bogota	➢ Flight code: UA1007
2	10/23	Mon	9:00-10:00 Visit to JICA Colombia office	➢ Courtesy & Explanation of work schedule (Work Plan 2)
3	10/24	Tue	8:00-9:00 ANLA Meeting	➢ Explanation of work schedule (Work Plan 2)
			9:30-11:00 ANLA Meeting	➢ Explanation of handbook contents (EIA)
			14:00-16:00 ANLA Meeting	➢ Explanation of draft technology seminar contents with Ministry of Environment
4	10/25	Wed	8:30-10:00 INVIAS Meeting	➢ Discussion on the construction of Toyo & La Linea Tunnel with INVIAS (QAS, Technology Transfer) ➢ Explanation of Environmental Diagnosis of Alternatives DAA
			10:00-10:30 Evacuation Drill	➢ Participate on the evacuation drill of Bogota
			14:00-16:00 ANLA Mini-Seminar (1) for starter	➢ 1. Environmental Management in Operation Phase by S. Tanaka ➢ 2. Fundamentals of ground water (relation

Day	Date		Activities	Outline
				between water inflow in tunnel & geology) by Teramoto
5	10/26	Thu	8:30-11:00 ANLA & INVIAS Meeting	➢ Explanation of DAA
			14:00-16:00 ANLA Mini-Seminar (2) for intermediate	➢ 3. Method of prediction, monitoring, & mitigation measures for ground subsidence by Nozue ➢ 4. Mechanism of Water contamination in Tunnel Construction Works by Miyaichi
6	10/27	Fri	8:30-11:00 JICAST Team meeting	➢ Review of the work and schedule reminding ➢ Send the agenda for the technology seminar to MOE
			19:25-21:05 Flight to Cartagena	➢ Flight code: FC8152
7	10/28	Sat	Sight Visit to Crespo Tunnel	
8	10/29	Sun	16:20-17:46 Flight to Bogota	➢ Flight code: LA4097
9	10/30	Mon	8:30-11:30 ANLA Meeting	➢ Discussion on C2.2 (Geology) of EIA Handbook ➢ Confirmation of the schedule for preparing EIA Handbook
			14:00-16:00 ANLA Meeting	➢ Question and Answer session on the actual projects
10	10/31	Tue	9:30-11:30 ANLA Meeting	➢ Discussion on C2.6 (Hydrology) & C2.7 (Water Quality) of EIA Handbook ➢ Confirmation of the schedule for preparing EIA Handbook
			14:30-16:45 ANLA Meeting	➢ Discussion on C2.9 (Hydrogeology) of EIA Handbook ➢ Confirmation of the schedule for preparing EIA Handbook
11	11/1	Wed	9:30-12:00 ANLA Meeting	➢ Discussion on C2.6 (Hydrology) & C2.7 (Water Quality) of EIA Handbook ➢ Confirmation of the schedule for preparing EIA Handbook
			16:00-17:00 ANLA Meeting	➢ Confirmation of the schedule for preparing EIA Handbook
12	11/2	Thu	10:00-12:00 ANLA Meeting	➢ Discussion on a Toyo Tunnel project (QAS, Technology Transfer)
			16:00-17:00 ANLA Meeting	➢ Finalization of EIA & DAA Handbook
13	11/3	Fri	A.M. ANLA wrap-up meeting	➢ Preparation of minutes
14	11/4	Sat	00:14 Departure from Bogota	➢ Flight code: UA1006
15	11/5	Sun	15:30 Arrival in Tokyo	➢ Flight code: UA7

*1 TOR: Terms of Reference
*2 TOC: Table of Contents
*3 DAA: Diagnostico Ambiental de Alternativia (Environmental Diagnosis of Alternatives)

2 業務の具体的内容

2-1 業務全般に係る作業

ワークプランに関して ANLA に説明・協議を行い更新した。また、第 3 回現地調査時までの調査団ならびに ANLA のワークプランについて協議・合意した（別添 1 議事録参照）。

2-2 【活動 1】既存資料の情報収集

第二回現地調査において、コロンビア国のトンネル事業の実施にあたって関連する以下の資料を収集した。

表－３　主な収集資料

No.	資料名	言語	概要
1	INVIAS の手がける事業について	西	INVIAS 作成
2	La Linea トンネルの概要	西	プレゼン資料
3	コロンビアの地質図	西	全国をカバーする 1:100,000 の地質図、CD-ROM

２-３【活動２】現状と課題の確認

(1)トンネル事業の現状と課題

収集した EIA 資料から、トンネル事業の実施にあたり、地質調査・評価に係るプロセス、水理検討に係るプロセスについては今日一般的に実施される標準的なプロセスに沿った検討が行われていることが伺われる。また環境影響低減対策についても比較案とされている工法は一般的な工法が網羅され、ジェットグラウトも事業において適用されている現状にあり、特段の課題は認められない。ラ・リネア・トンネルの現地踏査結果から、工事の後半に INVIAS 主導で導入された濁水処理施設は十分な濁水浄化能力が確認され、施設の維持管理も適切に行われており良好な状況であることを確認した。

上述の通り、個別の検討・技術については一定の水準にあることが確認されたが、事業実施におけるトンネル計画・設計における課題として、いずれのトンネル事業においても路線選定のプロセスが明確ではなく、施工性・経済性・社会環境影響の低減を主眼とした最適な路線選定が行われているとは言えない状況にあり、路線計画能力の向上が課題の一つとして挙げられる。ラ・リネア・トンネルの事業は、メイントンネル（8.6km）を始めとしてその他多くのトンネル・橋梁・接続道路からなる大プロジェクトである。個別の工事は一定の水準で実施されていることが伺われたが、環境問題で 2 年遅れて 2018 年完成の予定とされた工程に対し、現時点で既に 1 年以上の遅れが見込まれているなど、工程管理を始めとする工事監理が十分に実施されていないことが課題として挙げられる。

(2)トンネル事業の環境影響評価プロセスの現状

コロンビア国のトンネルを含む道路事業の環境影響評価のプロセスは、初めに代替案検討（DAA）が事業者によって実施され、ANLA が提案内容を評価した後、ルートの選定を行う。その後、調査・計画を含む事業の EIA が事業者によって実施され、申請に基づき ANLA が EIA を確認し、問題がないと判断された場合に、環境承認ライセンスを発行する。ANLA からのライセンスの交付を受け、事業者は工事を開始する。

(3)トンネル事業の環境影響評価プロセスの課題

トンネル事業の環境影響評価プロセスの課題として以下の 6 点が挙げられる。

① トンネル事業の路線選定は調査が十分ではない DAA 段階で実施され、合理的な判断の根拠がない段階で確定し、調査結果を踏まえた柔軟な変更ができない。

② 路線選定は ANLA が決定することとなっているが、十分な路線選定の能力がない。その結果、事例として挙げられた事業では非合理的な路線案が選定されている。

③ EIA 資料において、環境影響に係るスコーピング、各環境項目の優先度付けがされておらず、主要な課題が不明確である。
④ EIA 資料において、事業の基礎的な情報（平面図・縦断図・横断図）がなく、事業の全体像が把握できない状況である。
⑤ EIA 資料は③にも係り、全ての調査結果が網羅的に記載され膨大であることから、ANLA はその確認・評価に時間を要している。
⑥ ANLA 職員はトンネル事業に係る基礎的な技術力・知見が不足しており、場合によっては必ずしも適正な評価が行われていない。

(4)ANLA の体制に係る課題

コロンビア国において道路事業・エネルギー・資源開発等の事業は増加しているが、ANLA の職員数は十分ではなく、評価チームの体制構築が課題となっている。また、ANLA の環境評価にかかる要員の多くは契約社員の雇用形態をとっており、年間契約ベースとなっていることから、中・長期的な環境影響評価に係る技術・ノウハウの蓄積と継承が課題となっている。

2-4 【活動 3】技術便覧（案）の作成支援

技術便覧（案）の作成支援にあたって、調査団は ANLA より提供された DAA ならびに EIA の TOR に準拠して技術便覧の目次案を作成し、ANLA と協議を行った。今後の作業スケジュールとして目次案は 8 月中に ANLA により確定、調査団がコンテンツ案を作成し、9 月中にドラフト（英）を ANLA に送付、第 2 回現地調査時に協議することとした。

第 2 回現地調査において、協議議事録に示す通り分野ごとのカウンターパートを確認し、調査団が提案したスケジュールに沿って技術便覧案を作成することをカウンターパートと合意した。技術便覧の項目のうち、Geotechnics ならびに Vibration に関し技術便覧作成の支援要請を ANLA より受け、調査団は合意した。

なお DAA（代替案比較・路線選定）に関する技術便覧(案)作成支援の要請を受けたが、DAA に関する資料作成の TOR(案)をレビューした結果、その内容に改善すべき点が認められたため、ANLA にレビュー結果を提言し、DAA に関する技術便覧については TOR の確定が必要なことから本年度の調査では行わず、それに代わり TOR の目次案を送付した。

2-5 【活動 5】知見移転

(1)全般

知見移転は ANLA との協議の結果、ANLA が評価を実施した、もしくは実施中のプロジェクトを題材としたケーススタディとしてワークショップを通じた議論を行うとともに、質問回答票の交換を通じた活動によって実施することとして ANLA と合意した。

(2)現地セミナー

現地セミナーは ANLA との協議の結果、関係機関・関係者も含め、第 3 回渡航時（2018 年 3 月予定）に開催することとして ANLA が調整する旨、合意した。また、調査工程に示した通り、

トンネル供用時の環境管理、地表面沈下・地下水と地質・水質に関する 4 つの議題のミニセミナーを実施し、ANLA 職員に対して知見の移転を図った。

(3)ワークショップ

ワークショップ/ディスカッションは協議議事録に示す通り、6 回開催した。

3 業務の達成状況

(1)資料収集

本調査を通じて、業務の実施・全体並びに各派遣時のワークプランの更新にあたり、必要となる ANLA ならびにコロンビアのトンネル事業に関する一通りの情報収集ができた。今後、収集資料の分析を進め、ANLA 職員の能力開発に有効なワークショップの計画を行う。

(2)課題特定及び分析

上述の通り、現地調査を通じて一通りの課題を特定した。今後、調査を通じて引き続き課題の抽出・分析を行う。

(3)トンネル事業に係る技術助言

ワークショップを通じて、技術的な助言を行った。引き続き実事業の事例を通じたワークショップならびに質問回答票の活動を行うとともに、技術便覧（案）の作成を通じた技術助言を実施した。

(4)推奨行動計画案の作成

推奨行動計画案を調査団が作成し、第 3 回現地調査より協議を行うことで ANLA と合意した。

(5)現地セミナー（2017.12.20 時点）

2017 年 11 月 30 日の ANLA からのメール（メール①）により技術セミナーはキャンセルとなった。

（2017.11.3 時点）

第 3 回現地調査（3/4-3/18 の予定）時、3/12、3/13 の日時で ANLA が調整することとして合意した。参加者ならびにプログラムについても ANLA と協議の上、議事録に添付した通り素案を作成した。なお、関係機関・業者等を招待する公式なセミナーの開催は ANLA の上位官庁である MADS（Ministerio de Ambiente y Desarrollo Sostenible（参考訳 Ministry of Environment and sustainable development））が検討し決定する。正式な決定は来年 1 月下旬となる見込みで、現時点では公式なセミナーの開催の可否は決定していない。3 月に公式なセミナーを開催できない場合には、ミニセミナーとしての開催もしくは日程の再調整を含め、ANLA と再協議する。

以上

別添１　協議議事録

別添２　ハンドブック作成支援の進捗状況

調査時写真

写真１　INVIAS との協議状況

写真２　DAA に関する協議状況

写真３　ANLA 評価チームとの協議状況

写真４　ミニセミナーの実施状況１

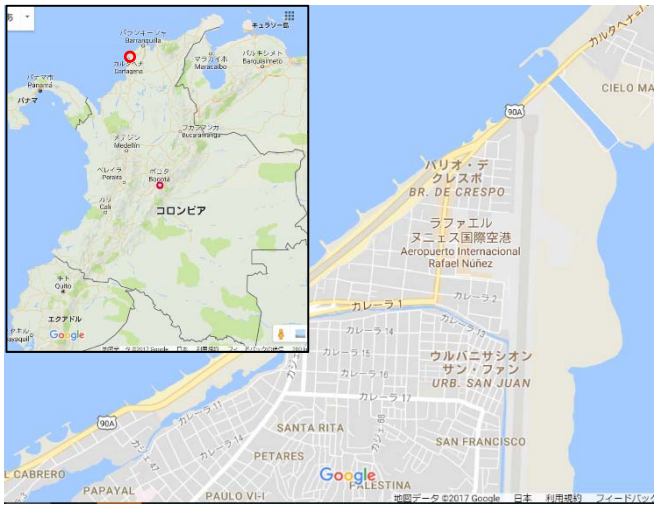
写真５　ミニセミナーの実施状況２

写真６　ミニセミナーの実施状況３

写真７　ANLA 幹部との懇親会１

写真８　ANLA 幹部との懇親会２

クレスポトンネル現地確認状況



クレスポトンネル

2016 年 4 月開通

開削トンネル・片側 2 車線× 2、延長約９００ｍ

諸元等につき、情報収集中

写真１　北西側坑口

写真２　北西部坑口２

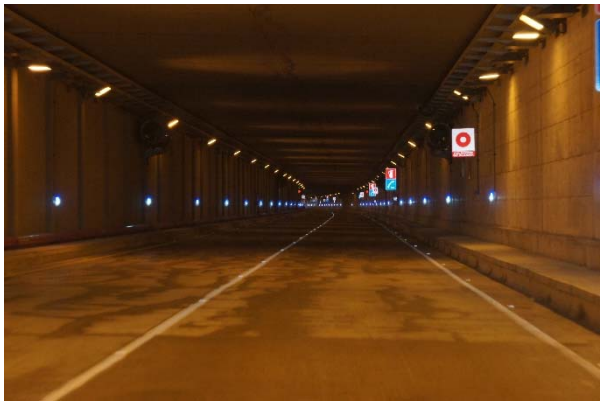


写真３　坑内の状況

写真４　上部の状況

写真５　非常用電源室(250kV)

コロンビア国トンネル分野 ANLA 組織強化アドバイザー業務
第 3 回　現地業務結果報告書

1 概要

1 - 1 調査団員名簿

表－１　調査団員名簿

No	Name	Position	Company	Duration
1	石本　一鶴 Ichizuru Ishimoto	総括／トンネル計画 Team Leader/ Tunnel Planner	日本工営 Nippon Koei	3/3－3/17
2	野末　康博 Yasuhiro Nozue	地質評価 Geological Specialist	日本工営 Nippon Koei	3/3－3/17
3	能登　和幸 Wako Noto	トンネル施工 Tunnel Construction Specialist	日本ｼﾋﾞｯｸｺﾝｻﾙﾀﾝﾄ NCC*	3/3－3/17
4	寺本　雅子 Masako Teramoto	水理評価分析 Geohydrology Specialist	日本工営 Nippon Koei	3/5－3/15
5	田中　真治 Shinji Tanaka	環境社会配慮 Environmental (Natural&Social) Specialist	日本工営 Nippon Koei	3/3－3/17
6	宮市　哲 Satoshi Miyaichi	地下水・地表面水変動予測（水質） Environmental (Water Quality) Specialist	日本工営 Nippon Koei	－
7	田中　光 Hikaru Tanaka	業務調整／トンネル計画 Coordinator/ Tunnel Planner	日本工営 Nippon Koei	3/3－3/17

*: Nippon Civic Consulting Engineers

1 - 2 調査工程

表－２　調査工程

Day	Date		Activities	Outline
1	3/3	Sat	22:40 Arrival in Bogota (Mr. Noto, Mr. S.Tanaka, Mr. H.Tanaka)	➢ Flight code: UA1007
2	3/4	Sun	0:10 Arrival in Bogota (Mr. Ishimoto, Mr. Nozue)	➢ Flight code: AA1123
			Team meeting	➢ At the hotel
3	3/5	Mon	09:00-0930 Visit to JICA Colombia Office	➢ Report of the results of the 2nd site survey ➢ Explanation of Work Plan (R4)
			10:50 Arrival in Bogota (Ms. Teramoto)	➢ Flight code: AV8374
			16:30-18:00 Kickoff meeting with ANLA	➢ Confirmation of work schedule ➢ Explanation of Work Plan (R4)
4	3/6	Tue	8:30-12:00 Team meeting	➢ Confirmation of work and schedule ➢ Discussion of Mini-Seminar contents
			14:00-16:00 ANLA meeting 1	➢ Confirmation of detailed work schedule ➢ Discussion of Mini-Seminar
5	3/7	Wed	8:30-12:00 ANLA Workshop 1&2	➢ EIA Handbook (Hydrology) ➢ EIA Handbook (Water Quality)
			15:00-16:00 ANLA meeting 2	➢ Discussion of Action Plan
6	3/8	Thu	Preparation for Mini-Seminar	
7	3/9	Fri	Attend on a public tunnel seminar	➢ ”WORKSHOP ON PROCESSES AND BEST WORLD PRACTICES IN TUNNELS - SUSTAINABILITY OF TUNNELS IN

Day	Date		Activities	Outline
				COLOMBIA"*
			Preparation for Mini-Seminar	
8	3/10	Sat	Site visit	➢ Bogota-Villavicencio Road ➢ Buenavista Tunnel etc.
9	3/11	Sun	Holiday	
10	3/12	Mon	0830-12:30 Mini-Seminar	➢ "Introduction of Japanese Practices for Environmental Management in Tunnel Construction Projects"
			14:00-16:30 ANLA Workshop 3	➢ Discussion of Rio Cauca Hydropower Project
11	3/13	Tue	10:00-10:30 ANLA Workshop 4	➢ EIA Handbook (Vibration)
			14:00-17:15 ANLA Workshop 5	➢ EIA Handbook (Hydrogeology)
12	3/14	Wed	08:00-10:00 Visit to ACTOS	➢ Information exchange ➢ Introduction of Japanese standard
			14:00-16:30 ANLA Workshop 6&7	➢ EIA Handbook (Geology) ➢ EIA Handbook (Geotechnics)
			15:00-16:00 Wrap up meeting with ANLA	➢ Preparation of wrap-up minutes
13	3/15	Thu	10:00 Visit to JICA Colombia Office	➢ Report of the results of the 3rd site survey
14	3/16	Fri	00:10 Departure from Bogota (Mr. Ishimoto, Mr. Nozue)	➢ Flight code: AA1122
			00:14 Departure from Bogota (Mr. Noto, Mr. S.Tanaka, Mr. H.Tanaka)	➢ Flight code: UA1006
			14:17 Departure from Bogota (Ms. Teramoto)	➢ Flight code: AV8373
			16:00 Arrival in Quito (Ms. Teramoto)	➢ Flight code: AV8873
15	3/17	Sat	15:30 Arrival in Tokyo (Mr. Noto, Mr. S.Tanaka, Mr. H.Tanaka)	➢ Flight code: UA7
			15:45 Arrival in Tokyo (Mr. Ishimoto, Mr. Nozue)	➢ Flight code: JL011

*Original Title: "TALLER SOBRE PROCESOS Y MEJORES PRACTICAS MUNDIALES EN TÚNELES - SOSTENIBILIDAD DE TÚNELES EN COLOMBIA"

2 業務の具体的内容

2-1 業務全般に係る作業

ワークプランの説明のため、ANLA に説明と協議を行いワークプランを更新した。また、第4回現地調査時までの調査団ならびに ANLA のワークプランについて協議・合意した（別添1議事録参照)。

2-2 【活動1】既存資料の情報収集

第二回現地調査において、コロンビア国のトンネル事業の実施にあたって関連する以下の資料を収集した。

表－3　主な収集資料

No.	資料名	言語	概要
1	ANLA BASICS	英	ANLA の概要説明のためのパワーポイント資料
2	TOR for EIA of road and tunnel project (Resolution751)	西 英訳済	ANLA が発行している EIA 図書の作成要件
3	EIA ならびに代替案検討(DAA)の TOR の比較資料	西	DAA の TOR の更新にあたって、EIA の TOR との比較資料
4	トンネルマニュアル Invias 2016	西	Invias のトンネル設計・施工に関するマニュアル（355P)
5	Cacao トンネル事業の EIA 資料	西	事業者より ANLA に提出された Cacao ト

			ンネル事業の EIA 申請
6	Cacao トンネル事業に対する環境ライセンス	西	ANLA より事業者に対して出状された環境ライセンス
7	Toyo トンネル事業の EIA 資料	西	事業者より ANLA に提出された Toyo トンネル事業の EIA 申請
8	EL Manso 事業の概要資料	西 英訳済	導水路トンネルである El Manso 事業の課題点に係る資料
9	その他	西	首記プロジェクト等に対するその他詳細なデータ他
10	INVIAS の手がける事業について	西	INVIAS 作成
11	La Linea トンネルの概要	西	プレゼン資料
12	コロンビアの地質図	西	全国をカバーする 1:100,000 の地質図、CD-ROM
13	トンネル施設に関するワークショップ資料	西	ACTOS セミナー資料
14	トンネル設備のライフサイクルに関する検討事例	西	ACTOS セミナー資料
15	トンネル保全ガイド（National Academy of Sciences/USA）	英	ACTOS セミナー資料
16	トンネル点検基準（FHWA-2008-0038/USA）	英	ACTOS セミナー資料
17	トンネル O&M、点検評価マニュアル（FHWA-HIF-15-005/USA）	英	ACTOS セミナー資料
18	NYX HEMERA 社*のカタログ（照明設備等）	英 西	ACTOS セミナー資料
19	Rio Cauca Hydropower Project に関する説明資料	西	ANLA 評価チームの説明資料

*カナダに本社のある民間会社、2018.3 のアクトスセミナーのコーディネータを担当

2-3【活動 2】現状と課題の確認

(1)トンネル事業の現状と課題

収集した EIA 資料から、トンネル事業の実施にあたり、地質調査・評価に係るプロセス、水理検討に係るプロセスについては今日一般的に実施される標準的なプロセスに沿った検討が行われていることが伺われる。また環境影響低減対策についても比較案とされている工法は一般的な工法が網羅され、ジェットグラウトも事業において適用されている現状にあり、特段の課題は認められない。ラ・リネア・トンネルの現地踏査結果から、工事の後半に INVIAS 主導で導入された濁水処理施設は十分な濁水浄化能力が確認され、施設の維持管理も適切に行われており良好な状況であることを確認した。

上述の通り、個別の検討・技術については一定の水準にあることが確認されたが、事業実施におけるトンネル計画・設計における課題として、いずれのトンネル事業においても路線選定のプロセスが明確ではなく、施工性・経済性・社会環境影響の低減を主眼とした最適な路線選定が行われているとは言えない状況にあり、路線計画能力の向上が課題の一つとして挙げられる。ラ・リネア・トンネルの事業は、メイントンネル（8.6km）を始めとしてその他多くのトンネル・橋梁・接続道路からなる大プロジェクトである。個別の工事は一定の水準で実施されていることが伺われたが、環境問題で 2 年遅れて 2018 年完成の予定とされた工程に対し、現時点で既に 1 年以上の遅れが見込まれているなど、工程管理を始めとする工事監理が十分に実施

されていないことが課題として挙げられる。

コロンビアではボゴタービジャビセンシオ道路の建設プロジェクトが進められている。第 3 回現地調査では本道路に並走する既設道路を通行し、現地の道路事業の現状について情報の収集を行った。（別紙参照）

(2)トンネル事業の環境影響評価プロセスの現状

コロンビア国のトンネルを含む道路事業の環境影響評価のプロセスは、初めに代替案検討（DAA）が事業者によって実施され、ANLA が提案内容を評価した後、ルートの選定を行う。その後、調査・計画を含む事業の EIA が事業者によって実施され、申請に基づき ANLA が EIA を確認し、問題がないと判断された場合に、環境承認ライセンスを発行する。ANLA からのライセンスの交付を受け、事業者は工事を開始する。

(3)トンネル事業の環境影響評価プロセスの課題

トンネル事業の環境影響評価プロセスの課題として以下の 6 点が挙げられる。

① トンネル事業の路線選定は調査が十分ではない DAA 段階で実施され、合理的な判断の根拠がない段階で確定し、調査結果を踏まえた柔軟な変更ができない。
② 路線選定は ANLA が決定することとなっているが、十分な路線選定の能力がない。その結果、事例として挙げられた事業では非合理的な路線案が選定されている。
③ EIA 資料において、環境影響に係るスコーピング、各環境項目の優先度付けがされておらず、主要な課題が不明確である。
④ EIA 資料において、事業の基礎的な情報（平面図・縦断図・横断図）がなく、事業の全体像が把握できない状況である。
⑤ EIA 資料は③にも係り、全ての調査結果が網羅的に記載され膨大であることから、ANLA はその確認・評価に時間を要している。
⑥ ANLA 職員はトンネル事業に係る基礎的な技術力・知見が不足しており、場合によっては必ずしも適正な評価が行われていない。

(4)ANLA の体制に係る課題

コロンビア国において道路事業・エネルギー・資源開発等の事業は増加しているが、ANLA の職員数は十分ではなく、評価チームの体制構築が課題となっている。また、ANLA の環境評価にかかる要員の多くは契約社員の雇用形態をとっており、年間契約ベースとなっていることから、中・長期的な環境影響評価に係る技術・ノウハウの構築が課題となっている。

なお、プロジェクトごとに専門員を招集して構成される ANLA の評価チームの組織に関する仕組みは、昨年の組織改編にて開始された体制であり、体制がうまく機能しているかどうか ANLA の職員もまだ見極めている途中である。一方で、一つのプロジェクトに対して評価にかけられる時間は限られており、職員数の不足は深刻な問題として ANLA の職員はとらえていることが判明している。

２-４【活動３】技術便覧（案）の作成支援

(1)技術便覧（案）の作成支援

技術便覧（案）の作成支援にあたって、調査団は ANLA より提供された DAA ならびに EIA の TOR に準拠して技術便覧の目次案を作成し、ANLA と協議を行った。今後の作業スケジュールとして目次案は８月中に ANLA により確定、調査団がコンテンツ案を作成し、９月中にドラフト（英）を ANLA に送付、第２回現地調査時に協議することとした。

第２回現地調査において、協議議事録に示す通り分野ごとのカウンターパートを確認し、調査団が提案したスケジュールに沿って技術便覧案を作成することをカウンターパートと合意した。技術便覧の項目のうち、Geotechnics ならびに Vibration に関し技術便覧作成の支援要請を ANLA より受け、調査団は合意した。

第２回現地調査終了時～第３回現地調査開始の間に ANLA 内の契約社員（本業務のカウンターパート）の契約更新があり ANLA 側の作業が中断したため、ハンドブック案の最終化にあたり、ANLA 側との協議を残して第３回現地調査を開始した。第３回現地調査では改めて各パートのカウンターパートを確認し、Geotechnics、Vibration を加えたパートごとに協議を行った。ANLA 側の要望を確認した上で、第４回現地調査前に補填すべき項目を明確にし、第４回調査時に調査団案のとりまとめを行うスケジュールで合意した。

(2)DAA の TOR 作成支援

なお DAA（代替案比較・路線選定）に関する技術便覧(案)作成支援の要請を受けたが、DAA に関する資料作成の TOR(案)をレビューした結果、その内容に改善すべき点が認められたため、ANLA にレビュー結果を提言し、DAA に関する技術便覧については TOR の確定が必要なことから本年度の調査では行わないことを合意した。

DAA の TOR は Decree1076-2015 に準拠して ANLA が２月末にドラフトを作成したことを確認した。本ドラフトは本年３月末に ANLA から環境省に提出、環境省はパブリックコンサルテーションプロセスを開始する。調査団はこのドラフトをレビューし、レビュー報告書を提出、本コメントについてはパブリックコンサルテーションプロセスの一部として扱われることを確認した。調査団のレビュー報告書については第４回現地調査時に説明する予定とする。

２-５【活動５】知見移転

(1)全般

知見移転は ANLA との協議の結果、ANLA が評価を実施した、もしくは実施中のプロジェクトを題材としたケーススタディとしてワークショップを通じた議論を行うとともに、質問回答票の交換を通じた活動によって実施することとして ANLA と合意した。

第３回の現地調査ではハンドブック各パートの協議、Rio Cauca 水力発電プロジェクトの協議を経て質問票の交換を行い第 ４ 回に向けて質問票をクローズしていく方針として合意している。

(2)現地セミナー

第 2 回現地調査において、現地セミナーは ANLA との協議の結果、関係機関・関係者も含め、第三回渡航時（2018 年 3 月予定）に開催することとして ANLA が調整する旨合意した。また、調査工程に示した通り、トンネル供用時の環境管理、地表面沈下・地下水と地質・水質に関する 4 つの議題のミニセミナーを実施し、ANLA 職員に対して知見の移転を図った。

第 3 回現地調査ではセミナーは環境省の予算上の制約から、ANLA 内でミニセミナーとして 3/12 に開催した。議題は①日本の EIA のプロセスの紹介、②トンネル地質に関する日本の事例、③トンネル水文に関する日本の事例、④トンネル施工に伴う振動について、⑤トンネルの補助工法についてであり、各セッションにて参加者と熱心な質疑も行われた。

なお、情報収集のために訪問した ACTOS（コロンビアのトンネル協会）にて、第 4 回現地調査時に ACTOS がアレンジするセミナーでの講演等を依頼されており、本件について ANLA、貴機構と協議調整することとしている。

(3)ワークショップ

ワークショップ/ディスカッションは主にハンドブックの作成に関する事項につき開催し、スケジュール表に示す通り、7 回開催した。

3 業務の達成状況

(1)資料収集

本調査を通じて、業務の実施・全体並びに各派遣時のワークプランの更新にあたり、必要となる ANLA ならびにコロンビアのトンネル事業に関する一通りの情報収集ができた。収集した資料、現地調査の結果等をとりまとめ、トンネル技術協会を通じて国内関係者に情報の展開を図る。

(2)課題特定及び分析

上述の通り、現地調査を通じて一通りの課題を特定した。これらを踏まえた今後のアクションプランの作成を行う。

(3)トンネル事業に係る技術助言

ワークショップを通じて、技術的な助言を行った。引き続き実事業の事例を通じたワークショップならびに質問回答票の活動を行うとともに、技術便覧（案）の作成を通じた技術助言を実施した。第 4 回現地調査まで引き続き技術的助言を行う。

(4)推奨行動計画案の作成

第 3 回現地調査にて推奨行動計画について、調査団の素案をもとに協議を行った。今後、第 4 回に向けて改めて調査団案を修正し、第 4 回現地調査にて説明を行う。

(5)現地セミナー

上述したように第３回現地調査では、ANLA 内のミニセミナーとして開催している。第４回現地セミナーとして ACTOS がアレンジする月例セミナーで、本業務の成果・その他を踏まえたセミナーを行うことが要請された。調査団は ANLA ならびに貴機構と協議してその開催について検討を行うと回答した。

以上

別添１　ボゴタービジャビセンシオ道路の現地調査

別添２　ACTOS 協議メモ

ボゴタービジャビセンシオ道路について

ボゴタービジャビセンシオ道路はボゴタ～南東部の中核都市であるビジャビセンシオを結ぶ約 120km の道路である。本道路は、ベネズエラ国境のプエルトカレーニョ～ボゴタ～ブエナベントゥーラ港を結ぶ同国の主要な物流を担う都市間道路となっている。山岳地帯を通過することから 9 つのトンネル（最長はブエナビスタトンネルで約 4.5km）を有しており、既存の道路は 2 車線（急こう配の上り車線には部分的に登坂車線が整備されている）である。短いトンネルは覆工を行っていないものを確認している。その他、山岳道路部では地すべりの痕跡が認められる区間があり、インターロッキング等による補修の痕跡などが見られた。

既存道路は大型トレーラー等の走行速度の遅い大型車両が多く、交通の支障をきたしていることから、ボトルネックとなっている区間に並走する道路の新設が民間事業者（ANI が管轄）によって進められている。本事業において進められている建設中のブエナビスタ 2 号トンネルでは、トンネル切羽の崩落事故が発生しているとの情報を得ている。また、本年 1 月に発生したグアヤベタルの斜張橋の崩落事故は本道路の一部である。本事業は民間事業者による事業であることから、公開されている情報が少なく情報の収集がやや困難な状況であるが、第 3 回現地調査期間中にとれたアポイントに基づき、第 4 回現地調査にてトンネル建設現場の視察を予定している。

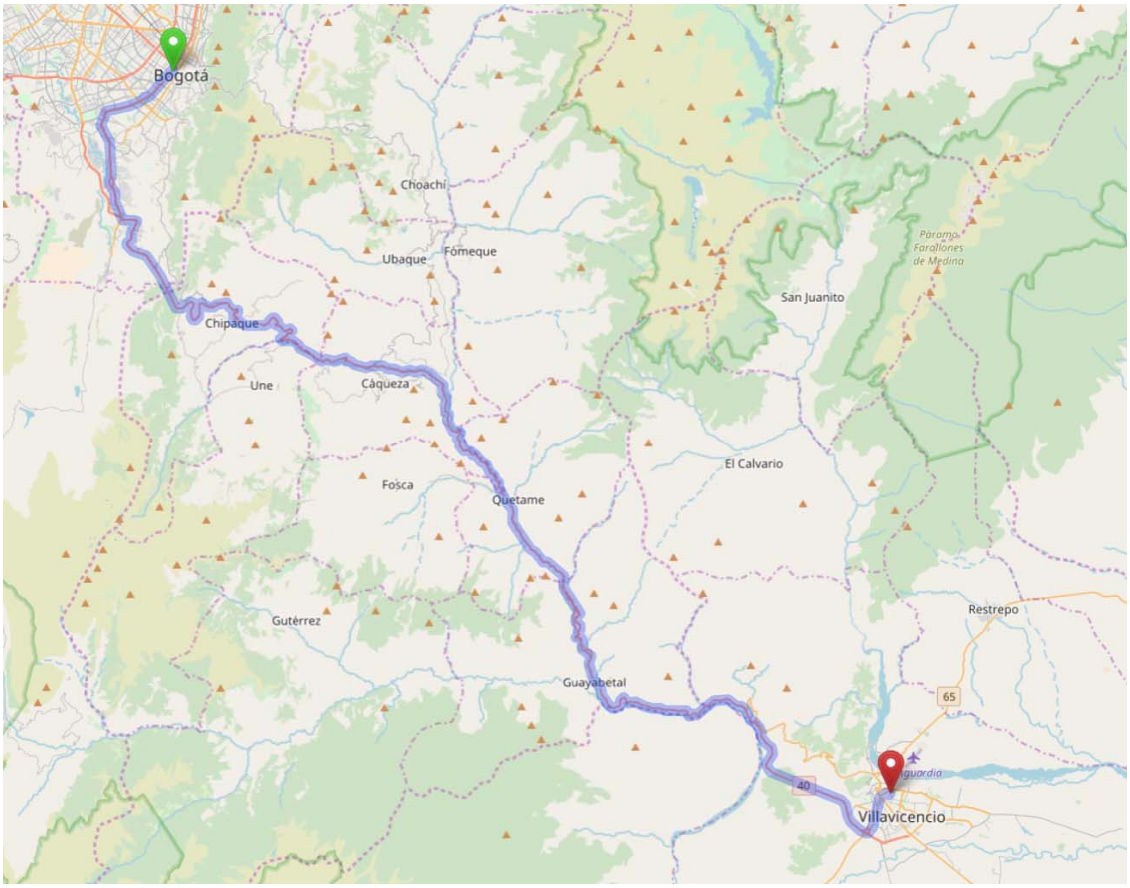


写真１　覆工コンクリートのないトンネル

写真２　ブエナビスタトンネル

写真３　７号トンネル（KM77+846）

写真４　７号トンネル近辺に建設中の PC 橋

写真５　１月に崩落した斜張橋

写真６　地すべりの痕跡と補修跡

ACTOS との協議・議事メモ

(1) 概要

日時：2018 年 3 月 14 日　AM8:00-10:00

場所：ACTOS 事務所

面談者： German Pardo A. (President)、 Enrique Silva Monteil (Vice President)

調査団： 石本、野末、能登、Alcides Corrales

(2) 議事メモ

- ACTOS は INVIAS の設計・施工マニュアルの整備の支援をしている。
- 道路以外、水力発電、マイニングのセクターに係るトンネルも対象としている
- ITA（国際トンネル協会）ともつながりが深く、Vice-President(Mr. Han Admiral)のサポートを受けている。
- コロンビアのトンネル建設にあたり、公共工事（INVIAS が管轄）において GBR(Geological Baseline Report)と現地状況の乖離度合いによって、発注者ー業者間の負担比率が決まっている。そのため、地質調査の精度向上に係る技術が求められている。なお、乖離度合いについては通常議論が起こり、ACTOS は中立の立場で技術的助言を行う。
- コンセッション事業の場合は ANI が管轄するが、その場合は事業の Phase II (Pre-FS 段階)にてすべての責任をコンセッショネアが負うが、リスク分析が十分でないケースが多い。
- コロンビアのトンネル事業は主にヨーロッパの基準を参考に構築している。
- 米国はあまりトンネル事業が盛んでないと認識、日本、イタリア、中国、オーストリア等の技術・建設業者に期待している。
- ACTOS では月例セミナーを開催しており、3/9 のセミナーもその一つ。可能であれば 5 月のセミナーの講演を依頼したい。議題はトンネル事業に係る Geotechnics、Hydro、Geology など。
- ACTOS のコーディネートで、各政府機関や学識者当の動員が可能で 120 名程度の参加者を募ることが可能。
- コロンビアのトンネル事業として、道路トンネル（径 10m）では 250km、水路トンネル（径 5 m）では 100km のトンネルが計画がある。その他マイニング、下水トンネルなど。すでに下水ではボゴタ市内に 70km のトンネルがある。
- TBM の技術に対する期待が大きい。

以上

コロンビア国トンネル分野 ANLA 組織強化アドバイザー業務

第 4 回　現地業務結果報告書

1 概要

1 - 1 調査団員名簿

表－１　調査団員名簿

No	Name	Position	Company	Duration
1	石本　一鶴 Ichizuru Ishimoto	総括／トンネル計画 Team Leader/ Tunnel Planner	日本工営 Nippon Koei	5/13－5/27
2	野末　康博 Yasuhiro Nozue	地質評価 Geological Specialist	日本工営 Nippon Koei	5/6－5/18
3	能登　和幸 Wako Noto	トンネル施工 Tunnel Construction Specialist	日本ｼﾋﾞｯｸｺﾝｻﾙﾀﾝﾄ NCC*	5/13－5/27
4	寺本　雅子 Masako Teramoto	水理評価分析 Geohydrology Specialist	日本工営 Nippon Koei	－
5	田中　真治 Shinji Tanaka	環境社会配慮 Environmental (Natural&Social) Specialist	日本工営 Nippon Koei	5/6－5/20
6	宮市　哲 Satoshi Miyaichi	地下水・地表面水変動予測（水質） Environmental (Water Quality) Specialist	日本工営 Nippon Koei	－
7	田中　光 Hikaru Tanaka	業務調整／トンネル計画 Coordinator/ Tunnel Planner	日本工営 Nippon Koei	5/6－5/27

*: Nippon Civic Consulting Engineers

1 - 2 調査工程

表－２　調査工程

Day	Date		Activities	Outline
1	5/6	Sun	23:10 Arrival in Bogota (Mr. Nozue, Mr. S.Tanaka, Mr. H.Tanaka)	➢ Flight code: AA1123
2	5/7	Mon	Team meeting	
3	5/8	Tue	14:30-16:30 ANLA meeting 1	➢ Schedule arrangement ➢ Confirmation of progress
4	5/9	Wed	Preparation for ANLA meeting on EIA Handbook	
5	5/10	Thu	14:00-15:00 ANLA meeting 2	➢ Explanation of the questionnaire from JICA Tokyo
6	5/11	Fri	10:00-11:00 ANLA workshop 1	➢ Finalization of EIA Handbook (Geology) with Ms. Francia, Mr. Helman, Ms. Maria
7	5/12	Sat	Holiday	
8	5/13	Sun	23:10 Arrival in Bogota (Mr. Ishimoto, Mr. Noto)	➢ Flight code: AA1123
9	5/14	Mon	Team meeting	
10	5/15	Tue	9:30-10:30 Visit to JICA Colombia Office	➢ Explanation of Work Plan (R5b)
			15:30-16:00 ANLA meeting 3	➢ Explanation of Questionnaire from JICA Tokyo
11	5/16	Wed	10:00-11:00 ANLA workshop 2	➢ Finalization of EIA Handbook (Hydrogeology) with Mr. David, Mr. Diego, Ms. Maria
			23:25 Departure from Bogota (Mr. Nozue)	➢ Flight code: AA1122

Day	Date		Activities	Outline
12	5/17	Thu	10:00-11:00 ANLA workshop 3	➢ Finalization of EIA Handbook (Water Quality, Hydrology) with Mr. Camilo, Ms. Maria
			14:00-15:00 ANLA workshop 4	➢ Finalization of EIA Handbook (Geotechnics) with Ms. Francia, Ms. Maria
13	5/18	Fri	13:30-17:30 Moving to Villavicencio for site visit	
			15:20 Arrival in Tokyo (Mr. Nozue)	➢ Flight code: JL011
			23:25 Departure from Bogota (Mr. S.Tanaka)	➢ Flight code: AA1122
14	5/19	Sat	Visit to the construction site of Buena Vista Tunnel 2	
15	5/20	Sun	15:20 Arrival in Tokyo (Mr. S.Tanaka)	➢ Flight code: JL011
16	5/21	Mon	Team meeting	
17	5/22	Tue	08:45-10:15 ANLA meeting 4 with JICA	➢ Confirmation of schedule ➢ Discussion on the effect of the project ➢ Confirmation of the questionnaire
			10:30-11:30 Meeting with JICA Tokyo	➢ Discussion on ACTOS Seminar
			14:50-16:30 ANLA meeting 5	➢ Confirmation of schedule
18	5/23	Wed	09:00-10:30 ACTOS meeting with JICA Tokyo	➢ Explanation of Action Plan ➢ Submission of Questionnaire
			15:50-17:00 ANLA meeting 6 with JICA	➢ Discussion on Hydroituango
			23:10 Arrival in Bogota (Mr. Isago)	➢ Flight code: AA1123
19	5/24	Thu	09:30-11:00 ANLA director meeting with JICA	➢ Wrap up of the project
			14:30-16:30 EDL meeting with JICA	➢ Discussion on concessionaire projects
20	5/25	Fri	08:00-13:00 ACTOS seminar	➢ BASIC CONCEPTS OF PLANNING, DESIGN, CONSTRUCTION AND MAINTENANCE OF ROAD TUNNELS IN JAPAN*
			23:25 Departure from Bogota (Mr. Ishimoto, Mr. Noto, Mr. H.Tanaka, Mr. Isago)	➢ Flight code: AA1122
21	5/26	Sat	Moving day	
22	5/27	Sun	15:20 Arrival in Tokyo (Mr. Ishimoto, Mr. Noto, Mr. H.Tanaka, Mr. Isago)	➢ Flight code: JL011

*Original Title: "CONCEPTOS BÁSICOS DE PLANEACIÓN, DISEÑO, CONSTRUCCIÓN Y MANTENIMIENTO DE TÚNELES DE CARRETERA EN JAPÓN"

2 業務の具体的内容

2-1 業務全般に係る作業

ワークプランの説明のため、ANLA に説明と協議を行いワークプランを合意・更新した。

2-2 【活動１】既存資料の情報収集

全現地調査を通じてコロンビア国のトンネル事業の実施にあたって関連する以下の資料を収集した。

表－３　主な収集資料

No.	資料名	言語	概要
1	ANLA BASICS	英	ANLA の概要説明のためのパワーポイント資料
2	TOR for EIA of road and tunnel project (Resolution751)	西 英訳済	ANLA が発行している EIA 図書の作成要件
3	EIA ならびに代替案検討(DAA)の TOR の比較資料	西	DAA の TOR の更新にあたって、EIA の TOR との比較資料
4	トンネルマニュアル Invias 2016	西	Invias のトンネル設計・施工に関するマニュアル（355P）

5	Cacao トンネル事業の EIA 資料	西	事業者より ANLA に提出された Cacao トンネル事業の EIA 申請
6	Cacao トンネル事業に対する環境ライセンス	西	ANLA より事業者に対して出状された環境ライセンス
7	Toyo トンネル事業の EIA 資料	西	事業者より ANLA に提出された Toyo トンネル事業の EIA 申請
8	EL Manso 事業の概要資料	西 英訳済	導水路トンネルである El Manso 事業の課題点に係る資料
9	その他	西	首記プロジェクト等に対するその他詳細なデータ他
10	INVIAS の手がける事業について	西	INVIAS 作成
11	La Linea トンネルの概要	西	プレゼン資料
12	コロンビアの地質図	西	全国をカバーする 1:100,000 の地質図、CD-ROM
13	トンネル施設に関するワークショップ資料	西	ACTOS セミナー資料
14	トンネル設備のライフサイクルに関する検討事例	西	ACTOS セミナー資料
15	トンネル保全ガイド（National Academy of Sciences/USA）	英	ACTOS セミナー資料
16	トンネル点検基準（FHWA-2008-0038/USA）	英	ACTOS セミナー資料
17	トンネル O&M、点検評価マニュアル（FHWA-HIF-15-005/USA）	英	ACTOS セミナー資料
18	NYX HEMERA 社*のカタログ（照明設備等）	英 西	ACTOS セミナー資料
19	Rio Cauca Hydropower Project に関する説明資料	西	ANLA 評価チームの説明資料

*カナダに本社のある民間会社、2018.3 のアクトスセミナーのコーディネータを担当

2-3【活動２】現状と課題の確認

(1)トンネル事業の現状と課題

収集した EIA 資料から、トンネル事業の実施にあたり、地質調査・評価に係るプロセス、水理検討に係るプロセスについては今日一般的に実施される標準的なプロセスに沿った検討が行われていることが伺われる。また環境影響低減対策についても比較案とされている工法は一般的な工法が網羅され、ジェットグラウトも事業において適用されている現状にあり、特段の課題は認められない。ラ・リネア・トンネルの現地踏査結果から、工事の後半に INVIAS 主導で導入された濁水処理施設は十分な濁水浄化能力が確認され、施設の維持管理も適切に行われており良好な状況であることを確認した。

上述の通り、個別の検討・技術については一定の水準にあることが確認されたが、事業実施におけるトンネル計画・設計における課題として、いずれのトンネル事業においても路線選定のプロセスが明確ではなく、施工性・経済性・社会環境影響の低減を主眼とした最適な路線選定が行われているとは言えない状況にあり、路線計画能力の向上が課題の一つとして挙げられる。ラ・リネア・トンネルの事業は、メイントンネル（8.6km）を始めとしてその他多くのトンネル・橋梁・接続道路からなる大プロジェクトである。個別の工事は一定の水準で実施されていることが伺われたが、環境問題で 2 年遅れて 2018 年完成の予定とされた工程に対し、現時

点で既に 1 年以上の遅れが見込まれているなど、工程管理を始めとする工事監理が十分に実施されていないことが課題として挙げられる。

コロンビアではボゴタービジャビセンシオ道路の建設プロジェクトが進められている。第 3 回、第 4 回現地調査では本道路に並走する既設道路を通行し、現地の道路事業の現状について情報の収集を行った。

(2)トンネル事業の環境影響評価プロセスの現状

コロンビア国のトンネルを含む道路事業の環境影響評価のプロセスは、初めに代替案検討（DAA）が事業者によって実施され、ANLA が提案内容を評価した後、ルートの選定を行う。その後、調査・計画を含む事業の EIA が事業者によって実施され、申請に基づき ANLA が EIA を確認し、問題がないと判断された場合に、環境承認ライセンスを発行する。ANLA からのライセンスの交付を受け、事業者は工事を開始する。

(3)トンネル事業の環境影響評価プロセスの課題

トンネル事業の環境影響評価プロセスの課題として以下の 6 点が挙げられる。

① トンネル事業の路線選定は調査が十分ではない DAA 段階で実施され、合理的な判断の根拠がない段階で確定し、調査結果を踏まえた柔軟な変更ができない。
② 路線選定は ANLA が決定することとなっているが、十分な路線選定の能力がない。その結果、事例として挙げられた事業では非合理的な路線案が選定されている。
③ EIA 資料において、環境影響に係るスコーピング、各環境項目の優先度付けがされておらず、主要な課題が不明確である。
④ EIA 資料において、事業の基礎的な情報（平面図・縦断図・横断図）がなく、事業の全体像が把握できない状況である。
⑤ EIA 資料は③にも係り、全ての調査結果が網羅的に記載され膨大であることから、ANLA はその確認・評価に時間を要している。
⑥ ANLA 職員はトンネル事業に係る基礎的な技術力・知見が不足しており、場合によっては必ずしも適正な評価が行われていない。

(4)ANLA の体制に係る課題

コロンビア国において道路事業・エネルギー・資源開発等の事業は増加しているが、ANLA の職員数は十分ではなく、評価チームの体制構築が課題となっている。また、ANLA の環境評価にかかる要員の多くは契約社員の雇用形態をとっており、年間契約ベースとなっていることから、中・長期的な環境影響評価に係る技術・ノウハウの構築が課題となっている。

なお、プロジェクトごとに専門員を招集して構成される ANLA の評価チームの組織に関する仕組みは、昨年の組織改編にて開始された体制であり、体制がうまく機能しているかどうか ANLA の職員もまだ見極めている途中である。一方で、一つのプロジェクトに対して評価にかけられる時間は限られており、職員数の不足は深刻な問題として ANLA の職員はとらえていることが判明している。

2-4 【活動３】技術便覧（案）の作成支援

(1)技術便覧（案）の作成支援

技術便覧（案）の作成支援にあたって、調査団は ANLA より提供された DAA ならびに EIA の TOR に準拠して技術便覧の目次案を作成し、ANLA と協議を行った。今後の作業スケジュールとして目次案は８月中に ANLA により確定、調査団がコンテンツ案を作成し、９月中にドラフト（英）を ANLA に送付、第２回現地調査時に協議することとした。

第２回現地調査において、協議議事録に示す通り分野ごとのカウンターパートを確認し、調査団が提案したスケジュールに沿って技術便覧案を作成することをカウンターパートと合意した。技術便覧の項目のうち、Geotechnics ならびに Vibration に関し技術便覧作成の支援要請を ANLA より受け、調査団は合意した。

第２回現地調査終了時～第３回現地調査開始の間に ANLA 内の契約社員（本業務のカウンターパート）の契約更新があり ANLA 側の作業が中断したため、ハンドブック案の最終化にあたり、ANLA 側との協議を残して第３回現地調査を開始した。第３回現地調査では改めて各パートのカウンターパートを確認し、Geotechnics、Vibration を加えたパートごとに協議を行った。

第４回現地調査では調査団が作成したパート毎に対応する C/P とともに最終確認を行い、コメントに対応する追記・修正を行った上で最終案を作成した。ANLA 側より技術便覧（案）の水質、その他のコンテンツについてプロジェクトの評価にあたり活用が始まっている、またその他のコンテンツについて準備を進めているとの報告があった。本調査で提供したコンテンツを活用し、ANLA が技術便覧を最終化、公文書化して活用が広がっていくことが期待される。

(2)DAA の TOR 作成支援

なお DAA（代替案比較・路線選定）に関する技術便覧(案)作成支援の要請を受けたが、DAA に関する資料作成の TOR(案)をレビューした結果、その内容に改善すべき点が認められたため、ANLA にレビュー結果を提言し、DAA に関する技術便覧については TOR の確定が必要なことから本年度の調査では行わないことを合意した。

DAA の TOR は Decree1076-2015 に準拠して ANLA が２月末にドラフトを作成したことを確認した。本ドラフトは本年３月末に ANLA から環境省に提出、環境省はパブリックコンサルテーションプロセスを開始する。調査団はこのドラフトをレビューし、レビュー報告書を提出、本コメントについてはパブリックコンサルテーションプロセスの一部として扱われることを確認した。

調査団のレビュー報告書については第４回現地調査前に ANLA 側に提出した。ANLA は DAA の TOR の文書化に関し、関係機関（INVIAS 等）との調整を進めているが、DAA の審査資料の増加を懸念する関係機関側からの反対意見が多く調整は難航している、そのため調査団からのコメントに対して十分な検討が行われていない状況を確認した。ANLA 側は DAA の TOR の発行に意欲を示しており、発行にあたってレビュー報告書の内容が活用されることが期待される。

2-5【活動４】推奨行動計画案の作成

第三回現地調査にて作成した推奨行動計画案について、第四回現地調査前に JICA と協議を行った上で更新し、本資料を基に ANLA と協議を行い、今後の対応方針について意見交換を行った。

2-6【活動５】知見移転

(1)全般

知見移転は ANLA との協議の結果、ANLA が評価を実施した、もしくは実施中のプロジェクトを題材としたケーススタディとしてワークショップを通じた議論を行うとともに、質問回答票の交換を通じた活動によって実施することとして ANLA と合意した。

第 3 回の現地調査ではハンドブック各パートの協議、Rio Cauca 水力発電プロジェクトの協議を経て質問票の交換を行った。

第 4 回現地調査では主に EHB の作成に関する質問事項が残っていたが、実施したワークショップ等を通じ ANLA と合意の上、全ての質問票をクローズした。

(2)現地セミナー

第 2 回現地調査において、現地セミナーは ANLA との協議の結果、関係機関・関係者も含め、第三回渡航時（2018 年 3 月予定）に開催することとして ANLA が調整する旨合意した。また、調査工程に示した通り、トンネル供用時の環境管理、地表面沈下・地下水と地質・水質に関する 4 つの議題のミニセミナーを実施し、ANLA 職員に対して知見の移転を図った。

第 3 回現地調査ではセミナーは環境省の予算上の制約から、ANLA 内でミニセミナーとして 3/12 に開催した。議題は①日本の EIA のプロセスの紹介、②トンネル地質に関する日本の事例、③トンネル水文に関する日本の事例、④トンネル施工に伴う振動について、⑤トンネルの補助工法についてであり、各セッションにて参加者と熱心な質疑も行われた。

なお、情報収集のために訪問した ACTOS（コロンビアのトンネル協会）にて、第 4 回現地調査時に ACTOS がアレンジするセミナーでの講演等を依頼されており、本件について ANLA、貴機構と協議調整することとした。

第 4 回現地調査では ACTOS 主催のセミナーにおいて、調査団から本業務で作成した技術資料の紹介、調査団が招聘した首都大学東京・砂金教授による「トンネルの調査・設計・施工・維持管理」に関する講義、(株)安藤・ハザマより「トンネル施工の先端技術」に関する講義を実施した。ANLA、INVIAS を始めとする複数の関係機関から 100 名を超える参加者を迎え、活発な質疑応答がなされた。

(3)ワークショップ

ワークショップ/ディスカッションは主にハンドブック(案)の最終化に関する事項につき開催し、スケジュール表に示す通り、4 回開催した。

３業務の達成状況

(1)資料収集

本調査を通じて、業務の実施・全体並びに各派遣時のワークプランの更新にあたり、必要となる ANLA ならびにコロンビアのトンネル事業に関する一通りの情報収集ができた。収集した資料、現地調査の結果等をとりまとめ、トンネル技術協会を通じて国内関係者に情報の展開を図る。

(2)課題特定及び分析

上述の通り、現地調査を通じて一通りの課題を特定した。特定した課題については推奨行動計画案の資料に記載、ANLA と本資料をもとに協議を行った。

(3)トンネル事業に係る技術助言

ワークショップを通じて、技術的な助言を行った。引き続き実事業の事例を通じたワークショップならびに質問回答票の活動を行うとともに、技術便覧（案）の作成を通じた技術助言を実施した。技術助言において作成した質問回答票は ANLA 組織内の参考資料として残り、ANLA の今後の業務での活用が期待される。

(4)推奨行動計画案の作成

第 3 回現地調査にて推奨行動計画について、調査団の素案をもとに協議を行った。第 4 回調査前に調査団案を修正し、第 4 回現地調査にて説明・協議を行った。

(5)現地セミナー

第 1 回~第 3 回までの現地調査において ANLA 内のミニセミナーを複数回開催した。また、第 4 回現地セミナーとして ACTOS がアレンジする月例セミナーで、調査団ならびに外部講師（首都大学砂金教授・(株)安藤・ハザマ）を迎えて講演を行った。開催したセミナーにおいて「トンネルけんせつに起因する地盤沈下並びに地下水の水位･流向の変動予測手法、評価手法、モニタリング手法、影響緩和対策工法」に関する ANLA 職員、ならびにコロンビア国の関係機関の職員の能力の開発に寄与することができたと考える。

以上

別添１　ボゴタービジャビセンシオ道路の現地調査（第四回視察を踏まえ一部追記）

ボゴタービジャビセンシオ道路について

ボゴタービジャビセンシオ道路はボゴタ～南東部の中核都市であるビジャビセンシオを結ぶ約 120km の道路である。本道路は、ベネズエラ国境のプエルトカレーニョ～ボゴタ～ブエナベントゥーラ港を結ぶ同国の主要な物流を担う都市間道路となっている。山岳地帯を通過することから 9 つのトンネル（最長はブエナビスタトンネルで約 4.5km）を有しており、既存の道路は 2 車線（急こう配の上り車線には部分的に登坂車線が整備されている）である。短いトンネルは覆工を行っていないものを確認している。その他、山岳道路部では地すべりの痕跡が認められる区間があり、インターロッキング等による補修の痕跡などが見られた。

既存道路は大型トレーラー等の走行速度の遅い大型車両が多く、交通の支障をきたしていることから、ボトルネックとなっている区間に並走する道路の新設が民間事業者（ANI が管轄）によって進められている。本事業において進められている建設中のブエナビスタ 2 号トンネルでは、トンネル切羽の崩落事故が発生しているとの情報を得ている。また、本年 1 月に発生したグアヤベタルの斜張橋の崩落事故は本道路の一部である。本事業は民間事業者による事業であることから、公開されている情報が少なく情報の収集がやや困難な状況であるが、第 3 回現地調査期間中にとれたアポイントに基づき、第 4 回現地調査にてトンネル建設現場の視察を予定している。

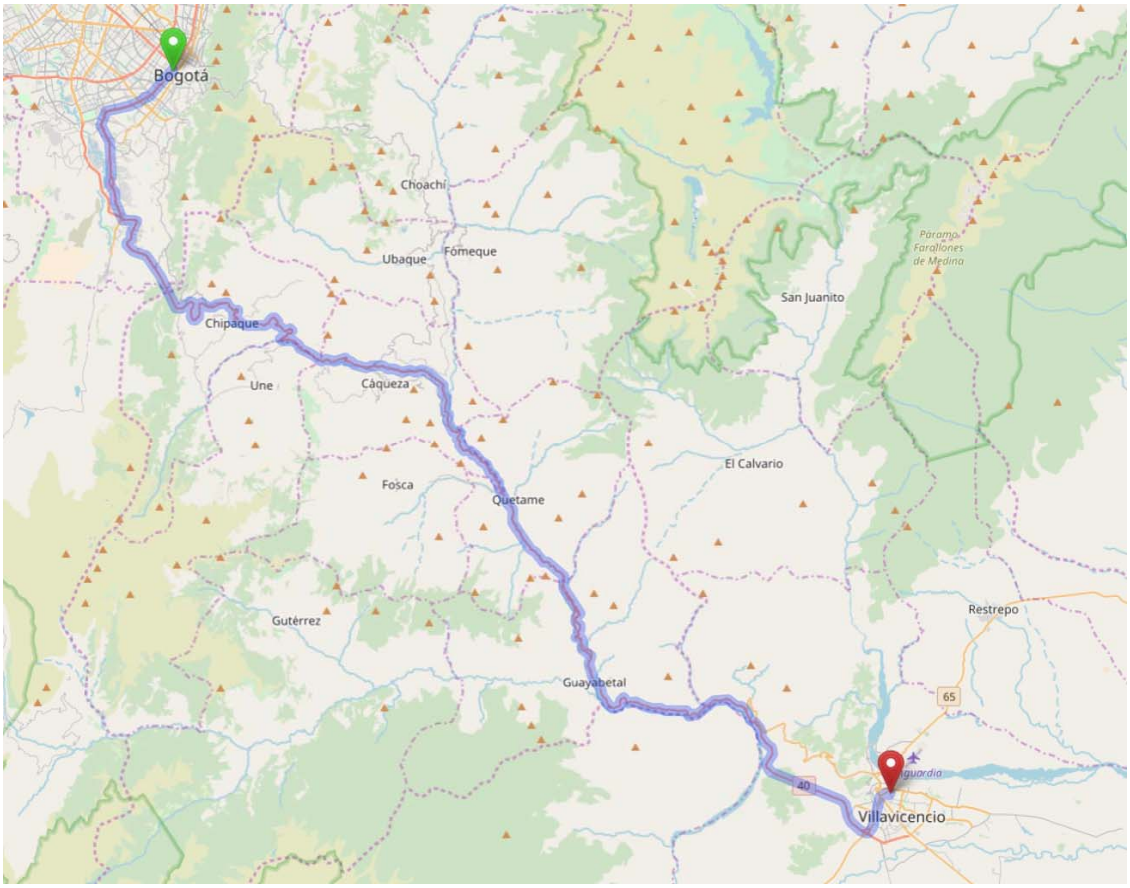


写真１　覆工コンクリートのないトンネル

写真２　ブエナビスタトンネル

写真３　７号トンネル（KM77+846）

写真４　７号トンネル近辺に建設中の PC 橋

写真５　１月に崩落した斜張橋

写真６　地すべりの痕跡と補修跡

ブエナビスタ 2 トンネル工事現場（2018/06/07 追記）

写真７　トンネル坑口

写真８　トンネル内部

写真９　ドリルジャンボ（古河製）

写真 10　セメント注入筒つきロックボルト

写真 11　トラスタイプの支保

写真 12　処々出現するシェール土

Ⅲ.質問回答票

<table>
<tr><th>No.</th><th>Category</th><th>Comments
(28/7/2017 by ANLA)</th><th>Answer 1</th><th>Response 2</th></tr>
<tr><td>(101)</td><td>Modeling, Env. Impact, & Water Quality</td><td>For ANLA, to evaluate numerical flow models, based on "finite elements", would bring greater benefits than evaluating models based on "finite differences"?

¿Para esta entidad evaluar modelos numéricos de flujo basados en “elementos finitos” traería mayores beneficios que evaluar modelos basados en “diferencias finitas”?</td><td>Both methods can be applied.
Generally, Finite Elements Method (FEM) is more suitable for complicated geological condition than Finite Differential Method (FDM) as shown in the summary table below. So nowadays, FEM is used more than FDM.
On the other hand, FEM needs much more memory to calculate and takes much time for simulation. This is the reason why sometimes FDM is more convenient for general evaluation purpose such as in pre-feasibility stage.

<table>
<tr><th>Method</th><th colspan="2">Element Decomposition</th><th>Boundary Deformation</th><th>Application example</th></tr>
<tr><td>FDM</td><td>Square, Rectangle</td><td>Easy</td><td>Complex</td><td>-River flow,
-Flood,
-Debris flow
-
Groundwater</td></tr>
<tr><td>FEM</td><td>Any polygon</td><td>Complex</td><td>Easy</td><td>-
Groundwater,
-Debris flow,
-stress analysis</td></tr>
</table>

It is important to note that even though complexed numerical model is developed, without given condition such as groundwater table level, amount of grondwater inflow, geological structures, hydraulic conductivity, meteorological data and so on, the result cannot achieve high analytical accuracy, whichever method you choose.

(31/07/2017 by
JICA ST- Env team, Tanaka, Miyaichi, Teramoto)

Ambos métodos pueden ser aplicados.
Generalmente, el Método de Elementos Finitos (MEF) es más adecuado para condiciones geológicas complicadas que el Método de Diferencias Finitas (MDF), como se muestra en la tabla de resumen a continuación. Así que hoy en día, MEF se usa más que MDF.
Por otro lado, MEF necesita mucha más memoria para calcular y toma mucho tiempo para la simulación. Esta es la razón por la cual a veces MDF es más conveniente para el propósito de evaluación general, como en la etapa de pre-factibilidad.
<table>
<tr><th>Método</th><th colspan="2">Descomposición de elementos</th><th>Deformación de fronteras</th><th>Ejemplo de aplicación</th></tr>
<tr><td>MDF</td><td>Cuadrado, Rectángulo</td><td>Fácil</td><td>Complejo</td><td>- Flujo del río,
-
inundación,
- Flujo de escombros
- Agua subterránea</td></tr>
</table></td><td>☒1) Sufficiently understood
☐2) Further explanation needed
☐3) Other

The answer posed by Nippon is clear, since as indicated in answer No. 1, the results of a tunnel project, according to the numerical method, can be similar and freely chosen.

In this way we can conclude as Authority, that in Colombia the 2 numerical methodologies (FEM and FDM) are implemented, which are evaluated in the pre-feasibility stage in order to obtain an infiltration limit inside the tunnel; volume that the constructor must take into account to implement the constructive measures that must present a direct relationship with the water conditions of the system to be intervened.

La respuesta planteada por Nippon es clara, ya que como indican en la respuesta No. 1 los resultados frente a un proyecto tunelero, de acuerdo al método numérico, pueden ser similares y de libre elección.

De esta forma podemos concluir como Autoridad, que en Colombia son implementadas las 2 metodologías numéricas (MEF y MDF), las cuales son evaluadas en la etapa de prefactibilidad con el fin de obtener en la licencia ambiental un límite de infiltración adentro del túnel, volumen que el constructor deberá tener en cuenta para implementar las medidas constructivas que deben presentar una relación directa con las condiciones hídricas del sistema a intervenir.</td></tr>
</table>

No.	Category	Comments (28/7/2017 by ANLA)	Answer 1	Response 2
			<table><tr><td>MEF</td><td>Cualquier polígono</td><td>Complejo</td><td>Fácil</td><td>- Agua subterránea, - Flujo de escombros, - Análisis de esfuerzos</td></tr></table> Es importante señalar que a pesar de que se desarrolla un modelo numérico complejo, sin una condición dada como el nivel de la capa freática, cantidad de entrada de agua subterránea, estructuras geológicas, conductividad hidráulica, datos meteorológicos, etc., el resultado no puede lograr una alta precisión analítica, tú eliges.	
(102)	**Modeling, Env. Impact, & Water Quality**	It would be necessary to require a specific numeral in the terms of reference, where you can indicate the relationship of which constructive methodology is going to be implemented and how it will intervene or will be developed in the simulation processes. The above, in order to articulate the different constructive methodologies with the prevention and mitigation of the environmental impact, during the characterization of the project. ¿Sería necesario requerir un numeral específico en los términos de referencia, donde se pueda indicar la relación de que metodología constructiva se va a implementar y esta como interviene o se verá desarrollada en los procesos de simulación? Lo anterior con el fin de articular las diferentes metodologías constructivas con la prevención y mitigación del impacto ambiental durante la caracterización del proyecto.	This issue should be continuously discussed with TOR team and JICA team. Yes. It should be implemented but not all case. In case to evaluate the effectiveness of the counter measure and especially in case you need to explain to stakeholders to acquire agreement, numerical model simulation is very useful. (02/08/2017 by Teramoto) Este tema debe ser discutido continuamente con el equipo de Términos de Referencia y el equipo de JICA. Sí. Debe implementarse, pero no en todos los casos. En caso de evaluar la efectividad de la contramedida, y especialmente en caso de que necesite explicar a los interesados para obtener un acuerdo, la simulación numérica del modelo es muy útil. (02/08/2017 por Teramoto)	☐1) Sufficiently understood ☐2) Further explanation needed ☒3) Other According to Nippon Koei's response, it is necessary to continue to dialogue continuously; nevertheless, it is clear that it is necessary to implement a specific item in the terms of reference, an explicit numeral that asks for the relationship of the constructive method with the care of the water resource, and its relationship with the numerical simulations. The above is proposed because in some cases this relationship does not exist. De acuerdo a la respuesta de Nippon, es necesario seguir dialogando continuamente; no obstante, es claro que, si es necesario implementar un ítem específico en los términos de referencia, un numeral explicito que solicite la relación del método constructivo con el cuidado del recurso hídrico, y su relación con las simulaciones numéricas. Lo anterior es propuesto debido a que en algunos casos no existe esta relación.
(103)	**Modeling, Env. Impact, & Water Quality**	Given the above, is it feasible to impose fixed and / or static infiltration flows, taking into account the results of numerical simulations? Teniendo en cuenta lo anterior, es viable imponer caudales de infiltración fijos y/o estáticos, teniendo en cuenta los resultados de las simulaciones numéricas.?.	Infiltrate water of tunnel is classified into two categories; concentrated inflow at the stage of construction and steady inflow after completion. In this context, infiltration flow rates change at project stage, at least during and after construction. (31/07/2017 by JICA ST- Env team) El agua de infiltración del túnel se clasifica en dos categorías; La entrada concentrada en la etapa de construcción y la afluencia constante después de la terminación. En este contexto, las tasas de flujo de infiltración cambian en la etapa del proyecto, al menos durante y después de la construcción. (31/07/2017 Por EEJICA- Equipo Ambiental)	☐1) Sufficiently understood ☐2) Further explanation needed ☒3) Other The answer is clear; however, it is important to continue discussing this important numeral. La respuesta es clara, no obstante, es importante seguir debatiendo este numeral tan importante.
(104)	**Modeling, Env. Impact, & Water Quality**	How do you establish, prior to construction, these infiltration flows in Japan?	In Japan, there are 4 standard methods used to predict infiltration flow rate and possible affected catchment area.	☒1) Sufficiently understood ☐2) Further explanation needed

No.	Category	Comments (28/7/2017 by ANLA)	Answer 1	Response 2
		Cómo se establecen antes de la construcción estos caudales de infiltración en Japón?	a. Case study of tunnelling on surrounding area or in similar geology (DAA stage: selection of alignment of tunnels.) b. Method using topographical or hydrogeological conditions. (EIA stage: design and planning of construction) c. Method using hydraulic formula (EIA stage: design and planning of construction) d. Numerical analysis by hydrogeological mode. (In case that if necessary) (31/07/2017 by JICA ST- Env team) En Japón, existen 4 métodos estándar para predecir el caudal de infiltración y la posible área afectada de la cuenca. a. Estudio de casos de túnel en el área circundante o en una geología similar (fase de DAA: selección del área de túneles). b. Método utilizando condiciones topográficas o hidrogeológicas. (Etapa EIA: diseño y planificación de la construcción). c. Método utilizando la fórmula hidráulica (EIA etapa: diseño y planificación de construcción) d. Análisis numérico por modo hidrogeológico. (En caso de que sea necesario) (31/07/2017 por EEJICA- Equipo ambiental)	☐3) Other The answer is clear. La respuesta es clara.
(105)	**Modeling, Env. Impact, & Water Quality**	Are there limits, prior to construction, or do they vary over time? In addition, if they vary over time, what methodology do they implement to describe this change in numerical simulations? Se tienen límites antes de la construcción, o varían con el tiempo, y si varían con el tiempo que metodología implementan para describir este cambio en las simulaciones numéricas?	One of approach is to make several scenarios with different conditions and carry out several simulations. Scenarios are made for example, before construction, during construction with/ without measure, construction with another measure, and after construction. (02/08/2017 by Teramoto) Una estrategia es hacer varios escenarios con diferentes condiciones y realizar varias simulaciones. Los escenarios se hacen, por ejemplo, antes de la construcción, durante la construcción con / sin medida, la construcción con otra medida, y después de la construcción. (02/08/2017 por Teramoto)	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other The answer is clear. La respuesta es clara.
(106)	**Modeling, Env. Impact, & Water Quality**	How often, it is advisable, that the company, which opts for the environmental license, update the numerical flow model? ¿Cada cuánto es recomendable que la empresa que opta por la licencia ambiental actualice el modelo numérico de flujo?	In Japan, the numerical model would be modified and updated when engineering design should be changed such as; - While drilling construction, geological and hydrogeological conditions are very different from original model - If actual hydrological impact is very different from expected situation with original numerical model, for example groundwater drawdown, dry-up of streams and so on. After construction work, normally the numerical model shall be modified at least once with new data obtained from the work and monitoring. The purpose of modification is 1) to re-examine the monitoring plan, 2) to evaluate environmental impact after work, 3) to use as explanation material for stakeholders. (31/07/2017 by JICA ST- Env team) En Japón, el modelo numérico sería modificado y actualizado cuando la ingeniería de diseño debería ser cambiada, tal como; - Mientras se perfora para la construcción, las condiciones geológicas e hidrogeológicas son muy diferentes del modelo original - Si el impacto hidrológico real es muy diferente de la situación esperada, con el modelo numérico original, por ejemplo, drenaje del agua subterránea, sequedad de arroyos, etc. Después de la construcción de la obra, normalmente el modelo numérico deberá ser modificado, al menos una vez, con los nuevos datos, obtenidos de la obra y el monitoreo. El propósito de la modificación es 1) reexaminar el plan de monitoreo, 2) evaluar el impacto ambiental después de la obra, 3) utilizar como material de explicación para las partes interesadas. (31/07/2017 por EEJICA- Equipo ambiental)	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other The answer is clear, and it gives us guidelines so that in the licensing process obligations are placed in front of the updating of the numerical simulations, which must be in accordance with the proposal of the Nippon Koei team. *(…)* 1. While drilling for construction, the geological and hydrogeological conditions are very different from the original model 2. If the actual hydrological impact is very different from the expected situation, with the original numerical model, for example, drainage of groundwater, dryness of streams, etc. 3. After the construction of the work, normally the numerical model must be modified, at least once, with the new data, obtained from the work and monitoring. The purpose of the modification is: a) re-examine the monitoring plan. b) evaluate the environmental impact after the work. c) use as explanation material for interested parties.

No.	Category	Comments (28/7/2017 by ANLA)	Answer 1	Response 2
				(…) La respuesta es clara, y nos da pautas para que en el proceso de licenciamiento se interpongan obligaciones frente a la actualización de las simulaciones numéricas, las cuales deben estar acordes con la propuesta de grupo Nippon. *(…)* *1. Mientras se perfora para la construcción, las condiciones geológicas e hidrogeológicas son muy diferentes del modelo original* *2. Si el impacto hidrológico real es muy diferente de la situación esperada, con el modelo numérico original, por ejemplo, drenaje del agua subterránea, sequedad de arroyos, etc.* *3. Después de la construcción de la obra, normalmente el modelo numérico deberá ser modificado, al menos una vez, con los nuevos datos, obtenidos de la obra y el monitoreo.* *El propósito de la modificación es:* *a) reexaminar el plan de monitoreo. b) evaluar el impacto ambiental después de la obra.* *c) utilizar como material de explicación para las partes interesadas.* *(…)*
(107)	**Modeling, Env. Impact, & Water Quality**	According to the minimum obligations, interposed in the aforementioned terms of reference, compared to the numerical flow simulations, what could be included or eliminated? ¿De acuerdo con las obligaciones mínimas interpuestas en los términos de referencia mencionados con anterioridad frente a las simulaciones numéricas de flujo, que le podría incluir o eliminar?	To be discussed with TOR team and JICA team. It can be modified in the version in 2018. Se discutirá con el equipo Términos de Referencia y el equipo JICA. Puede ser modificado en la versión en 2018.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other The answer is clear, and we hope to continue working concretely on the contribution that the team of Nippon Koei can make with respect to the next ToR. La respuesta es clara y se espera seguir trabajando de forma concreta en el aporte que el equipo de Nippon pueda tener en función de los próximos TER.
(108)	**Modeling, Env. Impact, & Water Quality**	What impacts are caused by construction / operation of tunnels on surface and groundwater quality and water supply? Impactos ocasionados por construcción/operación túneles sobre la calidad de agua superficial y subterránea y oferta hídrica.	-During Construction phase: High pH value and / or muddy water from excavation and concrete works. -During and after construction phase: Heavy metals originated nature from excavated muck (rock and soil) and inflow water. Acid drainage from excavated muck. (31/07/2017 by JICA ST- Env team) -Durante la fase de construcción: Alto valor de pH y / o agua fangosa, procedente de excavaciones y obras de hormigón. -Durante y después de la fase de construcción:	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other The answer is clear. La respuesta es clara.

No.	Category	Comments (28/7/2017 by ANLA)	Answer 1	Response 2
			Los metales pesados originados de manera natural, a partir de la moca excavada (roca y tierra) y agua entrante. Drenaje ácido de la tierra excavada. 31/07/2017 por EEJICA- Equipo ambiental)	

No.	Category	Comments (02/11/2017 by ANLA)	Answer 1	Response 2 Respuesta de ANLA
(215)	**Toyo Tunnel (Water Quality)**	What can be associated with the presence of high sulfates (greater than 100 mg /l of SO_4), alkalis (greater than 100 mg /l of $CaCO_3$) in natural water (springs and piezometers)? ¿A qué se puede asociar la presencia alta de sulfatos (mayor de 100 mg/l de SO4), álcalis (mayor de 100 mg/l de CaCO3) en agua naturales (manantiales y de piezómetros)?	(Respondent Miyaichi, 281117) SO_4^{2-} tends to concentrate in water which is affected by some source such as chemical fertilizer, sulfur spring, mine drainage, excrement. Alkalis tends to concentrate due to elution of Ca and Mg as hydrogencarbonate from sedimentary rock such as limestone. (Respuesta de Miyaichi, 281117) SO_4^{2-} tiende a concentrarse en el agua, la cual se ve afectada por alguna fuente, tal como fertilizante químico, manantial de agua sulfatada, drenaje de mina, excremento. Alkalis tiende a concentrarse debido a la elución de Ca y Mg como bicarbonatos de rocas sedimentarias tales como la caliza.	1) Sufficiently understood /Entendido
(216)	**Toyo Tunnel (Water Quality)**	What type of pollution in the water can be generated? ¿Qué tipo de contaminación en el agua se puede generar?	(Respondent Miyaichi, 281117) In general, water pollutants from tunnel projects are as follows. - SS from Soil (from general earthwork) - SS, Alkaline water, Metals from cement (from general concrete work) - Alkaline water, Acidic water and Metals from Groundwater (depends on the environment) - Acidic water and Metals from rock and soil (depends on the environment) (Respuesta de Miyaichi, 281117) En general, los contaminantes del agua de los proyectos de túneles son los siguientes. - Sólidos suspendidos del suelo (del movimiento general de tierras) - Sólidos suspendidos, aguas alcalinas, Metales del cemento (de la obra general de concreto) - Aguas alcalinas, aguas ácidas y metales del agua subterránea (depende del ambiente) - Aguas ácidas y metales de roca y suelo (depende del ambiente)	1) Sufficiently understood /Entendido
(217)	**Toyo Tunnel (Water Quality)**	What are the recommended management measures for the proper disposal of wastewater, which have been in contact with this type of water? ¿Cuáles son las medidas de manejo recomendadas para la disposición adecuada de las aguas residuales, que han estado en contacto con este tipo de aguas?	(Respondent Miyaichi, 281117) Countermeasures for wastewater from tunnel projects are generally as follows. - SS is treated by Solid – Liquid seperation, by installing settling pond (free settling) or wastewater treatment plant. – Alkaline and Acid are treated by Neutralization, by installing wastewater treatment plant – Metals is treated by Solid – Liquid separation, by installing wastewater treatment plant. (Respuesta de Miyaichi, 281117) Las contramedidas para las aguas residuales de proyectos de túneles generalmente son las siguientes. - Sólidos Suspendidos se tratan mediante separación sólido - líquido, instalando un estanque de sedimentación (sedimentación libre) o una planta de tratamiento de aguas residuales. - Bases y ácidos son tratados por neutralización, mediante la instalación de una planta de tratamiento de aguas residuales - Los metales se tratan por separación sólido - líquido, mediante la instalación de una planta de tratamiento de aguas residuales.	1) Sufficiently understood /Entendido
(218)	**Toyo Tunnel (Water Quality)**	What are the recommendations for the management of waste that has been in contact with this type of water? ¿Cuáles son las recomendaciones para el manejo de los residuos que han estado en contacto con este tipo de aguas?	(Respondent Miyaichi, 281117) Countermeasures for solid waste are generally as follows. These are for preventing exposure to rainwater and groundwater. A. For temporary storage site - Paving the ground by asphalt, or installing impermeable sheet or clay. - Covering by impermeable sheet B. For final disposal site - Content treatment by impermeable sheet or clay (Respuesta de Miyaichi, 281117) Las contramedidas para los desechos sólidos generalmente son las siguientes. Estos son para prevenir la exposición al agua de lluvia y subterránea. A. Para el sitio de almacenamiento temporal - Pavimentar el terreno con asfalto o instalar una capa impermeable o de arcilla. - Cubrir por una capa impermeable B. Para el sitio de disposición final - Tratamiento del contenido mediante capa impermeable o de arcilla	1) Sufficiently understood /Entendido
(219)	**Toyo Tunnel (Water Quality)**	What other types of chemical substances of natural origin should be taken into account to avoid producing contaminated water?	(Respondent Miyaichi, 281117) In Japanese case, elements shown in below might be expected to excess Japanese standards. - Cadmium (Cd), Chromium (Cr), Mercury (Hg), Selenium (Se), Copper (Cu), Lead (Pb), Arsenic (As), Fluorine (F), Boron (B)	1) Sufficiently understood /Entendido

No.	Category	Comments (02/11/2017 by ANLA)	Answer 1	Response 2 Respuesta de ANLA
		¿Qué otro tipo de sustancias químicas de origen natural deben ser tenidas en cuenta para evitar producir aguas contaminadas?	(Respuesta de Miyaichi, 281117) En el caso japonés, se puede esperar que los elementos que se muestran a continuación excedan los estándares japoneses. - Cadmio (Cd), cromo (Cr), mercurio (Hg), selenio (Se), cobre (Cu), plomo (Pb), arsénico (As), flúor (F), boro (B)	

No.	Category	Comments (28/7/2017 by ANLA)	Answer 1	Response 2 Respuesta de ANLA
(211)	**Toyo Tunnel 23 November 2017**	Technologically viable alternatives to ensure that the builder will be able to reduce the entrance flow to the tunnel by 90%. Alternativas tecnológicamente viables que permitan asegurar que el constructor podrá reducir el caudal de ingreso al túnel en un 90%.	Technololgicaly, Yes. Pre-Injection is also generally used in Japan. TBM (Tunnel Boring Machine) can be applied if geological condition is suitable for the method. TBM method is more effective to reduce water inflow. Tecnológicamente, sí. La preinjección también se usa generalmente en Japón. TBM (Tuneladora) se puede aplicar si el estado geológico es adecuado para el método. El método TBM es más eficaz para reducir la entrada de agua. (01/08/2017 por EEJICA-Equipo de Const. Noto, Nozue)	2) Further explanation needed/requiere más explicación
(211a)			(Respondent Noto, 231117) In the following cases, TBM is evaluated to be superior in terms of economy, safety and workability than NATM (New Austrian Tunnelling Method) in selecting the tunnel construction method in Japan. Because, in the case of NATM, and grouting method for the entire cross-section is necessary to stop water completely, which is expensive and the construction period increases. a) When all the tunnels are supposed to be spring water that is hindrance to NATM excavation. b) When it is unacceptable to influence the surrounding water sources in any way. (Respuesta de Noto, 231117) En los siguientes casos, se evalúa que TBM es superior en términos de economía, seguridad y viabilidad que NATM (Nuevo Método Austriaco para Perforación de Túneles) al seleccionar el método de construcción de túneles en Japón. Porque, en el caso de NATM, es necesario un método de lechada para toda la sección transversal para detener por completo el agua, lo cual es costoso y el período de construcción aumenta. a) Cuando se supone todo el túnel presenta agua de manantial, lo cual es un obstáculo para la excavación NATM. b) Cuando es inaceptable influir en las fuentes de agua circundantes de cualquier manera	1) Sufficiently understood /Entendido
(212)	**Toyo Tunnel 23 November 2017**	Constructive alternatives for the management of surface water depletion (impacts on water for human consumption, and for agricultural activities). Alternativas constructivas para manejo del abatimiento de aguas superficiales (impactos sobre el agua para consumo humano, de actividades agropecuarias).	Alternative (1) – Change of alignment Alternative(2) – Apply appropriate countermeasure (such as pre injection) Alternative(3) – Reuse of inflow water of the tunnel Alternative(4) – Others Alternativa (1) - Cambio de alineación Alternativa (2) - Aplicar la medida de contingencia apropiada (como la preinyección) Alternativa (3) - Reutilización del agua de entrada del túnel Alternativa (4) – Otros (01/08/2017 por EEJICA-Equipo de Const. Noto, Nozue)	2) Further explanation needed/requiere más explicación A que se refieren con Alternativa (4) – Otros, ya que cuando el estudio es de diagnóstico de alternativas no se cuenta con certeza de la conexión hidráulica entre el recurso superficial y el subterráneo. What do they mean by Alternative (4) - Others? since when the study is for the diagnosis of alternatives there is no certainty of the hydraulic connection between the surface and underground resources. Further explanation is requested, please.
(212a)			(Respondent Noto, 231117) -In the case of limited water resource impact and stable geology, NATM is an excellent method for economic, safety and construction. - If correspondence is not easy with Alternative 1 to 3 choices, NATM cannot be determined as the optimum construction method, so it is necessary to consider Alternative 4 what is adopting TBM.	1) Sufficiently understood /Entendido

No.	Category	Comments (28/7/2017 by ANLA)	Answer 1	Response 2 Respuesta de ANLA
			In case of: a) It is difficult to select a route with little effect on the water source. b) An auxiliary method such as grouting is needed over a long distance. c) It's difficult that reuse of inflow water of the tunnel as countermeasure. (Respuesta de Noto, 231117) -En el caso de impacto bajo en los recursos hídricos y con geología estable, NATM es un método excelente para la economía, la seguridad y la construcción. - Si la correspondencia no es fácil con las opciones de las Alternativas 1 a 3, NATM no se puede determinar como el método de construcción óptimo, por lo que es necesario considerar Alternativa 4 que está adoptando TBM. En caso de: a) Que sea difícil seleccionar un trazado con poco efecto en las fuentes de agua. b) Que sea necesario un método auxiliar como el grouting en una larga distancia. c) Que sea difícil reutilizar el agua de entrada del túnel como contramedida.	
(213)	**Toyo Tunnel**	Alternatives for handling the ZODMEs (Zones for Debris and Excavation Material Management), on rough terrain (in Colombia there is a risk that ZODMEs may be illegally intervened by the community, since in the area there is a possible presence of gold). Alternativas de manejo de las ZODME (Zona de Manejo de Escombros y Material de Excavación) en terreno quebrado (en Colombia existe el riesgo que las ZODME sean intervenidas de manera ilegal por la comunidad ya que en el área hay posible presencia de oro)	(1) Shall confirm whether excavated material has harmful contains or not (2) In case it not contains, reuse of the material is recommended or stock on the appropriate disposal site with agreement of local communities (3) In case of harmful, strictly controlled disposal site is established and dispose them (1) Debe confirmar si el material excavado contiene elementos nocivos o no (2) En caso de que no contenga, se recomienda la reutilización del material o la disposición en el sitio de eliminación apropiado, de acuerdo de las comunidades locales (3) En caso de que sea nocivo, se debe entablecer un sitio de disposición estrictamente controlado y disponerlos (01/08/2017 by JICAST-Const. team, Noto, Nozue)	1) Sufficiently understood /Entendido
(214)	**Toyo Tunnel**	Alternatives for handling variations in vibration levels and local seismicity. Alternativas para manejo de variación en los niveles de vibración y sismicidad local.	Alt(1) – Control the explosion (amount of explosive, area, etc) Alt(2) – Avoid night time explosion Alt(3) – Apply the mechanical excavation method Alt(4) – Apply low noise and vibration method Alt (1) - Controlar la explosión (cantidad de explosivo, área, etc.) Alt (2) - Evitar la explosión nocturna Alt (3) - Aplicar el método de excavación mecánica Alt (4) - Aplicar un método de bajo nivel de ruido y vibraciones (01/08/2017 by JICAST-Const. team, Noto, Nozue)	1) Sufficiently understood /Entendido

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
(221)	**Rio Manso Transfer**	What management measures can be applied to impacts on the geosphere component? Medidas de manejo para los impactos sobre el componente geosférico	Principally, water stopping work for construction should be implemented then continue monitoring. If target of the measure is for protection of flora and fauna, management measures to natural environment should be selected and applied very carefully based on scientific examination. Principalmente, se debe implementar el trabajo de detención de agua para la construcción y luego continuar el monitoreo. Si el objetivo de la medida es la protección de la flora y la fauna, medidas de manejo para el medio ambiente natural deberían ser seleccionadas y aplicadas con mucho cuidado, sobre la base de un examen científico. (03/08/2017 by JICAST-Env. team, Tanaka, Miyaichi, Teramoto)	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other The answer is clear. Es clara la respuesta
(222)	**Rio Manso Transfer**	What similar experiences have you experienced in other countries that help address this problem? Experiencias similares en otros países que ayuden a abordar esta problemática	Similar impact was expected at Takao road tunnel of Ken-oh-dou in Japan. This tunnel was planned through the quasi-national park area. Thus, the ministry of Land, Infrastructure and Transport which is implementer of this project applied the water-tide structure to the partial section of the tunnel. Meanwhile the Ministry organized special committee constituted by academic expert. They assessed the monitoring results and efficiency of the countermeasure during construction. Se esperaba un impacto similar en el túnel de carretera Takao de Ken-oh-dou en Japón. Este túnel fue planeado a través del área del parque cuasi-nacional. Así, el Ministerio de Tierra, Infraestructura y Transporte, que ejecuta este proyecto, aplicó la estructura de la marea de agua a la sección parcial del túnel. Mientras tanto, el Ministerio organizó un comité especial constituido por expertos académicos. Evaluaron los resultados del monitoreo y la eficiencia de la contramedida durante la construcción. (03/08/2017 by JICAST-Env. team, Tanaka, Miyaichi, Teramoto)	2) Further explanation needed/requiere más explicación More information or documentary references are required on the types of sensors / instruments used in the monitoring. Se requiere mayor información o referencias documentales sobre los tipos de sensores/instrumentos empleados en el monitoreo.
(222a)	**Rio Manso Transfer**		(Respondent Miyaichi, 041217) In japan, we use self-registering water-pressure gauge to record changes of the piezometric head as follow. https://in-situ.com/product-category/water-level-monitoring/level-temp-data-loggers/ http://www.osasi.co.jp/products/item/detail/101 https://www.oyo.co.jp/english/products_lists/water-level-measurement-sdl-mini/ (Respuesta de Miyaichi, 041217) En Japón, se utiliza medidor de presión de agua de auto-registro para registrar los cambios de la altura piezométrica, de la siguiente manera. https://in-situ.com/product-category/water-level-monitoring/level-temp-data-loggers/ http://www.osasi.co.jp/products/item/detail/101 https://www.oyo.co.jp/english/products_lists/water-level-measurement-sdl-mini/	1) Sufficiently understood /Entendido
(223)	**Rio Manso Transfer**	What measures do you recommend for managing the impacts with the communities around the area of influence of the project? Medidas recomendadas para el manejo de los impactos con las comunidades aledañas del área de influencia del proyecto.	It depends on condition of each community. In order for planning the appropriate countermeasure, the hearing-survey to resident would be needed for to each disappearing community. The stakeholder meetings among residents, developer, consultants, authorities and facilitator would be required occasionally. If necessary, a committee (review board) would be formulated with the members like professors and/or other experts. Depende de la condición de cada comunidad. Para planificar la contramedida apropiada, la encuesta de audiencia al residente sería necesaria para cada comunidad desaparecida. Las reuniones de las partes interesadas entre los residentes, los promotores, los consultores, las autoridades y el facilitador se requerirían ocasionalmente.	1) Sufficiently understood /Entendido The answer is clear. Es clara la respuesta

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
			Si es necesario, un comité (junta de revisión) se formularía con los miembros como profesores u otros expertos. (03/08/2017 by JICAST-Env. team, Tanaka, Miyaichi, Teramoto)	
(224)	**Rio Manso Transfer**	Would you recommend the use of transfers to increase flow rates? ¿Recomendarían el uso de trasvases para incrementar caudales?	We consider the additional work for stopping the intrusion into the tunnel is needed by some countermeasure method. After this work, it is possible to increase the flow rate of transfer. Consideramos que el trabajo adicional para detener la intrusión en el túnel es necesario por algún método de contramedida. Después de este trabajo, es posible aumentar el caudal de transferencia. (03/08/2017 by JICAST-Env. team, Tanaka, Miyaichi, Teramoto)	2) Further explanation needed/requiere más explicación Further explanation is requested in next visit. Se solicita mayor explicación en próxima visita.

No.	Category	Comments (by JICAST)	Answer 1 (by ANLA)	Response 2
(*221)	XXXXXX field (XX /XX/20XX by JICAST)		(Respondent XXXX)	Select/Seleccionar opción
(*222)	XXXXXX field (XX /XX/20XX by JICAST)		(Respondent XXXX)	Select/Seleccionar opción
(*223)	XXXXXX field (XX /XX/20XX by JICAST)		(Respondent XXXX)	Select/Seleccionar opción
(*224)	XXXXXX field (XX /XX/20XX by JICAST)		(Respondent XXXX)	Select/Seleccionar opción

No.	Category	Comments (30/10/2017 by ANLA)	Answer 1	Discussion btw ANLA & JICAST	Response 2
(230)	**Piedra sol**				1) Sufficiently understood 2) Further explanation needed 3) Other
(231)					
(232)					
(233)					

No.	Category	Comments (30/10/2017 by ANLA)	Answer 1	Response 2 Respuesta de ANLA
(241)	Soto Norte project (mining)	Do you consider it necessary to adjust the conceptual hydrogeological model, so that the company can separately characterize the hydrogeological units according to the type of rock reported? Our interest is for the sedimentary units present in the study area, on which it is planned to locate the dry tailings deposit and the infrastructure to dispose the exploited material. ¿Consideran necesario ajustar el modelo hidrogeológico conceptual, con el fin que la empresa pueda caracterizar por separado las unidades hidrogeológicas en función del tipo de roca reportado? Nuestro interés es por las unidades sedimentarias presentes en el área de estudio, sobre las cuales se proyecta ubicar el depósito de relaves secos y la infraestructura para disponer el material explotado.		Select/Seleccionar opción
(242)	Soto Norte project (mining)	Do you consider it important that we ask the company to include in the characterization of the baseline of the hydrogeological component, the quaternary deposits identified and the fault systems of regional and local type? Should they describe their incidence in the fracturing of the units that generate zones of greater permeability by establishing their capacities and their behavior? How can we technically support this request of characterization? ¿consideran importante que les solicitemos a la empresa incluir en la caracterización de la línea base del componente hidrogeológico, los depósitos cuaternarios identificados y los sistemas de fallas de tipo regional y local? ¿Deberían describir su incidencia en el fracturamiento de las unidades que generan zonas de mayor permeabilidad estableciendo sus capacidades y su comportamiento? ¿Como podríamos justificar técnicamente la necesidad de esta caracterización?		Select/Seleccionar opción
(243)	Soto Norte project (mining)	Is it appropriate to request the company that the adjustments of question 231 be reflected in the discretization of the numerical modeling that was done to define the hydrogeological baseline? This question is directed to that in the field we evidenced the existence of hillside deposits with permanent upwelling, which were not included in the numerical or conceptual modeling. ¿Es pertinente solicitar a la empresa que los ajustes de la pregunta 231 se reflejen en la discretización de la modelación numérica que se hizo para definir la línea base hidrogeológica? Esta pregunta está dirigida a que en campo evidenciamos la existencia de depósitos de ladera con surgencia permanente, que no fueron incluidos en la modelación numérica ni tampoco en la conceptual.		Select/Seleccionar opción
(244)	Soto Norte project (mining)	Do you consider that for the analysis of environmental impacts of the hydrogeological component, the following information is necessary? • Data and report of the isotopy performed for the characterization. • Data and report of the pumping tests carried out. • Data and report of the geophysical information. • Annexes and native data of the numerical hydrogeological model. • Inventory of 100% underground water points in the areas of the tunnels, exploitation and tailings and sterile deposits. In the geotechnical annex, the company described the Lefranc tests, but did not report the descent curves and their recovery. ¿How can we technically justify the need for this information? ¿Consideran que, para el análisis de impactos ambientales del componente hidrogeológico, es necesaria la siguiente información? • Datos e informe de la isotopía realizadas para la caracterización. • Datos e informe de las pruebas de bombeo realizadas.		Select/Seleccionar opción

No.	Category	Comments (30/10/2017 by ANLA)	Answer 1	Response 2 Respuesta de ANLA
		• Datos e informe de la información geofísica. • Anexos y datos nativos del modelo hidrogeológico numérico. • Inventario de puntos de agua subterránea al 100% en las áreas de los túneles, explotación y depósitos de relaves y estériles. En el anexo geotécnico, la compañía describió las pruebas Lefranc, pero no reportó las curvas de abatimiento y su recuperación. ¿Como podríamos justificar técnicamente la necesidad de esta información?		
(245)		Considering the sensitivity that the hydrogeological component represents environmentally and in the social dynamics, do you consider it necessary to request the company to perform the characterization or inventory of 100% underground water points (specifically in the areas of the tunnels, exploitation and deposits of tailings and sterile) with the accompaniment of the communities in the area of influence? About this matter, in Japan, how do you request information that requires the support of the community? Teniendo en cuenta la sensibilidad que el componente hidrogeológico representa ambientalmente y en la dinámica social, ¿Consideran necesario solicitar a la empresa realizar la caracterización o inventario de puntos de agua subterránea al 100% (específicamente en las áreas de los túneles, explotación y depósitos de relaves y estériles) con el acompañamiento de las comunidades del área de influencia? Con relación a este asunto, en Japón, ¿cómo solicitan información que requiera el apoyo de la comunidad?		Select/Seleccionar opción

No.	Category	Comments (30 /10/2017 by ANLA)	Answer 1 (respuesta 01/11/2017)	Response 2 Respuesta de ANLA
(410)	Geology field	En numeral C. 2.2.2 A qué se refieren con "Topografía de fallas" y "sección con presión irregular" ?, Como se evidencian en campo? cuáles son los elementos que los determinan. In numeral C. 2.2.2, What do you mean by "Fault topography" and "section with uneven pressure"? ¿How can you evidence those points in the field? ¿what are the elements that determine them?	La topografía de fallas es la expresión topográfica que incluye el escarpe de falla, facetas terminales, etc. Ver **Figura C.2.2.4 Topografía de fallas**. Y los expertos pueden identificarlo al revisar el mapa topográfico cuidadosamente y realizar un reconocimiento de campo. 'La sección con presión desigual' indica acerca de la sección donde la presión del terreno no es normal. En general, cerca del portal del túnel, la presión de la pared a menudo es más grande de lo normal. Ver **Figura C.2.2.5 Sección con presión irregular del** capitulo. Fault topography is the topographic expression including Fault scarp, Terminal facet and so on. See also Fig1. And it can be identified by the experts to review the topographic map carefully and to conduct field reconnaissance. 'The section with uneven pressure' indicate about the section where the earth pressure is not normal condition. Generally, near the tunnel portal, the pressure of side wall is often larger than normal. See also Fig2.	1) Sufficiently understood /Entendido
(411)	Geology field	En numeral C. 2.2.2, cuando mencionan "Área de deslizamiento de tierra", ¿se hace referencia a sitios con deslizamientos activos? Es decir, ¿independiente de la distancia entre el techo del túnel y la superficie topográfica? In numeral C. 2.2.2, when you mention "Landslide area", it is a reference made to sites with active landslides? That is, independent of the distance between the roof of the tunnel and the topographic surface?	El "área de deslizamiento de tierra" puede identificarse a menudo mediante el estudio cuidadoso del mapa topográfico y el reconocimiento de campo por parte de los expertos. Los estándares japoneses mencionan que el deslizamiento no afecta al túnel en caso de una distancia de más de 2D (dos veces el ancho del túnel) o 20 m entre el techo del túnel y la superficie deslizante (ver **Figura C.2.2.3 Topografía de deslizamiento**). Sin embargo, como este manual es para la preparación de EIA, el punto a tener en cuenta es que la construcción del túnel puede causar el deslizamiento de tierra. Por ejemplo, cortar taludes cerca de los portales de los túneles puede ser a menudo la causa de los deslizamientos de tierra. 'Landslide area' can be often identified by the careful study of topographic map and field reconnaissance by the experts. Japanese standards mention that the sliding don't effect to the tunnel in case of the distance of more than 2D (twice as tunnel width) or 20m between tunnel roof and sliding surface (See also Fig3). However, as this handbook is for the preparation of EIA, the point to be attention is the case that the construction of the tunnel may cause the landsliding. For example, cutting near the tunnel portal may be often the cause of landsliding.	1) Sufficiently understood /Entendido
(412)	Geology field	Dentro del mismo EIA se establecen las Clases A y B?, o la clase A sería un estudio preliminar para la clase B? Classes A and B are established within the same EIA, or would be class A be a preliminary study for class B?	Clase A significa área prioritaria, y Clase B área no prioritaria para evaluación ambiental. En el primer paso de EIA, creemos que es importante priorizar el área por la significancia de los riesgos previstos. Entonces esta clasificación debe llevarse a cabo en el mismo EIA. Class A means priority Area, and Class B does non-priority Area for environmental assessment. At the first step of EIA, we think it's important to prioritize the area by the significance of the predicted risks. So this classification need to be carried out in the same EIA.	1) Sufficiently understood /Entendido
(413)	Geology field	En el C.2.2.4, Puede explicar en detalle a que refiere el método para la Clase Tipo A Modelo de onda cinemática In C.2.2.4, can you explain in detail the method Type A "Kinematic Wave Model"	Esta descripción es para el estudio hidrológico, se elimina del documento. This description is for the hydrological study. We will delete and revise the flowchart.	1) Sufficiently understood /Entendido
(414)	Geology field	En la Figura C.2.2.1, Puede explicar en detalle a que se refiere el método Análisis cualitativo basado en cambios en las condiciones del suelo superficial. In Figure C.2.2.1, can you explain in detail the method Type B "Qualitative analysis based on changes of surface ground conditions"	Esta descripción es para el estudio hidrológico, se elimina del documento This description is for the hydrological study. We will delete and revise the flowchart.	1) Sufficiently understood /Entendido
(415)	Geology field	Dentro del análisis de impactos "Impacto ambiental estimado", debe incluirse las vibraciones, y potenciales proyectiles balísticos generados por voladura en roca (se debe tener en cuenta que, en Colombia, la excavación de los túneles se realiza por el método de perforación y voladura y no de TBM. Within the impact analysis "Estimated environmental impact", the vibrations, and potential ballistic projectiles generated by rock blasting must be included (it must be taken into account that, in Colombia, the excavation of the tunnels is carried out by the drilling and blasting method and not TBM.	El problema debido a la vibración y el ruido durante la construcción se debe considerar por separado de la geología. Se elaboró un capítulo aparte de este. The problem due to Vibration and Noise during construction should be considered separately from geology. We will propose the additional chapter for this matter.	1) Sufficiently understood /Entendido
(416)	Geology field	En 2.2.2. (3) Metodología, procesos y procedimiento: ¿Los estudios de pozos corresponden a las mismas perforaciones?	No hay ninguna regulación que indique el número apropiado y la ubicación de los puntos topográficos para la construcción del túnel en el mundo. En realidad, está el caso de que se realizaron 10 perforaciones (y pozo) para el levantamiento y monitoreo	1) Sufficiently understood /Entendido

No.	Category	Comments (30 /10/2017 by ANLA)	Answer 1 (respuesta 01/11/2017)	Response 2 Respuesta de ANLA
		¿cuál es el mínimo número de perforaciones que deben ser realizadas por unidad de longitud de túnel? ¿Por qué no se proponen perforaciones en zonas denominadas de "Presión irregular del terreno"? In 2.2.2.(3) Methodology, Process and Procedure: Do the well studies correspond to the same perforations? What is the minimum number of perforations that must be made per unit length of tunnel? Why are not drilling proposed in areas called "Irregular terrain pressure"?	de un túnel de 1km, y en el otro caso se realizaron 5 perforaciones. El plan apropiado para el estudio y el monitoreo debe hacerse proyecto por proyecto, considerando cada condición única. There is no regulation indicate the appropriate number and location of the survey points for the tunnel construction in the world. Actually, there is the case 10 boreholes (and well) were conducted for the survey and monitoring of 1km tunnel, and the other case 5 boreholes were did. The appropriate plan for survey and monitoring need to be made by project by project considering each unique condition.	

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
(421)	Hydrology field (30 /10/2017 by ANLA)	¿En la información requerida de hidrología porque no se solicita la determinación del caudal ambiental? ¿Como se determina hasta cuando la disminución del flujo base no afecta la cuenca? **Flujo ambiental: volumen de agua requerido en términos de calidad, cantidad, duración y estacionalidad para el apoyo de los ecosistemas acuáticos y para el desarrollo de las actividades socioeconómicas de los usuarios aguas abajo de la fuente de la que dependen estos ecosistemas**. In the required hydrology information, ¿Why the determination of the environmental flow is not requested? ¿How is it determined even when the decrease in base flow does not affect the basin? **Environmental flow: volume of water required in terms of quality, quantity, duration and seasonality for the support of aquatic ecosystems and for the development of the socio-economic activities of the users downstream of the source on which these ecosystems depend**.	It has already mentioned at C.2.6.2. (C.2.6.3 Check list for required investigation items). Please refer the table C.6.2.3. If more detailed description would be necessary, please modify this section of EHB. Ya se ha mencionado en C.2.6.2. (C.2.6.3 check list para los elementos de investigación requeridos). Por favor, referir la tabla C.6.2.3. Si fuera necesaria una descripción más detallada, por favor modificar esta sección en el EHB (manual ambiental).	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(422)	Hydrology field (30 /10/2017 by ANLA)	La determinación del área de influencia hidrológica según la experiencia japonesa se extiende 1 km a ambos lados del trazado del túnel, ¿qué criterios se tienen en cuenta para esa delimitación además de la disminución del nivel piezométrico? porque no se extiende el área de influencia a toda la cuenca aguas abajo del trazado? The determination of the area of hydrological influence according to the Japanese experience extends 1 km on both sides of the alignment of the tunnel, so: ¿What criteria is taken into account for this delimitation in addition to the decrease in the piezometer level? ¿Why is not the area of influence extended to the entire basin downstream of the alignment?	The width of 1 km is rough indicator. It depends on our experience and not depend on result of analytical study. The reason of not including the downstream basin area follow. The area which is near tunnel would be affected large impact. But as it become far from the tunnel alignment, the impact from the tunnel project would become smaller. The meaning of 1km is only indicator, so you can determine the area which has water source near this boundary into prioritize area even though it located in outside of boundary. We added other method to determine the affected area of hydrology. Please refer the revised Hydrology section of EHB. (16th Dec. 2017) El ancho de 1 km es un indicador aproximado. Depende de nuestra experiencia y no depende del resultado del estudio analítico. La razón de no incluir el área de cuenca aguas abajo es la siguiente: El área que está cerca del túnel se vería afectada por un gran impacto. Pero, a medida que se aleja del trazado del túnel, el impacto del proyecto del túnel se reduciría. El significado de 1 km es solo un indicador, así que se puede determinar el área que tiene una fuente de agua cerca de este límite en el área de prioridad, incluso si se encuentra fuera del límite. Agregamos otro método para determinar la hidrología del área afectada. Por favor, consulte la sección revisada de Hidrología de EHB. (16 de diciembre de 2017)	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other

No.	Comments from ANLA	Answer 1 (Teramoto_Tanaka_7th March)	Answer 2 Respuesta de ANLA
(430.1)	What impact or variations in water quantities can be expected in the base flow of a nearby water stream? How is this variation monitored, considering the number of measurement points, frequency and type of tracking systems? ¿Que impacto o variaciones en las cantidades de agua se puede esperar en el flujo base de una corriente hídrica cercana? ¿Como se hace seguimiento a esta variación, pensando en la cantidad de puntos de medición, frecuencia y tipo de sistemas de seguimiento?	(Respondent Miyaichi, 220218) Base flow is controled by the hydrogeological environment such as soil, rock and rainfall. If the surface condition is significantly changed, it may affect on the base flow rate. It is important to monitor both variation of rainwater, landuse and flow rate, at least monthly. Flow rate is measured by "velocity of water flow", "cross sectional area of stream". Then, water-level-discharge curve is developed for target stream. Once water-level-discharge curve is developed, it is easy to grasp flow rate by water level. (Respuesta de Miyaichi, 220218) El flujo base está controlado por el entorno hidrogeológico, como el suelo, la roca y la lluvia. Si la condición de la superficie cambia significativamente, puede afectar la tasa de flujo de la base. Es importante monitorear la variación del agua de lluvia, el uso del suelo y el caudal, al menos mensualmente. El caudal se mide por "la velocidad del flujo de agua", "área de la sección transversal de la corriente". Luego, la curva de descarga del nivel del agua se desarrolla para la corriente objetivo. Una vez que se desarrolla la curva de descarga del nivel del agua, es fácil captar el caudal por nivel de agua.	2) Further explanation needed/requiere más explicación
(430.2)	**(2) Classification of the investigation methods; (c) Methodology, Process and Procedure; a) Area division** Regarding "On the EIA study guidelines in Japan, 1 km from the tunnel alignment is used as a maximum affected width based on experience of EIA studies in Japan. The conceptual figure for dividing survey area is shown below", Could this area of analysis be established, through the delimitation of the hydrographic basin intervened by the tunnel area? Se podría establecer esta área de análisis a través de la delimitación de la Cuenca hidrográfica que subscribe el área del túnel?	This method is kind of simplified method which is described in EIA guideline for Road project in Japan. This method is taking user's convenience into account based on the experience in Japan.	1) Sufficiently understood /Entendido
(430.3)	**(3)Check list for required investigation items; (b)Other Related Technical Information; a)Survey period** The sources of information for this temporality are very limited, in fact under the conditions of Colombia it is almost unlikely, and in case they did exist, the quality of the information is not very good. 2 climatic periods are requested, which constitutes a year of monitoring. Is it verifiable that requesting more information in that monitoring year could correct the lack of historical information, through the execution of more monitoring in the year? Las Fuentes de información para esta temporalidad son muy reducidas, realmente bajo las condiciones del país es casi improbable y así existieren la calidad de esta información no es muy buena. Se solicitan 2 periodos climáticos, lo que constituye un año de monitoreo. ¿Buscar mayor información en ese año de monitoreo, podría subsanar la ausencia de información histórica, incluyendo más campañas en el año?	After EIA starts, it is recommended to monitor necessary meteoric, hydrologic, and water quality data. To cover data from all seasons, sampling at 4 times a year (every 3 months) should be necessary. For the monitoring points that is classified into Class A, it is recommended to monitor every month during EIA, construction and some certain period of O & M (normally 2 years in Japan).	1) Sufficiently understood /Entendido
(430.4)	**(3)Check list for required investigation items; (b)Other Related Technical Information; c)Survey items** Could we know the limits of detection and quantification of the techniques used in Japan? Podríamos conocer los límites de detección y cuantificación de las técnicas usadas en Japón?	Boron: (Limit of Quantification (LOQ)) ICP atomic emission spectroscopy (0.02mg/L) Methylene blue Spectrometric Method (0.007mg/L) ICP mass spectrometry (0.0005mg/L) (Under-line shows typical analysis method in Japan) Fluorine: (LOQ)) Absorption Spectrometry (0.1mg/L) Ion selective electrode (0.1mg/L). Quality standards can be consulted on https://www.env.go.jp/en/water/wq/wp.pdf and https://www.env.go.jp/en/water/wq/nes.html	1) Sufficiently understood /Entendido
(430.5)	**(3)Check list for required investigation items; (b)Other Related Technical Information; c)Survey items** For this in Colombia we use the parameters requested by standard, in accordance with the generating industrial activity. According to the use of the tunnel, we could establish the parameters of water quality related to the vehicle fleet and those related to the characteristics of the rocky mantle of the tunnel. In this sense, based on the information provided by the user in the EIA (analysis of the rocky mantle, uses and users, among other variables), how could we show that the inclusion of new parameters is necessary (parameters that perhaps the consultant did not initially contemplate)?. This way in order to complement the follow-up monitoring. Para esto usamos los parámetros solicitados por norma de acuerdo a la actividad que lo genera. De acuerdo con el uso del túnel, podíamos establecer los parámetros de calidad de agua relacionados con parque automotor y los relacionados con las características del manto rocoso del túnel.	Possible hazardous materials derived by tunnel construction from natural environment are Cd, Cr(VI), Hg, Se, Pb, As, F, B, depending on the host rock. Acid and SS are also needed to be monitored. During the EIA survey, if some natural hazardous materials are observed to be a risk from the project, it is recommended to implement analysis and identify parameters to be monitored. It is of course needed to monitor other parameters defined as environmental standards according to water use in addition to the heavy metals identified above.	1) Sufficiently understood /Entendido

No.	Comments from ANLA	Answer 1 (Teramoto_Tanaka_7th March)	Answer 2 Respuesta de ANLA
	En este sentido, con base en la información entregada por el usuario en el EIA (análisis del manto rocoso, usos y usuarios, entre otras variables), se podría efectuar la inclusión de nuevos parámetros que quizá el consultor no contemplo en el análisis inicial y complementar así los monitoreos que se seguirán reportando en los ICAS.		
(430.6)	**(3)Check list for required investigation items; (b)Other Related Technical Information; c)Survey items** Regarding "Shading: pollutants are originated from natural sources. Until completion of the construction, it is difficult to judge whether pollution occurs or not. It is important to continue judging by chemical analysis of Inflow water, excavated muck and cement regularly." This would depend on the progress of construction activities. Currently in Colombia semi-annual reports are made, but in this period many residues and cement accumulation can be obtained. How is this evaluation done in Japan? Esto dependería del avance de las actividades de construcción, actualmente se hacen reportes semestrales, en este tiempo pueden obtenerse muchos residuos y aprovisionamiento de cementos. Como se realiza esta evaluación en Japón?	This would also depend on the status of construction site in Japan. Example: Inspection of the muck is conducted every 5000 m3 in low-risk rock and 1000 m3 in high-risk rock. (Further investigation is necessary)	1) Sufficiently understood /Entendido
(430.7)	**Table C.2.7.4, analysis method: Mass balance equation** It would therefore be advisable, to seek discharge techniques that reduce the mixing length? Por lo tanto sería recomendable busca técnicas de descarga que disminuyan la longitud de mezcla?	It would be not necessary because the speed of the river flow in mountain area is usually very fast. Pollutant would be mixed completely within short length.	1) Sufficiently understood /Entendido
(430.8)	**(6) Mitigation and monitoring; (b) Other Related Technical Information; b) Monitoring and Tracing** When you state "The desirable period of monitoring is at least 2 years", for two years or every two years? What is the recommended frequency of monitoring and what is it based on? ¿Durante dos años o cada dos años? Cuál es la frecuencia recomendada de monitoreo?	Recommended monitoring term is 2 years after completion of the construction based on countermeasure manual in Japan. The frequency of the monitoring of pollutant is twice a year. (dry season and rainy season)	1) Sufficiently understood /Entendido
(430.9)	**Page 14: Commented [MPFC9]** Since ANLA cannot recommend constructive methods (changing alignment…), Is it possible to establish constraints different from constructive ones (from the social component, for example) to mitigate the impact? En métodos constructivos no tenemos injerencia. Pero se podría establecer algunos condicionantes desde lo que se pretende mitigar en los aspectos ambientales y sociales?	It is difficult to be dealt as the social matter. This is chemical pollution issue.	2) Further explanation needed/requiere más explicación
(430.10)	**Table C.2.6.8 Monitoring Item; Monitoring item: Stream(River) flow** This considers 2 data per month per monitoring point? Esto considera 2 datos por mes por punto de monitoreo?	Recommended monitoring term is 2 years after completion of the construction based on countermeasure manual in Japan. The frequency of the monitoring of pollutant is twice a year. (dry season and rainy season)	1) Sufficiently understood /Entendido
(430.11)	As in the case of Hydrology, the 1 km criterion is subjective and does not have a justifiable technical support, what technical criteria could be applied to define the area for the analysis of water quality? Igual que en el caso de Hidrología, el criterio de 1 km es subjetivo y no tiene un soporte técnico justificable, ¿que criterios técnicos se podrían aplicar para definir el área para el análisis de la calidad hídrica?	(Respondent Miyaichi, 220218) 1km is a Japanese technical standard and used commonly. It is established empirically by many experiments in Japan. Instead of distance, volume of stream water can be the criteria because water volume is a determinant factor of dilution of water contamination. In Japan, it is roughly assumed that the influenced area of water quality is upto the point where volume of stream water becomes 3 times larger than the discharge point of effluent. Water volume can be assumed to be proportional to the area of watershed. (Respuesta de Miyaichi, 220218) 1 km es un estándar técnico japonés y se usa comúnmente. Se establece empíricamente a partir de muchos experimentos en Japón. En lugar de la distancia, el volumen de agua de la corriente puede ser el criterio porque el volumen de agua es un factor determinante de la dilución de la contaminación del agua. En Japón, se supone más o menos que el área influenciada de la calidad del agua es hasta el punto donde el volumen del agua de la corriente se vuelve 3 veces mayor que el punto de descarga del efluente. Se puede suponer que el volumen de agua es proporcional al área de la cuenca.	1) Sufficiently understood /Entendido
(430.12)	For the analysis of water quality, the need for information from previous 10 years is mentioned, in the case of the absence of this history, how would this information gap be corrected? Para el análisis de calidad hídrica, se menciona la necesidad de contar con información de 10 años anteriores, en el caso de no existir este histórico, ¿cómo se subsanaría dicho vacío de información?	(Respondent Miyaichi, 220218) At least one year monitoring is necessary to cover all seasons. If there are observation data collected in similar environment such as land use, vegetation and climate and so on, there is some possibility to correct the gap by that data. If it is possible to set up modeling based on measured data, we can predict previous information. (Respuesta de Miyaichi, 220218) Se necesita al menos un año de monitoreo para cubrir todas las estaciones.	1) Sufficiently understood /Entendido

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		Si hay datos de observación recopilados en un entorno similar, como el uso de la tierra, la vegetación y el clima, y así sucesivamente, existe la posibilidad de corregir la brecha con esos datos. Si es posible configurar un modelado basado en datos medidos, podemos predecir información previa.	
(430.13)	Regarding monitoring and follow-up, it is proposed that the desirable period of monitoring is at least 2 years. Should not this monitoring be continuous? likewise it is established that, if the result of monitoring exceeds the target level, mitigation measures should be reconsidered and monitoring period should also be extended, what does the "target level" refers to? En lo concerniente al monitoreo y seguimiento, se propone que el período deseable de monitoreo es de al menos 2 años, ¿este monitoreo no debería ser continuo? de igual manera se establece que si el resultado de la supervisión excede el nivel del objetivo, las medidas de mitigación deben ser reconsideradas, ¿a que hace referencia el nivel objetivo o deseado?	(Respondent Miyaichi, 220218) "Target level" is set as a goal level of pollutants, which is determined in each project, in many case it is same as the environmnetal standards. In case of a excess of the target level, monitoring period should be extended and mitigation measures should be reconsidered. In this context, it means that monitoring should be continued at least 2 more consecutive years after achieving target level. (Respuesta de Miyaichi, 220218) El "nivel objetivo" se establece como un nivel objetivo de contaminantes, que se determina en cada proyecto, en muchos casos es igual a los estándares ambientales, en muchos casos es igual a los estándares ambientales. En caso de un exceso del nivel objetivo, el período de monitoreo debería extenderse y las medidas de mitigación deberían reconsiderarse. En este contexto, significa que el monitoreo debe continuar por lo menos 2 años consecutivos más, después de alcanzar el nivel objetivo.	1) Sufficiently understood /Entendido

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2 (by ANLA)
(433)	Hydrogeology (8th Mar 2018)	**Pag. 5 (i) Comprehensive data collecting range** Hay soporte técnico o de norma para sustentar el criterio "It could be considered that the data collecting area is defined as the catchment of the small stream crossing tunnel alignment and its end is the point where small stream meet large river which have more than 3 times of flow quantity than the small stream"? En Colombia no tenemos una norma con ese criterio, y tendríamos que darle una justificación al usuario. Is there a standard support the criterion "It could be considered that the data collecting area is defined as the catchment of the small stream crossing tunnel alignment and its end is the point where small stream meet large river which have more than 3 times of flow quantity than the small stream "? In Colombia we do not have a standard with this criterion, and we would have to give the user a justification.	Respuesta emitida oralmente durante la reunión, no obstante, no pudo establecerse respuesta aceptable para ANLA debido a que este criterio no se establece en estándar o metodología.	☒3) Other Agradecemos por favor contar con casos de estudio/ejemplos en los cuales se hubiese usado el criterio de flujos mayores a 3 veces el de los afluentes pequeños.
(434)	Hydrogeology (8th Mar 2018)	**Table of (2) Methodology, process and procedure** **(c) Hydrogeological investigation** Uno de los aspectos que puede ser valioso de la consultoría es definir el alcance de cada uno de los estudios. Lo que queremos con el manual de túneles es definir ese alcance y requisitos mínimos de la investigación hidrogeológica. Por ejemplo: cuantos sondeos/km son suficientes, cuantas muestras de roca y agua, cuantas pruebas de bombeo y métodos, cuándo es pertinente hacer test de inyección o uso de trazadores y bajo qué características One of the aspects that can be valuable of the consultancy is to define the scope of each one of the studies. What we want with the tunneling manual is to define the scope and minimum requirements of hydrogeological research. For example: how many probes / km are sufficient, how many samples of rock and water, how many pumping tests and methods, when is it appropriate to do injection test or use of tracers and under what characteristics?	Respuesta emitida oralmente durante la reunión, no obstante, se hace la solicitud respetuosa de tener ejemplos de aplicación.	☒3) Other Agradecemos por favor contar con casos de estudio/ejemplos de túneles de más de 1 km, en los cuales pudiéramos identificar ya sea por condiciones hidrogeológicas, fallas, ubicación de centros poblados, los requerimientos mínimos que se consideraron en la investigación.
(435)	Hydrogeology (8th Mar 2018)	**Pag. 17 • Numerical modelling and simulation** Es una de las principales herramientas para la toma de decisiones respecto a la viabilidad ambiental de la construcción del túnel, por favor explicar con más detalle este ítem desde su conocimiento y experiencia, y sugerir modelos para aplicar con sus criterios de evaluación. It is one of the main tools for making decisions regarding the environmental viability of tunnel construction, please explain this item in more detail from your knowledge and experience, and suggest models to apply with your evaluation criteria.	No es posible responder durante la reunión debido a que la aplicación de modelos depende de las características particulares del proyecto	☒3) Other . Agradecemos por favor compartir casos de estudio/ejemplos, en los cuales pudiéramos conocer la aplicación de modelos de acuerdo con las condiciones hidrogeológicas, fallas, etc.
(436)	Hydrogeology (8th Mar 2018)	**c.2.9.4 Modelling for Estimate of Environmental Impact** **(1) Other Related Technical Information** ¿Qué otra información se requiere? What other information is required?	No es posible responder durante la reunión debido a que la información depende del modelo a aplicar.	☒3) Other Agradecemos por favor compartir casos de estudio/ejemplos, en los cuales pudiéramos conocer la aplicación de modelos de acuerdo con las condiciones hidrogeológicas, fallas, etc (igual que en la pregunta anterior 435).
(437)	Hydrogeology (8th Mar 2018)	**Table C.2.9.4 Analytic method on Hydrogeology** Debido a que no existe una referencia especial o estándar internacional en el que se puedan consultar estos "métodos analíticos recomendados", agradecemos por favor compartir casos de estudio/ejemplos, en los cuales pudiéramos conocer la aplicación de los métodos analíticos sugeridos. Due to the fact that there are not special reference or international standard to consult this "Recommended analytic methods", can you provide explanation/examples to understand the application of the methods?	[Respondent: Teramoto, 8th May 2018] Explanation provided after Table C.2.9.4 Analytic method on Hydrogeology. Explicación de modelos a continuación de la tabla C.2.9.4.	☒1) Sufficiently understood
(438)	Hydrogeology (8th Mar 2018)	**Pag. 24 Table C.2.9.7 General information for mitigation measures of reducing or shutting out the inflow** En cuanto a las medidas que se enumeran y que corresponden a las técnicas de construcción, ¿tiene previsto mostrar en el manual los parámetros de referencia cuando se utilizan esas técnicas? Por ejemplo, si se usa lechada de tipo XXX, el flujo de agua se reduciría en% porcentual.	No es posible responder durante la reunión.	☒3) Other Agradecemos por favor compartir ejemplos sobre los beneficios o problemas que generan las medidas de

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2 (by ANLA)
		Regarding the measures that are listed and that correspond to construction techniques, do you plan to show in the handbook the reference parameters when those techniques are used? For example, if grouting of XXX type is used, the water flow would be reduced in a % percentage.		reducción del flujo de ingreso de agua (costos, permeabilidad, etc).

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
(430)	Hydrogeology	En la tabla C.2.9.1 no se contempla la hidro geoquímica. ¿No hay impactos asociados a las características químicas del macizo y de las aguas subterráneas que deban considerarse? Por ejemplo, drenajes ácidos/básicos, altos contenidos de sales disueltas, sólidos suspendidos, etc. Table C.2.9.1 does not include hydro geochemistry. Are there no impacts associated with the chemical characteristics of the massif and groundwater that should be considered? For example, acid / basic drains, high contents of dissolved salts, suspended solids, etc.	[Respondent: Teramoto, 10th Nov 2017] Las características químicas se mencionarán en la sección.C.2.7-calidad del agua. Esta sección C.2.9 se enfocará en más bien hacia problemas de aguas subterráneas. Chemical characteristics shall be mentioned in section.C.2.7-water quality. This section of C.2.9 will focus on more or like groundwater issues.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(431)	Hydrogeology	Con respecto al cuadro C.2.9.1. No está claro por qué hay daños agrícolas causados por aguas subterráneas frías. Regarding Table C.2.9.1. It is not clear why there is agricultural damage caused by cold groundwater.	[Respondent: Teramoto, 10th Nov 2017] Debe ser eliminado del cuadro. El daño agrícola se causa en el campo de arroz en Japón, pero no en Colombia. It should be deleted. Agricultural damage is caused on rice field in Japan but not in Colombia.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(439)	Hydrogeology (8th Mar 2018)	Pag. 12 Table (a) Recolección de información; Datos sobre geografía, geología, hidrología, hidrogeología, metrología, meteorología. Especificar a qué datos se refiere con “Data regarding geography, geology, hydrology, hydrogeology, Metrology, Meteorology” Specify what data is referred to with "Data regarding geography, geology, hydrology, hydrogeology, Metrology, Meteorology"	Se responde con la información de a) Data collection sobre ambiente hidrogeológico.	☒1) Sufficiently understood
(440)	Hydrogeology (8th Mar 2018)	C.2.9.3 Check list for required investigation items, (1) Other Related Technical Information En relación con "Para el análisis detallado de la hidrogeología, básicamente se requiere recopilar datos meteorológicos a largo plazo, como por encima de diez (10) años", ¿Qué pasa si tal información no está disponible? Muchas cuencas pequeñas y medianas en Colombia no tienen datos. Regarding “For the detailed analysis on hydrogeology, it is basically required to collect long term meteorological data such as above ten (10) years”, What if such information isn’t available? Many small and medium-sized basins in Colombia have no data…	La pregunta supera el alcance técnico de la consultoría, es una condición actual de la información en Colombia. Se omite.	☒3) Other La pregunta supera el alcance técnico de la consultoría, es una condición actual de la información en Colombia.
(441)	Hydrogeology (8th Mar 2018)	Pag. 12 Table (g) Evaluation and Estimation Los requisitos no muestran el modelo hidrogeológico numérico, entonces el modelo numérico no es necesario? Survey requirements are not shown to define numerical hydrogeological model, so the numerical model is not needed?	Se modifica para EIA como recomendada (B) y para DAA cuando sea necesario (C)	☒1) Sufficiently understood
(442)	Hydrogeology	Pag. 13 (c) Hydrogeological investigation	Si	☒1) Sufficiently understood

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
	(8th Mar 2018)	Cuando dices "levantamiento hidrológico", ¿corresponde al inventario? When you say "Hydrological survey ", corresponds to inventory?		
(443)	Hydrogeology (8th Mar 2018)	Pag. 14 ¿Qué es "registro de verbosidad"? Esto para traducir correctamente ese término al español. What is "verbosity logging" ? This in order to correctly translate that term into Spanish.	Se debe sustituir toda la descripción por Registros de pozo en general.	☒1) Sufficiently understood
(444)	Hydrogeology (8th Mar 2018)	Pag. 15 • Water quality in laboratory No tenemos un estándar ambiental para las aguas subterráneas, entonces ¿Qué estándar internacional nos sugieren? We do not have an environmental standard for groundwater, so what standard do you suggest we can use?	Se recomienda usar los estándares de agua superficial al no tenerse otros, o revisar los Environmental Quality Standards for Groundwater Pollution en https://www.env.go.jp/en/water/gw/gwp.html	☒1) Sufficiently understood
(445)	Hydrogeology (8th Mar 2018)	Pag. 17 • Hydraulic analysis No entendemos la diferencia entre esta idea y la mencionada tres puntos arriba (• Estimación del flujo de agua en el túnel en la página 16) El método detallado *** en donde se muestra? I don't understand the difference between this idea and that mentioned three points above (•Estimation of water inflow into tunnel on page 16) The (detailed method is explained in ***) is shown where?	Se debe eliminar la descripción del análisis hidráulico.	☒1) Sufficiently understood
(446)	Hydrogeology (8th Mar 2018)	Table C.2.9.5 The result of the analysis Scenario with project, Water inflow rate during construction by tunnel sections. Su sugerencia es el análisis durante la construcción, entonces, ¿Considera que no sirve analizar la entrada de agua durante la operación del túnel? Your suggestion is the analysis during construction, so, do you consider that it is of no use to analyze water inflow during tunnel operation?	Se incluirá la entrada de agua en el escenario con proyecto.	☒1) Sufficiently understood
(447)	Hydrogeology (8th Mar 2018)	C.2.9.5 Evaluation of the Environmental impact (2) Other Related Technical Information En relación con "Hay dos métodos de evaluación para la evaluación de impacto en Japón. El primero es comparar el resultado del pronóstico con el estándar nacional o los objetivos nacionales ", esto es algo que no tenemos en Colombia. Por ejemplo, no contamos con estándares o un criterio general para aceptar o denegar la extracción estimada de aguas subterráneas por encima del túnel o la tasa estimada de entrada de agua dentro del túnel. Al final, la decisión tiene subjetividad. ¿Puede explicarnos los estándares japoneses / metas nacionales en ese asunto? Regarding "There are two methods of evaluation for the impact assessment in Japan. The first is compare the result of forecast with	Respuesta emitida oralmente durante la reunión	☒1) Sufficiently understood

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
		national standard or national goals", this is something we miss in Colombia. For example, we don't have standards or a general criterion to accept or deny the estimated drawdown of groundwater above the tunnel or the estimated water inflow rate inside the tunnel. At the end, the decision has subjectivity. Can you explain us the Japanese standards / national goals in that matter?		
(448)	Hydrogeology (8th Mar 2018)	C.2.9.5 Evaluation of the Environmental impact (3) Methodology, Process and Procedure La pregunta es, ¿cuál es el valor de la tasa de agua de entrada que podemos establecer como "aceptable"? ¿Existe una metodología que podamos estandarizar? The question is, what is the inflow water rate value that we can set as "acceptable"? Is there a methodology that we can standardize?	No se tiene un estándar para tasa de agua de entrada, ni tampoco se cuenta con un criterio cuantitativo para definir aceptable o no.	☒1) Sufficiently understood
(449)	Hydrogeology (8th Mar 2018)	Table C.2.9.6 The result of the evaluation Cuando sugiera "Por lo tanto, se evaluaría como un impacto pequeño en la hidrogeología". El ejemplo no evalúa la reducción de la cabeza hidráulica sobre el túnel, ¿debería incluirse? When you suggest "Therefore, it would be evaluated as small impact on hydrogeology.", the example does not evaluate the groundwater drawdown over tunnel, should it be included?	Se incluirá la reducción de Cabeza hidráulica.	☒1) Sufficiently understood
(450)	Hydrogeology (8th Mar 2018)	Pag. 23, C.2.9.6 Mitigation and monitoring (2) Other Related Technical Information En cuanto a "En Japón, el objetivo del monitoreo es ajustar el método de medidas de mitigación que no tenían suficiente información para la eficiencia en el momento del estudio de EIA". En Japón, cuando el constructor ajusta las medidas de mitigación, implica una aprobación previa de las autoridades ambientales u otras antes de su implementación? Regarding "In Japan, the purpose of monitoring is adjusting the method of mitigation measures which did not have enough information for efficiency at the time of EIA study", In Japan, when constructor adjust mitigation measures, does it imply a pre-approval from the environmental or other authorities before its implementation?	No requiere aprobación.	☒1) Sufficiently understood
(451)	Hydrogeology (8th Mar 2018)	**Pag. 2 (2) Other Related Technical Information:** Se mantiene la subjetividad de que es un impacto significativo. Pueden sugerir alguna metodología para eliminar/disminuir la subjetividad de la identificación del área de influencia? Subjectivity is maintained on what is a significant impact. Can you suggest some methodology to eliminate / diminish the subjectivity of the identification of the area of influence?	Respuesta emitida oralmente durante la reunión, no obstante, no pudo establecerse respuesta aceptable para ANLA debido a la complejidad para desarrollar la evaluación de proyectos mediante revisión de criterios cuantitativos, reemplazando criterios cualitativos.	☒3) Other No se sugieren metodologías para eliminar/disminuir la subjetividad, por tanto en Japón el área de influencia se va identificando a partir de la recolección de información secundaría para clasificar las secciones del túnel, luego se hace recolección de información primaria para usarse en modelaciones y poder evaluar el impacto, diferente a como se adelanta esto en Colombia.
(452)	Hydrogeology (8th Mar 2018)	**Pag. 12 Table** **Etiquetas A: Requerido, B: Recomendado, C: cuando es necesario, podría ser más claro, ¿tal vez puede sugerir una etiqueta cuantitativa?**	No pudo establecerse respuesta aceptable para ANLA debido a la complejidad para desarrollar la investigación hidrogeológica de proyectos estableciendo a criterio cualitativo su necesidad A,B o C.	☒3) Other

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
		Labels A: Required, B: Recommended, C: When it is necessary, could be clearer, maybe you can suggest a quantitative label?		

No.	Category	Comments (25/10/2017 by INVIAS)	Answer 1	Response 2
(501)	**Inquiries from contractor's perspective (25 October 2017)**	General effects during the construction and operation of the tunnel over the water table. Is there a variation between the construction and the operating phase or does it tend to stabilize? Efectos generales durante la construcción y operación del túnel sobre los niveles freáticos. ¿Existe variación entre la fase de construcción y de operación o tiende a estabilizarse?	Water table always changes by the annual fluctuation due to rainy season. Considering the mean water table, it steeply goes down when the construction starts. After the lining works, the water table slightly recovers, but basically it becomes stable at the lower level than its original level. La tabla de agua siempre cambia por la fluctuación anual debido a la temporada de lluvias. Teniendo en cuenta el nivel freático medio, éste se reduce abruptamente cuando comienza la construcción. Después de que el revestimiento funciona, el nivel freático se recupera ligeramente, pero básicamente se estabiliza en un nivel más bajo que su nivel original.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(502)	**Inquiries from contractor's perspective (25 October 2017)**	What are the major impacts identified during tunnel construction? Cuáles son los mayores impactos identificados durante la construcción de túneles.	Environmental Impact which caused from tunnel project on EIA study of Japan are follows. 1. Geological field: Subsidence of the ground, Lowering of groundwater table, drought of stream 2. Physical environment: Air pollution, Noise, vibration from the construction equipment, water pollution from contaminated infiltration water 3. Natural environment: Deterioration of ecosystem Los impactos ambientales causados por el proyecto del túnel en el estudio de EIA de Japón, son los siguientes: 1. Campo geológico: Subsidencia del suelo, descenso del nivel freático, sequía del arroyo 2. Entorno físico: contaminación del aire, ruido, vibración generada por los equipos de construcción, contaminación del agua a partir del agua de infiltración contaminada 3. Medio ambiente natural: Deterioro del ecosistema	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(503)	**Inquiries from contractor's perspective (25 October 2017)**	How can the origin of the waters be identified by drilling tunnels (aquifer waters, runoff infiltration waters, etc.)? Cómo se puede identificar la procedencia de las aguas al perforar los túneles (Aguas de acuíferos, aguas de infiltración de escorrentía, etc).	It is possible to estimate the origin of inflow water by evaluating data of water chemistry in comparison with hydrogeological settings. As for analysis of water chemistry, major ion (anion and cation) content and stable isotopes of H and O are commonly used. Major ion data should be summarized in figures such as "Stiff diagram" and "Trilinear Diagram" to classify water samples from different water bodies and estimate the origin of these water. Stable isotope data is plotted in a delta diagram to evaluate origin and a ratio of mixture of different water bodies. To estimate age of groundwater, radioactive isotopes are analyzed. For water analysis, water from tunnel inflow water, regional deep and shallow groundwater, rain water, rivers and other surface water should be analyzed before, during and after the construction. Es posible estimar el origen del agua de influjo mediante la evaluación de los datos de la química del agua en comparación con el entorno hidrogeológico. En cuanto al análisis de la química del agua, el contenido de iones mayores (aniones y cationes) y los isótopos estables de H (Deuterio) y O (Oxígeno 18) son comúnmente utilizados. Los principales datos de iones deben resumirse en figuras, tales como "Diagrama Stiff" y "Diagrama Piper", para clasificar las muestras de agua de diferentes cuerpos de agua y estimar el origen de estas aguas. Los datos de isótopos estables se trazan en un diagrama delta para evaluar el origen y una relación de mezcla de diferentes cuerpos de agua. Para estimar la edad del agua subterránea, se analizan los isótopos radiactivos. Para el análisis del agua, el agua del flujo de entrada del túnel, el agua subterránea profunda y somera, el agua de lluvia, los ríos y otras aguas superficiales deben considerarse antes, durante y después de la construcción.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(504)	**Inquiries from contractor's perspective (25 October 2017)**	What do you consider to be the main determinants for the definition of a tunnel´s alignment?	The main determinants differ by the circumstances. In our general practice, we need to consider what major design controls are to be taken into account. For example, the followings are described as the design controls to be considered in the route selection. • Ease of topography • Practicality of designing an alignment according to the required geometric standard within the topography • Avoidance (or mitigation) of areas of known geo-hazard, including landslides, flooding and problematic soils • Avoidance of environmentally protected areas and other sensitive habitats • Avoidance of the location or areas of cultural heritage value (including archaeological sites, sites of historical importance, religious sites and other locations of ethnic or community value) • The need to maximize connectivity of villages and towns and improve rural mobility • The need to maximize traffic connectivity and access to economic resources and markets • The need to select the shortest distance alignment, bearing in mind the factors given above. See also "Route Selection Manual – 2013", << http://www.era.gov.et/documents/24017/68464/Route+Selection+Manual+-+Chapter+1-5.pdf>>.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other

		Cuales consideran son los condicionantes principales ´para la definición del trazado de un túnel.	Los principales condicionantes difieren según las circunstancias. En nuestra práctica general, debemos considerar qué grandes controles de diseño deben tenerse en cuenta. Por ejemplo, los siguientes se describen como los controles de diseño a considerar en la selección de trazado. • Facilidad de la topografía • Practicidad de diseñar una alineación de trazado, de acuerdo con el estándar geométrico requerido dentro de la topografía • Evitar áreas de geo-amenazas conocidas, incluidos deslizamientos de tierra, inundaciones y suelos problemáticos • Evitar áreas protegidas ambientalmente y otros hábitats sensibles • Evitar la locación o áreas de patrimonio cultural de valor (incluidos sitios arqueológicos, sitios de importancia histórica, sitios religiosos y otros lugares de valor étnico o comunitario) • La necesidad de maximizar la conectividad de pueblos y ciudades y mejorar la movilidad rural • La necesidad de maximizar la conectividad del tráfico y el acceso a los recursos económicos y los mercados • La necesidad de seleccionar la alineación de trazado de distancia más corta, teniendo en cuenta los factores indicados anteriormente. Ver también "Route Selection Manual – 2013" (Manual de Selección de Trazado – 2013), << http://www.era.gov.et/documents/24017/68464/Route+Selection+Manual+-+Chapter+1-5.pdf>>.	
(505)	**Inquiries from contractor's perspective (25 October 2017)**	Different methodologies or technologies used in the collection of infiltration water in the drilling and construction stages of the tunnel, to avoid contamination. Diferentes metodologías o tecnologías utilizadas en la colección de aguas de infiltración en las etapas de perforación y construcción del túnel, para evitar su contaminación	There are two types of water during the excavation period, the infiltration water and the construction water. The separation of these two types of water could be possible when it is confirmed more economical solution. For example, at a very long tunnel, excavation position and infiltration position are in far distance. Hay dos tipos de agua durante el período de excavación, el agua de infiltración y el agua de construcción. La separación de estos dos tipos de agua podría ser posible cuando se confirme la medida más económica. Por ejemplo, en un túnel muy largo, la posición de excavación y la posición de infiltración están muy lejos.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(506)	**Inquiries from contractor's perspective (25 October 2017)**	At what time is it ideal to carry out the installation of the piezometric network to perform the modeling of the pumping cone and measurements of the water tables? In a project where the excavation has already been carried out and with a large percentage of coating, how to proceed with the installation of piezometers and what impact might have on the construction of the tunnels. What other systems could be used to evaluate the cone of despondency and the impact on water tables, when you do not have a baseline. En qué momento es ideal realizar la instalación de la red piezométrica para realizar la modelación del cono de abatimiento y mediciones de los niveles freáticos? En un proyecto donde ya se ha realizado la excavación y con un gran porcentaje de revestimiento, cómo se debería proceder para realizar la instalación de piezómetros y que incidencia podría tener sobre la construcción de los túneles. Que otros sistemas se podría utilizar para evaluar el cono de abatimiento y el impacto sobre los niveles freáticos, cuando no se tiene una línea base.	1) Piezometer is installed in order to monitor the fluctuation of the groundwater table. 2) When do we need to monitor the groundwater table? 3) Level of the groundwater table should be monitored in order to • Level (a): Record the level of the groundwater table before the project as the status of "as is (baseline)" however, the recording should be longer period than one year in order to observe the annual fluctuation by rainy season. • Level (b): Record the level of the groundwater table during the construction, then the effect of the tunnel excavation to the groundwater level can be monitored. In case, there would be some negative impact to the residential area and/or agricultural areas occurred, the fluctuation might be one cause of those phenomenon. • Level (c): Record of the level of the groundwater level after completion of the tunnel construction works. This recording should be continued 1-2 years after the completion of the works until the groundwater table become stable. 4) Impact of the tunnel construction works should be evaluated in comparison among the above three (3) groundwater tables. 5) In case that the constructor did not recorded either or both of Level (a) and Level (b), the constructor should record the Level (c) for confirmation of the status of the groundwater table is becoming "stable" and no further negative impact would be caused by the works. 1) Un piezómetro es instalado para monitorear la fluctuación del nivel freático 2) ¿Cuándo necesitamos monitorear el nivel freático? 3) El nivel del nivel freático debería ser monitoreado para: • Medida (a): Registro del nivel freático antes del proyecto, como línea base; sin embargo, el registro debe ser de un período más largo que un año para observar la fluctuación anual por estación lluviosa. • Medida (b): Registro del nivel freático durante la construcción, luego se puede monitorear el efecto de la excavación del túnel al nivel del agua subterránea. En caso de que haya algún impacto negativo en el área residencial y / o en las áreas agrícolas, la fluctuación podría ser una de las causas de esos fenómenos. • Medida (c): Registro del nivel del agua subterránea después de la finalización de las obras de construcción del túnel. Este registro debe continuarse 1-2 años, después de la finalización de las obras, hasta que el nivel freático se estabilice. 4) El impacto de los trabajos de construcción del túnel debería evaluarse en comparación con las tres (3) medidas del nivel freático, mencionadas anteriormente.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other

			5) En caso de que el constructor no haya registrado una o ambas Medida (a) y Medida (b), el constructor debe registrar la Medida (c) para confirmar que el estado del nivel freático se está volviendo "estable" y que las obras no causarán más impacto negativo.	

No.	Category	Comments (by JICAST)	Answer 1 (by ANLA)	Response 2
(*511)	XXXXX (XX /XX/20XX by JICAST)			☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(*512)	XXXXX (XX /XX/20XX by JICAST)			☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other

No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
(610)	**Environmental Management in Operation Phase (25 October 2017)**	¿Cómo se pueden escoger los sistemas de absorción de ruido para fase de operación en túneles? A partir de la longitud del túnel o de que características? How can the noise absorption systems be chosen for the operation phase in tunnel projects? Do the alternative depends upon the length of the tunnel or other features?	It needs study of traffic noise from tunnel portal to decide a type of noise absorption equipment and length of installing section. Japan developed the prediction model of traffic noise, and we use it for design of facility. The factors which have great effect to ambient noise is traffic volume. The length of the tunnel has small effect on traffic noise.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(611)	**Environmental Management in Operation Phase (25 October 2017)**	¿Qué materiales se usan con mayor frecuencia en los sistemas de absorción de ruido? What are the common materials used in noise absorption systems?	A porous material such as a rockwool or glass wool are using for a sound absorption material of road facility.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(612)	**Environmental Management in Operation Phase (25 October 2017)**	¿Qué modelos computacionales sugieren para modelar la calidad del aire en túneles? What "computer models" do you suggest/recommend to model/estimate the quality of air in tunnels?	In Japan, we use Gaussian dispersion model for prediction of air pollution around tunnel portal.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(613)	**Environmental Management in Operation Phase (25 October 2017)**	¿Qué medidas de control/mitigaciones se usan en los sitios donde se instala la tubería de salida/ingreso de aire en túneles? What control / mitigation measures are used at the sites where the tunnel air inlet / outlet pipe is installed?	There are some countermeasures for reduction air pollution impact near the outlet of the tunnel. The easy method is installing high height of stack in air outlet.	☒1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(614)				☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(615)				☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(616)				☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other

No.	Category	Comments (by JICAST)	Answer 1 (by ANLA)	Response 2
(*610)	XXXXX (XX /XX/20XX by JICAST)			☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(*611)	XXXXX (XX /XX/20XX by JICAST)			☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other

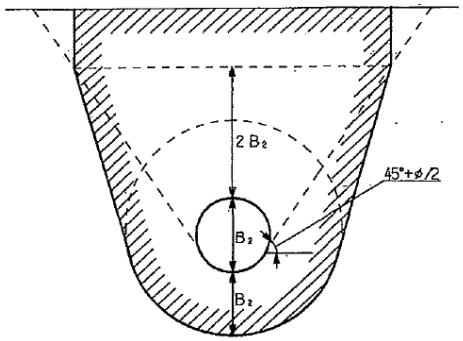
No.	Category	Comments (by ANLA)	Answer 1 (by JICAST)	Response 2
(620)	**Fundamentals of ground-water (relation between water inflow in tunnel & geology) (25 October 2017)**			☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(621)				☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(622)				☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other

No.	Category	Comments (by JICAST)	Answer 1 (by ANLA)	Response 2
(*620)	XXXXX (XX /XX/20XX by JICAST)			☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other
(*621)	XXXXX (XX /XX/20XX by JICAST)			☐1) Sufficiently understood ☐2) Further explanation needed ☐3) Other

No.	Category	Comments (26/10/2017 by ANLA)	Answer 1 (03/11/2017 by JICASST)	Response 2 Respuesta de ANLA
(630)	**Ground Subsidence**	¿Las zonas de mala calidad definidas por el índice de Barton o Bienawski corresponden a las que deberían ser evaluadas como una potencial zona de subsidencia? The areas of poor quality defined by the Barton or Bienawski index, correspond to those that should be evaluated as a potential subsidence zone?	Hay una gran posibilidad de que se produzca hundimiento, especialmente en los estratos no consolidados, tales como taludes, rocas altamente fracturadas. El sistema Q y RMR (Rock Mass Rating) tienen como objetivo básicamente la masa rocosa. Por lo tanto, no se puede decir que la mala calidad basada en los sistemas se evalúa como zona de subsidencia potencial. Los trabajos de excavación apropiados con el tipo de soporte apropiado pueden evitar la deformación de la sección del túnel y la subsidencia en la superficie. El sistema Q (Barton) no es común en Japón; por otro lado, uno de los estándares japoneses es establecido con referencia a la idea de RMR (Bienawski). Debido a la complejidad de la geología en Japón, el gobierno de Japón ha desarrollado el estándar particular para ajustar la geología. There is high possibility to occur subsidence especially at the unconsolidated stratum such as talus, highly fractured rocks. Q system & RMR (Rock Mass Rating) is targeting basically rock mass. Thus it cannot be said that the poor quality based on the systems is evaluated as potential subsidence zone. Appropriate excavation works with appropriate support type can avoid the deformation of tunnel section and the subsidence on the surface. Q system (Barton) is not common in Japan, on the other hand one of Japanese standard is established with reference to the idea of RMR (Bienawski). Because of the complexity of geology in japan, the government of Japan have developed the particular standard to adjust the geology.	1) Sufficiently understood /Entendido
(631)	**Ground Subsidence**	¿cuáles son los métodos para analizar y monitorear las vibraciones en las zonas cercanas al proyecto? What are the methods to analyze and monitor vibrations in the areas near the project?	La vibración puede predecirse mediante la ecuación de amortiguación de vibraciones. En Japón, existe la regulación de la vibración y el ruido en las construcciones. Esta regula los métodos de monitoreo y la tolerancia. La foto 1 muestra un ejemplo del medidor de nivel de vibración. El constructor debe monitorear la vibración de la construcción en el borde del sitio de construcción, durante el tiempo de construcción, utilizando dicho equipo en Japón. Vibration can be predicted by the vibration damping equation. In Japan, there are the regulation of construction vibration and noise. This regulate the methods of monitoring and the allowance. **Photo.1** shows an example of the vibration level meter. Constructor have to monitor the construction vibration at the border of construction site during construction using such equipment in Japan.	1) Sufficiently understood /Entendido
(632)	**Ground Subsidence**	Entendiendo que el área de monitoreo en superficie es función del diámetro del túnel ¿cuál es el radio o diámetro recomendado? Understanding that the surface monitoring area is a function of the diameter of the tunnel, what is the recommended radius or diameter?	La figura 1 muestra el indicador aproximado del área de influencia. Esto se hizo en base a las experiencias de proyectos de construcción de túneles en Japón. **Fig1** shows the rough indicator of the area of influence. This was made based on the experiences of tunnel construction projects in Japan.	1) Sufficiently understood /Entendido
(633)	**Ground Subsidence**	¿cómo se relaciona la subsidencia con las vibraciones por voladuras? How is the subsidence related to the vibrations by blasting?	La vibración durante la construcción no se considera como la causa de la subsidencia en general. A menudo consideramos el ruido y la vibración de la construcción por separado de los problemas de la geología. Vibration during construction is not considered as the cause of subsidence in general. We often consider construction noise and vibration separately from issues of geology.	1) Sufficiently understood /Entendido
(634)	**Ground Subsidence**	¿la escogencia del método FEM/DEM depende del tipo de característica geológica y del nivel de fractura, o del diseño geométrico del túnel? Does the choice of the method FEM/FDM/DEM depend on the type of geological feature and the level of fracture, or on the geometric design of the tunnel?	La selección depende principalmente de la cantidad de nivel de deformación prevista y el comportamiento asumido. Como el FEM normal se programa basándose en la teoría de la deformación infinitesimal, no se puede aplicar en caso de que se produzca una gran deformación con un gran esfuerzo. Sin embargo, una gran deformación no puede aceptarse en general en la etapa de diseño, incluido el EIA, se puede decir que el FEM es el método más común. The selection mainly depends on the amount of predicted strain level and assumed behavior. As the normal FEM is programmed based on the infinitesimal deformation theory, it cannot be applied in case the large deformation with large strain is occurred. However the large deformation cannot be accepted in genera at the design stage including EIA, it can be said that the FEM is the most common method.	1) Sufficiently understood /Entendido
(635)	**Ground Subsidence**	¿Cuál es el costo promedio de emplear el método de tubería en techo? (Valores relacionados con la longitud del túnel. What is the average cost of using the pipe roof method? (Are there values related to the length of the tunnel?	El costo unitario (USD / m en la sección estándar del túnel) se puede estimar aproximadamente de la siguiente manera; AGF (Congelamiento Artificial del Suelo): 120,000 USD / m Techo de tubería: 265,000 USD / m Inyección de chorro horizontal: 220,000 USD / m Hormigón: 240.000 USD / m The unit cost (USD/m on Standard road tunnel section) can be roughly estimated as follows; AGF: 120,000 USD/m Pipe Roof: 265,000 USD/m Horizontal Jet grouting: 220,000 USD/m	1) Sufficiently understood /Entendido

No.	Category	Comments (26/10/2017 by ANLA)	Answer 1 (03/11/2017 by JICASST)	Response 2 Respuesta de ANLA
			Slit Concrete: 240,000 USD/m	

(Muestra de Medidor de Niveles de Vibración)
Photo1. Sample photo of Vibration Level Meter



B2: Diameter of Tunnel section (Diámetro de la sección del túnel) Φ: internal friction angle (ángulo de Fricción Interna)
Fig.1 Rough indicator of the area impacted by tunnel excavation (Indicador aproximado del área impactada por la excavación del túnel)

No.	Category	Comments (26/10/2017 by ANLA)	Answer 1	Response 2 Respuesta de ANLA
(640)	**Water Contamination**	¿Cuánto tiempo en promedio dura la reacción química en la cual se forma agua acidificada? How long (average) lasts the chemical reaction in which acidified water is produced?	(Respondent Miyaichi, 281117) Depende de algunas condiciones, de la siguiente manera; a) volumen total de rocas y suelos. b) ambiente de exposición de rocas y suelos. c) tamaño de las partículas de rocas y suelos. d) contenido total de compuestos causantes Por lo tanto, es difícil responder con precisión al período de tiempo de duración, aunque debemos suponer al menos desde varios años hasta varias décadas. Es muy importante que evitemos la acidificación, es decir, que se necesita un tratamiento adecuado de la roca y el suelo excavados. En Japón, si se espera la acidificación, la prueba de laboratorio se implementará antes de la construcción y se juzgará si se necesitan contramedidas o no. It depends on some conditions as follows; a) total volume of rock and soils. b) exposure environment of rock and soil. c) particle size of rock and soil. d) total content of causative compounds. So, it is difficult to answer the period of duration time precisely but we should suppose at least from several years to several decades. But it is most important that we should avoid causing acidification, that is, appropriate treatment of excavated rock and soil is needed. In Japan, if acidification is expected, laboratory test will implement before construction and judging whether countermeasures are needed or not.	Select/Seleccionar opción
(641)	**Water Contamination**	las rocas que se extraen del túnel pueden generar contaminación por lavado desde las aguas lluvia ¿the rocks that are extracted from the tunnel, can generate contamination by being washed by rainwater?	(Respondance Miyaich, 281117) La respuesta es sí Pero un punto importante no es solo el lavado por lluvia, sino que la reacción química genera contaminantes. La reacción química es inducida por la exposición al agua y al oxígeno. La elución necesita agua y la acidificación necesita agua y oxígeno. Es por eso que cubrimos o retenemos el lodo con revestimiento impermeable, tales como capas y arcilla para no infiltrar agua y oxígeno. Answer is Yes. But important point is not just washing by rain, but chemical reaction generates pollutants. The chemical reaction is induced by exposure to water and oxygen. Elution needs water and acidification needs water and oxygen. That's why we cover or contain the muck by impermeable liner such as sheet and clay in order not to infiltrate Water and Oxygen.	Select/Seleccionar opción

Ⅳ.技術便覧の作成に係る資料

(1) The advisory report for ANLA Environmental Handbook

(2) The review report on TOR for DAA

Table of Contents

A. GENERAL

A.1 General

In accordance with Memorandum between ALNA and JICA dated 15/2/2017, JICA procured the consultant for the provision of advisory service to ANLA for strengthening of the institutional capacity on the tunnel sector. JICA selected Nippon Koei Co., Ltd. as the JICA Study Team (JICAST) for the provision of those capacity development services.

JICAST started the consulting services on 27 June 2017, including the four (4) times of visit to ANLA in Bogota, Colombia, and the services is to be continued until 20 July 2018.

To support the preparation of the ANLA Environmental Handbook (ANLA-EHB) is one of the major scope of the consulting services provided by JICAST.

JICAST have mobilized the state-of-art knowledge and experience available to prepare the ANLA-EHB, with continuous transfer of technology, holding works shops and mini-seminars, for ALNA staff during the period of the site visits.

It is understood that the development speed of the infrastructure in Colombia is getting faster and the scale of the projects are getting larger, accordingly the responsibility of ANLA is also getting more important in the infrastructure development industries in Colombia.

JICAST wish that this report can be a good reference for ANLA to prepare the ANLA-EHB for its first edition, then ANLA would be able to further develop continuously towards the future with feedback from the practices, time to time.

A.2 Coverage of This Report

This report is prepared based on Resolution 751 issued by Ministry of Environment and Sustainable Development (MADS) dated 26 March 2015, and the structure of the contents of this report is following the structure of the Resolution 751.

However, it should be noted that the contents of this report does not cover the full technical fields of the Resolution 751 as shown in Table A.2-1 below.

Table A.2-1 Coverage of This Report

Clause No. in 751	Coverage of This Report
5.1 Abiotic environment	C.2 Abiotic environment
	C.2.1 General
5.1.1 Geology	C.2.2 Geology
5.1.2 Geomorphology	
5.1.3 Crating	
5.1.4 Soils and land use	
5.1.5 Hydrology	C.2.6 Hydrology
5.1.6 Water quality	C.2.7 Water quality
5.1.7 Uses of Water	
5.1.8 Hydrogeology	C.2.9 Hydrogeology
5.1.9 Geotechnics	C.2.10 Geotechnics
5.1.10 Atmosphere	
	C.2.12 Vibration
5.2 Biotic environment	
5.3 Socio economic environment	
5.4 Ecosystem Services	

Note: Gray-out fields are not covered by this report.

A.3 Purpose of This Report

This report, Advisory Report for ANLA Environmental Handbook (ANLA-EHB), is prepared by JICAST intending to be a good reference document for ANLA to develop and complete the ANLA-EHB by themselves.

It is intended the following steps by ANLA would be timely taken:

Step 1: ANLA prepare the ANLA-EHB (Revision 0) for the technical fields which are covered by this report, with reference to this report,

Step 2: ANLA further update the ANLA EHB (Revision 1) for the technical fields which are NOT covered by this report.

A.4 How to Use This Report

It is intended to use this report as follows:

Use 1: Utilization of the technical knowledge shown in the report

Use 2: Utilization of the methodology and procedure for each technical field shown in this report

JICAST have been provided several technical discussions with ANLA staff for each technical field during the site visits.

It is expected that ANLA staff, after several discussions with JICAST, become knowledgeful sufficiently for the preparation of its own produced handbook.

A.5 Expected Status of ANLA-EHB

JICAST wish that the ANLA-EHB would be a good general reference for all stakeholders related all types of tunnels in general, and mountainous road tunnels in particular.

Furthermore, ANLA-EHB could be further upgraded as one of legal documents such as MADS-EHB sometime in the future after showing its value for increasing the efficiency for the environmental assessment process in the infrastructure development in Colombia.

A.6 Continuous Improvement of Handbook supported by Feedback of Actual Practices

“Continuous Improvement” is a key for a technology/technique could be widely spread or not in any industries in the world.

It is expected that ANLA could hold some technical seminar, for all related stakeholsders, periodically for exchange of feedbacks from the actual practices of EIA services, and subsequently and accordingly ANLA could take the key role for revision of the handbook continuously.

B. HANDBOOK FOR ALTERNATIVE STUDY (DAA)

B.1 GENERAL

B.1.1 General

This "Advisory Report for ANLA Environmental Handbook (ANLA-EHB-DAA)" (this Report) is prepared by JICA Study Team (JICST) to provide some reference information for ANLA to prepare the technical handbook of DAA for tunnel related projects.

B.1.2 Background

During the first site visit to ANLA between 21 Juley to August 2017, JICAST noticed that ANLA's DAA process seems not allowed to revise the alignment and it would result as "expensive project", JICST then recommended ANLA to consider the "alignment alternative study" in the ANLA's DAA process.

After a series of discussion, ANLA and JICAST agreed to prepare an advisory report for the preparation of the environmental handbook for the stage of the DAA study, said "ANLA-EHB-DAA".

B.2 RESULTS OF REVIEW

B.2.1 Documents Reviewed

Following documents are reviewed:

1) Manual for Design, Construction, Operation and Maintenance of Road Tunnels, 2016, (Hereinafter the INVIAS-MAN-RTN)
2) Manual of Geometric Design, 2000, (Hereinafter the INVIAS-MAN-GMTRY)
3) Decree 1076-2015, "By which the Single Regulatory Decree of the Environment Sector and Sustainable Development Sector is issued"
4) Decree 2041-2014, "By which Title VIII of Law 99 of 1993 on environmental licenses is regulated"
5) Decree 1255-2006, "By which the Terms of Reference for the elaboration of the Environmental Diagnosis of Alternatives for specific projects are invoked and other determinations are adopted"
6) Decree 1277-2006, "By which the Terms of Reference for the elaboration of the Environmental Diagnosis of Alternatives for linear projects are invoked and other determinations are adopted"
7) Terms of Reference for the Elaboration of the Environmental Diagnosis of Alternatives – DAA, in Linear Projects of Transport Infrastructure (Roads and Railways, including tunnels), (Hereinafter the ANLA-DAA-TOR)
8) Terms of Reference for the Elaboration of the Environmental Impact Studies - EIA, required for the processing of road and/or tunnel construction projects with their accesses (Hereinafter the ANLA-EIA-TOR)

B.2.2 Documents Not Reviewed

Following documents are listed in INVIAS-MAN-RTN, however, could NOT be obtained: It seems that the guideline related to "Fase 1" is a good reference to DAA.

1) INVÍAS, Requerimientos técnicos para estudios y diseños de carreteras a nivel de fase III, in Numeral 3.9 - Capítulo IX Estudio y diseño de túneles. 2011: Bogotá.
2) INVÍAS, Requerimientos técnicos para estudios y diseños de carreteras a nivel de **fase I**, in Numeral 3.3 - Vol III Prefactibilidad de túneles. 2011: Bogotá.

3) INVÍAS, Requerimientos técnicos para estudios y diseños de carreteras a nivel de fase II, in Numeral 3.8 - Vol VIII Estudios para túneles. 2011: Bogotá.

B.2.3 Definition of Project Stages and Phase

At the beginning, the necessity of the environmental study should be confirmed. Following INVIAS manuals is showing the project implementation stages and related survey items in each stage.

B.2.3.1 Reviewed Documents

(a) By INVIAS Road Tunnel Design Manual (INVIAS-MAN-RTN)

The INVIAS-MAN-RTN defines the followings stages of a road tunnel project:

Table B.2-1 Definition of Project Stages (INVIAS-MAN-RTN)

No.	Stage	Sub-stage	Description
1	Planning		
2	Studies and Designs	Phase 1 Pre-Feasibility Study	• Concept design based on secondary information and technical visit to the project location. • Scale: 1/25,000 or 1/10,000 • **DAA Phase**
		Phase 2 Feasibility Study	• Preliminary design based on primary information. • Scale: 1/2,500 or 1/500(Portal), 1/5,000 for geotechnical • Start to EIA for Environmental License
		Phase 3 Detailed Design	• Detailed engineering studies • Scale: 1/2,000 (body) or 1/500 (portal) • Detailed geotechnical survey • Technical specifications • Approve EIA and issue Environmental License
3	Construction		• Final design is executed during the construction • Construction survey: 1/1000 (body), 1/200 (portal) • Execute environmental monitoring
4	Operation and Maintenance		• Execute environmental monitoring

(b) By INVIAS Geometric Design Manual (INVIAS-MAN-GMTRY)

The INVIAS-MAN-GMTRY defines the followings phases of a project of new roads:

Table B.2-2 Definition of Project Phase (INVIAS-MAN-GMTRY)

No.	Sub-stage (Phase)	Activities
1	Phase 1 Pre-Feasibility Study	1) Acquisition of the existing cartography of the project area 2) Traffic study 3) Identification, based on the cartographic information, of possible route corridors 4) Aerial recognition 5) Identification, on 1: 10,000 restitutions, of homogeneous sections from the point of view of design speed 6) Assignment of the Preliminary Design Speed to each homogeneous road section 7) Drawing of the slope line on restitutions 1: 10,000 8) Site Reconnaissance 9) Adjustment of the road sections considered homogeneous and of the preliminary design speeds assigned to them 10) Study of Traffic Capacity and Level of Service 11) Definitive assignment of the Road Section Design Speed (V_{TR}) 12) Layout of the slope line in the terrain 13) Drawing the sketch of the slope line in the field 14) Preliminary environmental impact study 15) Preliminary economic evaluation 16) Preparation of the Final Report of Phase 1. Pre-Feasibility
2	Phase 2 Feasibility Study	1) Site Reconnaissance of the route corridor 2) Overhaul of the slope line in the field 3) Topographical survey of the route corridor 4) Preliminary study of the stratigraphy along the route corridor 5) Definitive design of the centerline in plan, pre-design in profile, pre-design of the cross section and definition of some aspects required for the geometric design 6) Preparation of the Final Environmental Impact Study 7) Preliminary preparation of studies and complementary designs 8) Preparing the preliminary project cost 9) Definitive economic evaluation 10) Preparation of the Final Phase 2 Report. Feasibility
3	Phase 3 Definitive Design	1) Eventual improvement of the terrain model in the right of way 2) Geotechnical evaluation along the centerline of the road 3) Studies prior to the design of the centerline in profile and the cross section 4) Definitive design of the centerline in profile 5) Definitive design of the cross sections 6) Earth movement analysis 7) Studies and definitive complementary designs 8) Preparation of the final project cost 9) Preparation of the final documentation

B.2.3.2 Review Comments

The INVIAS manual define the stages in the construction project.

It is strongly recommended to use same project staging among all stakeholders. Thus, ANLA should use the project staging same with one used in the INVIAS manuals.

B.2.4 Criteria for the Location of Road Tunnel (INVIAS-MAN-RTN)

B.2.4.1 Reviewed Document

Article 5.4.1 "Criteria for the Location of Road Tunnel" in INVIAS-MAN-RTN shows **good stipulation for the route selection of a road tunnel project:**

Table B.2-3 Criteria for the Location of Road Tunnel (by INVIAS-MAN-RTN)

5.4.1 Criteria for the location of the tunnel

In the geometric design of a tunnel it is necessary to evaluate the advantages and disadvantages of the location of the structure in a certain area. This way, it is possible to determine a layout that diminishes the problems associated with the location and direction of the tunnel. The most relevant factors are the following [102]:

1) Financial factors
   - Construction costs
   - Maintenance and operation costs
   - Financial benefits
2) Technical and mobility factors
   - Effectiveness to solve geologic and geotechnical problems in surface, which substantially increases to the costs and the risk of the open sky route operation.
   - Security for mobility aspects (longitudinal profile, sidewalk, illumination, ventilation, SOS stations, etc.)
   - Intersections (rampways, grade-separates, etc.)
   - Decrease or affectation in the mobility of adjacent routes during and after the construction
   - Risk by landslides, floods, etc.
   - Topographic, geologic and geotechnical problems
   - implementation schedule and its impact in mobility
3) Social-environmental factors
   - Emissions (noise, gases)
   - Location of the entrances as focused spots of emissions (propagation of sound waves, gases) 1.
   - Protection, conservation zones and natural reserve
   - Use of the soil
   - Incidence of the separation of communities
   - Old fillings
   - Impact in the water balance of the area
   - Impact in the communities and residential areas
   - Landscaping

B.2.4.2 Reviewed Comments

INVIAS-MAN-RTN shows standard contents for the route selection including the location of tunnel(s), however, those contents of "Financial" and "Technical and Mobility" are not covered by the TOR-DAA.

It should be emphasized that the ultimate objective of the DAA is to select the optimum route

for the project. The TOR-DAA should cover whole of a route selection process, or the engineering and financial parts should be covered by appropriate other organization like INVIAS.

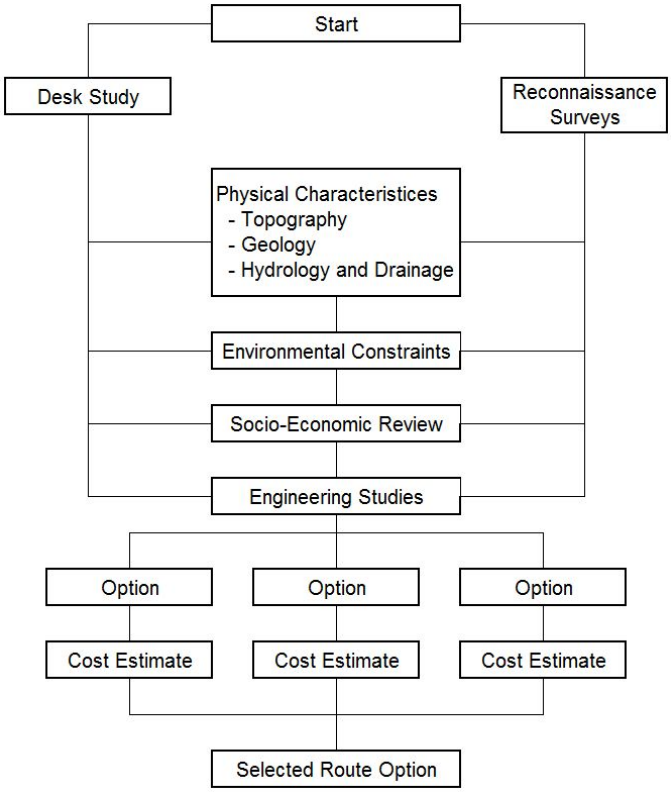


Figure B.2-1 (Sample) Process of Route Selection

Table B.2-4 (Sample) Criteria for Route Selection

Category	Sub-category
Alignment	Terrain classification
	Alignment type
	Design standards
Structures	Type of Major Structures
	Required Clearances
Construction Materials	Sources
	Access arrangements
Geotechnical	Problematic rocks
	Problematic soils
	Landslides
	General founding conditions
	Slope materials
Hydrology/drainage	Natural drainage pattern
	High water levels
	Bridge locations
	Tunnel locations (Geohydrology)
Environmental/Social	Land use
	Population distribution
	Water resources
	Water quality
	Sensitive habitats
	Protected/reserved areas

B.2.5 Required National Condition Survey and Analysis (INVIAS-MAN-RTN)

B.2.5.1 Reviewed Document

Table B.2-5 shows the required contents of natural condition survey in INVIAS Road Tunnel Manual (INVIAS-MAN-RTN).

Table B.2-5 Required Natural Condition Survey in INVIAS Road Tunnel Manual (INVIAS-MAN-RTN)

Survey Item	Phase No.		
	1 Pre-Feasibility	2 Feasibility	3 Definitive Design
	DAA	EIA	
4 Natural Condition Survey and Analysis 4.1 Glossary	-	-	-
4.2 General 4.2.1 Basic aspects of the survey and analysis	-	-	-
4.3 Hydrogeological study	-	-	-
4.3.1 Water balance	Y	Y	Y
4.3.2 Inventory of water points	-	Y	Y
4.3.3 Physicochemical sampling	-	Y	Y
4.3.4 Hydraulic parameters: pumping tests	-	R	Y
4.3.5 Directions of flow	-	Y	Y
4.3.6 Hydrogeological map	-	Y	Y
4.3.7 Vulnerability of aquifer	-	Y	Y
4.3.8 Stages of the hydrogeological model	-	Y	Y
4.3.9 Instrumentation of groundwater levels during construction phase	Y	Y	Y
4.4 Site exploration and survey	-	-	-
4.4.1 Site exploration and survey planning	Y	Y	Y
4.4.2 Secondary information sources	Y	-	-
4.4.3 Topography	Y	Y	Y
4.4.4 Geology	Y	Y	Y
4.4.5 Geologic, geotechnical and hydrogeological model	Y	Y	Y
4.4.6 Mapping and analysis for the discontinuity of the rocky mass	Y	Y	Y
4.4.7 Classification of the rocky mass	Y	Y	Y
4.4.8 Exploration by geophysical methods	-	Y	Y
4.4.9 Exploratory boring	-	-	-
4.4.9.1 General aspects	Y	Y	Y
4.4.9.2 Boring log	-	Y	Y
4.4.9.3 Core and soil boring sampling	-	Y	Y
4.4.10 Other exploratory methods	-	-	R
4.4.11 Laboratory and in-situ tests	-	-	-
4.4.11.1 Laboratory tests	-	Y	Y
4.4.11.1.1 Ground tunnels	-	-	R
4.4.11.1.2 Rock tunnels (tests to intact rock)	-	-	R
4.4.11.2 Tests and evaluation methods in boring hole (in-	-	Y	Y

Survey Item	Phase No.		
	1 Pre-Feasibility	2 Feasibility	3 Definitive Design
	DAA	EIA	
situ)			
4.4.11.2.1 On rock	-	Y	Y
4.4.11.2.2 On ground	-	Y	Y
4.4.11.3 Number of tests	-	Y	Y
4.4.12 Determination of the state of efforts in-situ	-	Y	Y
4.5 Environmental conditions survey	Y	Y	Y

B.2.5.2 Reviewed Comments

As shown in Table B.2-6, the required natural condition surveys are limited in Phase 1: Pre-feasibility study.

The DAA should refer to the Pre-Feasibility Study Report, therefor the contents of the TOR-DAA should be consistent with the INVIAS manual.

B.2.6 Definition of DAA and EIA

B.2.6.1 Reviewed Documents

(a) By Decree 2041-2014

There are several definitions of DAA and EIA in Degrees, and Decree 2041-2014 would provide the best description:

Table B.2-6 Definition of DAA (Decree 2041-2014)

TITLE III

ENVIRONMENTAL STUDIES

Article 13. Environmental studies. The environmental studies referred to in this title are the environmental diagnosis of alternatives (DAA) and the environmental impact study (EIA), which must be presented to the competent environmental authority.

The environmental studies are subject to the issuance of technical concepts by the competent environmental authorities.

Article 14. About the terms of reference. The terms of reference are the general guidelines that the environmental authority indicates for the preparation and execution of environmental studies that must be presented to the competent environmental authority.

The environmental studies will be prepared based on the terms of reference that are issued by the Ministry of Environment and Sustainable Development. The applicant must adapt them to the particularities of the project, work or activity.

The applicant for the environmental license must use the terms of reference, in accordance with the specific conditions of the project, work or activity that it intends to develop.

The terms of reference proffered by the Ministry of Environment and Sustainable Development will remain fully valid, prior to the entry into force of this decree.

When the Ministry of Environment and Sustainable Development has not issued the terms of reference for the preparation of a specific environmental impact study, the environmental authorities will set them specifically for each case within fifteen (15) business days following the presentation of the request.

Notwithstanding the use of the terms of reference, the applicant must submit the study in accordance with the General Methodology for the Presentation of Environmental Studies, issued by the Ministry of Environment and Sustainable Development, which will be mandatory compliance.

Paragraph 1°. For the projects, works or activities of the infrastructure sector, the terms of reference of the environmental diagnosis of alternatives (DAA), **may only require pre-feasibility phase information**, in accordance with the provisions of Law 1682 of 2013 or the standard that the substitute, modify or repeal. Therefore, the terms of reference for the DAA of the infrastructure sector must be adjusted by the Ministry of Environment and Sustainable Development, within a period of six (6) months counted from the publication of this decree.

Paragraph 2°. The Regional Autonomous Corporations, Sustainable Development, Large Urban Centers and Public Environmental Establishments referred to in Law 768 of 2002, should take as a reference the generic terms of reference issued by the Ministry of Environment and Sustainable Development.

Paragraph 3°. The Ministry of Environment and Sustainable Development, with the support of ANLA, will update the General Methodology for the Presentation of Environmental Studies within a term no longer than six (6) months from the publication of this decree.

Article 15. Participation of the communities. The communities should be informed of the scope of the project, with emphasis on the impacts and proposed management measures and assess and incorporate into the environmental impact study, when considered appropriate, the contributions received during this process.

In cases where required, compliance with the provisions of Article 76 of Law 99 of 1993, in terms of prior consultation with indigenous and traditional black communities, in accordance with the provisions of the regulations governing the matter.

Article 16. Of the Manual of Evaluation of Environmental Studies of Projects. For the evaluation of environmental studies, environmental authorities will adopt the general criteria defined in the Manual for the Evaluation of Environmental Project Studies issued by the Ministry of Environment and Sustainable Development.

Paragraph. The Ministry of Environment and Sustainable Development, with the support of ANLA, will update the Manual for the Evaluation of Environmental Studies of Projects within the following six (6) months counted from the issuance of the decree.

CHAPTER I

Alternative Diagnosis of Alternatives (DAA)

Article 17. Object of the environmental diagnosis of alternatives. The environmental diagnosis of alternatives (DAA), aims to provide the information to evaluate and compare different options presented by the petitioner, under which it is possible to develop a project, work or activity. The different options must consider the geographical environment, the biotic, abiotic and socioeconomic characteristics, the comparative analysis of the effects and risks inherent in the work or activity; as well as the practical solutions and control and mitigation measures for each of the alternatives.

The above, to provide the elements required to select the alternative or alternatives that allow optimizing and rationalizing the use of resources and avoiding or minimizing the risks, effects and negative impacts that may be generated.

Article 18. Enforceability of the environmental diagnosis of alternatives. Those interested in the projects, works or activities described below should request a ruling from the competent environmental authority about the need to present the Environmental Diagnosis of Alternatives (DAA). Below, only the activities related to roads, railways and transfer are presented:

12. The construction of roads, tunnels and other associated infrastructure of the national, secondary and tertiary road network.
13. The construction of second roads.
15. The construction of railways and variants of these.
16. Projects that require transfer from one basin to another.

Article 19. Basic content of the environmental diagnosis of alternatives. The environmental diagnosis of alternatives (DAA) must be prepared in accordance with the General Methodology for the Presentation of Environmental Studies referred to in **Article 14 of this decree** and the terms of reference issued for this purpose and contain at least the following:

1. Objective, scope and description of the project, work or activity.
2. The general description of the alternatives for locating the project, work or activity characterizing environmentally the area of interest and identifying the areas of special management, as well as the characteristics of the social and economic environment for each alternative presented.
3. Information on the compatibility of the project with the land uses established in the Land Management Plan or its equivalent. The foregoing, without prejudice to the provisions of Decree 2201 of 2003, or the rule that modifies or replaces it.
4. The identification and comparative analysis of the potential risks and effects on the environment; as well as the use and / or use of the natural resources required for the different alternatives studied.
5. Identification of the communities and the mechanisms used to inform them about the project, work or activity.
6. An environmental cost-benefit analysis of the alternatives.
7. Selection and justification of the chosen alternative.

Article 20. Criteria for the evaluation of the environmental diagnosis of alternatives (DAA). The environmental authority will review the study based on the Manual of Environmental Studies of Projects of **Article 16 of this decree**. Likewise, it will evaluate that the environmental diagnosis of alternatives (DAA) complies with what is established in **Articles 14, 17 and 19 of this decree**, and that the interested party has presented for each of the alternatives of the project, the corresponding comparative analysis of environmental impacts, specifying which of these cannot be avoided or mitigated.

It should be reviewed and evaluated that the diagnosis information is relevant and sufficient for the selection of the best alternative of the project, and that it presents well-founded answers to the concerns and observations of the community.

CHAPTER II

Environment Effect investigation

Article 21. Of the study of environmental impact (EIA)

Article 22. Criteria for the evaluation of the environmental impact study

TITLE IV

PROCESS FOR THE OBTAINING OF THE ENVIRONMENTAL LICENSE

Article 23. Of the evaluation of the environmental diagnosis of alternatives (DAA)

In the cases contemplated in **Article 18 of this decree**, the following procedure will be provided:

1. The interested party in obtaining an environmental license must make a written request addressed to the competent environmental authority, in which he / she will request that it be determined if the project, work or activity requires or not the elaboration and presentation of Environmental Diagnosis of Alternatives (DAA), attaching for the purpose, the description, the objective and scope of the project and its location by means of coordinates and plans.

Within fifteen (15) business days following the filing of the application, the environmental authority shall decide, by means of an official letter about the need to submit or not a DAA, attaching the terms of reference for the preparation of the DAA or the EIA.

2. In case of requiring DAA, the interested party must file the study referred to in article 19 of this decree, along with a copy of the identification document and the certificate of existence and legal representation, in case of being a legal entity. Received the information with the full requirements, the competent environmental authority will immediately proceed to issue an administrative act of initiation of environmental diagnosis of alternatives evaluation (DAA), act that will be communicated in the terms of Law 1437 of 2011 and will be published in the bulletin of the competent environmental authority, under the terms of Article 70 of Law 99 of 1993.

3. Once the administrative procedure has been completed, the competent environmental authority will evaluate the submitted documentation, check that the study complies with the minimum requirements contained in the Environmental Studies Evaluation Manual and will visit the project when it deems appropriate, to which will have fifteen (15) business days; The competent environmental authority may request from the applicant, within three (3) business days and only once, the additional information it deems pertinent to decide.

4. The petitioner will have a term of one (1) month to gather the required information, a term that may be extended by the competent environmental authority in an exceptional manner, before the expiration of the term and for an equal term, upon request of the interested party in accordance with the provisions of article 17 of Law 1437 of 2011 or the regulation that modifies, replaces or repeals it.
In any case, the additional information provided by the applicant must be exclusively that required and may only be provided once. If the applicant provides information different from that stated in the request or the same is subject to additions after the initially delivered, the competent environmental authority will not consider such information within the evaluation process of the request.
5. If the applicant does not gather the information in the terms established in the previous numeral, the environmental authority will order the file of the request for pronouncement on the DAA and will make the return of all the documentation provided by administrative act that It will be notified in the terms of the law.
6. Once the information on the part of the interested party is complete, the competent environmental authority will have ten (10) business days to evaluate the DAA, choose the alternative on which the corresponding Environmental Impact Study should be prepared and set the respective terms of reference, by administrative act that will be notified in accordance with the provisions of Law 1437 of 2011 and will be published in the bulletin of the environmental authority in the terms of article 71 of Law 99 of 1993.
7. The resources established in Law 1437 of 2011 come from the decision making the decision on the DAA.
Paragraph. When the environmental diagnosis of alternatives (DAA), does not meet the minimum requirements established in the Manual for the Evaluation of Environmental Studies adopted by the Ministry of Environment and Sustainable Development and the criteria set forth in **Articles 14,17 and 19 of this decree**, the authority by administrative act will terminate the process and the applicant may submit a new application.

Article 24. Of the request for environmental license and its requirements. In cases where a ruling on the enforceability of the environmental diagnosis of alternatives (DAA) is not required or once said procedure has been completed, the interested party in obtaining an environmental license must file with the competent environmental authority the environmental impact study **Article 21 of this decree** and annex the following documentation:
1. Unique Environmental License Form.
2. Plans that support the EIA, in accordance with the provisions of Resolution 1415 of 2012, which modifies and updates the Geographic Storage Model (Geodatabase) or that replaces, modifies or repeals it.
3. Estimated cost of investment and operation of the project.
4. Power duly granted when acting through proxy.
5. Proof of payment for the provision of the environmental license evaluation service. For applications filed with the ANLA, self-assessment must be made prior to the submission of the environmental license application. If the user requires for payment of the evaluation service the settlement made by the competent environmental authority, this must be requested at least fifteen (15) business days before the submission of the application for environmental licensing.
6. Identification document or certificate of existence and legal representation, in the case of legal persons.
7. Certificate from the Ministry of the Interior on the presence or absence of ethnic communities and the existence of collective territories in the project area in accordance with the provisions of Decree 2613 of 2013.
8. Copy of the filing of the document required by the Colombian Institute of Anthropology and History (ICANH), through which the provisions of Law 1185 of 2008 are complied with.

9. Format approved by the competent environmental authority for the preliminary verification of the documentation that forms the environmental license application.
10. Repealed by Article 1 of Decree 783 of 2015. ~~Certification of the Special Administrative Unit for the Management of Dispossessed Lands, in which it is indicated if a macro-focalized and / or macrofocalized area is superimposed over the area of influence of the project, or if it has been requested by a inclusion in the registry of land stripped or forcibly abandoned, affecting any of the properties.~~
Paragraph 2°. The Ministry of Environment and Sustainable Development with the support of the ANLA within a maximum period of six (6) months following the publication of this decree, will update the National Environmental License Application Form and adopt the preliminary review format of the Study. of Environmental Impact.
Paragraph 3°. In the case of ANLA projects, works or activities, the applicant must also file a copy of the Environmental Impact Study with the respective regional environmental authorities. From the previous filing, a certificate must be submitted to the ANLA at the time of the request for an environmental license

B.2.6.2 Review Comments

Decree 2041-2014 stipulates the definitions of DAA and EIA clearly, thus this definition should be shown the TOR-DAA.

Following documents should be prepared timely:

- General Methodology for the Presentation of Environmental Studies
- Manual of Environmental Studies of Projects
- Manual of Evaluation of Environmental Studies of Projects

B.2.7 Confirmation of DAA Process by Decree 1076-2015

B.2.7.1 Reviewed Document

As stipulated in Page 7 of the ANLA-DAA-TOR, the DAA procedure must follow the work sequence in Article 2.2.2.3.6.1 of Decree 1076-2015 as shown in Figure B.2-2.

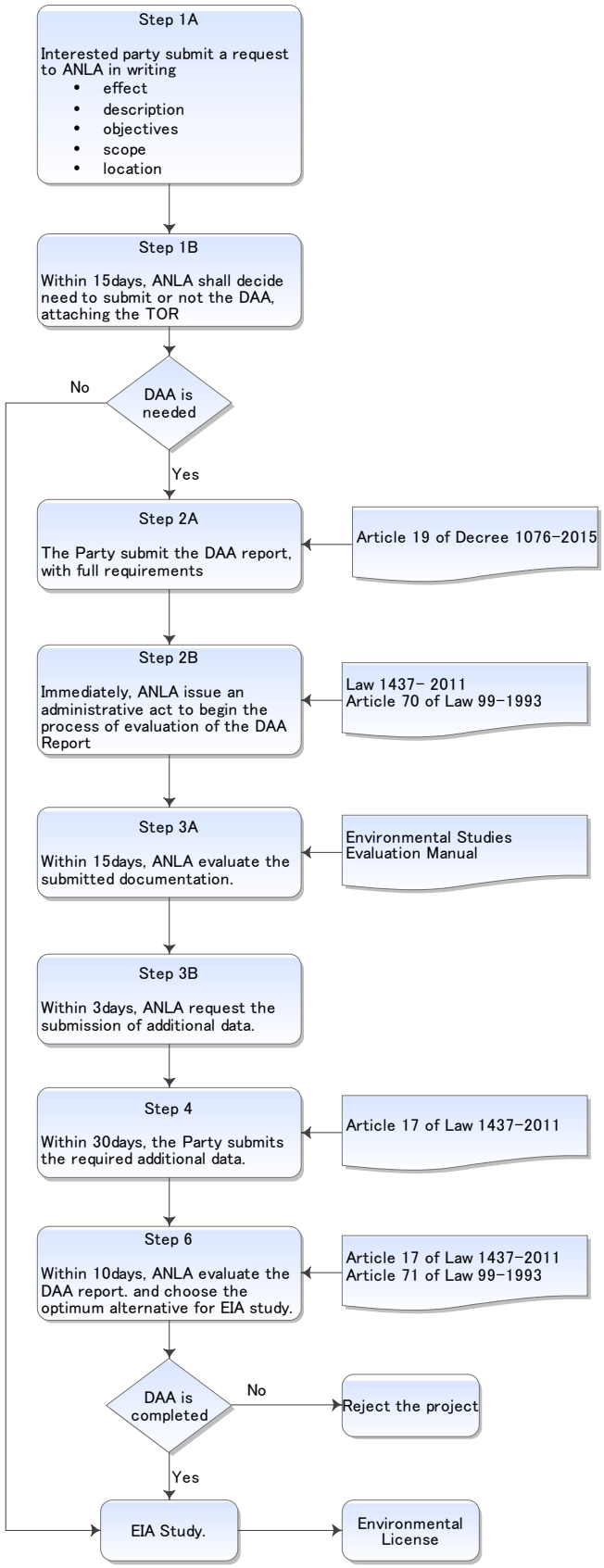


Figure B.2-2 DAA Procedure in Decree 1076-2015

B.2.7.2 Reviewed Comments

Decree 1076-2015 and Decree 2041-2014 show the same DAA procedure, with reference to several Law and Decree.

It is recommended to integrate all legal documents in one document.

B.2.8 Contents of DAA Document by Latest TOR of DAA

B.2.8.1 Reviewed Document

Table B.2-7 shows the required contents to be shown in a DAA report by the latest TOR of DAA.

Table B.2-7 Required Contents in DAA Report (by Draft Final TOR of DAA)

1 OBJECTIVES
2 GENERAL
2.1 BACKGROUND
2.2 SCOPES
2.3 METHODOLOGY
3 PROJECT DESCRIPTION
3.1 LOCATION
3.2 PROJECT DESIGN
3.3 TECHNICAL DESCRIPTION OF PROJECT ALTERNATIVES
3.3.1 Infrastructure and existing special areas
3.3.2 Technical characteristics
3.3.3 Phases and activities of the project
3.3.4 Project schedule
4 STUDY AREA
5 CHARACTERIZATION OF THE STUDY AREA
5.1 ABIOTIC MEDIA
5.1.1 Geology
5.1.2 Geomorphology
5.1.3 Soils
5.1.4 Hydrology
5.1.5 Water uses
5.1.6 Hydrogeology
5.1.7 Geotechnics
5.1.8 Atmosphere
5.1.9 Landscape
5.2 BIOTIC MEDIA
5.2.1 Terrestrial Ecosystems
5.2.2 Aquatic Ecosystems
5.2.3 Analysis of ecological connectivity and habitat fragmentation
5.2.4 Strategic, sensitive ecosystems and / or protected area
5.3 SOCIOECONOMIC MEDIUM
5.3.1 Participation and socialization with communities
5.3.2 Demographic component
5.3.3 Spatial component
5.3.4 Economic component
5.3.5 Cultural component
5.3.6 Archaeological component

B.2.8.2 Reviewed Comments

As commented above, required contents of the TOR-DAA is very detailed and could not be covered in terms of general requirements in Phase 1: Pre-feasibility study shown in INVIAS manual.

B.3 RECOMENDATIONS

B.3.1 General

JICAST reviewed several documents including Decrees, INVIAS Manuals and MADS/ANLA TORs, related to DAA process, and then identified some issues for improvement of the quality of TOR-DAA as described below.

B.3.2 Recommendation (1), Show Definition of DAA Process

It seems Decree 2041-2014 provides the best explanation of the DAA process. This explanation should be fully shown in the TOR-DAA.

B.3.3 Recommendation (2), Show All Legal Documents, Guidelines and Manuals related to Project DAA Process

There are several legal documents, guidelines and manuals related to the DAA process. Those documents should be listed, with the issue year, as the basis of the DAA procedure in the project.

Technology is elaborating time to time, as the results applicable technology, at the time of conducting the DAA, is also changing, and those updates in each stage of the planning, studies and designs, construction, operation and maintenance of the road tunnel project should be timely reflected.

Listing of those related documents are essential to be recorded for showing the applicable technology at the time of the DAA.

B.3.4 Recommendation (3), Show Overall Project Implementation Sequence and Role of DAA Process in the Implementation

In general, the project life of a road tunnel project lasts for long. Moreover, there would sometimes be some changes of the project scope, and those are inevitable as the nature of large-scaled infrastructure development project. In case, the route selection would be re-done, the DAA process should also be re-done.

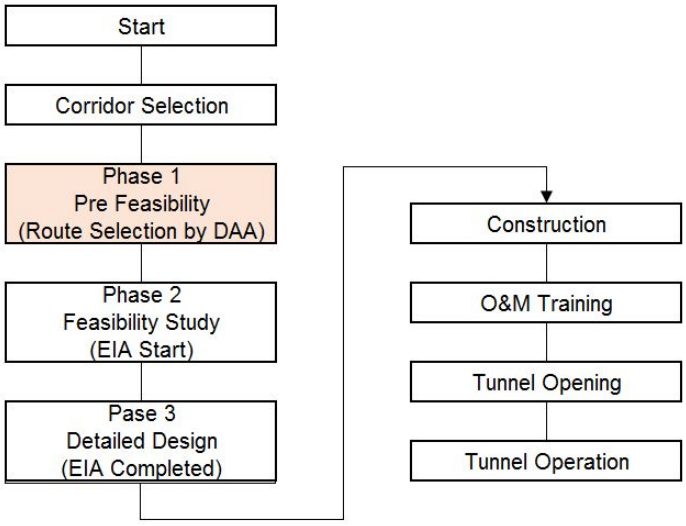


Figure B.3-1 (Sample) DAA Process in Overall Project Implementation

Considering this nature of the road tunnel project, the overall project implementation sequence and schedule at the time of DAA should be recorded in the DAA report, with the chronicle of the project in the past and the time record of the DAA process carried out.

The official project implementation schedule should be shared, time to time, through the planning stage to the operation stage as "official chronicle".

B.3.5 Recommendation (4), Show Possible Project Types, Project Organization Structures and Role Demarcation, especially in DAA and EIA Process

It is understood that there are several project types for the implementation of infrastructure development project in Colombia:

- Design, Bid, Build (DBB) type
- Build, Operation, Transfer (BOT) type

The project type and project organization structure should be shown in the DAA report for easy understanding of role in the preparation of both DAA report and EIA report.

Responsibility of the preparation of DAA report and EIA report should also be clearly mentioned for efficient and effective communication during the evaluation of those reports.

For example:

- For DBB projects: INVIAS is responsible for the preparation of DAA report and EIA report,
- For BOT projects: The investor is responsible for the preparation of DAA report and EIA report.

B.3.6 Recommendation (5), Show Scope Demarcation, with Quantity of Survey and Analysis, between DAA and EIA

It seems that the scope demarcation of DAA and EIA is not clearly described in the TOR of DAA and EIA respectively.

As tabulated in Table B.2-1, and as described in Chapter 4 of INVIAS-MAN-RTN, the natural and social condition survey for each design phase, Phase 1, Phase 2, Phase 3, are to be differentiated. These differentiated levels of the survey and analysis should be standardized showing standard quantity of the surveys and analysis in each design phase, and for the preparation for each DAA report and EIA report.

Otherwise the applicant cannot prepare those reports efficiently with standard depth with appropriate quantities of the survey and subsequent analysis. And ANLA cannot evaluate those report efficiently and effectively.

B.3.7 Recommendation (6), Show Criteria and Standard Process of Route Selection

It should be emphasized that the ultimate objective of the DAA is to select the optimum route for the project.

Article 5.4.1 "Criteria for the Location of Road Tunnel" in INVIAS-MAN-RTN shows good stipulation for the route selection of a road tunnel project as shown in Table B.2-3.

B.3.8 Recommended Modifications of the Latest TOR-DAA

Summarizing the above, the recommended modifications of the latest TOR-DAA can be tabulated as shown in Table C.8-1.

Table B.3-1 Recommended Modifications of the Latest TOR-DAA

No.	Recommendation	Suggested Modifications to Latest TOR-DAA	Level of Action
1	Show Definition of DAA Process	Insert the definition of DAA stipulated in Decree 2041-2014.	Easy
2	Show All Legal Documents, Guidelines and Manuals related to Project DAA Process	Insert the list of all legal documents, guidelines and manuals related to the DAA process	Medium
3	Show Overall Project Implementation Sequence and Role of DAA Process in the Implementation	Insert the form of project implementation	Easy
4	Show Possible Project Types, Project Organization Structures and Role Demarcation, especially in DAA and EIA Process	Insert the project types, project organization structures and the role demarcation, especially in DAA and EIA process	Medium
5	Show Scope Demarcation, with Quantity of Survey and Analysis, between DAA and EIA	Discuss with INVIAS and define the level of survey and analysis in each DAA and EIA.	Difficult
		Insert the standard quantities required in the DAA.	Medium
6	Show Criteria and Standard Process of Route Selection	Discuss with INVIAS and prepare the route selection manual	Medium
		Prepare the standard evaluation manual of DAA.	Medium

B.4 PROPOSED STRUCTURE OF TOR FOR THE DAA

B.4.1 General

Summarizing the above and with reference to typical practices in the world, JICAST proposed the following structure for the TOR of DAA.

B.4.2 Proposed Structure of the TOR of ANLA-EHB-DAA

Table B.4-1 Proposed Structure of the TOR of ANLA-EHB-DAA (Revision 1)

1 GENERAL
1.1 General
1.2 Definition of DAA
1.3 Objectives of the TOR-DAA
1.4 Legal Requirements and Procedural Guidelines for the DAA
1.5 Project Type and Stakeholders
1.6 Scope of the DAA
1.7 Preparation of the DAA
1.8 Preparation of the DAA evaluation report
2 OUTLINE OF PROJECT PROPOSED
2.1 General
2.2 Legal Requirements and Procedural Guidelines
2.3 Established Design Criteria
2.4 Traffic Studies
2.5 Route Selection Study
2.6 Selected Project Route
2.7 Preliminary Design
2.8 Project Schedule
2.9 Project Cost
2.10 Economic and Financial Analysis
2.11 Project Organization
2.12 Project Implementation Plan
2.13 Issues to be Studied during ANLA's EIA Phase
3 ENVIRONMENTAL AND SOCIAL ISSUES
3.1 General
3.2 Legal Requirements and Procedural Guidelines
3.3 Study Area
3.4 Abiotic Media
3.5 Biotic Media
3.6 Socioeconomic Medium
3.7 Environmental Risk
3.8 Environmental Zoning
3.9 Initial Environmental Examination (IEE)
4 ROUTE SELECTION
4.1 General
4.2 Methodology

C. HANDBOOK FOR EIA

C.1 General

In this section C, reference and instructions of the environmental impact study are described. The basic policy of the contents are follows.

- The subtitle and contents of this section follow the fields and contents of TOR for EIA. (Resolution 751 on 26th March 2015)
- The contents of each subsection have a function of to provide supplemental information of the EIA study

JICAST recommend classifying the study area. This method can make concentrate to the hypothetical environmental impact. On this classification, it is important to take account the affected target of the environmental impact aspects in study area. This idea is inspired from the recommended method by IAIA (INTERNATIONAL ASSOCIATION FOR IMPACT ASSESSMENT). JICAST recommend making two categories for the EIA study as below table.

Table C. 1.1 Classification of the study area

CLASS	Explanation	
CLASS A	Priority Area	This area includes the target which would be affected hypothetical environmental impact from the proposed project. The examples of the target are residence, hospital, protected wet land, protected area, precious ecosystem etc.
CLASS B	Non-Priority Area	This area does not include the target.

After this classification, it is possible to concentrate the EIA study of the hypothetical impact and to make efficient of the study.

C.2 Abiotic environment

Recently abiotic environmental impact became more obvious on the tunnel project in Colombia. Especially the impact of the geological field and hydrogeological field from tunnel project caused serious issue in recent years. That is reason why, JICAST prepared the handbook of these field prior to the other fields.

C.2.1 General

The classification of the study field is the basic policy of this handbook. But on some fields, it is difficult to make divided sections and define the priority area. (e.g. vibration. geotechnics) Hence on these subsections, categorization of the study area is omitted.

For the priority area, it is required to conduct detailed survey, specific survey and detailed analysis in general. On the other hand, on non-priority area, it is not necessary to conduct comprehensive survey and to conduct detailed analysis.

The contents of this section C cover the general methods of EIA and procedure of the EIA study in each field. There are many new survey methods and analysis method which were developed in recent years on environmental field. These new methods are introduced as much as possible, but it is difficult for this

handbook to explain whole of the characteristics and dealing methods of those, because these methods are advanced field in general. Therefore, JICAST recommend requesting advice about the dealing of the new methods from the academy or other third-party specialist of these field, if these advanced methods would be used on EIA study. In general, technical advisory committee on EIA is quite common in many other countries.

The contents of each field have a structure as follows.

1. General: The first subsection is the outline of study for each environmental aspect. This subsection also includes the estimation of the hypothetical environmental impacts.
2. Classification of the survey area: The second subsection shows the classification of the survey area base on the assumed impacts which are estimated previous subsection. The purpose of this study is to concentrate to the important impact or issue.
3. Checklist for required investigation items: The third subsection shows the required information based on the TOR for EIA in Colombia.
4. Methodology, Process and Procedure: The fourth subsection is described method for predicting environmental impact which are assumed in section 1.
5. Evaluation of the Environmental impact
6. Mitigation and monitoring: Mitigation and monitoring method is shown in section 6th which is also based on the TOR.

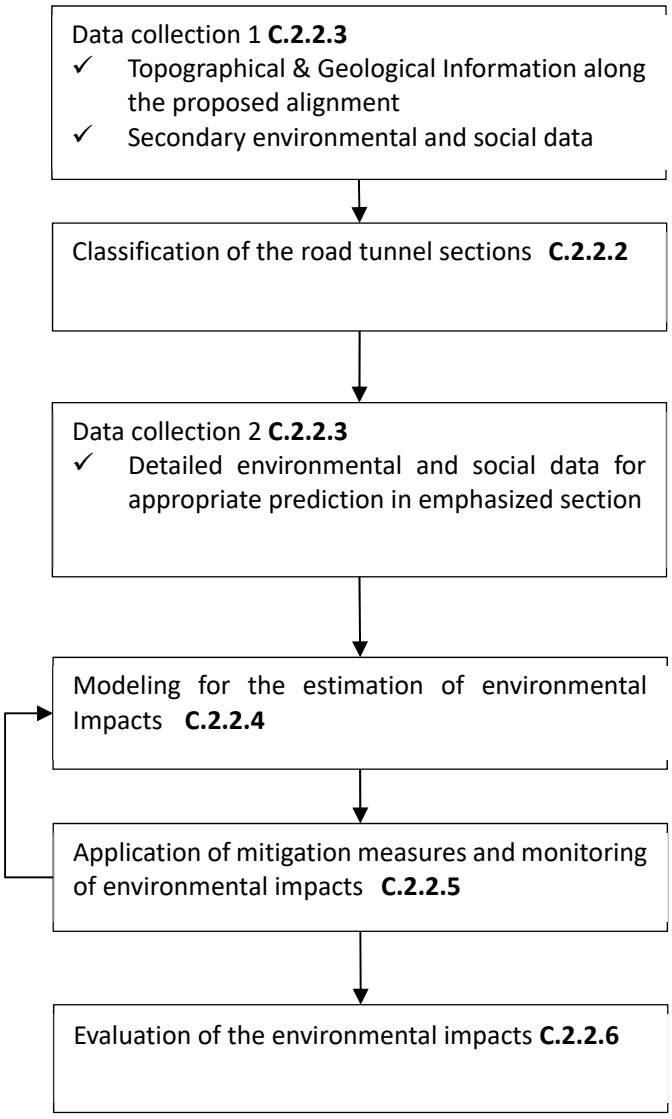
C.2.2 Geology

C.2.2.1 General

This section provides the technical information regarding the geology for EIA study and also the countermeasures for reducing environmental impacts and monitoring method during and after construction.

(1) General workflow

The general workflow of geological impact study as shown in following diagram. The geological survey for the study shall be basically carried out in compliance with 'Invías 2016-Manual de Túneles para Colombia'



Overview	
The required Items of general information · Topographical map (1:25,000 or 1:100,000) · Geological map (1:25,000 or 1:100,000) · Road Plan drawing (Vertical & Horizontal Alignment), Standard Road Section	
Dividing road tunnel into several sections and classifying each section to priority area or Non-Priority area.	
CLASS A Priority Area	CLASS B Non-Priority Area
Detailed information for numerical analysis · Topo graphical map (1:500 – 1:2,500) · Borehole Survey Log/ Labo. Test results · Geological Profile in detail (1:500 – 1:2,500)	· Topo graphical map (1:5,000) · Geological Profile in detail (1:5,000)
· Numerical Analysis (Sliding failure analysis, FEM, etc)	Qualitative evaluation by using the secondary data.
· Borehole Survey Log · Laboratory Test results · Geological Profile in detail	Not required
· Evaluation based on the impact of daily life point of view · Evaluation of impact of precious nature point of view	

Figure C.2.2.1 Flowchart of the study on geological impact

(2) Estimated environmental impact

It is important to clarify the environmental and social impacts caused by construction and operation of the tunnel for classification of the divided sections. The assumed environmental impacts on geology are shown below.

Table C.2.2.1 Possible Impacts on Geology

From the daily life or livelihood point of view
· Ground subsidence and Deformation · Landslide at the Tunnel portal
From the precious or protected nature point of view
·
From the Occupational health and safety point of view
· Tunnel collapse

C.2.2.2 Rank the significance of the area of influence

(1) Referenced TOR

The description referred from the TOR for EIA (Resolution 0751, 26 March 2015) is shown in the box below.

4.AREAS OF INFLUENCE
4.2 DEFINITION, IDENTIFICATION, AND DELIMITATION OF THE AREA OF INFLUENCE
…

It is important to clarify that the result of the delimitation can be reflected in one or several polygons, by identifying the area of influence for each component, group of components or media.

The area of influence by component, group of components or medium should be based on units of analysis such as: watersheds, ecosystems, territorial units, and those identified by the applicant within the EIA. Each area of influence per component, group of components or medium, must have a minimum unit of analysis which must be properly supported.

(The rest is omitted)

(2) Other Related Technical Information

THE PRINCIPLES of ENVIRONMENTAL IMPACT ASSESSMENT BEST PRACTICE say that Environmental Impact Assessment should be focused. (INTERNATIONAL ASSOCIATION FOR IMPACT ASSESSMENT, 1996) The process of the EIA study should be concentrated on significant environmental effects and key issues. Therefore, it is recommended to evaluate and rank the significance of environmental impact on each section of the project alignment.

(3) Methodology, Process and Procedure

(a) Identify the area need to be carefully considered

The area division should be conducted with careful study of the basic information of topographical and geological map and proposed alignment.
The preliminary study for the geological condition should be start from terrain analysis with reference to topographic map, generally on a scale of 1:25,000. The points to be consider can be shown as follows;

- landslide area (See also **Figure C.2.2.3**)
- Vale, valley
- Fault topography (See also Figure C.2.2.4)
- The section with uneven pressure (See also Figure C.2.2.5)

- Geological and topographical stability of tunnel portal
- Unconsolidated soil

These conditions may cause the negative impacts to the environment, such as the land slide or deformation of the land. The area can be often identified by the careful study of topographic map and field reconnaissance by the experts. The earthquake environment shall be also considered for the appropriate evaluation of the risks of landslides. The predicted strength and frequency of earthquakes can be obtained referring to the standard, 'REGLAMENTO COLOMBIANO DE CONSTRUCCIÓN SISMO RESISTENTE, March 2010, Asociación Colombiana de Ingeniería Sísmica'.

The land deformation may often occur in the area near the tunnel portal. Regarding the land slide issue, the cutting near the tunnel portal around land slide area may often be the cause of land sliding. Thus, the careful study on these areas is required for avoiding the negative impact to the Environment and securing the construction safety. Additionally, the Japanese standards mention that the sliding don't effect to the tunnel in case of the distance of more than 2D (twice as tunnel width) or 20m between tunnel roof and sliding surface (See also Figure C.2.2.6).

The figure below shows the points to be considered for area division from the geological points of view.

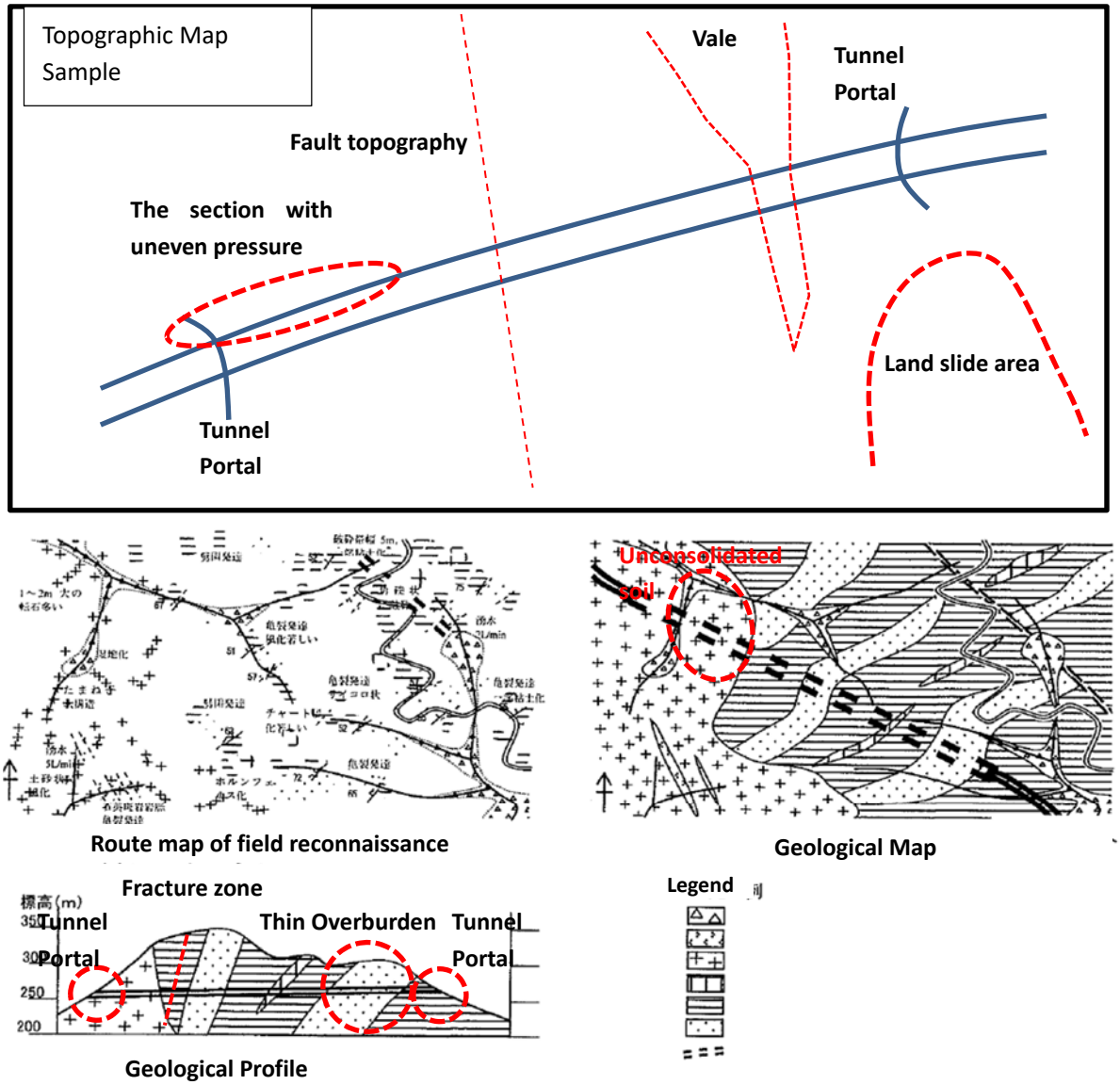
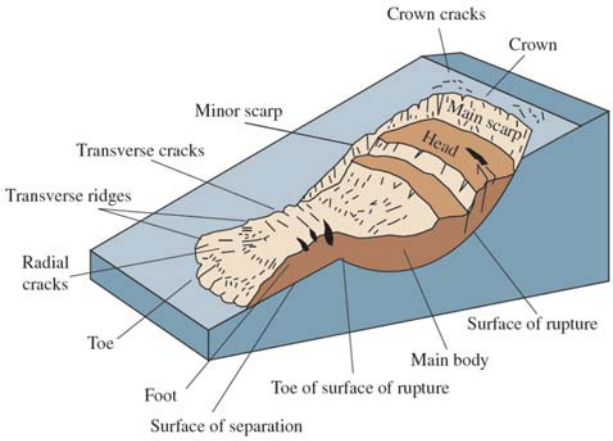
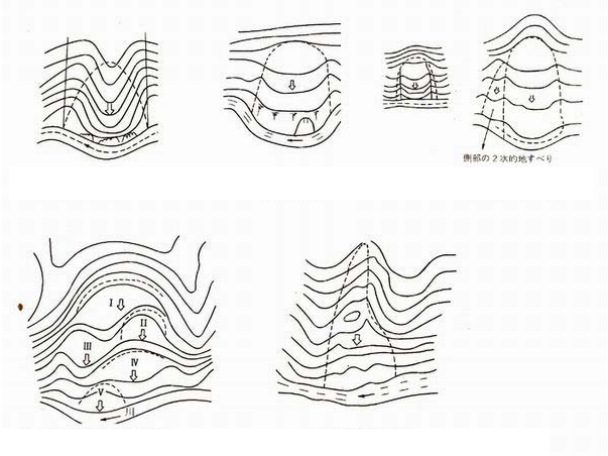


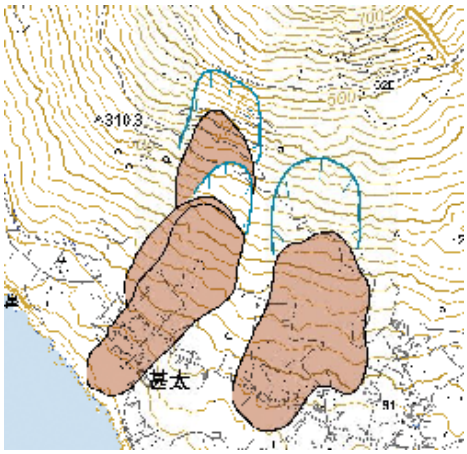
Figure C.2.2.2 Points to be considered for area division



Source: USGS website https://pubs.usgs.gov/fs/2004/3072/pdf/fs2004-3072.pdf



Typical landslide topography

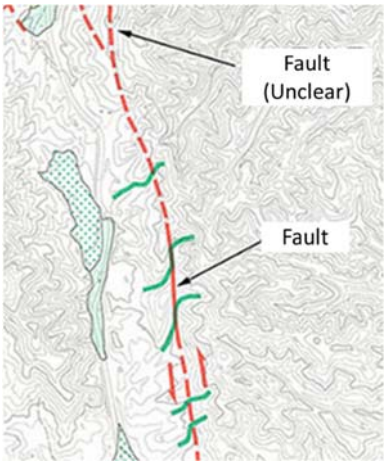


Example of Landslide mapping

Explanatory Notes;

The land slide can be identified by the careful observation of the topography from topographic map, stereopsis of aerial photograph, digital elevation map and field reconnaissance. Mapping of the land slide area after identification is also important for the appropriate evaluation.

Figure C.2.2.3 Landslide Topography



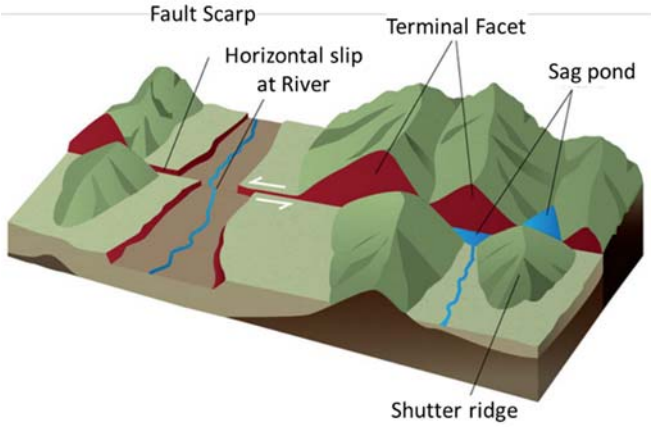
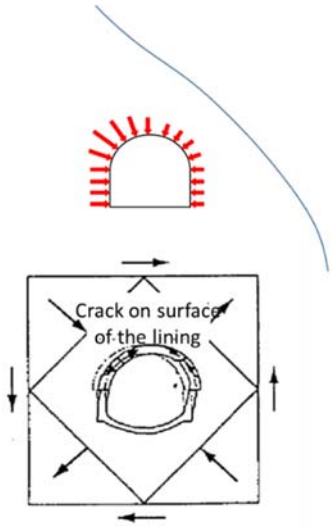


Figure C.2.2.4 Fault Topography



Explanatory Notes;

Uneven pressure means the condition where the earth pressure is different at each side on the wall of the tunnel.

The condition is commonly observed at the tunnel section in the slope topography. The condition could cause deformation of the tunnel in the long term and generally it's very difficult to deal with this phenomenon by some countermeasures especially at the site with land-sliding. Therefore, the route selection with avoiding passing such the section is very important in DAA process.

Figure C.2.2.5 The section with uneven pressure

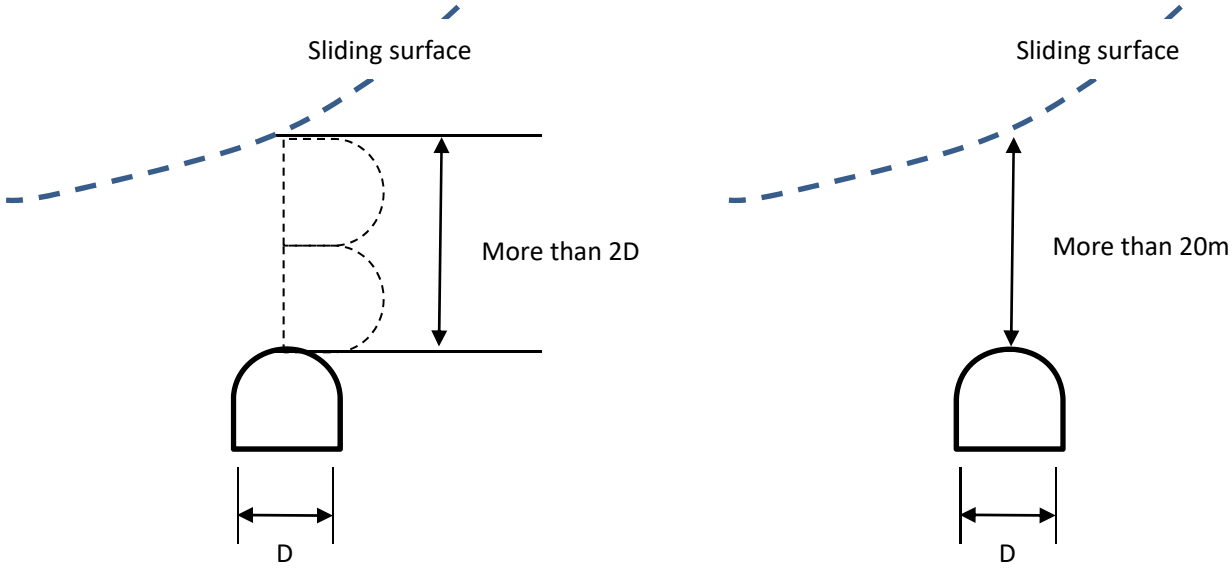


Figure C.2.2.6 Distance between tunnel and sliding without negative impact

(b) Classification

The classification is done for focusing the EIA on the area/section with significant impact predicted. As the purpose of the classification is to study and evaluate environmental impact efficiently, the classification results shall be carefully confirmed. Class A is defined as the priority area for EIA and need to be surveyed in detail, and the Class B as the non-priority area. The environmental impact of both classes shall be assessed, however the assessment in Class B can be carried out qualitatively by using secondary data. Many kinds of geological Impact from tunnel project could be assumed as described above. The sections shall be classified with reference to the preliminary study and land use on the surface for emphasizing on EIA study. Following figure shows the outline of area classification.

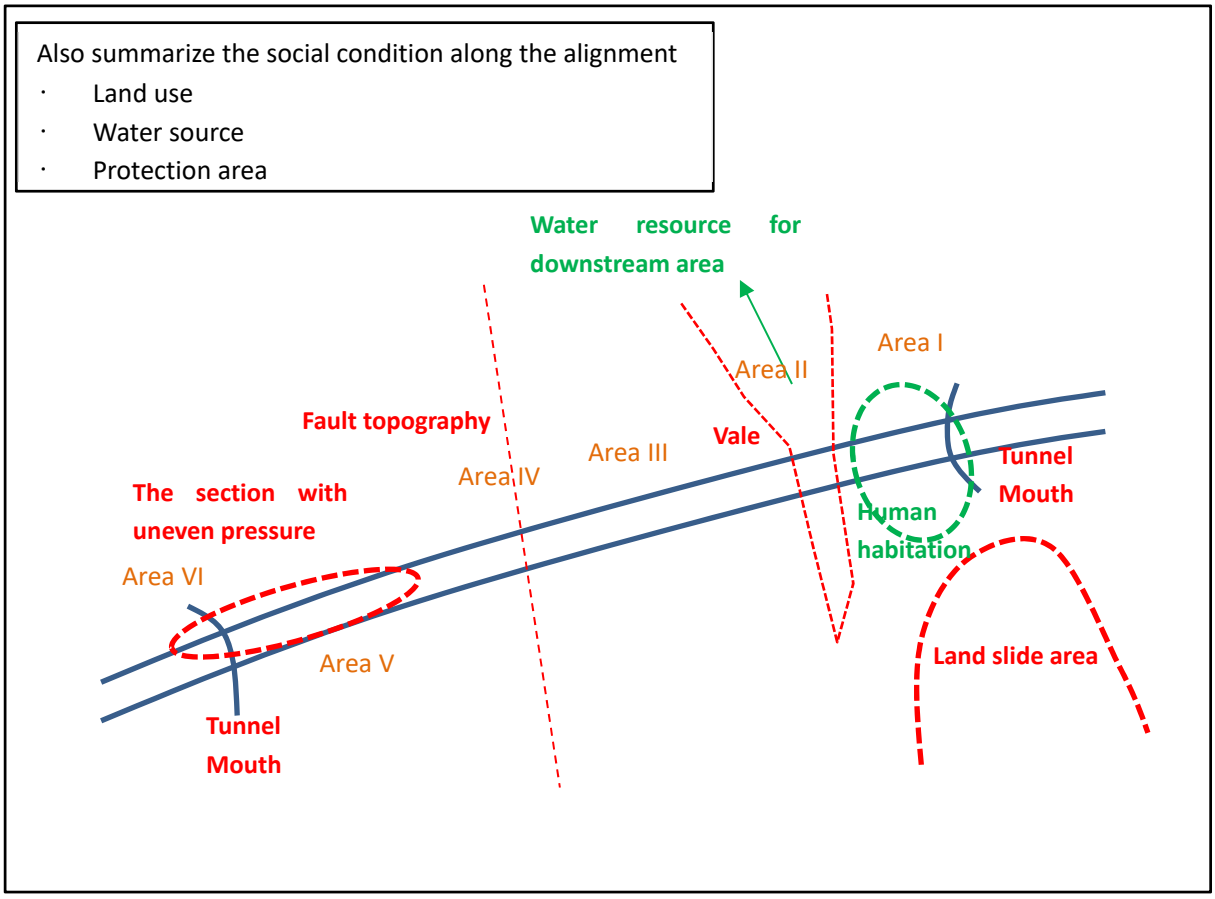


Figure C.2.2.7 Outline of Area Classification

(4) Output

The result of classification could be organized into table as shown below. The conditions, class and the reason of classification are described in this table.

Table C.2.2.2 Classification of Environmental Impact

Study Area	Geological & Topographical Conditions						Others		Class		Remarks
	Land Slide	Fractured zone	Fault	Unconsolidated soil	Uneven Pressure	Vale	Human habitation or other facility	Water resouce	A	B	
I	✓						✓		✓		Tunnel portal
II						✓		✓	✓		
III										✓	
IV			✓						✓		
V					✓				✓		
VI					✓				✓		Tunnel portal

Note, Class A means it need elaborate method for survey, prediction and mitigation study.

C.2.2.3 Check list for required investigation items

(1) Referenced TOR

The items of investigation on EIA study can be classified corresponding to the area class. On the class "A" area, the detailed information will be required. On the other hand, comprehensive information in influence area is used for classification of the study area. (See section C.2.2.2)
The description referred from the TOR for EIA (Resolution 0751, 26 March 2015) is shown in the box below.

5.1.5 Geology
For the area of influence of the component, group of components or medium, the general geological mapping adjusted to the project with photointerpretation and field control must be presented; (Surface deposits, colluvia, moraines, alluviums, etc.), which are more likely to present instability processes.

For the area where the project activities will be developed, geological information should be included in the plan and illustrative profiles in which the projected alignments and geological conditions prospected in homogeneous sections throughout the project can be identified.

For the area of influence of the component, group of components or mediums for the construction of tunnels, a conceptual geological model must be presented, from which the following information is obtained:

1. **Identification of the lithological units and structural situation along the corridor of the tunnel, that allow to know the geological condition of the rocky massif. For this purpose, it is necessary to lay out the model in plan and longitudinal and transverse profiles.**
2. **Identification of sections with different rock qualities, if applicable.**
3. **Structural Condition.**

(The rest is omitted)

(2) Other Related Technical Information

Geological Investigation can be planned and executed with reference to the following standard documents.

- 4.4.8 Geological investigation methods, Invías 2016-Manual de Túneles para Colombia
- Geotechnical Baseline Reports for construction, suggested guidelines, ASCE, 2007
- Strategy for site investigation of tunneling projects, ITA REPORT No.15, May 2015
- ASTM Volume 04.08 Soil and Rock(I):D420-D5876, ASTM Volume 04.09 Soil and Rock(II) D5877-Latest
- Techinical Manual for Design and Construction of Road Tunnels – Civil Elements, 2009 FHWA, US DoT

(3) Methodology, Process and Procedure

(a) Methodology

The survey methods shall be selected considering the items need to be clarified. The planning of the geological survey shall be executed in accordance with '4.4.8 Geological investigation methods, Invías 2016-Manual de Túneles para Colombia'. The manual introduce major exploration methods exclusive of borehole survey as follows.

- Surface exploration
- Seismic exploration in borehole (Velocity wave logging)

- Seismic exploration
- Electric exploration

These methods should be selected with careful consideration of the applicability.

Other methods are also often used as the survey for tunneling. The table below shows the standard investigation methods.

Table C.2.2.3 Standard investigation methods

Investigation Items \ Investigation Methods		Document Survey	Geological Reconnaissance	Seismic Exploration	Hydrological Survey	Groundwater Investigation	Borehole Survey	Borehole logging: Velocity Wave	Borehole logging: Electric Logging	Borehole logging: Diameter Logging	Borehole logging: Temperature Logging	Standard Penetratoin Test	Borehole Loading Test	Laboratory Tests	Borehole observation
Topo	Land Slide	○	○				○								
	Uneaven earth pressure	○	○												
	Overburden thickness	○		△											
Geo. Structure	Geological Profile	△	○	○			○	△	△						○
	Fault, Fold	△	○				○	△							○
Soil & Rock Characterization	Characterization of rocks	△	○				○		△						○
	Rock facies	△	○				○								○
	Fracture		△	○			○	○							○
	Weathering, Alteration		△	○			○	○	△						○
	Concretion degree		○	△			○	△	△	○		○			○
Under groundwater	Aquifer Stratum		○		○	○	○		○	○	△				○
	Underground water level		△			○	○								
	Permiability					○									
Mechanical Property	Shear Strength											△		○	△
	Cohesive strength, Friction Angle											△		○	△
	Deformation coefficient											△	○	○	○
	N value											○			
Physical Property	Elastic wave velocity			○				○							
	Ultrasonic velocity													○	
	Density													○	
	Grain size													○	
	Liquid and Plastic Limit													○	
	Water content													○	
Mineralogical Characteristics	Clay mineral													○	
	Slaking													○	
	Water absorption													○	

○ Highly Effective
△ Effective

(b) lithological units and structural situation/ sections with different rock qualities/ Structural Condition

The lithological units shall be identified in consistence with 'Invías 2016-Manual de Túneles para Colombia'. The manual indicate that the rock classification should be basically in comply with the ASTM D 5868 ' Standard Guides for Using Rock-Mass Classification Systems for Engineering Purposes'.

(4) Output

The required information for each class is shown below table. (Check list)

Table C.2.2.4 Checklist of the required information

Survey items		Required items / parameters
General Information for classification	1. Geological Condition	➢ Geological map (1:25,000-1:100,000)
	2. Topographical Condition	➢ Topographic map (1:25,000)
	3. Project Plan	➢ General information of the project ➢ Design Drawings (General plan, longitudinal

Survey items		Required items / parameters
		and cross-section profile)
Information for detailed analysis on class A area	4. Geological Condition	➢ Field reconnaissance results ➢ Geological profile ➢ Summary of Borehole logs and in-situ investigation logs ➢ Summary of laboratory test results
	5. Topographical Condition	➢ Topographical map in detail (1:500-1:2,500) ➢ Longitudinal profile ➢ Cross-section drawing

C.2.2.4 Modeling for Estimate of Environmental Impact

(1) Referenced TOR

The description referred from the TOR for EIA (Resolution 0751, 26 March 2015) is shown in the box below.

8.ENVIRONMENTAL ASSESSMENT
For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.
(The rest is omitted)

Geological analysis must be done on two stages (With and Without project) in accordance with this TOR. On these two scenarios, the impacts on geology, such as the surface deformation must be appropriately forecasted using the appropriate methods of analysis.

(2) Other Related Technical Information

Geological analysis for evaluating the impacts can be planned and executed with reference to the following standard documents.

- 5.5.2.7 Detailed determination of construction methods and the system behavior, 5.11.3 Design of portals, Invías 2016-Manual de Túneles para Colombia

(3) Methodology, Process and Procedure

a. Slope Stability Analysis

Slope stability analysis is conducted for the evaluation of the impact of landslide. The methods of sliding failure analysis have been well established and it can be selected with reference to '5.11.3 Design of portals, Invías 2016-Manual de Túneles para Colombia'. The calculation model shall be made according to the actual topographic survey and geological survey results, and the calculation shall be done with the reliable software. The safety factor calculated shall be meet the regulated safety factors (ex. Table 5-17 Safety Factors, Invías 2016-Manual de Túneles para Colombia).

b. Deformation Analysis

The analysis methods shall be selected by the design engineer considering the applicability of the methods. The occurrence of large deformation cannot be accepted basically during the actual project implementation, so the FEM shall be often applied for the pre-construction evaluation. Other methods are applied as the analysis of reverse engineering for the clarification of the cause of the problem occurred. The **Table C.2.2.5** below shows the methods used for the analysis of evaluation of the tunneling impacts.

Table C.2.2.5 Comparison table of deformation analysis methods

Methods	Objective	Applicability
Finite Element Method (FEM)	Continuum analysis	Most popular and many experiences, not suitable for phenomenon with large deformation
Finite Difference Method (FDM)	Continuum analysis	More suitable for phenomenon with large deformation
Discrete Element Method (DEM)	Non-Continuum analysis	Not many experiences, Suitable as large deformation analysis
Discontinuous Deformation Analysis (DDA)	Non-Continuum analysis	Not many experiences, Suitable as large deformation and non-continuum analysis

Modelling is also important issues for the evaluation. The calculation model shall be made according to the actual topographic and geological survey results. For the evaluation, the careful selection, 2D or 3D is necessary for evaluation planning considering the applicability. 2D model is used in many cases because of its easiness. However, it is necessary to apply 3D models in case that the 2D model is not suitable for figure out the environmental impact targeted considering the difference of each model (See also Figure C.2.2.8).

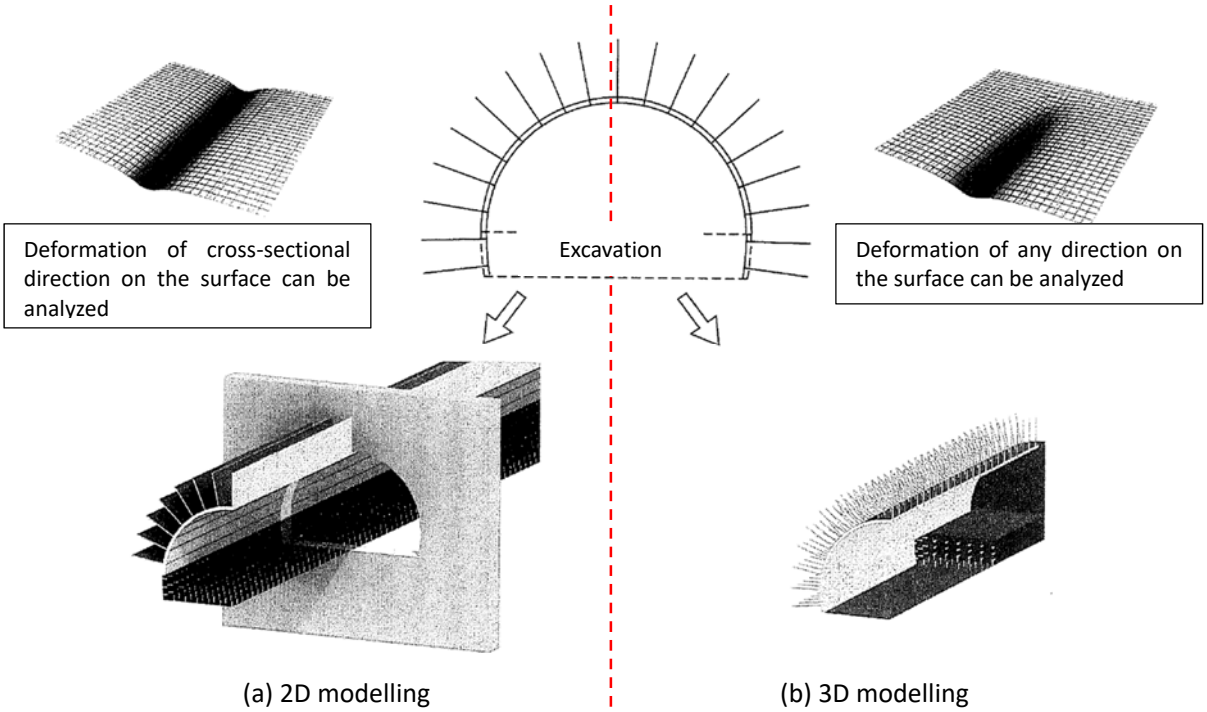
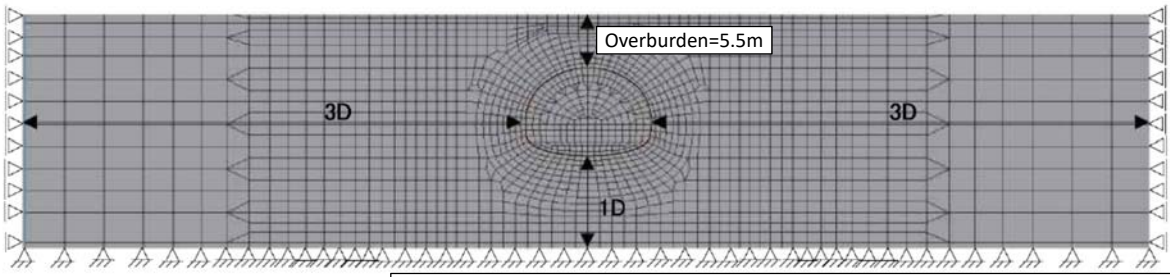
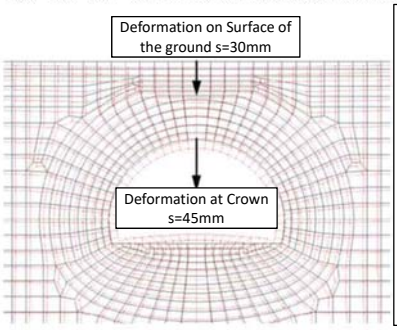


Figure C.2.2.8 Difference between 2D and 3D modelling



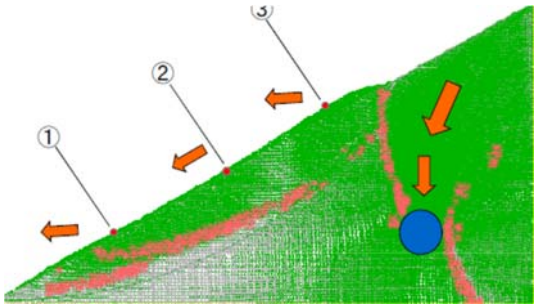


Explanatory Notes;

FEM Analysis is commonly used to estimate the deformation of the area impacted during and after construction. Because the method adopts complex conditions and is easily conducted by the common software established. On the other hand, the method is not suitable for the analysis with large deformation such as sliding.

The modeling shall be executed carefully reflecting the actual condition based on the survey results.

(a) FEM Analysis

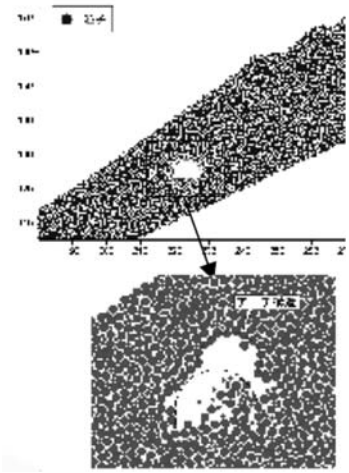


Explanatory Notes;

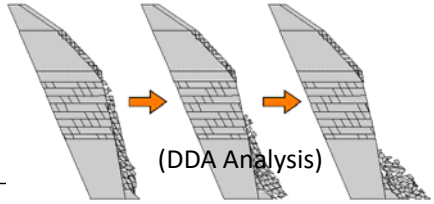
FDM Analysis is also commonly applied to the evaluation of tunnel construction project. In general, the method is more suitable for the analysis of the condition with larger deformation.

The example is the case study for the analysis of relation between landslide and tunnel.

(b) FDM Analysis



(DEM Analysis)



(DDA Analysis)

Explanatory Notes;

DEM and DDA analysis can be applied to the phenomenon with discontinuous condition. Therefore, these analysis is utilized for the simulation of rock fall, collapse of the tunnel and so on. These methods are not commonly used for the evaluation during planning stage of tunnel projects.

(c) Other methods

Figure C.2.2.9 Examples of deformation analysis

(4) Output

The output of the analysis should be summarized with the allowance value. It shall be determined whether estimated value can be accepted or not by comparing with the allowance value. Allowance value can be determined considering target facilities with reference to related standards.

Table C.2.2.6 Sample output items

Results (Estimated amount of deformation, Safety factor)	Allowance	Evaluation
Deformation at Point A: dz = 50 mm	30mm (for example)	Need to consider the countermeasure
Safety factor of sliding at section A: Fs = 1.8	More than 1.2(for example)	OK

C.2.2.5 Evaluation of the Environmental impact

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT

For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.

(The rest is omitted)

8.1 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT-FREE SCENARIO

In the analysis of the impacts prior to the project, the activities that have had the greatest impact on the changes in the areas of influence must be identified. In addition, the current state of the medium (abiotic, biotic and socioeconomic) and its environmental sensitivity should be qualified and quantified, and the analysis of trends must be made, considering the regional and local development perspective, economic dynamics, and government plans, The preservation and management of natural resources and the consequences that the anthropic and natural activities of the region have for the ecosystems.

(The rest is omitted)

8.2 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT SCENARIO

Based on the environmental assessment for the project-free scenario and the ratings obtained for each impact, the impacts generated by the project on the environment should be identified, described and qualified as a result of the interaction between the activities of said environment and the components of each medium. It is worth noting that this assessment is done without taking into account the environmental management programs, given that, according to their significance, the Environmental Management Plan is formulated.

(The rest is omitted)

(2) Other Related Technical Information

NEED TO BE ADDED, ex. Environmental Standard in Colombia

(3) Methodology, Process and Procedure

The assessment procedures need to follow the environmental standard in Colombia with reference to EIA documents of the project.

(4) Output

The evaluation results need to be summarized clearly as shown below;

Table C.2.2.7 Sample of output

The Results of the evaluation
➢ The impacts predicted are identified appropriately in EIA method. ➢ The estimated deformation of surface on the ground due to construction is within XXX mm (allowance value (house, facility) =xx, with or without countermeasure. ➢ Monitoring plan for controlling the environmental and social impact is planned appropriately. ➢ It can be determined that the estimated environmental impacts due to the project implementation meet the criteria in compliance with the Colombian standards and the monitoring plan can reduce the environmental risks during construction.

C.2.2.6 Mitigation and monitoring

(1) Referenced TOR

The description referred from the TOR for EIA (Resolution 0751, 26 March 2015) is shown in the box below.

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.1 Environmental Management Program
…

An Environmental Management Plan (PMA) must be presented, structured in programs and subprograms (when required) and based on the hierarchy of management of potential identified impacts, considering as a first option measures for preventing and avoiding the occurrence of impacts; In the second option, measures to mitigate and/or minimize said impacts; Measures to correct or restore environmental conditions and, finally, compensatory measures will be considered.

For the identified impacts, environmental management measures should be considered taking into account that the same measure can be applied to the management of different impacts and that an impact can be managed through different measures.

The approach of programs, subprograms and measures should focus on comprehensive control of environmental impacts; For such purpose, it must be considered that there may be impacts that occur in different environments (for example, contamination of the surface water resource can affect elements of the abiotic, biotic and socioeconomic environments) and / or components (for example, the traditional economic activities of the population may affect the economic, demographic, cultural, etc.).

The PMA programs must specify:
1. **Objective(s) of each program and subprogram.**
2. **Goals related to identified objectives.**
   Indicators that allow monitoring of the achievement of the goals proposed for each objective, as

well as to determine the effectiveness of each program and subprogram.

3. **Impacts to be managed by each program (based on impact assessment). Phase(s) of the project in which each program and subprogram would be implemented.**
4. **Application location (s) (cartographic location where possible).**
5. **Description of management measures (specific actions) to be developed within each program and subprogram, specifying the type of measure (prevention, mitigation, correction and compensation).**
6. **List of proposed works to be implemented. The designs must be presented as documents annexed to the EIA.**
7. **Estimated schedule of program implementation.**
8. **Estimated costs of implementing each program.**

(The rest is omitted)

(2) Other Related Technical Information

- 5.8 Support Measures, Invías 2016-Manual de Túneles para Colombia
- Techinical Manual for Design and Construction of Road Tunnels – Civil Elements, 2009 FHWA, US DoT
- ASTM Volume 04.08 Soil and Rock(I):D420-D5876, ASTM Volume 04.09 Soil and Rock(II) D5877-Latest

(3) Methodology, Process and Procedure

1) Monitoring

The monitoring methods shall be selected in accordance with '5.7.4 Monitoring methods, Invías 2016-Manual de Túneles para Colombia'. The manual indicates the basic methods for monitoring the impacts including deformation and water pressure.

The points to be considered for planning of the monitoring are shown in table below;

Table C.2.2.8 The points to be considered for monitoring plan

Item	Points to be considered
Measurement items	➢ Clarify purposes of the measurement ➢ Importance of the target facility, level of the predicted impact, allowable limit of the impact
Accuracy	➢ Necessary accuracy of monitoring shall be secured for keeping the safety of target facility, need to compare actual behavior and allowance
Monitoring Location	➢ Estimated deformation area, importance of the target facility
Monitoring points	➢ Importance of the target facility, frequency ➢ Layout of construction facility
Monitoring methods	➢ Accuracy, measurement items, frequency ➢ Secure the construction safety
Monitoring period	➢ From : before having the impact by construction works To: After confirmation of the settling of impacts
Monitoring frequency	➢ Importance of the target facility ➢ Estimated progress rate of deformation
Management structure for monitoring	➢ Determination of the allowance for management ➢ Management and monitoring structure ➢ Assignment of monitoring manager, Establish of emergency

Item	Points to be considered
	network
Data collection and storage	➢ Utilizing for O&M, Feedback for the planning and design in the future, Further study

Regarding the planning of the monitoring, to make clear the objectives is the priority. Then the Items, Location & Number, Period & Frequency and allowance value are determined considering above points and need to be clearly mentioned in the document of monitoring plan. Additionally, the management plan for monitoring and safety control is important, the points below need to be determined before the beginning of the construction.

- Responsible person for monitoring and safety management
- Emergency network
- Responsible person for management of construction during emergency

2) Auxiliary Method

To considering the Auxiliary methods can be referred to '5.8 Support Measures, Invías 2016-Manual de Túneles para Colombia'. The Auxiliary method is developing by the contractors in the world, and many types are in practical use. For the selection of appropriate method, the points below are important.

- Clarify the cause and mechanism of the problem predicted
- Clarify the objective of the application of the method
- Determine the target performance of the method

Table C.2.2.9 shows the comparing table of auxiliary methods, and the purpose and the applicability of the methods can be confirmed in.

Table C.2.2.9 Comparing Table of Auxiliary Methods

Method			Purpose						Ground which method can be applied		
			Construction safety				Environmental preservation				
			Face stabilization			Groundwater control	Subsidence control	Neighboring structure protection			
			Crown stabilization	Face stabilization	Footing stabilization				Hard rock	Soft rock	Soil
	Presupport	Forepoling (filling, grouting)	X						X	X	X
Subsidence control	Presupport	Steel pipe forepiling (grouting)	X				X	X		X	X
Subsidence control	Presupport	Pipe roof	X				X	X		X	X
Subsidence control	Presupport	Horizontal jet grouting (injection and mixing)	X	X	X		X	X			X
Subsidence control	Presupport	Slit concrete method	X				X	X		X	X
Face	reinforcement	Face shotcrete		X					X	X	X
Face	reinforcement	Face bolt		X					X	X	X
Subsidence control	reinforcement	Long face bolt		X			X		X	X	X
Subsidence control	Footing reinforcement	Footing reinforcement bolt			X		X			X	X
Subsidence control	Footing reinforcement	Footing reinforcement pile			X		X			X	X
Subsidence control	Footing reinforcement	Temporary invert			X		X			X	X
Groundwater control	Drainage	Drainage boring	X	X	X	X			X	X	X
Groundwater control	Drainage	Well point	X	X	X	X					X
Groundwater control	Drainage	Deep well	X	X	X	X					X
Groundwater control	Drainage	Drainage drift	X	X	X	X			X	X	X
Subsidence control	Water searing	Grouting	X	X	X	X	X	X	X	X	X
Subsidence control	Water searing	Cut-off wall				X	X	X			X
Subsidence control	Ground reinforcement	Grouting	X	X				X	X		X
Subsidence control	Ground reinforcement	Vertical pre-reinforcement	X	X				X			X

Fig shows the selection chart for reference of the planning of auxiliary methods. After selection of the method, the study including structural analysis is required for the design. In the process, the specification of the method is determined in detail for avoiding the harmful impact to the environment due to construction. And the performance of the method need to be analyzed generally by numerical analysis method, and mentioned clearly in the EIA documents.

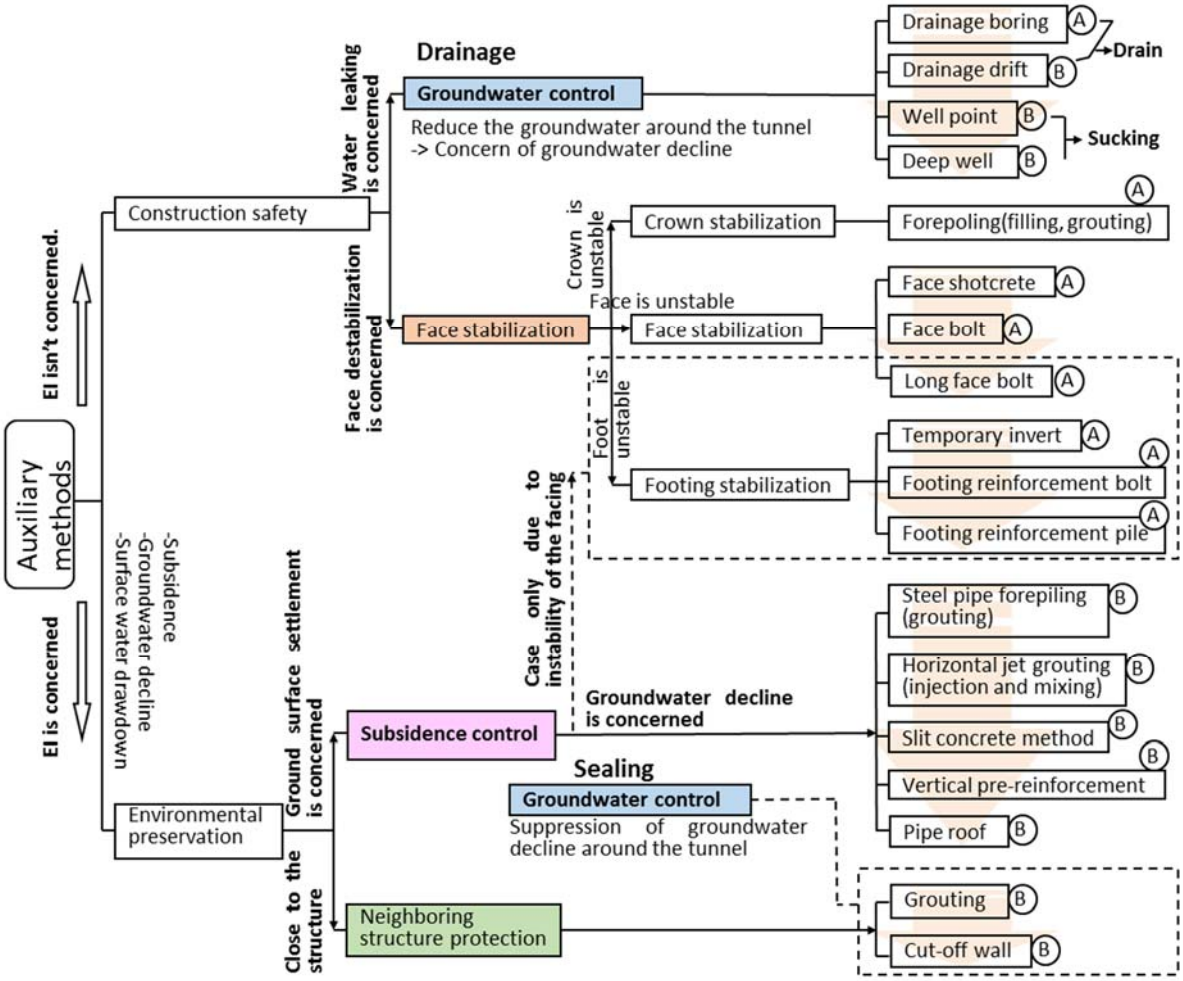


Figure C.2.2.10 Selection Chart of Auxiliary Methods

(4) Output

The output of the monitoring and mitigation measures should be summarized with the items as shown in Table C.2.2.10.

Table C.2.2.10 Sample of output

items		Remarks
Monitoring	Objective	Need to be mentioned clearly
	Monitoring Items	Deformation of the ground, water level, deformation of the tunnel section, etc
	Equipment and System	-
	Location & Number	-
	Period & Frequency	Shall be monitored before beginning of construction
	Allowance Values	Need to be determined for each monitoring item
	Management Plan	Responsible person, monitoring structure, emergency network
Auxiliary Method	Method selection	Objective, Method applied, Design drawings, etc
	Environmental impact estimated	Analysis results by numerical simulation

C.2.3 Geomorphology

C.2.4 Landscape

C.2.5 Soils and land use

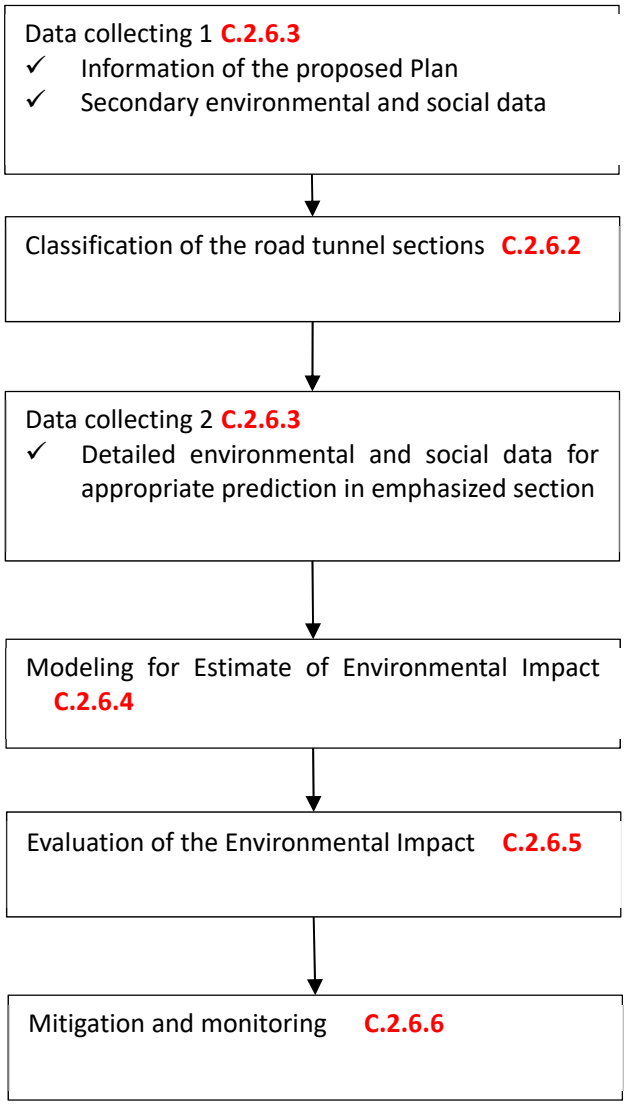
C.2.6 Hydrology

C.2.6.1 General

The content of this section presents the specific method of collecting and analysis on hydrology for EIA study. This section also introduces the countermeasures for environmental effect caused by road tunnel project and monitoring method on hydrology during constructing and after constructing.

(1) General workflow

The general workflow of hydrologic impact study shown in following diagram.



Overview	
The required Items of general information · Surface geological map · Drainage map · Protected area map · Road Plan drawing, Standard Road Section	
Dividing road tunnel into several sections and classifying each section to priority area or Non-Priority area.	
CLASS A Priority Area	CLASS B Non-Priority Area
More detailed data for numerical analysis · Meteorological data · Flow rate of drainage	Not required
· Rational method · Storage function model · Kinematic wave model · Series tank model	Qualitative analysis based on changes of surface ground conditions
· Evaluation based on the impact of daily life point of view · Evaluation of impact of precious nature point of view	
· Meteorological data · Flow rate of drainage	Not required

Figure C.2.6.1 Flowchart of the study on hydrological impact

(2) Estimated environmental impact

It is important to clarify the environmental and social impact caused by construction and operation of the tunnel for classification of the divided sections. The assumed environmental impacts on hydrology are shown below.

Table C.2.6.1 Estimated Impact on hydrology

From the daily life or livelihood point of view
· Drought of water source · Increase of flood · Decrease of irrigation water · Increase of disaster caused by storm water runoff ·
From the precious or protected nature point of view
· The loss or shrink of the protected wetland · Significant change of flow rate of river which have precious ecosystem ·
From the Occupational health and safety point of view
·

C.2.6.2 Classification of the investigation methods

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

4.AREAS OF INFLUENCE
4.2 DEFINITION, IDENTIFICATION, AND DELIMITATION OF THE AREA OF INFLUENCE
…

It is important to clarify that the result of the delimitation can be reflected in one or several polygons, by identifying the area of influence for each component, group of components or media.

The area of influence by component, group of components or medium should be based on units of analysis such as: watersheds, ecosystems, territorial units, and those identified by the applicant within the EIA. Each area of influence per component, group of components or medium, must have a minimum unit of analysis which must be properly supported.

(The rest is omitted)

(2) Other Related Technical Information

THE PRINCIPLES of ENVIRONMENTAL IMPACT ASSESSMENT BEST PRACTICE say that Environmental Impact Assessment should be focused. (INTERNATIONAL ASSOCIATION FOR IMPACT ASSESSMENT, 1996) The process of the EIA study should be concentrated on significant environmental effects and key issues. Therefore, it is recommended to identify the possible area or section of significant environmental effect.

(3) Methodology, Process and Procedure

(a) Area division

It is effective method for EIA study to make a concentrate on important area for environment and society. On hydrology, hydrogeology and water quality field, the catchment area of the stream/river which are crossing over the tunnel alignment can be used for this purpose. The conceptual images of the divided study areas are shown below figure. These colored catchments could be assumed as the affected area on hydrology, hydrogeology and water quality fields by tunnel construction. There is possibility to be extended study area by more detailed investigation through the EIA study.

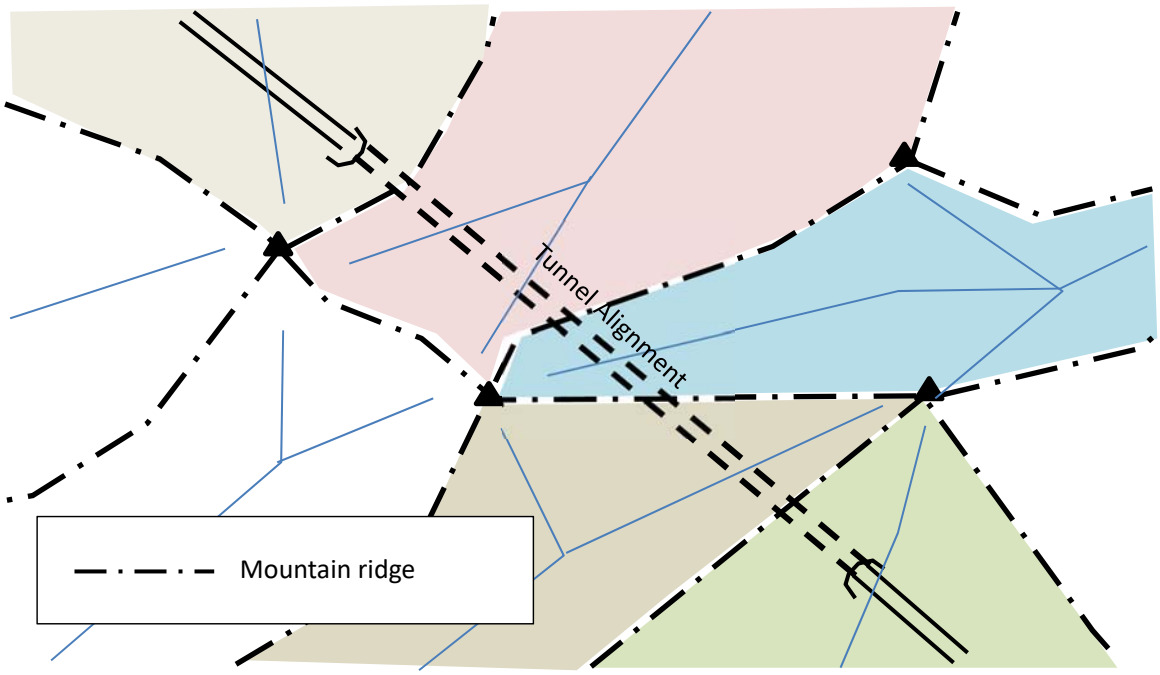


Figure C.2.6.2 Conceptual Image of the EIA study area dividing on Hydrology

(b) Data collecting range

(i) Comprehensive data collecting range

Comprehensive data should be collected for the grasping the object which would be received impact from tunnel project. (e.g. Location of the water intake, wetland where precious/ fragile species live in, etc.) On hydrology field, the comprehensive data could be gathered from the catchment area which is formed by small stream. It could be considered that the data collecting area is defined as the catchment of the small stream crossing tunnel alignment and its end is the point where small stream meet large river which have more than 3 times of flow quantity than the small stream.

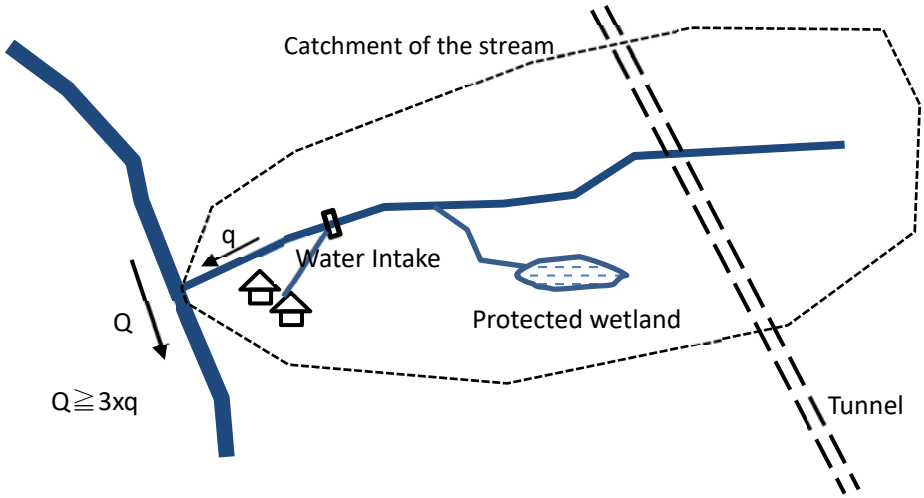


Figure C.2.6.3 Area of comprehensive data collecting

(ii) Data collecting range for analysis/modeling of the impact

In contrast with the comprehensive data, the detailed data for prediction of the environmental impact would be required. The data collecting range is usually don't need such a wide area as comprehensive data. There are some methods to set the range. Most easy method is to use fixed distance from tunnel alignment. On the EIA study guidelines in Japan, 1 km from the tunnel alignment or the distance to the mountain ridge line within 1km from tunnel alignment is used as a maximum affected width based on experience of EIA studies in Japan. The conceptual figure for dividing survey area is shown below.

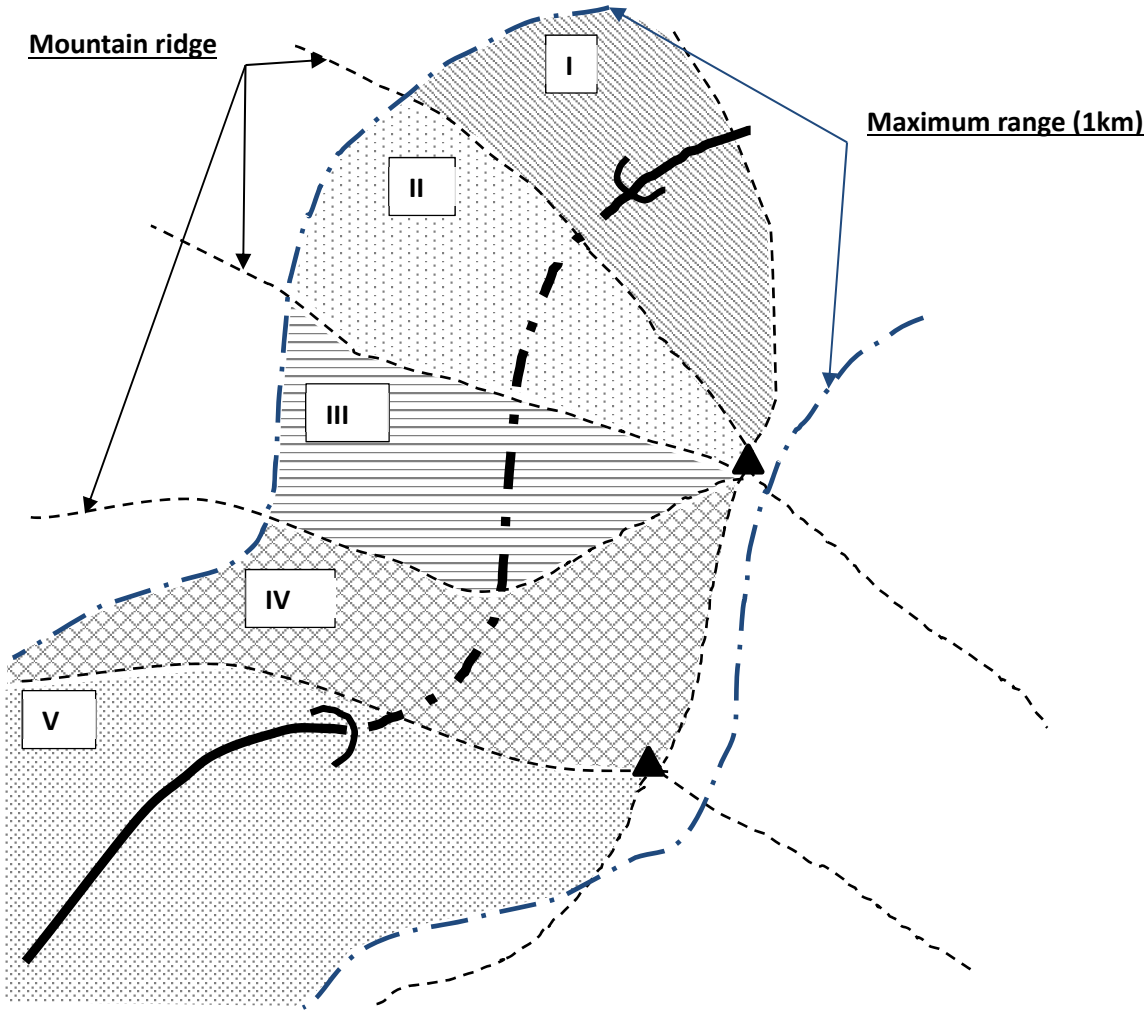


Figure C.2.6.4 Assuming affected area in Japan

Meanwhile, there is other analytic method to set the range. The Takahashi's Method is the one of this. Takahashi's method is developed in 1961 and this method is still using for tunnel design in Japan. On Takahashi's method, the hydrological method is usually used to set affected area of tunnel construction. This method is based on the idea of strong relation between affected area and topography. This method uses mean coefficient of permeability which is defined as:

$$k_t = \frac{R^2}{(6 \times H)}$$

where,

k_t: Mean coefficient of permeability

R: Width of the catchment area

H: Relative height of ground water

The mean coefficient of permeability is calculated by following process.

1. To measure the catchment area (A)
2. To measure the length of measure stream of the catchment (L)
3. The average width of catchment (R) is calculated (2R=A/L)
4. To divide catchment into n sections

5. To calculate mean height using below formula

$$\mathrm{Hm} = \left\{\frac{(H_{1R}+H_{1L})}{2} + \frac{(H_{2R}+H_{2L})}{2} + \cdots\right\} \div n$$

6. The mean coefficient of permeability is calculated ($k_t = R^2 / (6 \times H_m)$)

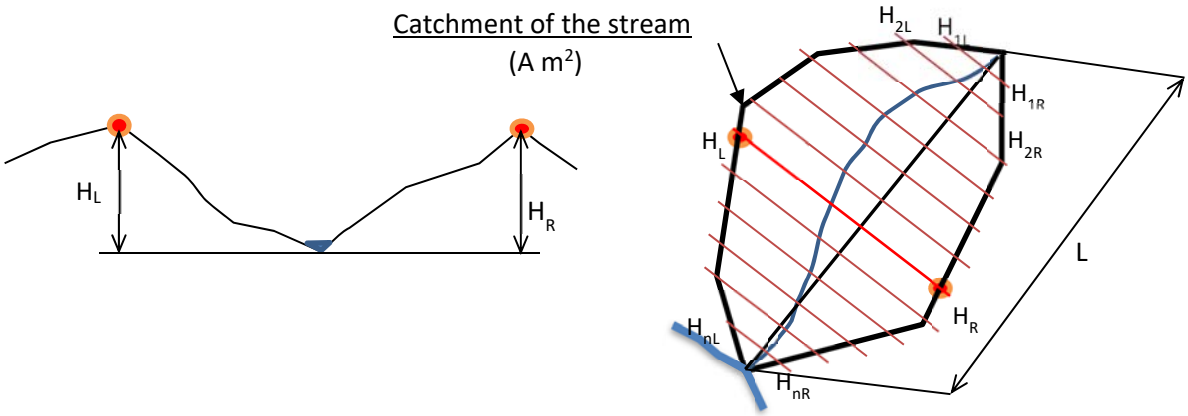


Figure C.2.6.5 Explanation of Takahashi's method

It is possible to obtain the affected width of each section using graphical method. The changed formula of mean coefficient of permeability is shown below.

$H_m = R^2 / (6 \times k_t)$

From drawing the relation of R and H into tunnel section drawing, the width of affected area is obtained graphically. The crossing point of H-R curve and topological line is the limit of affected area as below figure.

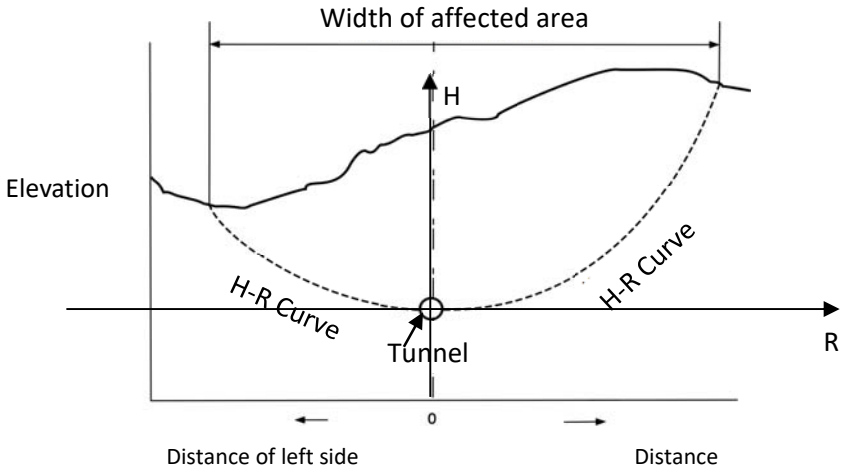


Figure C.2.6.6 Width of the affected area (Takahashi's Method)

The actual example of the Takahashi's method is shown below. This example is show the impact of the road tunnel construction to the surface water and groundwater around the tunnel. (Jiro Fujii (2003), Case study of the water environment impact assessment due to the road tunnel construction, Technical Forum of ZENCHIREN, Japan, https://www.web-gis.jp/e-Forum/2003/063.PDF) On this study, the affected area and impact to the flowrate of the small stream was assumed by the Takahashi's method.

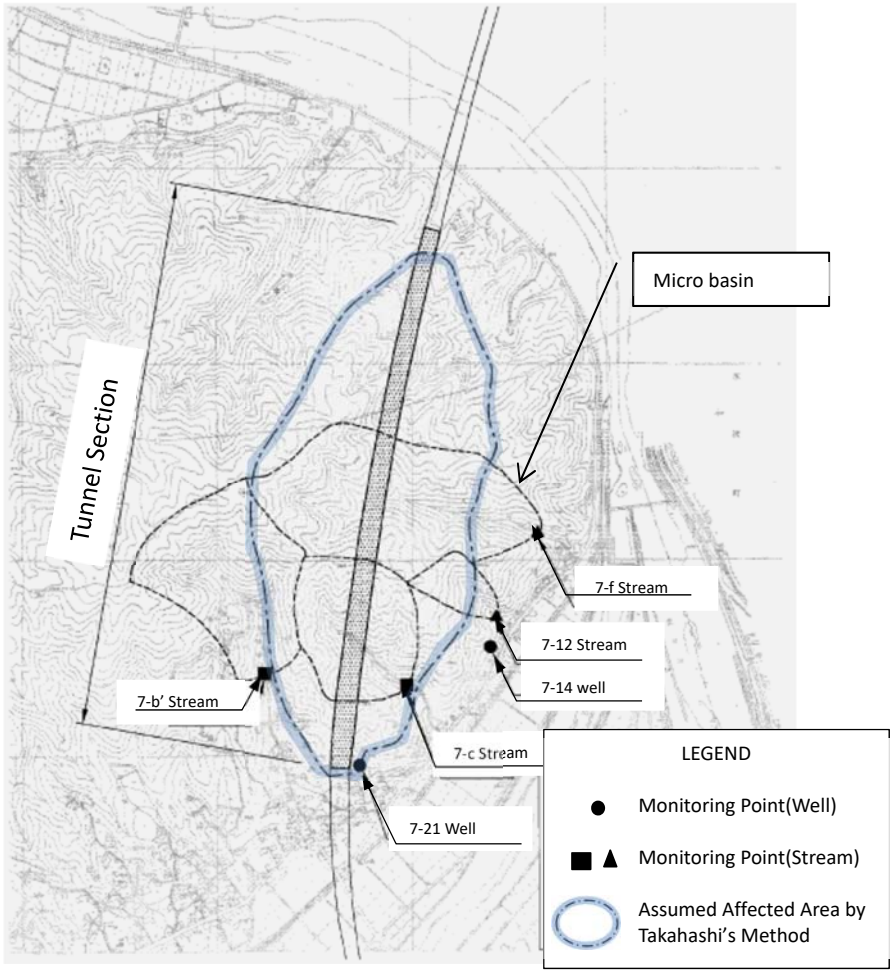


Figure C.2.6.7 Sample of the Takahashi's Affected method

The result of the flow rate in each monitoring point on dry season is shown below table.

Table C.2.6.2 Comparison between Estimation and Observation

Monitoring Point	Area of the micro basin (ha)	Monitored flowrate Before Construction (l/min)	Forecasted Value by Takahashi's method (l/min)	Monitored flowrate After Construction (l/min)
7-b'	15.1	20	13.95	18
7-c	10.1	30	0.00	5
7-12	2.2	2.5	1.00	2.5
7-f	18.6	30	5.99	27

From this case, it is supposed that estimated flow rate by Takahashi's method is the safe-side prediction.

(c) Classification

Many kinds of hydrological Impact from tunnel project could be assumed. However, most of the impact are related to the water flow changes. Basically, hydrological impact will be occurred by outflow from the tunnel and changing surface of ground. Therefore, the specific area which include outflow from the tunnel or changing by earthworks should be emphasized on EIA study. Following figure shows the outline of area classification. If changes of water flow would be assumed from the hydrogeological study in any area, it is possible to emphasize that area on EIA study.

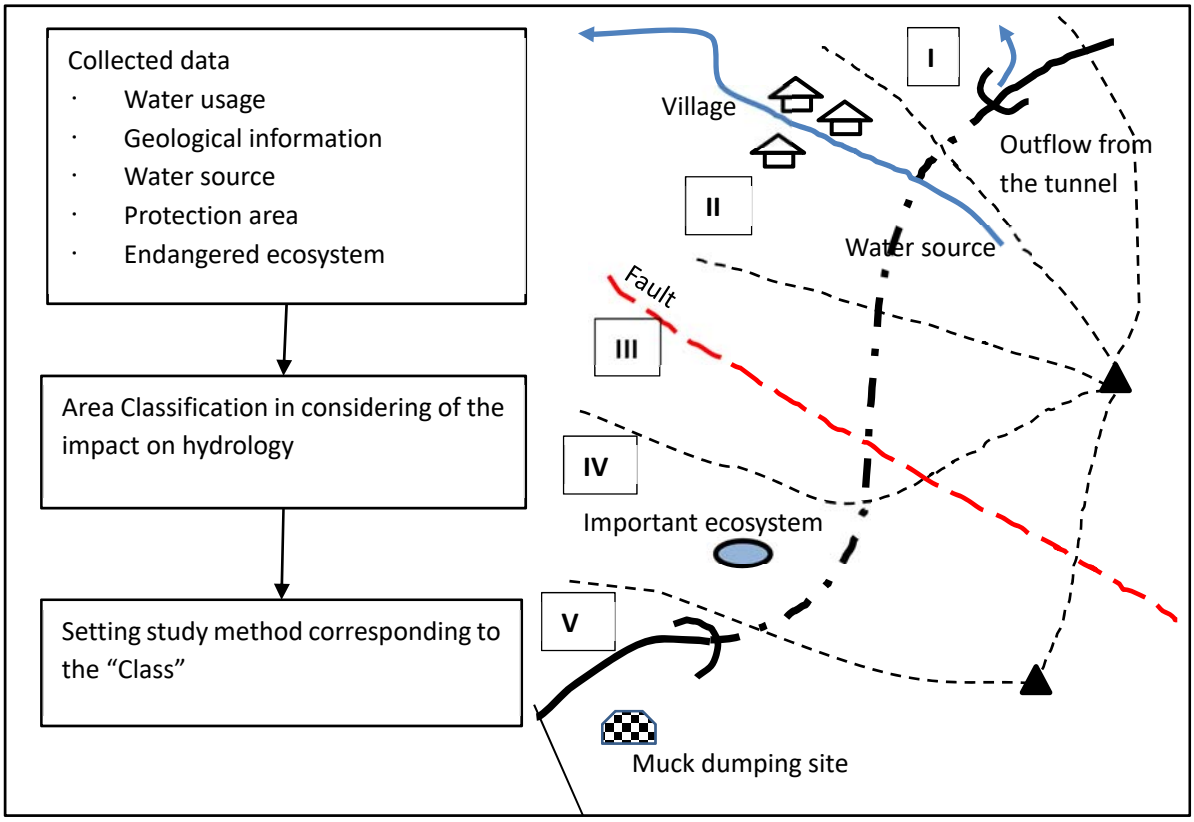


Figure C.2.6.8 Outline of Area Classification

(4) Output

The result of classification could be organized into table as shown below. The conditions, class and the reason of classification are described in this table.

Table C.2.6.3 Classification of Environmental Impact

Study Area	Conditions for hydrology				Class A	Class B	Remarks
	Outflow from the tunnel	Disposal site	Geological aspects	Ecological aspects			
I	✓				○		Outflow from the tunnel
II						○	Non-Outflow
III			✓			○	Non-Outflow
IV				✓		○	Non-Outflow
V		✓			○		Muck dumping

Study Area	Conditions for hydrology				Class A	Class B	Remarks
	Outflow from the tunnel	Disposal site	Geological aspects	Ecological aspects			
							site will change the surface-runoff conditions.

Note, Class A means it need elaborate method for survey, prediction and mitigation study.

C.2.6.3 Check list for required investigation items

(1) Referenced TOR

The items of investigation on EIA study can be classified corresponding to the area class. On the class "A" area, the detailed information will be required. On the other hand, comprehensive information in influence area is used for classification of the study area. (See section **C.2.6.2**) The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

5.1.5 Hydrology

For the area of influence of the component, the hydrological study should contain the following information:

1. **Identified lentic and lotic systems as well as watersheds within the area of influence of the component, including recharge zones, which should be located on 1: 25,000 scale maps or more detailed.**
2. **Marine and coastal systems within the area of influence of the component, which must be located on 1: 25,000 scale maps or more detailed.**
3. **Watersheds classified according to the structure established by IDEAM for the management and management of watersheds, contemplated in the National Policy for Integral Management of Water Resources. Description of the regional drainage patterns, the hydrological regime and the flow characteristics of major streams and those to be intervened from the historical or calculated daily data records of maximum, medium and minimum flows (or monthly, if No daily records). The presentation of the graphical summary of the flow series should be made using, as far as possible, box-and-whisker plots indicating the maximum, medium and minimum values and the main percentiles.**
4. **Description and location, through a scale map of 1: 25,000 or more detailed, of the hydrographic network and the type and distribution of drainage networks.**
5. **Identification of fluvial dynamics of the sources that may be affected by the project, as well as possible alterations to its natural regime (temporal and spatial relationship of floods).**
6. **Main morphometric characteristics of the hydrographic analysis units associated to the intervention points, as well as those associated with the information points used for the hydrological characterization.**

For the tunnel sections, the following information must be submitted:

7. **Detailed inventory of all inland water sources (lentic and lotic), as well as the internal and coastal marine waters that are in the area of influence of the component and possible connectivity with the tunnel.**
8. **Analysis of water dynamics and variations of its natural regime.**

9. Estimation of levels and characteristic flows of inventoried currents. Location of streams and water bodies in relation to the tunnel at 1: 10,000 scale or more detailed

(The rest is omitted)

(2) Other Related Technical Information

For the detailed analysis on hydrology, it is basically required to collect long term meteorological data such as above ten (10) years. It is necessary to collect the annual data (rainfall data) at least.

(3) Methodology, Process and Procedure

(a) Inventory of water sources

(b) Topographic information

(c) Meteorological information

(4) Output

The required information for each class is shown below table. (Check list)

Table C.2.6.4 Checklist of the required information

Survey items		Required items / parameters
General Information for classification	1. lentic and lotic systems	Watersheds and drainage basin
	2. Marine and coastal systems	Marine and coast
	3. Watersheds classified according to the structure established by IDEAM	Watersheds and drainage basin
	4. Hydrographic network and the type and distribution of drainage networks.	Distribution of drainage network
Information for detailed analysis on class A area	5. Identification of fluvial dynamics of the sources	Historical data or Analytical data of flood
	6. Main morphometric characteristics of the hydrographic analysis units associated to the intervention points	Topographic data, land use data, Distribution of plants
	7. Detailed inventory of all inland water sources	Drainage network, Flow rate, Representative river section and profile
	8. Analysis of water dynamics and variations of its natural regime	Depth, Width, Velocity, of the River based on the result of the hydraulic analysis
	9. Estimation of levels and characteristic flows of inventoried currents.	

C.2.6.4 Modeling for Estimate of Environmental Impact

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT

For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the

general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.
(The rest is omitted)

Hydrological analysis must be done on two stages (With and Without project) in accordance with this TOR. On without scenario, impact on hydrology must be forecast from the future developing plan which is changing river flow or land use proposed by government or private proponent.

(2) Other Related Technical Information

(3) Methodology, Process and Procedure

(a) CLASS A (Priority Area)

In the priority area, detailed analytic method should be taken. There are many hydrological analytic method, so analyst could select the way to conform with the purpose of analysis. The recommended method of impact analysis on hydrology is shown below table.

Table C.2.6.5 Analytic method on Hydrology

Level of analysis	Kind of the impact	Recommended analytic model
Level 1	• The kind of impact which is difficult to recover by current technology or existing method from the impact which is mentioned chapter 2.6.1. • The kind of impact which has complex conditions such as complex terrain. This kind of the impact is not fit to the simplified model.	• Numerical analysis with using GIS system • Storage function method • Tank Model
Level 2	• The kind of impact which is easier to recovery by current technology or existing method. • The kind of impact which has simple conditions.	• Rational Method (Water Balance Equation) • Qualitative method

More information of method for analysis are shown below table.

Table C.2.6.6 The detailed information of analysis method

The name of analysis method	Explanation
Qualitative method	In general, this method is used for small or little impact and the impact which is hard to analyze quantitatively. This method analyzes the impact from the change of conditions or other related information based on the experience of similar situations. On hydrologic field, if there is small change of runoff condition by the project, the impact could be predicted small qualitatively.
Rational Method (Water Balance Equation)	The rational method is a simple technique for estimating discharge from a small watershed. Application of the rational method is based on a simple formula that relates runoff-producing potential of the

The name of analysis method	Explanation
	watershed, the average intensity of rainfall for a particular length of time, and the watershed drainage area.
Tank Model	The tank model is the composed of few tanks laid vertically. These tanks have several side-outlets. The side outlets representing surface runoff, intermediate runoff and sub-base runoff. In general, it is not easy to define the coefficient of formulation for this model.
Storage function model	The concept of this model is to divide rainfall into the component of quick runoff and the component of slow runoff. The storage function is used for the representing of slow runoff component. This model gives the good result of analysis corresponding with real runoff but, it is not easy to define the formulation of the storage function.
Numerical analysis with using GIS system	In this method, the watershed is divided into many meshed small areas. This model also traces the runoff from the small area. This method usually calculated on the GIS system.

(b) CLASS B (Non Priority Area)

In the simplified area, it is not estimated significant impact, thus it is suitable to analysis by the qualitative method.

(4) Output

The result of the analysis could be organized as below and it must contain the two scenarios.

Table C.2.6.7 The result of the analysis

Scenario	The Result of the Analysis	Remarks (Condition)
Without Project	The frequency of annual flood at XX village … An average flow rate during wet season would be same as current situation.	
With Project	The increased frequency of annual flood at XX village … An average flow rate during wet season would be increased XX% from current situation.	

C.2.6.5 Evaluation of the Environmental impact

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT

For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.

(The rest is omitted)

8.1 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT-FREE SCENARIO

In the analysis of the impacts prior to the project, the activities that have had the greatest impact on the changes in the areas of influence must be identified. In addition, the current state of the medium (abiotic, biotic and socioeconomic) and its environmental sensitivity should be qualified and quantified, and the analysis of trends must be made, considering the regional and local development perspective, economic dynamics, and government plans, The preservation and management of natural resources and the consequences that the anthropic and natural activities of the region have for the ecosystems.

(The rest is omitted)

8.2 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT SCENARIO

Based on the environmental assessment for the project-free scenario and the ratings obtained for each impact, the impacts generated by the project on the environment should be identified, described and qualified as a result of the interaction between the activities of said environment and the components of each medium. It is worth noting that this assessment is done without taking into account the environmental management programs, given that, according to their significance, the Environmental Management Plan is formulated.

(The rest is omitted)

(2) Other Related Technical Information

There are two methods of evaluation for the impact assessment in Japan. The first is compare the result of forecast with national standard or national goals. The second is the evaluation from efficiency of the mitigation measures conducted by project implementer. It is important to judge from the effort of project implement agency.

(3) Methodology, Process and Procedure

If national standard or local standard for hydrology is existed, these standards could be used for evaluation of environmental impact. In case of no official standards, it is appropriate to use degree of influence. As an example, it is conceivable to use frequency of the flood. If the increase of flood frequency with project scenario is less than XX% over the frequency without project scenario, it would be acceptable.

(4) Output

The result of the evaluation could be organized as below.

Table C.2.6.8 The result of the evaluation

The Result of the evaluation
The frequency of annual flood at XX village with project scenario would be predicted to excess XX% over frequency without project scenario. Therefore, it would be evaluated as small impact on hydrology.

C.2.6.6 Mitigation and monitoring

(1) Referenced TOR

(a) Environmental Management Program

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.1 Environmental Management Program
…

An Environmental Management Plan (PMA) must be presented, structured in programs and subprograms (when required) and based on the hierarchy of management of potential identified impacts, considering as a first option measures for preventing and avoiding the occurrence of impacts; In the second option, measures to mitigate and/or minimize said impacts; Measures to correct or restore environmental conditions and, finally, compensatory measures will be considered.

For the identified impacts, environmental management measures should be considered taking into account that the same measure can be applied to the management of different impacts and that an impact can be managed through different measures.

The approach of programs, subprograms and measures should focus on comprehensive control of environmental impacts; For such purpose, it must be considered that there may be impacts that occur in different environments (for example, contamination of the surface water resource can affect elements of the abiotic, biotic and socioeconomic environments) and / or components (for example, the traditional economic activities of the population may affect the economic, demographic, cultural, etc.).

The PMA programs must specify:

9. **Objective(s) of each program and subprogram.**
10. **Goals related to identified objectives.**
    Indicators that allow monitoring of the achievement of the goals proposed for each objective, as well as to determine the effectiveness of each program and subprogram.
11. **Impacts to be managed by each program (based on impact assessment). Phase(s) of the project in which each program and subprogram would be implemented.**
12. **Application location (s) (cartographic location where possible).**
13. **Description of management measures (specific actions) to be developed within each program and subprogram, specifying the type of measure (prevention, mitigation, correction and compensation).**
14. **List of proposed works to be implemented. The designs must be presented as documents annexed to the EIA.**
15. **Estimated schedule of program implementation.**
16. **Estimated costs of implementing each program.**

(The rest is omitted)

(b) Monitoring and Tracing

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.2 Monitoring and Tracking Plan
…

a. Tracking and monitoring of plans and programs
For such purpose, the plan must precise of:

1. **Actions to be developed to obtain the information and/or data to calculate the indicators proposed in the PMA.**
2. **Criteria used for the approach of each indicator.**
3. **Frequency of measurement.**
4. **Justification of the representativeness of the indicator raised, as well as the information used for its calculation.**

b. Tracking and monitoring the trend of the medium
For the tracking and monitoring of the environmental components, the plan must include at least:

1. **Objectives.**
2. **Environmental components to monitor.**
3. **Indicators (quantitative and qualitative) aimed at establishing changes in the trend of the medium, specifying what is intended to be measured and monitored with each one.**
4. **Location of monitoring sites, with the respective cartographic location, when applicable.**
5. **Identification of management measures that affect the trend of the medium.**
6. **Description of the procedures used to measure the trend of the medium, relating the necessary instruments.**
7. **Frequency and duration of the monitoring.**
8. **Criteria for analysis and interpretation of results.**

(The rest is omitted)

(2) Other Related Technical Information

In Japan, the purpose of monitoring is adjusting the method of mitigation measures which did not have enough information for efficiency at the time of EIA study. In the case of this, contractor or implementer must collect the information about efficiency of mitigation measures and modify the method for more valid way.

(3) Methodology, Process and Procedure

(a) Environmental Management Program

Counter measures for environmental and social impact should be selected preventing or avoiding measures at first. In general, these preventing or avoiding measures could be selected at DAA study. If it is difficult to avoid or prevent the impacts at the time of EIA study, mitigation measure should be implemented as a second option.
The general process of selecting mitigation measure on hydrology is shown below figure.

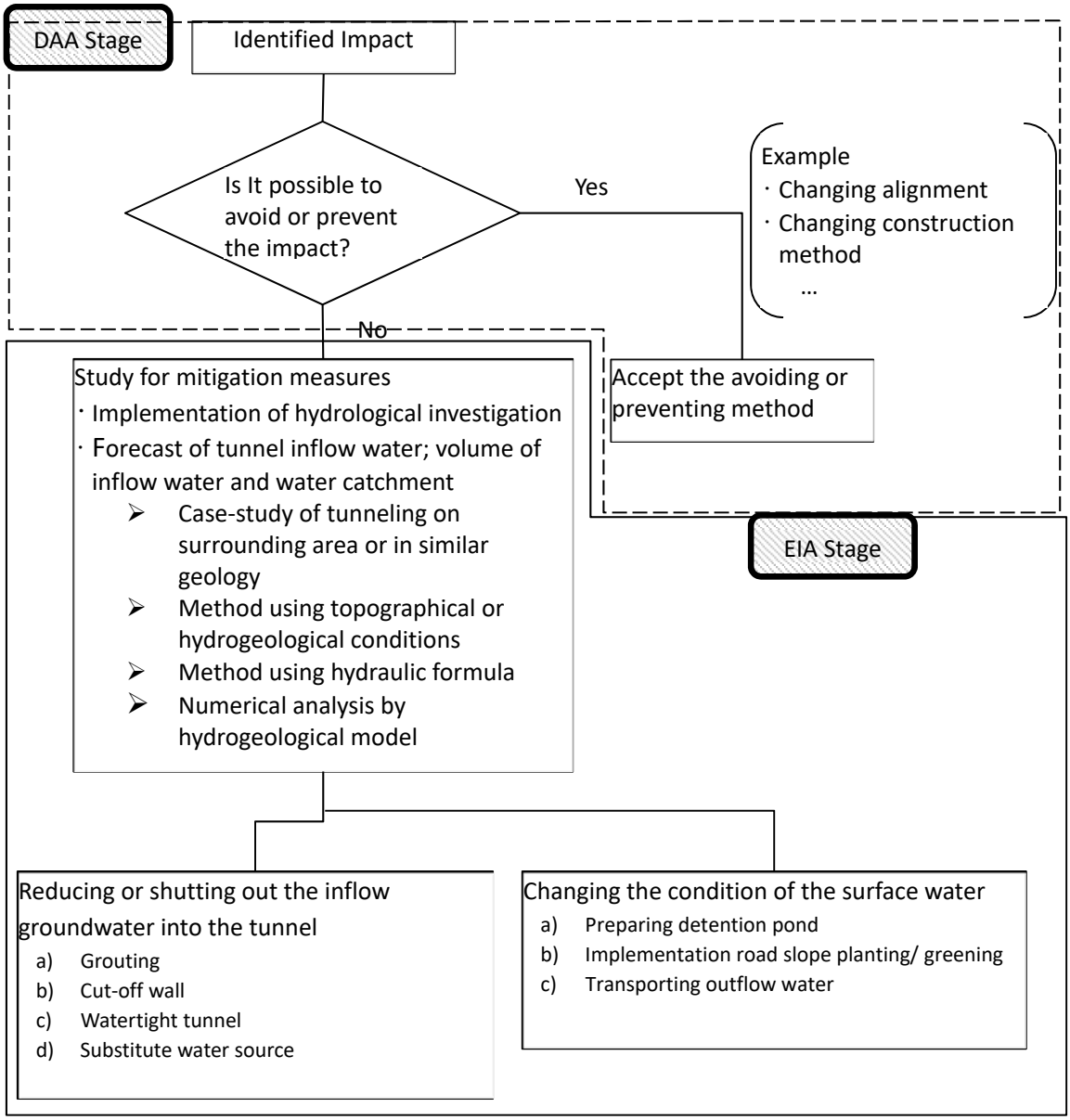


Figure C.2.6.9 Flow diagram of the mitigation measure study on Hydrology

The general information for mitigation measures of reducing or shutting out the inflow into the tunnel are below. (See the Subsection C.2.10 geotechnics for more detailed information)

Table C.2.6.9 General information for mitigation measures of reducing or shutting out the inflow

a) Grouting Grouting is the method of Injecting grout material into interconnected pore or void of ground to reduce water flow.
b) Cut-off wall This method is the installing steel or concrete wall around the tunnel alignment to control volume of inflow.
c) Watertight tunnel Waterproof is applying at entire circumference of tunnel to shut out inflow water after completion of construction
d) Substitute water source: new construction of well and water supply reservoir

(b) Monitoring and Tracing

(i) Tracking and monitoring of plans and programs

The flow diagram of monitoring for PMA is shown below figure.

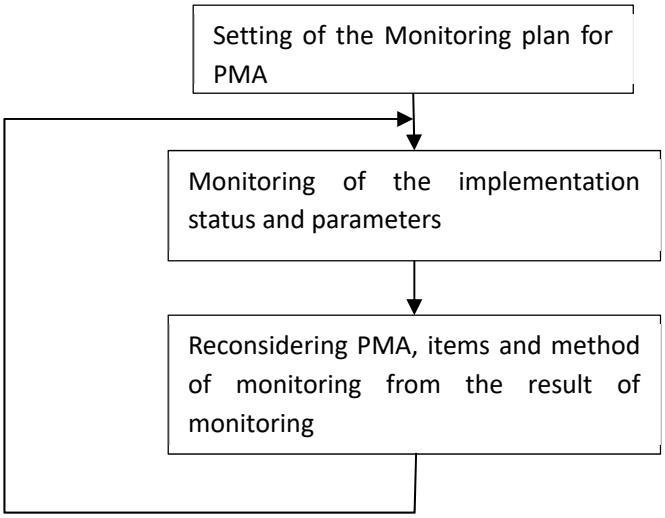


Figure C.2.6.10 Flow diagram for PMA monitoring

(ii) Tracking and monitoring the trend of the medium

The impact on hydrology is caused from water flow. Therefore, the flow rate should be monitored. The example of the monitoring item is below table.

Table C.2.6.10 Monitoring Item

Monitoring item	Parameter	Monitoring Method
Stream(River) flow	Flow rate (m^3/h)	Location: It is better to measure at the most downstream of affected catchment. Frequency: Successive 12 months (Including dry and wet season) Method: Self recorded type water gauge
Inflow into the Tunnel	Flow rate (m^3/h)	Location: The flow channel in the tunnel Method: Self recorded type water gauge

(4) Output

(a) Environmental Management Program

In general, some measures exist on hydrological field for preventing or mitigating impact from tunnel construction. On Environmental management program, the more efficient and enablable measures should be selected as countermeasures for environmental impact. The result of consideration should also contain the items which are restricted in TOR for EIA. Here is example of form on hydrological countermeasures.

Table C.2.6.11 Environmental Management Program on hydrology

Id	Counter measure	1.Objective	2.Effectiveness/ Indicator of effect	3./7.Implementation period/ Phase	4.Implementation area / location	5./6.Management measures	8.Estimated costs	Remarks
1								
2								
3								
4								
5								
6								
7								

(b) Monitoring and Tracing

(i) Tracking and monitoring of plans and programs

The required information according to the TOR should be collected. Here is example form of monitoring plan.

Table C.2.6.12 PCM monitoring plan

Mitigation measure	Outline of the mitigation measure	The Index or parameter of monitoring	criteria	Frequency of the monitoring

(ii) Tracking and monitoring the trend of the medium

C.2.7 Water quality

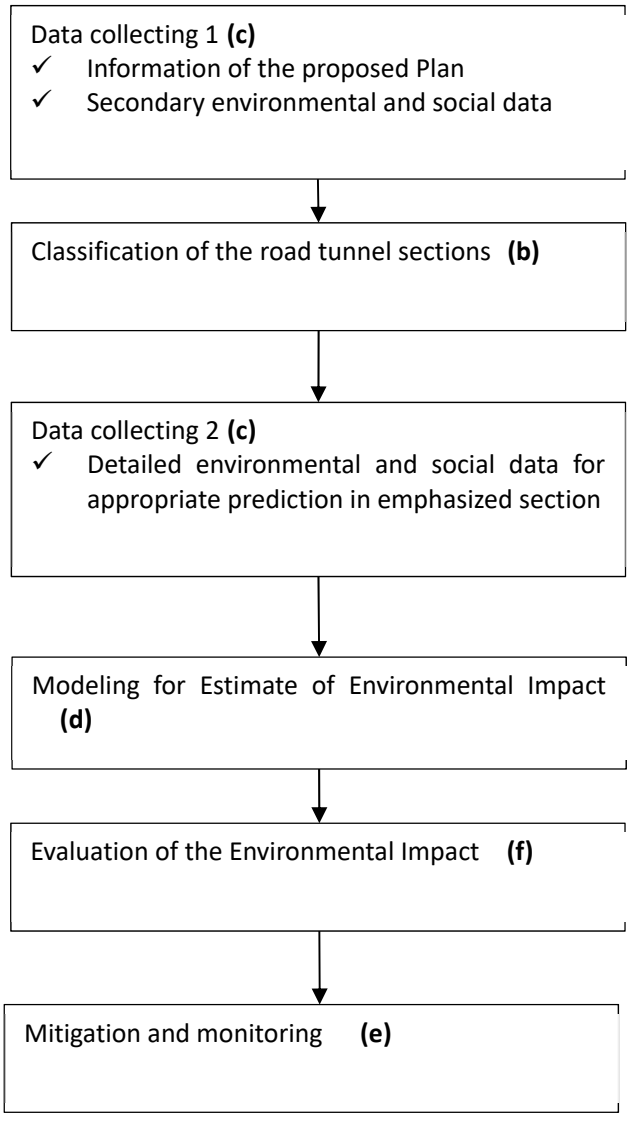
C.2.7.1 General

C.2.7.2 Inland water bodies

(1) General

The content of this section presents the specific method of collecting and analysis on water quality for EIA study. This section also introduces the countermeasures for environmental effect caused by road tunnel project and monitoring method on water quality during constructing and after constructing.

(a) General Workflow



Overview	
The required Items of general information · Surface geological map · Drainage map · Protected area map · Road Plan drawing, Standard Road Section · Muck dumping site (including temporary strage site and embankment which made of muck)	
Dividing road tunnel into several sections and classifying each section to prioritized section or Non-Priority section.	
CLASS A Priority Area	CLASS B Non-Priority Area
More detailed data for numerical analysis · Meteorological data · Flow rate of drainage and river · Surface / ground water quality data · Soil / rock quality data	Not required
· Mass balance analysis · Qualitative analysis based on mitigation measures	Qualitative analysis
· Evaluation based on the impact of daily life point of view · Evaluation of impact of precious nature point of view	
· Meteorological data · Water quality and flow rate of drainage and river water. · Water quality of ground water.	Not required

Figure C.2.7.1 Flowchart of the study on water quality impact

(b) Estimated environmental impact

It is important to clarify the environmental and social impact caused by construction and operation of the tunnel for classification of the divided sections. The assumed environmental impacts on water quality are shown below.

Table C.2.7.1 Estimated Impact on water quality

From the daily life or livelihood point of view
· Excess of environmental standards · Excess of drinking water standards · Adverse effects on agriculture, livestock and /or recreational use.
From the precious or protected nature point of view
· The loss or shrink of the protected wetland · Significant change of water quality of water body which have precious ecosystem
From the Occupational health and safety point of view
·

(2) Classification of the investigation methods

(a) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

4.AREAS OF INFLUENCE
4.2 DEFINITION, IDENTIFICATION, AND DELIMITATION OF THE AREA OF INFLUENCE
…

It is important to clarify that the result of the delimitation can be reflected in one or several polygons, by identifying the area of influence for each component, group of components or media.

The area of influence by component, group of components or medium should be based on units of analysis such as: watersheds, ecosystems, territorial units, and those identified by the applicant within the EIA. Each area of influence per component, group of components or medium, must have a minimum unit of analysis which must be properly supported.

(The rest is omitted)

(b) Other Related Technical Information

THE PRINCIPLES of ENVIRONMENTAL IMPACT ASSESSMENT BEST PRACTICE say that Environmental Impact Assessment should be focused. (INTERNATIONAL ASSOCIATION FOR IMPACT ASSESSMENT, 1996) The process of the EIA study should be concentrated on significant environmental effects and key issues. Therefore, it is recommended to identify the possible area or section of significant environmental effect.

(c) Methodology, Process and Procedure

a) Area division

It is effective method for EIA study to make a concentrate on important area for environment and society. On hydrology, hydrogeology and water quality field, the catchment area of the stream/river

which are crossing over the tunnel alignment can be used for this purpose. The conceptual images of the divided study areas are shown below figure. These colored catchments could be assumed as the affected area on hydrology, hydrogeology and water quality fields by tunnel construction. There is possibility to be extended study area by more detailed investigation through the EIA study.

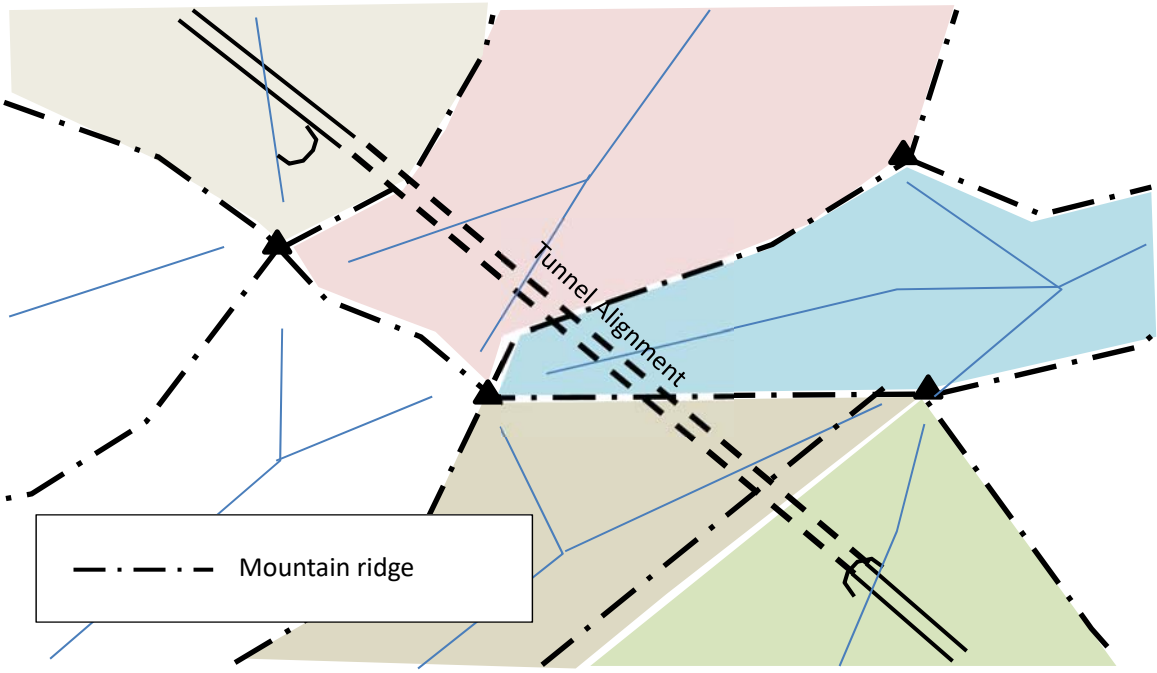


Figure C.2.7.2 Conceptual Image of the EIA study area dividing on Water quality

b) Data collecting area

(i) Comprehensive data collecting area

Comprehensive data should be collected to grasp the object which would be received impact from tunnel project. (e.g. Location of the water intake, wetland where precious/ fragile species live in, etc.) On Water quality field, the comprehensive data could be gathered from the catchment area which is formed by small stream. It could be considered that the data collecting area is defined as the catchment of the small stream crossing tunnel alignment and its end is the point where small stream meet large river which have more than 3 times of flow quantity than the small stream. The rate of flow quantity can be assumed by the rate of catchment area.

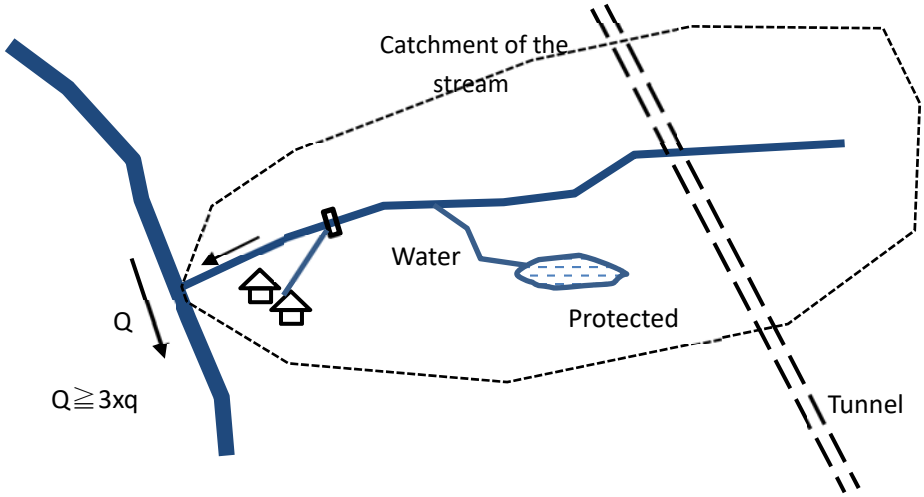


Figure C.2.7.3 Area of comprehensive data collecting

(ii) Data collecting area for analysis/modeling of the impact

In contrast, the prediction of the environmental impact need detail data. The area for collecting this data is usually don't need such a wide area. There are some ways to set this area. Most easy method is to use fixed distance from tunnel arraignment. On the EIA study guidelines in Japan, 1 km from the tunnel alignment is used as a maximum affected width based on experience of EIA studies in Japan. The conceptual figure for dividing survey area is shown below.

One method for classification is dividing survey area and classifying each survey area. Basically, it makes sense using watershed for dividing area on hydrology. The conceptual figure for dividing survey area is shown below. This shows the basic idea of area division so it is possible to extend corresponding to the any condition or situation.

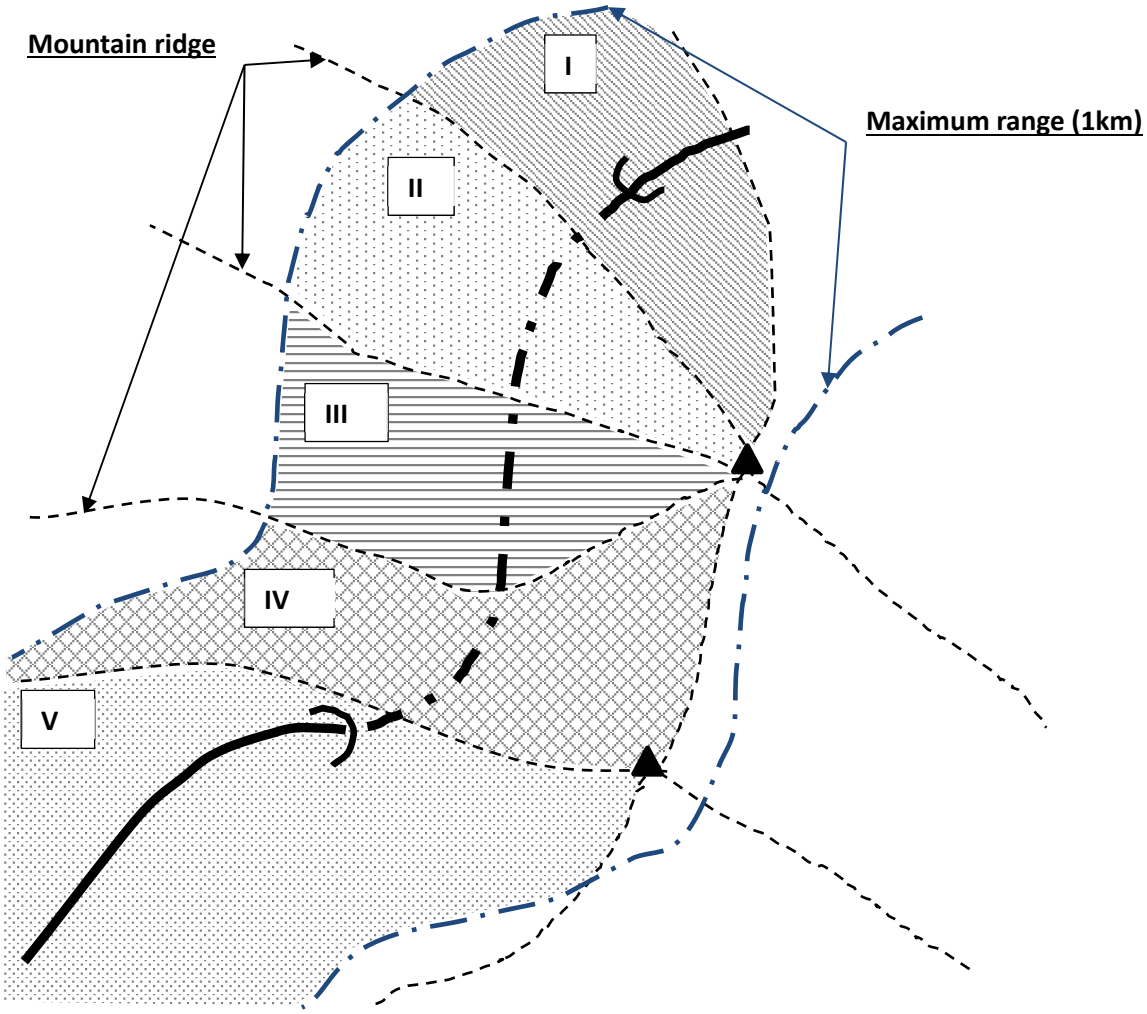


Figure C.2.7.4 Assumed affected area in Japan

c) Classification

Many kinds of water quality Impact from tunnel project could be assumed. However, most of the impact are related to the source of pollution. Basically, water quality impact will be occurred by outflow from the tunnel and leachate muck. Therefore, the specific area which include outflow from the tunnel or leachate from muck would be come out should be emphasized on EIA study. Following figure shows the outline of area classification. If changes of water quality would be assumed in any area, it is possible to emphasize that area on EIA study.

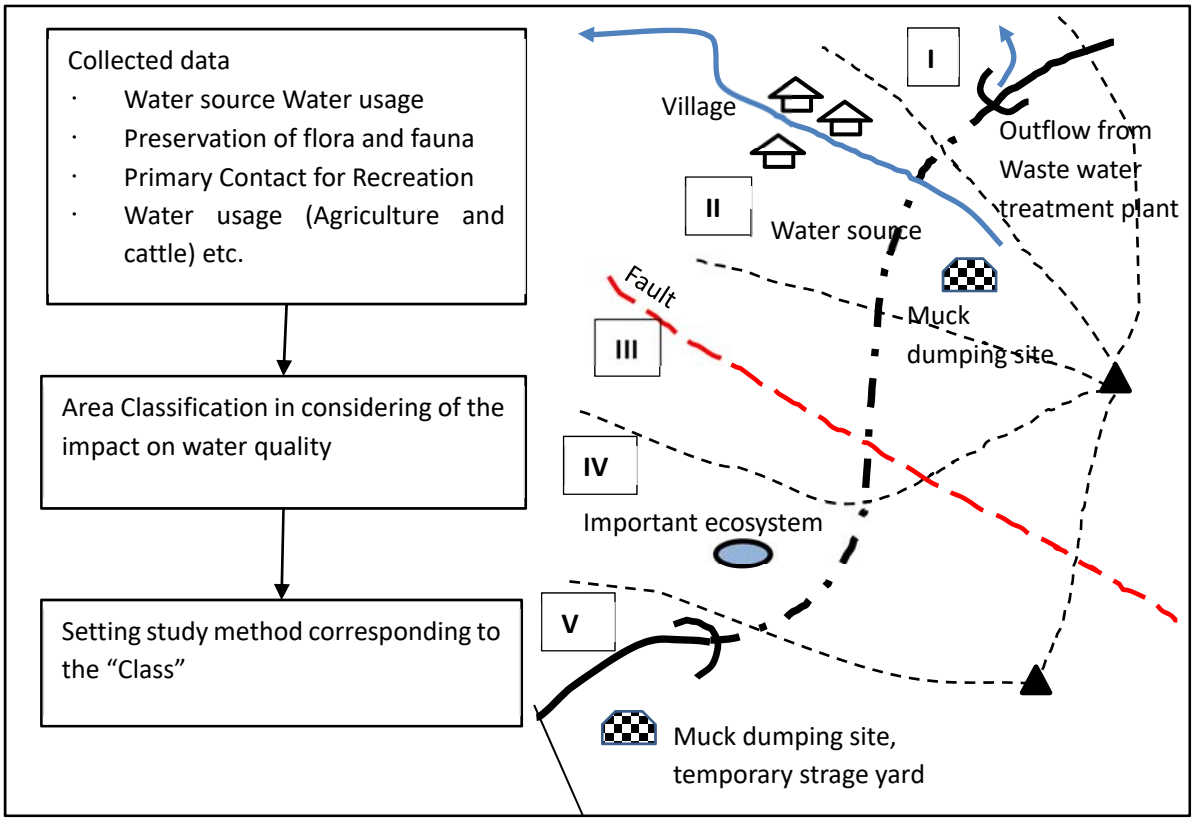


Figure C.2.7.5 Outline of Area Classification

(d) Output

The result of classification could be organized into table as shown below. The conditions, class and the reason of classification are described in this table.

Table C.2.7.2 Classification of Environmental Impact

Study Area	Conditions for water quality				Class A	Class B	Remarks
	Outflow from the tunnel	Disposal site	Water use	Ecological aspects			
I	✓				○		Outflow from the waste water treatment plant
II		✓	✓		○		Leachate from muck dumping site
III						○	Non-Outflow
IV				✓		○	Non-Outflow
V		✓			○		Leachate from muck dumping site

Note, Class A means it need elaborate method for survey, prediction and mitigation study.

(3) Check list for required investigation items

(a) Referenced TOR

The items of investigation on EIA study can be classified corresponding to the area class. On the class "A" area, the detailed information will be required. On the other hand, comprehensive information in influence area is used for classification of the study area. (See section **(b)**) The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

5.1.6 Water Quality

5.1.6.1 Inland Water Bodies

The physicochemical and bacteriological characterization of the water currents of the area of influence of the component must be completed, susceptible of intervention by the project (concession or dumping); And of bodies of water that are of use for human and domestic consumption (ministry of law) or water concession in the sections of the area of influence of the hydro component (Hydrographic Subzones or their subsequent level and to the Micro-watersheds according to the established classification by IDEAM). The two (2) climatic periods (dry season and rainy season) must be considered, presenting in the EIA the corresponding one to the elaboration period of the same and presenting estimates for the other period through duly validated technical tools. Before starting the construction, the verification of the presented estimate must be carried out, by means of primary information (sampling and characterizations). This will be validated by the environmental authority.

The sampling sites should be georeferenced and their representativeness must be justified, in terms of spatial and temporal coverage. These serve as a basis for establishing the monitoring of the water resource during the construction of the project.

The methods, techniques and periodicity of the samples must be presented, analyzing the water quality based on the correlation of the physicochemical and hydrobiological data.

As a minimum, the parameters established in the following table must be characterized:

Table 5 List of the physicochemical parameters to be measured to characterize water bodies, according to the use and use proposed to give the same with the development of the project and those that are of use for human consumption and domestic or water concession

(Table 5 is omitted)

The calculation of the Langelier index and Buffer Capacity (Tampon) of the water body must be carried out in order to implement the respective environmental management measures.

The Water Quality Index (ICA) and the Water Quality Potential Alteration Index (IACAL) should be estimated for the flows corresponding to the Hydrographic Subzones (according to the classification established by IDEAM for the management and Watershed management). The main tributary water bodies and those that have concessions for human, domestic, agricultural, livestock and / or recreational use should be included in the analysis.

The characterization of the water quality, the sediment layer and the water contained in these sediments on the receiving body and the main tributaries and abstractions should be carried out following a sampling program (using the time Calibrated trip), where the same mass of water flowing

downstream is followed, to reduce the uncertainty due to the temporary variability of the discharges on the body of water.

The samples taken must be of integrated type in the depth and in the cross section, following the guidelines established by the IDEAM. The water quality assessment should follow the guide for monitoring of water, prepared by IDEAM, INVEMAR and DANE, or that which modifies, replaces or repeals it.

All water quality samplings must be performed thprough laboratories accredited by IDEAM, or the entity responsible for their accreditation, both for sampling and for parameter analysis. In case there are no accredited laboratories for the analysis of a parameter, the laboratories accredited by IDEAM can send the sample to an international laboratory accredited in their country of origin or by an international standard, while the accreditation process is in place in the laboratories Countries.

(b) Other Related Technical Information

a) Survey period

For the detailed analysis on water quality, it is basically required to collect long term observational data such as above ten (10) years. It is necessary to collect the data including dry season and rainy season at least.

b) Sampling site

Sampling site should be set not only evaluation point (e.g. Water intake point) but also upstream of discharge point. Upstream of discharge point would be an important point to evaluate the impact from the tunnel project after construction phase.

c) Survey items

Flow rate should be measured because it has significant effect on water quality.

In Japanese case, fluorine (F) and boron (B) are measured as environmental pollutants which are originating from nature. Please refer the example of Japanese regulated pollutants from natural source at end of this subsection.

It is important to determine survey items in relation to factors that may cause pollution.

Table C.2.7.3 Factors of impact to water quality and survey items

Project phase	Material	Survey items (chemical analysis)				Activity
		SS	Alkaline (high pH)	Acid (low pH)	Metals and metalloids (nature originated)	
Construction	Soil	✓				Earth Works such as muck disposal
	Cement	✓	✓		✓	Cement Works such as Grouting
	Groundwater		✓	✓	✓	Exavation -> Inflow Water
Operation	Groundwater		✓	✓	✓	Continuing Inflow Water
	Muck			✓	✓	Muck disposal

Shading: pollutants are originated from natural sources. Until completion of the construction, it is difficult to judge whether pollution occurs or not. It is important to continue judging by chemical analysis of Inflow water, excavated muck and cement regularly.

(c) Methodology, Process and Procedure

a) Characterization of water quality for each hydro component
b) Justification of the sampling site
c) Presentation of the methods, techniques and periodicity of the sample
d) Calculation of the Langelier index and Buffer Capacity
e) Estimation of ICA and IACAL
f) Order of sampling (using the time Calibrated trip)
g) Sampling method
h) Water quality assessment
i) Sampling and parameter analysis done by accredited laboratories
j) (added to the existing TOR) ground water quality analysis, soil / rock quality analysis, acidification test
k) (added to the existing TOR) flow regime

(d) Output

The required information for each class is shown below table. (Check list)

Table C.2.7.4 Checklist of the required information

Survey items		Required items / parameters
General Information for classification	—	Site of discharge point of effluent, disposal / temporary storage of muck.
	—	Water intake point, recreational use zone.
Information for detailed analysis on class A area	1. Characterization of water quality for each hydro component	Result of characterization of water quality for each hydro component
	2. Justification of the sampling site	Mapping the sampling site Sampling frequency
	3. Presentation of the methods, techniques and periodicity of the sample	Methods, techniques and periodicity of the sample Analyzing water quality data based on the correlation of the physicochemical and hydrobiological data
	4. Calculation of the Langelier index and Buffer Capacity	Langelier index Buffer Capacity
	5. Estimation of ICA and IACAL	Water quality index (ICA) Water quality potential alteration index (IACAL)
	6. Order of sampling (using the time Calibrated trip)	Result of sampling order
	7. Sampling method	Sampling method in accordance with guidelines established by the IDEAM

Survey items		Required items / parameters
	8. Water quality assessment	Water quality assessment in accordance with guide prepared by the IDEAM, INVEMAR and DANE
	9. Sampling and parameter analysis done by accredited laboratories	Name of laboratories which conducted sampling and /or analysis Certification ID of laboratories
	10. ground water quality analysis, soil / rock quality analysis, acidification test	Result of ground water quality analysis, soil / rock quality analysis, acidification test
	11. flow regime	Flow rate of the river Intake point, discharge point Tributary

(4) Modeling for Estimate of Environmental Impact

(a) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT
For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.
(The rest is omitted)

Water quality analysis must be done on two stages (With and Without project) in accordance with this TOR. On without scenario, impact on water quality must be forecast from the future developing plan which is changing water quality proposed by government or private proponent.

(b) Other Related Technical Information

(c) Methodology, Process and Procedure

a) CLASS A (Priority Area)

In the priority area, analytic method should be taken, but except for effluent from waste water treatment plant, it is rare that conditions for quantitative prediction can be set (e.g. volume and concentration of leachate). So, there is a possibility to apply qualitative method in the priority area. The recommended method of impact analysis on water quality is shown below table.

Table C.2.7.5 Analytic method on Water quality

Level of analysis	Kind of the impact	Recommended analytic model
Level 1	• The kind of impact which is difficult to recover by current technology or existing method from the impact which is mentioned chapter (a)	• Mass balance equation • Qualitative method
Level 2	• The kind of impact which is easier to recovery by current technology or existing method.	• Qualitative method

More information of method for analysis are shown below table.

Table C.2.7.6 The detailed information of analysis method

The name of analysis method	Explanation
Qualitative method	In general, this method is used for small or little impact and the impact which is hard to analyze quantitatively. This method analyzes the impact from the change of conditions or other related information based on the experience of similar situations. On water quality field, quantitative method is applicable to the case that can avoid environmental impacts by mitigation measure.
Mass balance equation	The concept of this equation is the principle of conservation of mass. Mass balance equation can consider generation and consumption term, but in case of water quality prediction of tunnel projects, it is no use considering these terms. Simple mass balance equation is recommended where complete mixing of the inflow with the river water. $C_d = (Q_uC_u + Q_iC_i) / (Q_u + Q_i)$ Where C_d is calculated concentration Q_u is flow rate of upstream of inflow C_u is concentration of upstream of inflow Q_i is flow rate of inflow C_i is concentration of inflow In case of calculation of pH, buffer capacity can also be considered.

b) CLASS B (Simplified Area)

In the simplified area, it is not assumed significant impact, thus it is suitable to analysis by the qualitative method.

(d) Output

The result of the analysis could be organized as below and it must contain the two scenarios.

Table C.2.7.7 The result of the analysis

Scenario	The Result of the Analysis	Remarks (Condition)
Without Project	The concentration of XX at YY point…	
With Project	The concentration of XX at YY point…	

(5) Evaluation of the Environmental impact

(a) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT

For the identification and evaluation of environmental impacts, it is necessary to characterize the areas

of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.
(The rest is omitted)

8.1 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT-FREE SCENARIO
In the analysis of the impacts prior to the project, the activities that have had the greatest impact on the changes in the areas of influence must be identified. In addition, the current state of the medium (abiotic, biotic and socioeconomic) and its environmental sensitivity should be qualified and quantified, and the analysis of trends must be made, considering the regional and local development perspective, economic dynamics, and government plans, The preservation and management of natural resources and the consequences that the anthropic and natural activities of the region have for the ecosystems.
(The rest is omitted)

8.2 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT SCENARIO
Based on the environmental assessment for the project-free scenario and the ratings obtained for each impact, the impacts generated by the project on the environment should be identified, described and qualified as a result of the interaction between the activities of said environment and the components of each medium. It is worth noting that this assessment is done without taking into account the environmental management programs, given that, according to their significance, the Environmental Management Plan is formulated.
(The rest is omitted)

(b) Other Related Technical Information

There are two methods of evaluation for the impact assessment in Japan. The first is compare the result of forecast with national standard or national goals. Please refer the Environmental Quality Standards (EQS) for groundwater pollution in Japan at the end of this subsection.
The second is the evaluation from efficiency of the mitigation measures conducted by project implementer. It is important to judge from the effort of project implement agency.

(c) Methodology, Process and Procedure

The project proponent considers if the possible environmental impacts by the project are avoided or reduced to the extent possible, and if the standards or targets concerning environmental protection are satisfied.

(d) Output

The result of the evaluation could be organized as below.

Table C.2.7.8 The result of the evaluation

The Result of the evaluation
The concentration of XX(pollutants) at XX point with project scenario would be predicted to increase XXmg/L from without project scenario, but it meets environmental standard. Therefore, it would be evaluated as small impact on water quality.

(6) Mitigation and monitoring

(a) Referenced TOR

a) Environmental Management Program

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.1 Environmental Management Program
…

An Environmental Management Plan (PMA) must be presented, structured in programs and subprograms (when required) and based on the hierarchy of management of potential identified impacts, considering as a first option measures for preventing and avoiding the occurrence of impacts; In the second option, measures to mitigate and/or minimize said impacts; Measures to correct or restore environmental conditions and, finally, compensatory measures will be considered.

For the identified impacts, environmental management measures should be considered taking into account that the same measure can be applied to the management of different impacts and that an impact can be managed through different measures.

The approach of programs, subprograms and measures should focus on comprehensive control of environmental impacts; For such purpose, it must be considered that there may be impacts that occur in different environments (for example, contamination of the surface water resource can affect elements of the abiotic, biotic and socioeconomic environments) and / or components (for example, the traditional economic activities of the population may affect the economic, demographic, cultural, etc.).

The PMA programs must specify:

1. **Objective(s) of each program and subprogram.**
2. **Goals related to identified objectives.**
   Indicators that allow monitoring of the achievement of the goals proposed for each objective, as well as to determine the effectiveness of each program and subprogram.
3. **Impacts to be managed by each program (based on impact assessment). Phase(s) of the project in which each program and subprogram would be implemented.**
4. **Application location (s) (cartographic location where possible).**
5. **Description of management measures (specific actions) to be developed within each program and subprogram, specifying the type of measure (prevention, mitigation, correction and compensation).**
6. **List of proposed works to be implemented. The designs must be presented as documents annexed to the EIA.**
7. **Estimated schedule of program implementation.**
8. **Estimated costs of implementing each program.**

(The rest is omitted)

b) Monitoring and Tracing

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.2 Monitoring and Tracking Plan
…

a. Tracking and monitoring of plans and programs
For such purpose, the plan must precise of:

1. **Actions to be developed to obtain the information and/or data to calculate the indicators proposed in the PMA.**
2. **Criteria used for the approach of each indicator.**
3. **Frequency of measurement.**
4. **Justification of the representativeness of the indicator raised, as well as the information used for its calculation.**

b. Tracking and monitoring the trend of the medium
For the tracking and monitoring of the environmental components, the plan must include at least:

1. **Objectives.**
2. **Environmental components to monitor.**
3. **Indicators (quantitative and qualitative) aimed at establishing changes in the trend of the medium, specifying what is intended to be measured and monitored with each one.**
4. **Location of monitoring sites, with the respective cartographic location, when applicable.**
5. **Identification of management measures that affect the trend of the medium.**
6. **Description of the procedures used to measure the trend of the medium, relating the necessary instruments.**
7. **Frequency and duration of the monitoring.**
8. **Criteria for analysis and interpretation of results.**

(The rest is omitted)

(b) Other Related Technical Information

a) Environmental Management Program

It is important to confirm that mitigation measures for water quality might give adverse effect on other environmental components. (e.g. If sludge from waste water treatment plant is disposed improperly, other environmental problems will occur. ）

b) Monitoring and Tracing

Monitoring and tracing should be implemented at same point of baseline survey. The desirable period of monitoring is at least 2 years. If the result of monitoring exceeds the target level, mitigation measures should be reconsidered and monitoring period should also be extended.

(c) Methodology, Process and Procedure

a) Environmental Management Program

Counter measures for environmental and social impact should be selected preventing or avoiding measures at first. In general, these preventing or avoiding measures could be selected at DAA study. If it is difficult to avoid or prevent the impacts at the time of EIA study, mitigation measure should be implemented as a second option.

The general process of selecting mitigation measure on water quality is shown below figure.

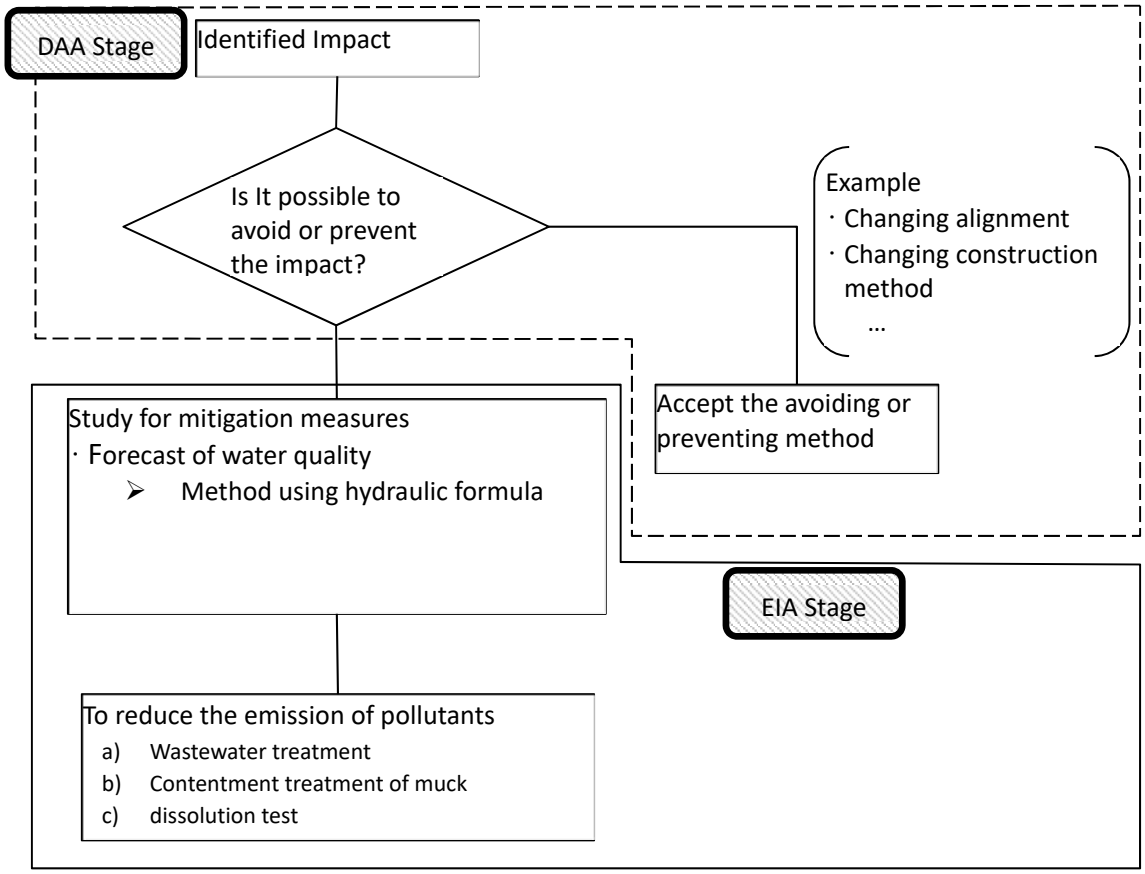


Figure C.2.7.6 Flow diagram of the mitigation measure study on water quality

The general information for mitigation measures of reducing or shutting out the inflow into the tunnel are below. Please refer the Outline of the countermeasures at the end of this subsection.

Table C.2.7.9 General information for mitigation measures of reduction of the emission of pollutants

a)	Wastewater treatment Sanitization or Neutralization treatment by waste water treatment system
b)	Contentment treatment of muck Neutralization to prevent the acidification of muck > dispersal or mixing of caustic lime Structure of disposal pit > Brock muck to rain or groundwater > Impermeable liner Monitoring by assay of muck, inflow water or discharged water from disposal pit
c)	dissolution test Implementation dissolution test of sample mixed with target soil and solidifying material before construction.

b) Monitoring and Tracing

(i) Tracking and monitoring of plans and programs

The flow diagram of monitoring for PMA is shown below figure.

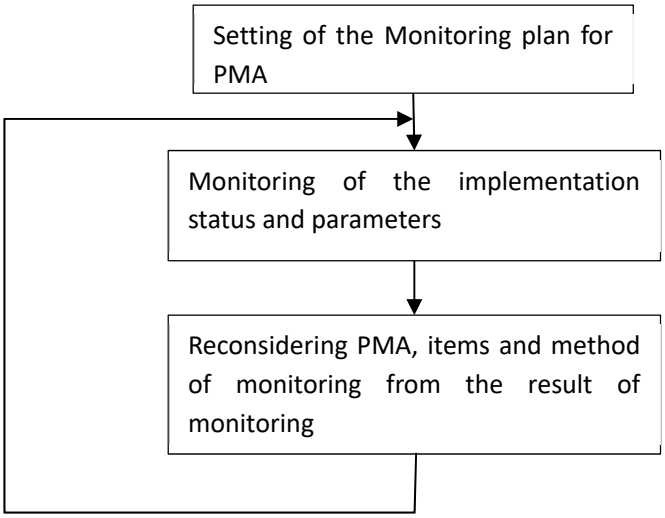


Figure C.2.7.7 Flow diagram for PMA monitoring

(ii) Tracking and monitoring the trend of the medium

The impact on water quality is caused by effluent. Therefore, the pollutants and flow rate of effluent should be monitored. The example of the monitoring item is below table.

Table C.2.7.10 Monitoring Item

Monitoring item	Parameter	Monitoring Method
Stream(River) flow	Pollutants (mg/L) Flow rate (L/s)	Location: Nearest evaluation point from effluent discharge and upstream from effluent discharge point. Frequency: Once a month (Including dry and wet season) Method: Chemical analysis for pollutants. Field measurement for flow rate.
Inflow into the Tunnel	Pollutants (mg/L) Flow rate (L/s)	Location: The flow channel in the tunnel Frequency: Same as stream(River) flow Method: Same as stream(River) flow
Effluent from wastewater treatment plant	Pollutants (mg/L) Flow rate (L/s)	Location: Outlet of plant Frequency: Same as stream(River) flow Method: Same as stream(River) flow or self-registering equipment
Leachate from muck disposal site	Pollutants (mg/L) Flow rate (L/s)	Location: Outlet of disposal site Frequency: Same as stream(River) flow Method: Same as stream(River) flow or self-registering equipment

(d) Output

a) Environmental Management Program

In general, some measures exist on water quality for preventing or mitigating impact from tunnel construction. Here are some examples of water quality countermeasures.

Table C.2.7.11 Environmental Management Program on water quality

Id	Counter measure	1.Objective	2.Effectiveness/ Indicator of effect	3./7.Implementation period/ Phase	4.Implementation area / location	5./6.Management measures	8.Estimated costs	Remarks
1								
2								
3								
4								
5								
6								
7								

b) Monitoring and Tracing

(i) Tracking and monitoring of plans and programs

The required information according to the TOR should be collected. Here is example form of monitoring plan.

Table C.2.7.12 PCM monitoring plan

Mitigation measure	Outline of the mitigation measure	The Index or parameter of monitoring	criteria	Frequency of the monitoring

(ii) Tracking and monitoring the trend of the medium

Annex of the Water quality

1. EQS for groundwater pollution in Japan

   Environmental Quality Standards (EQS) for groundwater pollution were issued in 1997 by Ministry of environment (MoE) and they are required to be maintained in order to protect human health. This standard is restricted to take account into drinking water which is absorbed into the human body for long period. Therefore, if there would be a probability of drinking water pollution excessing those standard from the discharged water of project site, project proponent should consider the counter measure of discharge water.

Table EQS for ground water pollution in Japan

Item	Standard Values	Item	Standard Values
Cadmium	0.003mg/liter or less	tetrachloroethylene	0.01mg/liter or less
total cyanogen	not detectable	1,3-dichloropropene	0.002mg/liter or less
Lead	0.01mg/liter or less	Thiram	0.006mg/liter or less
chromium (VI)	0.05mg/liter or less	Simazine	0.003mg/liter or less
Arsenic	0.01mg/liter or less	Thiobencarb	0.02mg/liter or less
total mercury	0.0005mg/liter or less	Benzene	0.01mg/liter or less
alkyl mercury	not detectable	Selenium	0.01mg/liter or less
PCB	not detectable	nitrate nitrogen and nitrite nitrogen	10 mg/liter or less
dichloromethane	0.02mg/liter or less	Fluoride	0.8 mg/liter or less
carbon tetrachloride	0.002mg/liter or less	Boron	1 mg/liter or less
vinyl chloride monomer	0.002mg/liter or less	1,4-dioxane	0.05mg/liter or less
1,2-dichloroethane	0.004mg/liter or less		
1,1-dichloroethylene	0.1mg/liter or less		
1,2-dichloroethylene	0.04 mg/liter or less		
1,1,1-trichloroethane	1mg/liter or less		
1,1,2-trichloroethane	0.006mg/liter or less		

2. Provisional Manual for the treatment of contaminated rocks and soils which contain heavy metals from natural source on construction site

   Ministry of Land, Infrastructure, Transportation and tourism (MLIT) issues this provisional manual on March of 2013.This manual shows pollutant and its treating methods from construction site such as road, tunnel and other infrastructure based on the experience in Japan. It is also possible to assume the water pollution from natural resource on the construction site in Colombia using from the following table.

Table Example of Japanese regulated Pollutants originated from natural source

pollutants	Clarke's number (mg/kg)	Associated Geology
Zinc (Zn)	70	Usually associated with ores of other common metals such as Pb, Cu, Cd, and Fe.
Cadmium (Cd)	0.2	Usually found associated with zinc ores.
Chromium (Cr)	100	Naturally found in soils. Ultra basic rock and Serpentinite may contain more than 1000mg/kg.
Mercury (Hg)	0.08	Usually lain between volcano or hydrothermal minerals near metallic ore deposit
Selenium (Se)	0.05	Sedimentary rock such as sandstone, limestone and phosphate rock may contain 1 to 100mg/kg.
Copper (Cu)	55	Sedimentary rocks with copper deposit
Lead (Pb)	13	There is a tendency that total content is higher in alkali soil than in acid soil.
Arsenic (As)	1.8	It can be much more concentrated in arsenic-containing ores such as arsenopyrite (FeAsS). especially those found near gold- and other metal-rich areas.
Fluorine (F)	625	Generally occurred as minerals such as fluorspar (CaF2), cryolite (Na2AlF6), fluorapatite Ca5(PO4)3F)
Boron (B)	10	Marine mudstone may contain around 100mg/kg.

Note: Clarke's Number is expressing the average content of the chemical elements in the earth's crust.

3. Outline of the countermeasures in the tunnel construction site
   It is difficult to show the detailed specification of the water treatment facility of the construction site, because Its required capacity is basically based upon the actual situation of the site. The following table shows outline of the countermeasures in construction site for each pollutant.

Table Outline of the countermeasures in construction site

Pollutant	To avoid producing	Appropriate treatment
SS from Soil	• Avoiding soil erosion ✓ Covering by sheet ✓ Drainage trench	Solid – Liquid Separation by installing settling pond or treatment plant.
Alkaline from Cement	• Controlling the quantity of water with concrete works	Neutralization by treatment plant.
Metals from Cement	• Selecting cement material with little possibility of elution	Solid – Liquid Separation by treatment plant.
Acid, Alkaline, Metals from Groundwater	• Grouting • Water – tight structure	Solid – Liquid Separation by treatment plant.
Metals from Rock, Soil	• Avoiding exposure to rainwater and groundwater ✓ impermeable liner such as sheet and clay ✓ Compaction	Solid – Liquid Separation by treatment plant.
Acid from Rock, Soil	• Avoiding exposure to rainwater, groundwater and Oxygen ✓ impermeable liner such as sheet and clay ✓ Compaction	Neutralization, Solid – Liquid Separation by treatment plant.

C.2.8 Water usage

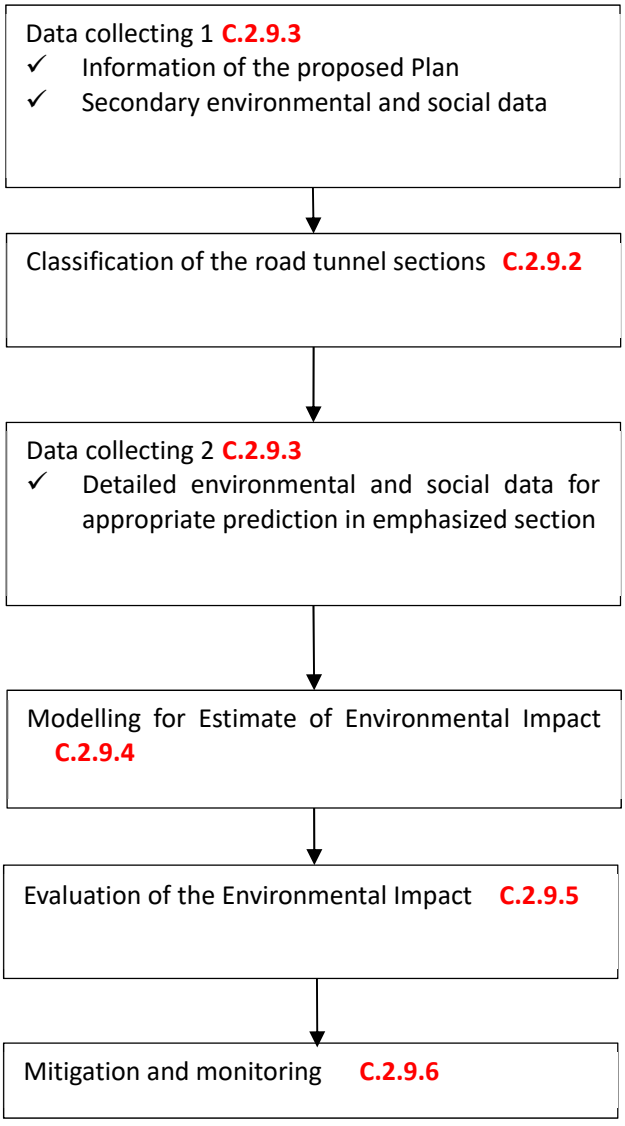
C.2.9 Hydrogeology

C.2.9.1 General

The content of this section presents the specific method of collecting and analysis on hydrogeology for EIA study. This section also introduces the countermeasures for environmental effect caused by road tunnel project and monitoring method on hydrology during constructing and after constructing.

(1) General workflow

The general workflow of hydrogeologic impact study shown in following diagram.



Overview	
The required Items of general information · Aerial photograph, Digital topographic map · Surface geological map · Drainage map · Land use map · Meteorological data · Protected area map · Road Plan drawing, Standard Road Section · Water well Inventory	
Dividing road tunnel into several sections and classifying each section to prioritized section or Non-Priority section.	
CLASS A Priority Area	CLASS B Non-Priority Area
More detailed data to evaluate groundwater flow regime · Hydrogeological data · Geophysical data · Geochemical data · Borehole data (piezometric head)	Not required
Evaluation of groundwater inflow during and after construction · Water balance analysis · Numerical modelling ·	Qualitative analysis based on changes of surface ground conditions
· Evaluation based on the impact of daily life point · Evaluation of impact of precious nature point · Evaluation from the OHS point	
Setting up EMP and items for monitoring · Groundwater inflow rate · Regional groundwater flow · Piezometric head	Not required

Figure C.2.9.1 Flowchart of the study on hydrological impact

(2) Estimated environmental impact

It is important to clarify the environmental and social impact caused by construction and operation of the tunnel for classification of the divided sections. The assumed environmental impacts on hydrogeology are shown below.

Table C.2.9.1 Estimated Impact on hydrogeology

From the daily life or livelihood point of view
· Drought of water source / spring · Over capacity of drainage / river by tunnel inflow
From the precious or protected nature point of view
· The loss or shrink of the protected wetland

C.2.9.2 Classification of the investigation methods

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

4.AREAS OF INFLUENCE
4.2 DEFINITION, IDENTIFICATION, AND DELIMITATION OF THE AREA OF INFLUENCE
…

It is important to clarify that the result of the delimitation can be reflected in one or several polygons, by identifying the area of influence for each component, group of components or media.

The area of influence by component, group of components or medium should be based on units of analysis such as: watersheds, ecosystems, territorial units, and those identified by the applicant within the EIA. Each area of influence per component, group of components or medium, must have a minimum unit of analysis which must be properly supported.

(The rest is omitted)

(2) Other Related Technical Information

THE PRINCIPLES of ENVIRONMENTAL IMPACT ASSESSMENT BEST PRACTICE say that Environmental Impact Assessment should be focused. (INTERNATIONAL ASSOCIATION FOR IMPACT ASSESSMENT, 1996) The process of the EIA study should be concentrated on significant environmental effects and key issues. Therefore, it is recommended to identify the possible area or section of significant environmental effect.

(3) Methodology, Process and Procedure

(a) Area division

It is effective method for EIA study to make a concentrate on important area for environment and society. On hydrology, hydrogeology and water quality field, the catchment area of the stream/river which are crossing over the tunnel alignment can be used for this purpose. The conceptual images of the divided study areas are shown below figure. These colored catchments could be assumed as the affected area on hydrology, hydrogeology and water quality fields by tunnel construction. There is possibility to be extended study area by more detailed investigation through the EIA study.

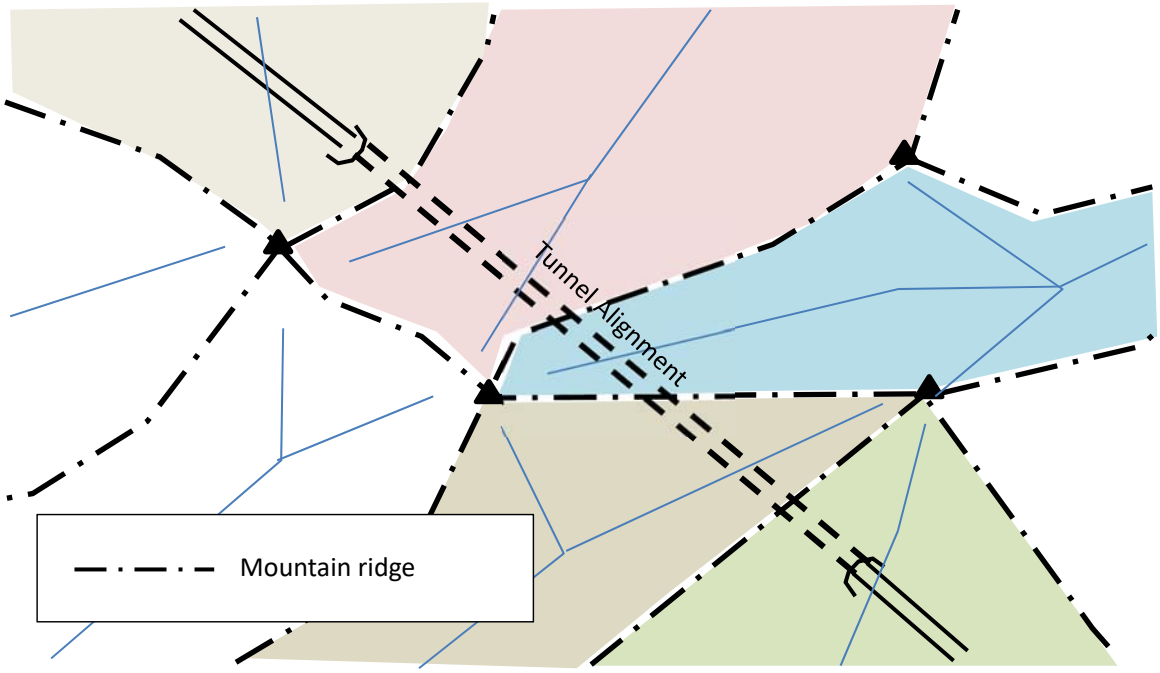


Figure C.2.9.2 Conceptual Image of the EIA study area dividing on Hydrology

(b) Data collecting range

(i) Comprehensive data collecting range

Comprehensive data should be collected for the grasping the object which would be received impact from tunnel project. (e.g. Location of the water intake, wetland where precious/ fragile species live in, etc.) On hydrology field, the comprehensive data could be gathered from the catchment area which is formed by small stream. It could be considered that the data collecting area is defined as the catchment of the small stream crossing tunnel alignment and its end is the point where small stream meet large river which have more than 3 times of flow quantity than the small stream.

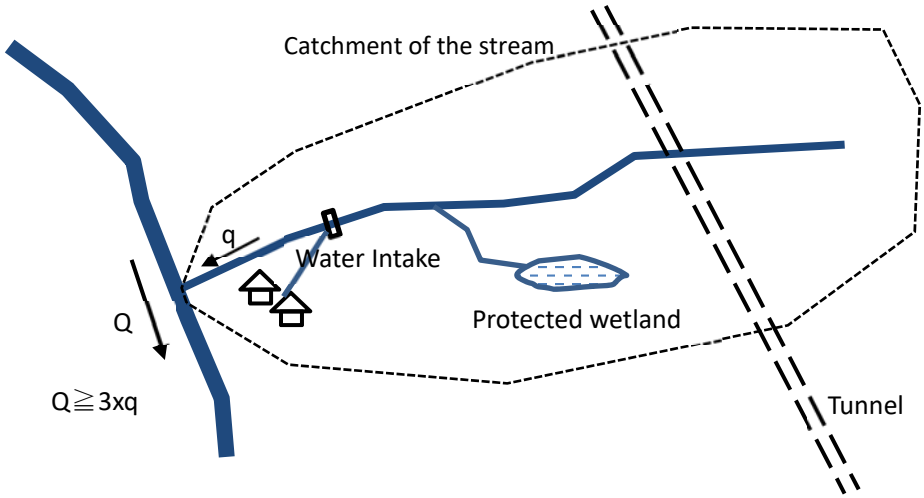


Figure C.2.9.3 Area of comprehensive data collecting

(ii) Data collecting range for analysis/modeling of the impact

In contrast with the comprehensive data, the detailed data for prediction of the environmental impact would be required. The data collecting range is usually don't need such a wide area as comprehensive data. There are some methods to set the range. Most easy method is to use fixed distance from tunnel alignment. On the EIA study guidelines in Japan, 1 km from the tunnel alignment or the distance to the mountain ridge line within 1km from tunnel alignment is used as a maximum affected width based on experience of EIA studies in Japan. The conceptual figure for dividing survey area is shown below.

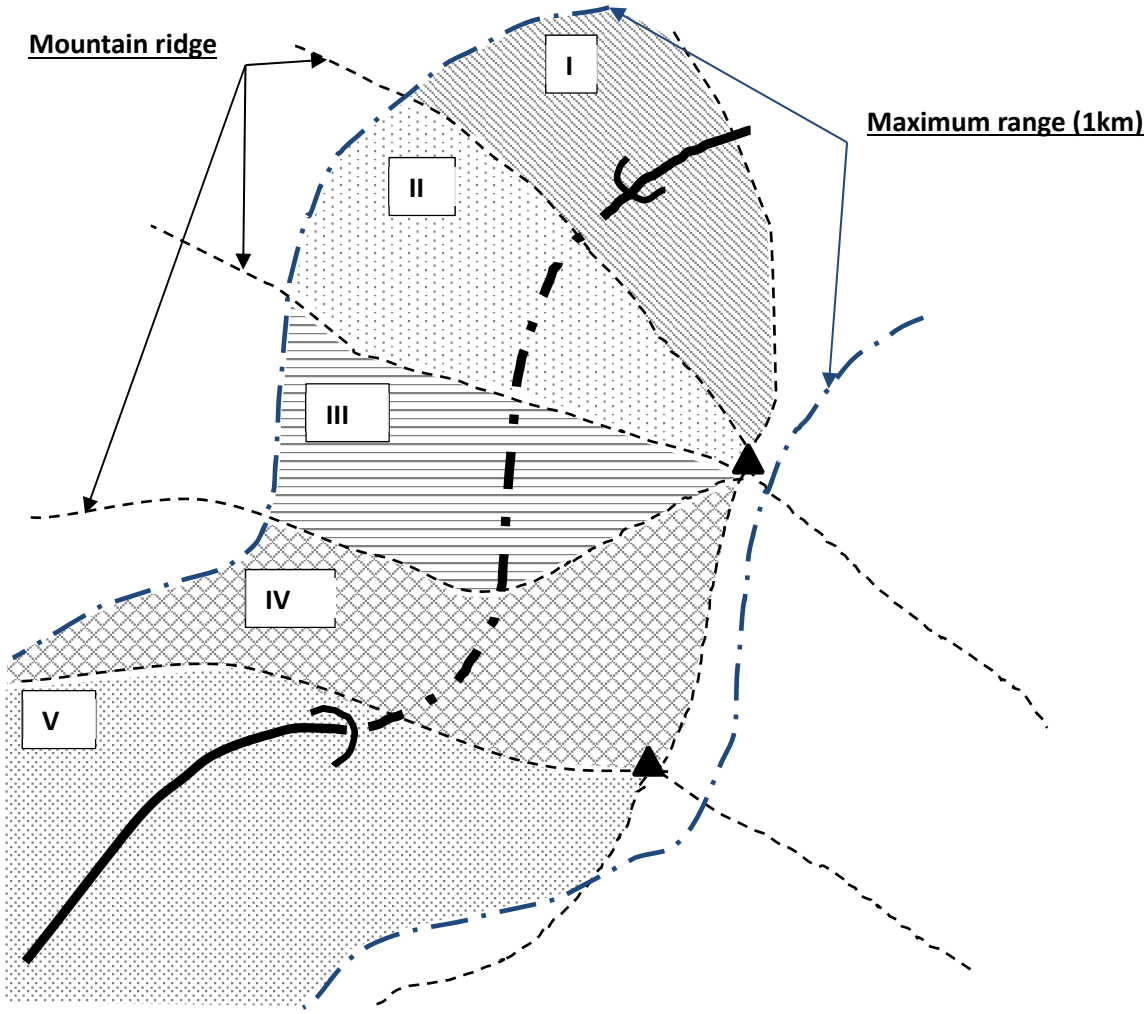


Figure C.2.9.4 Concept of Area division

Meanwhile, there is other analytic method to set the range. The Takahashi's Method is the one of this. Takahashi's method is developed in 1961 and this method is still using for tunnel design in Japan. On Takahashi's method, the hydrological method is usually used to set affected area of tunnel construction. This method is based on the idea of strong relation between affected area and topography. This method uses mean coefficient of permeability which is defined as:

$$k_t = \frac{R^2}{(6 \times H)}$$

where,

k_t: Mean coefficient of permeability

R: Width of the catchment area

H: Relative height of ground water

The mean coefficient of permeability is calculated by following process.

7. To measure the catchment area (A)
8. To measure the length of measure stream of the catchment (L)
9. The average width of catchment (R) is calculated (2R=A/L)
10. To divide catchment into n sections

11. To calculate mean height using below formula

$$\mathrm{Hm} = \left\{\frac{(H_{1R}+H_{1L})}{2} + \frac{(H_{2R}+H_{2L})}{2} + \cdots\right\} \div n$$

12. The mean coefficient of permeability is calculated ($k_t = R^2 / (6 \times H_m)$)

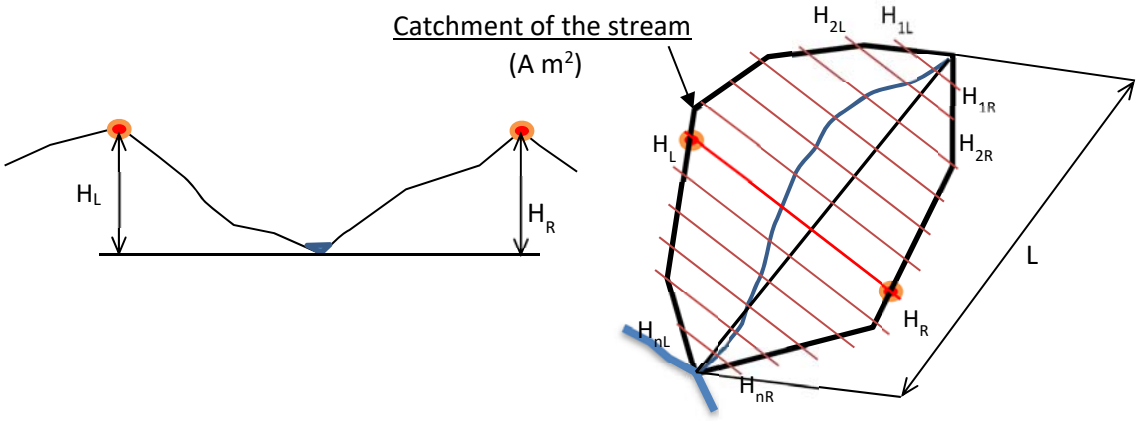


Figure C.2.9.5 Explanation of Takahashi's method

It is possible to obtain the affected width of each section using graphical method. The changed formula of mean coefficient of permeability is shown below.

$H_m = R^2 / (6 \times k_t)$

From drawing the relation of R and H into tunnel section drawing, the width of affected area is obtained graphically. The crossing point of H-R curve and topological line is the limit of affected area as below figure.

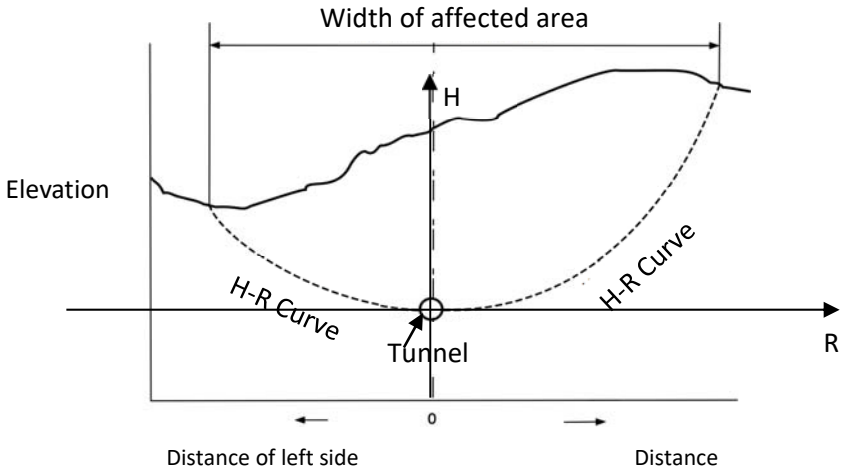


Figure C.2.9.6 Width of the affected area (Takahashi's Method)

(c) Classification

Many kinds of hydrogeological Impact from tunnel project could be assumed. However, most of the impact are related to the groundwater changes. Basically, hydrogeological impact will be occurred by inflow into the tunnel. Therefore, the specific area which include fault/ fractured zone or include important water source or wetland above the tunnel alignment should be emphasized on EIA study. Following figure shows the outline of area classification. If changes of groundwater would be assumed from the other hydrogeological study in any area, it is possible to emphasize that area on EIA study.

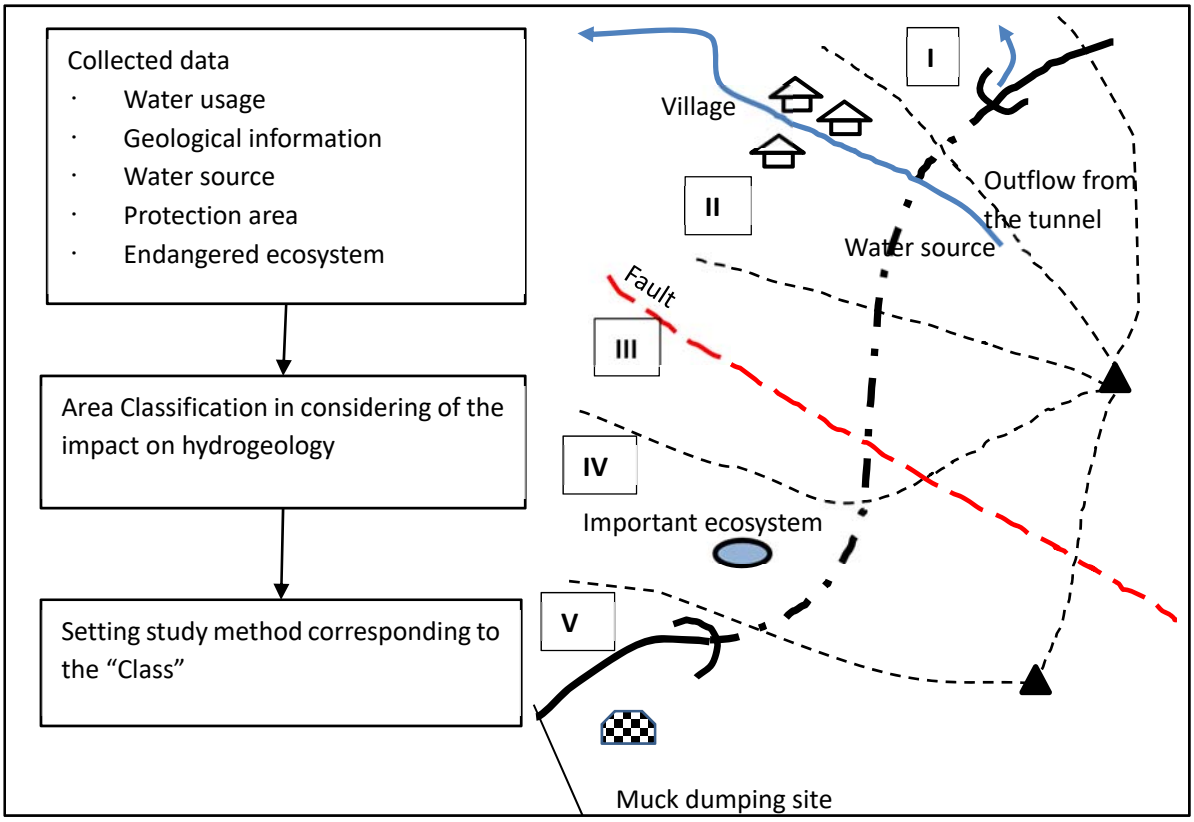


Figure C.2.9.7 Outline of Area Classification

(4) Output

The result of classification could be organized into table as shown below. The conditions, class and the reason of classification are described in this table.

Table C.2.9.2 Classification of Environmental Impact

Study Area	Conditions for hydrogeology				Class A	Class B	Remarks
	Geological aspects		Ecological aspects	Life environment /water source			
	Fault/ Fractured zone	Permeable layer					
I						○	
II				✓	○		
III	✓				○		
IV			✓		○		
V						○	

Note, Class A means it need elaborate method for survey, prediction and mitigation study.

C.2.9.3 Check list for required investigation items

The items of investigation on EIA study can be classified corresponding to the area class. On the class "A" area, the detailed information will be required. On the other hand, comprehensive information in influence area is used for classification of the study area. (See section **C.2.9.2**) The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

5.1.8 Hydrogeology

The scope of this component is focused on the identification and characterization of groundwater and aquifers present in the area, so that a baseline can be established that serves as a reference point for the subsequent monitoring of this resource in terms of quality and quantity.

For the area of influence of the hydrogeological component, regional aquifers, their recharge and discharge zones, general flow directions, the type of aquifer, qualities and types of current uses must be identified, also considering the hydrogeological investigations carried out in the area by different government institutions, as well as plans and regulation of water currents held by the regional environmental authority.

For the area of influence of the hydrogeological component, where due to construction activities the existing aquifers may be modified, the following information must be provided:

- **Analysis of existing hydrogeological, hydrological, geophysical information (reports of geophysical prospecting including georeferencing of vertical electric soundings (SEV) or other geophysical methods that have been carried out in the area, geoelectric profiles and correlation of lithological units), geochemistry and Characterization of groundwater, existing cartography of the area, identifying in all cases the source of information.**
- **Inventory, georeferencing and leveling of groundwater points including wells, reservoirs and springs, indicating use and estimated number of users.**
- **Identification of the geological unit captured by its characterization using the parameters defined in the table above under the titles "Water Component" and the operating Flow.**
- **Determination or estimation of the direction of groundwater flow and possible hydraulic connections between aquifers and surface water bodies.**
- **Identification of natural recharge and discharge areas of aquifers.**
- **Inherent vulnerability of aquifers to pollution, justifying the selection of the method used to determine it, with aims of protecting the quality of the aquifer.**

Additionally, and for the sections that involve the construction of tunnels, the following information must be included:

- **Hydrology, water balance and recharge of the hydrogeological units present.**
- **Appropriate methods must be used to determine the recharge, explaining its selection. An analysis of the recharge processes presented in the aquifers under study and their quantification should be submitted.**
- **Analysis of the aquifer's contamination risk by the development of activities and proposed works.**
- **Conceptual hydrogeological model. Based on the analysis and integration of the above information, a conceptual hydrogeological model of aquifers present in the area should be defined, including the following aspects: delimitation of recharge, transit and discharge zones;**

Flow directions; Hydraulic connections between different aquifer units and surface sources; Definition of areas with potential for use. The hydrogeological characterization of the present units must be carried out according to the International Hydrogeological Legend, or to the conventions adopted by the Colombian Geological Service.

- **Numerical model of groundwater flow. A numerical model must be developed, using the appropriate software for the specific characteristics of aquifers present in the area and supporting its selection. This model should represent the conceptual hydrogeological model defined above and should take into account the following aspects:**

  - **Definition of the area of interest for modelling. Definition of appropriate hydraulic boundaries.**
  - **Model input data (historical levels, hydraulic parameters of the different layers to be modeled, flow directions, hydraulic connections).**
  - **Horizontal and vertical discretization of the area of interest and appropriate definition of the number of mathematical layers, using analysis of scenarios with secondary information.**
  - **Completion of the assembly stage, and of having the necessary information, the calibration.**

(The rest is omitted)

(1) Other Related Technical Information

For the detailed analysis on hydrogeology, it is basically required to collect long term meteorological data such as above ten (10) years. It is necessary to collect the annual data (rainfall data) at least.

(2) Methodology, Process and Procedure

Hydrogeological investigation shall be implemented at each stage of tunnel development from route selection to operation and maintenance, so called step-by-step investigation. The hydrogeological investigation at the early stage of route selection (DAA) and planning (EIA) is important in order to identify risks and fundamental solutions before execution of detail design and construction. Accuracy of estimation of water inflow and groundwater flow shall be improved by continuous investigation and modification.
Hydrological investigation can be classified into several categories as shown in the following table. In this table, rate of necessity of each investigation is also indicated.

Table C.2.9.3 Classification of the hydrogeological survey

Category	Purpose of Investigation	Project Stage / Survey Item	DAA (Route selection)	EIA (planning)	During Construction	O&M
(a) Data collection	To overview regional hydrogeological condition.	Data regarding geography, geology, hydrology, hydrogeology, Metrology, Meteorology	A	A	B	C
		Social and environmental information; groundwater usage, conservation area, irrigation etc..	A	A	C	C
(b) Case study	To estimate water inflow of target tunnel.	Data from other tunnel construction projects: water inflow amount, location and target geology etc..	A	A	B	C
(c) Hydrogeological investigation	To identify structure of aquifers.	Surface hydrogeological survey	A	A	B	-
		Geophysical survey	B	A	B	-
		Boring investigation	B	A	A	-
		Borehole logging	B	A	A	-
		Water quality on site	A	A	A	B
		Water quality in lab	C	A	B	B
	To evaluate characteristics of aquifers.	Pumping test	C	A	C	C
		Injection test	C	B	C	C
		Tracer test	C	C	C	C
(d) Water Balance	To examine water balance.	Meteorological survey (rainfall and temperature)	A	A	A	A
		Surface water (river flow, lake and reservoirs, springs etc..)	A	A	A	A
		Groundwater table (monitoring well, existing well)	A	A	A	A
		Evapotranspiration	C	C	C	C
		Water inflow into tunnel	-	-	A	A
(e) Contamination	To identify contamination risks.	Case study from similar geological condition	B	B	C	C
		Water quality analysis	C	C	C	C
		Laboratory test	C	C	C	C
(f) Hydrological Environment	To examine water resources.	Location and amount of springs, streams, lakes and reservoirs.	A	A	B	B
		Inventory of water wells	A	A	B	B
	To examine water usage.	Water supply system, sewerage system, industrial and agricultural use	B	A	B	B
(g) Evaluation	To define conceptual hydrogeological model	Integration of investigation results	B	A	C	C

Category	Purpose of Investigation	Project Stage / Survey Item	DAA (Route selection)	EIA (planning)	During Construction	O&M
and Estimation	To estimate possibility of hydrogeological impact	Water inflow into tunnel (amount and location, water catchment area)	A	A	A	B
		Relation between rainfall, river flow and water inflow into tunnel	C	A	A	B
		Impact on environment and water use	A	A	A	B
	To analyze impact	Hydraulic analysis	B	A	C	C
		Numerical modelling and simulation	C	A/ C	C	C

A: Required, B: Recommended, C: When it is necessary

(a) Data collection

It is important to collect and analyze existing information to grasp perspectives of hydrogeological settings, not only aquifer structure but also water balance, hydrological environment and social aspects. Following information is recommended to collect in this stage.

- **Data regarding hydrogeological environment**
  - Aerial photograph
  - Digital topographic map
  - Surface geological map
  - Drainage map
  - Land use map
  - Meteorological data
  - River water discharge rate

- **Data regarding social environmental component and others**
  - Inventory of wells
  - Protected area map
  - Water resource and use
  - Record of natural disasters

(b) Case study

In early stage, it is quite difficult to determine the location and amount of water inflow into tunnel and its impact to regional groundwater. However, it is possible to predict using case studies in a similar condition of geography, geology and soil covering.

It may be useful to predict the existence of water inflow if the possible relation is indicated from examples, such as;

- Correlation between geology and amount of water inflow (ex: volcanic sediments has high rate of water inflow.)

- Correlation between geography and location and amount of water inflow (ex: Under the area of sand and gravel sediments with depression topography has high rate of water inflow.)
- Correlation between fault/structure and water inflow (ex: The amount of water inflow in metamorphic and igneous rocks depends on the existence of fracture zones.)

(c) Hydrogeological investigation

• Surface hydrogeological survey

- Geological survey:
  Geological reconnaissance is implemented to reveal geological structure.
  Survey items are for example; 1) rock type, 2) lithofacies, 3) bedding, 4) schistosity, 5) strike and dip, 6) joint and fracture, 7) fault system, 8) fold system, 9) soil particle, 10) grain size distribution, 11) consolidation, hardness, degree of weathering/ alteration, etc.

- Hydrological survey:
  Hydrological reconnaissance should be implemented to examine the structure of aquifers.
  Location/distribution and amount shall be identified on; 1) springs, 2) shallow and deep wells, 3) lake and pond, 4) streams and rivers.

• Geophysical survey

- Seismic prospecting:
  Elastic wave velocity is measured to estimate the structure of fracture type aquifers by examining degree of weathering and alteration, fracture and consolidation.

- Electric prospecting:
  Vertical electrical resistivity survey is commonly applied to identify structure of aquifers.

• Boring survey

- Geological survey:
  Collect information to identify aquifer structure. All obtained information during drilling is summarized with geological column such as R.Q.D, rate of drilling, amount of drilling water, and variation of water table. Permeability should be determined with result of pumping test and logging.

- Groundwater survey:
  If it is for groundwater investigation, install casings with screen design at target aquifer, develop as monitoring well.

• Borehole logging

Normally, velosity logging, electric logging and temperature logging are implemented to identify the depth and permeability of aquifer.
Logging data should be examined with geological column.

• Water quality on site

- Parameter:
  pH, temperature, electric conductivity

- Location:
  river, lake, pond, spring, water well, and other surface water around the target area should be checked on site.
- It is recommended to monitor water quality both seasons of high and low water levels.

- **Water quality in laboratory**

Water quality analytical data can be used to examine groundwater flow system.

- Parameter:
  Dissolved ion concentration such as Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, SO_4^{2-}, Alkalinity, Hardness, and other parameters defined in environmental standard
- Water sample:
  river, lake, pond, spring, water well, and other surface water around the target area should be checked on site.
- It is recommended to monitor water quality both seasons of high and low water levels.

- **Pumping test, Injection test.**

Capacity of aquifer is evaluated with storage coefficient, transmissivity and hydraulic conductivity by pumping test and/or injection test.

- **Tracer test**

It is implemented to trace chemical concentration as a tracer of groundwater flow regime. Chemical regent which is not harmful for water environment such as salt, isotopes.

(d) Water balance

Numerical investigation of water input, output and storage in target area of target duration.
Water balance is expressed simply as following equation.

$$R=(D_2-D_1)+E+(G_2-G_1)+\triangle S$$

Where, R: rainfall, D_1: inflow of surface water, D_2: runoff of surface water, E: Evapotranspiration, G_1: inflow of groundwater, G_2: discharge of groundwater, $\triangle S$: change in storage

- **Meteorological survey**

- Purpose: to estimate amount of rainfall
- Data: Rainfall, Temperature
- Location: Close to the tunnel site.
- Interval: Daily
- Duration: at least 1year

- **Surface water**

- Purpose: to estimate amount of discharge in target catchment
- Data: River flow rate
- Location: appropriate location to measure river flow
- Interval: Daily, continuous measurement to compare with rainfall by hydrograph
- Duration: at least 1year

- **Groundwater table**
  - Purpose: to monitor variation of water table with rain event and seasonal change
  - Data: water table of monitoring wells
  - Location: monitoring wells inside target watershed
  - Interval: Daily or hourly, continuous measurement to compare with rainfall
  - Duration: at least 1year

- **Evaporation-Transpiration**

  Estimate by water balance method, Thornthwaite method, or measurement by atomometer.

- **Water inflow into tunnel**

  Measurement of amount of water inflow.

(e) Contamination

(referred in Section C.2.7)

(f) Hydrogeological environment

- **Water resource**
  - Types of resource: rain, spring, river, lake, reservoir
  - Data: location, amount, water quality, temperature, discharge etc…
- **Inventory of water wells**
  - Data: location, well structure, aquifer depth, pumping rate, water table, water quality, water temperature, ownership etc..
- **Water use**
  - Water use condition: land use, irrigation, industry, water supply and sewerage.

(g) Evaluation and Estimation

- **Integration of investigation results**

  Conceptual hydrogeological model should be developed for the target area, based on the analysis and integration of information obtained from all investigations.

  A conceptual hydrogeological model of aquifers present in the area should be defined, including the following aspects:
  - delimitation of recharge,
  - transit and discharge zones;
  - Flow directions;
  - Hydraulic connections between different aquifer units and surface sources;
  - Definition of areas with potential for use.

  The hydrogeological characterization of the present units must be carried out according to the International Hydrogeological Legend, or to the conventions adopted by the Colombian Geological Service.

- **Estimation of water inflow into tunnel**

  Amount and location of water inflow into tunnel and its catchment area shall be estimated for both

during construction and after construction.

- During construction: unsteady inflow
- After construction: constant inflow

- **Evaluation of relation rainfall, runoff and water inflow into tunnel**

  Estimate water inflow into tunnel from the relation with amount of rainfall and runoff such as following methods.

  - Regression analysis
  - Tank model method

- **Estimate impact on environment and water use**

  Analyze hydrological environment impact and water use in terms of quantity and quality by tunnel construction project.

- **Hydraulic analysis**

  Amount of water inflow into tunnel is estimated by hydraulic formula both during construction and after construction. (detailed method is explained in ***)

  - During construction: unsteady inflow
  - After construction: constant inflow

- **Numerical modelling and simulation**

  Modelling hydrogeology around tunnel to reproduce the present state of groundwater flow. Then simulate water inflow by applying seepage flow equation. (detailed method is explained in ***)

(3) Output

The required information for each class is shown below table. (Check list)

Table C.2.9.4 Checklist of the required information

Category	Purpose of Investigation	Survey Item	Required items / Parameters	Remarks
General Information for classification				
(a) Data collection	To overview regional hydrogeological condition.	Data regarding geography, geology, hydrology, hydrogeology, metrology, meteorology	- Aerial photograph - Digital topographic map - Surface geological map - Drainage map - Land use map - Meteorological data (Rainfall, Temperature) - River water discharge rate	Map resolution is 1/100,000-1/500,000 for geological map, and 1/100,000 for Land use map Data for recent 10 years
		Social and environmental	- Inventory of wells - Protected area map	

Category	Purpose of Investigation	Survey Item	Required items / Parameters	Remarks
		information	- Water resource and use - Record of natural disasters	
Information for detailed analysis on class A area				
(b) Case study	To estimate water inflow of target tunnel.	Data from other tunnel construction projects: water inflow amount, location and target geology etc..	- Possibility of water inflow in accordance with geology and geological structure	
(c) Hydrogeological investigation	To identify structure of aquifers.	Surface hydrogeological survey	- Plain geological map - cross sectional geological map along tunnel - Structure of aquifer	
		Geophysical survey	- structure of aquifer	
		Boring investigation	- geological column - geological section - aquifer structure - water table	
		Borehole logging	- velocity logging - electrical logging - temperature logging	Interval at 1 m
		Water quality on site	- measurement data	
		Water quality in lab	- analytical data - hexa-diagram and stiff diagram. - groundwater flow	
	To evaluate characteristics of aquifers.	Pumping test/ Injection test	- storage coefficient - transmissivity - hydraulic conductivity	
		Tracer test	- groundwater flow direction and rate	
(d) Water Balance	To examine water balance.	Meteorological survey	- amount of rainfall	
		Surface water	- amount of runoff - hydrograph	
		Groundwater table	- amount of storage - groundwater potential map	
		Evapotranspiration	- amount of evapotranspiration	
		Water inflow into tunnel	- measurement data	
(e) Contamination	To identify contamination risks.	Case study from similar geological condition	- potential risk	
		Water quality	- Present status of water quality	

Category	Purpose of Investigation	Survey Item	Required items / Parameters	Remarks
		analysis		
		Laboratory test	- estimated concentration of hazardous material in water inflow	
(f) Hydrological Environment	To examine water resources.	Location and amount of springs, streams, lakes and reservoirs.	- present status of water resource around tunnel	
		Inventory of water wells		
	To examine water usage.	Water supply system, sewerage system, industrial and agricultural use	- present status of water use around tunnel	
(g) Evaluation and Estimation	To define conceptual hydrogeological model	Integration of investigation results	- Drawings which present recharge and discharge area, groundwater flow directions with hydrogeological data.	
	To estimate possibility of hydrogeological impact	Water inflow into tunnel	- Estimated amount and location of water inflow during and after construction	
		Relation between rainfall, river flow and water inflow into tunnel	- Estimated amount water inflow	
		Impact on environment and water use	- calculation from water balance	
	To analyze impact	Hydraulic analysis	- amount of water inflow during and after construction	
		Numerical modelling and simulation	- groundwater potential during and after construction	

C.2.9.4 Modelling for Estimate of Environmental Impact

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT

For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.

(The rest is omitted)

Hydrological analysis must be done on two stages (With and Without project) in accordance with this TOR. However, it is not possible to assume hydrogeological impact without tunnel project since no project will not have any influence on underground environment.

(2) Other Related Technical Information

Not available

(3) Methodology, Process and Procedure

(a) CLASS A (Priority Area)

In the priority area, detailed analytical method should be taken. There are many hydrogeological analytic method, so analyst could select the way to conform with the purpose of analysis. The recommended method of impact analysis on hydrogeology is shown below table.

Table C.2.9.5 Analytic method on Hydrogeology

Level of analysis	Kind of the impact	Recommended analytic method
Level 2	• The kind of impact which is easier to recovery by current technology or existing method. • The kind of impact which has simple conditions.	(i) Statistical method (ii) Multiple regression (iii) Hydraulics formulas (iv) Tank Model / Nash Model
Level 1	• The kind of impact which is difficult to recover by current technology or existing method from the impact which is mentioned chapter 2.6.1. • The kind of impact which has complex conditions such as complex terrain. This kind of the impact is not fit to the simplified model.	(i) Statistical method (ii) Multiple regression (iii) Hydraulics formulas (iv)Tank Model / Nash Model (v) Hydraulics formulas (Takahashi's formula) (vi) Numerical modelling and simulation

(i) Statistical method

It is the method to estimate the water inflow and/or drawdown of the groudwater table by using the records of tunnel construction in the similar geological condition. Although there is no case where all the natural condition is same to the target project, it is possible to obtain useful information during planning stage.

Following figure shows the relationship between length of the tunnel and the total volume of groundwater inflow into tunnel and the table shows the relationship between the types of geology and the specific groundwater discharge into tunnel from Japanese cases.

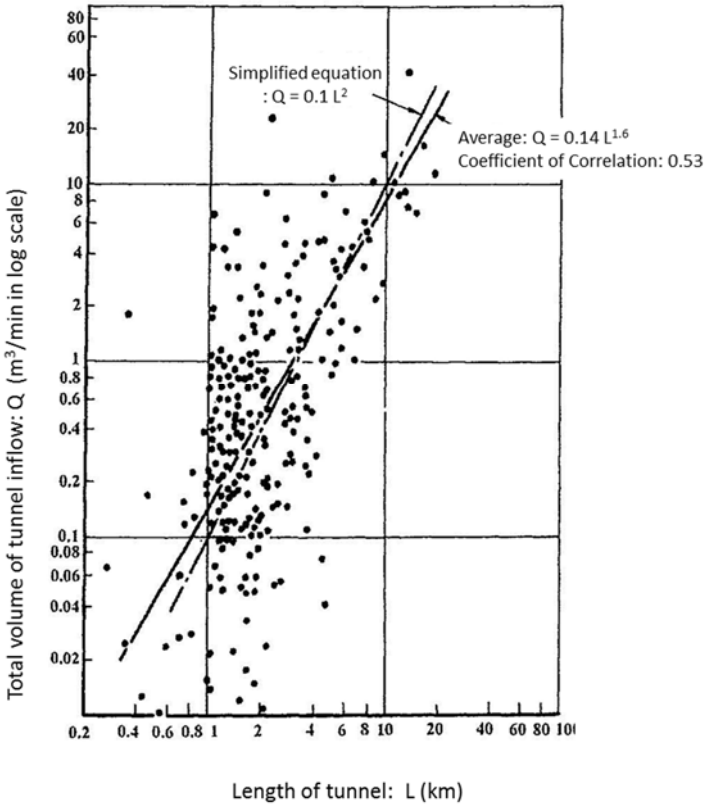


Figure C.2.9.8 Relation between Length of tunnel and tunnel inflow

Table C.2.9.6 Relation geology of tunnel and specific tunnel inflow

Geology		Range of specific water inflow (m^3/min/km)	Average of specific water inflow (m^3/min/km)
Volcanic rock		**<u>0.85 – 10.0</u>**	**<u>3.71</u>**
Pyroclastic rock		0.0035 - 0.9	0.30
Plutonic rock		**<u>0.17 - 3.80</u>**	**<u>1.38</u>**
Gneiss		0.018 - 0.84	0.20
Mesozoic rock		**<u>0.10 -4.50</u>**	**<u>0.79</u>**
Paleozoic rock		0.0 – 0.95	0.17
Tertiary Pleistocene	conglomerate	0.02 – 3.60	0.84
	sandstone, shale, tuff	0.014 – 0.96	0.25
	mudstone	0.0 – 0,26	0.07

<u>Number with underline</u> shows the data from the fractured zone in the same rock

Source: Sub-committee of Environmental Conservation (1983), Japan Tunnel Association (JST) "Report of the study on inflow and drought caused by tunnel construction vol.2"

(ii) Multiple Regression

It is possible to estimate volume of groundwater inflow into tunnel by using prediction formula derived from the correlation between rainfall and groundwater inflow.

Each rainfall event causes surface discharge and groundwater inflow after tens to hundreds of times time scale. When this tendency is constant for every rainfall event, it is possible to estimate the relation by multi-regression analysis by calculating daily ratio of inflow after rainfall event.

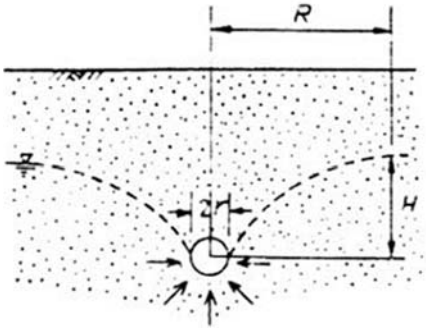
(iii) Hydraulics formulas

Under the simple condition such as a small undulation, it is possible to estimate the inflow rate based on the hydraulics formulas.

- **Constant water inflow**

  This is the normally produced inflow from the normal underground. This inflow rate which is estimated by the hydraulics formulas is often used for the detailed design of the drainage facility of the tunnel. There are many options of hydraulics formulas. The inflow which is calculated by representative formula is given by

$$Q = \frac{2\alpha \cdot k \cdot H \cdot L}{ln\frac{R}{r}}$$



  , where
  α is (π/2) + (H/R),
  Q is Constant Ground Water in Tunnel (m^3/s),
  k is Water Permeability in Ground (m/s),
  H is Height from tunnel center to ground water level (m),
  L is Section length of Tunnel (m),
  R is Radius of impact (m),
  and r is Radius of Tunnel (m).

- **Temporary water inflow**

  This is the temporary occurred inflow when tunnel is constructing in the fault or fractured zone. In general, this type of inflow rate would be reduced as time advances. There are many options of hydraulics formulas. The inflow which is calculated by representative formula is given by

$$Q = \frac{4\pi \cdot k \cdot b \cdot H}{2.3ln\frac{2.25k \cdot b \cdot t}{r^2 S}}$$

  , where
  Q is Temporary Ground Water in Tunnel (m^3/s),
  k is Water Permeability in Ground (m/s),
  b is Thickness of the permeable layer (m)
  H is Height from tunnel center to ground water level (m),
  S is Coefficient of the retention,
  and r is Radius of Tunnel (cm).

- **Sample calculation of the constant water inflow**

  This is the sample calculation of the constant water inflow for the reference.
  The radius of the planned tunnel is 5.6m, and other condition of the sample is shown below table.

Table C.2.9.7 Conditions of the sampleCalculation

Bor.No	Kilometric point	Tunnel Planning Level (Level of spring line)	Ground Level (m)	Ground Water		Water Permeability	
				Level (m)	H (m)	Lugeon value (μL)	Coefficient of Water Permeability (m/s)
BV-T1	4 + 230	90.171	148.22	133.008	42.837	0.38	0.38×10^{-10}
BV-T3	4 + 500	86.492	173.23	173.230	86.738	0.35	0.35×10^{-10}

NOTE: Lugeon value should apply value around 1Mpa (10kg/cm2) that is effective pressure.
Coefficient of water permeability equaled Lugeon value (μL) x 1 x 10^{-10}

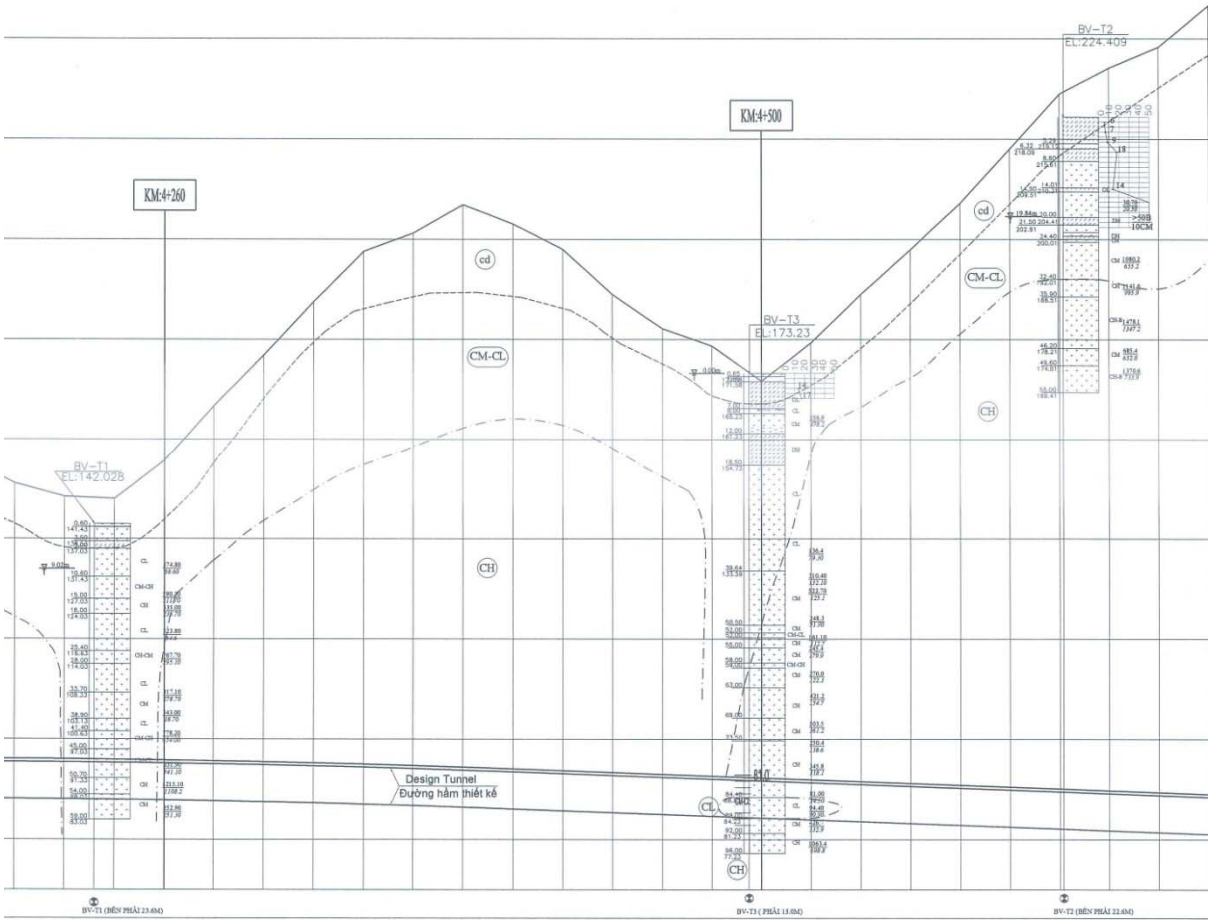


Figure C.2.9.9 Geological Profile of the sample

The sample calculation is conducted by average value of BV-T1 and BV-T2.

k = (0.38 + 0.35) / 2 x 10^{-10} = 0.37 x 10^{-10} (m/s)

H : (42.837 + 86.738) / 2 = 64.788 (m)

L : 1.0 Km = 1,000 (m)

R : r + 1.0 m (assumed value) = 5.7 (m)

r : 11.2 / 2 = 5.6 (m)

$\alpha = (\pi/2) + (H/R) = 12.94$

$$Q = \frac{2\alpha \cdot k \cdot H \cdot L}{ln\frac{R}{r}} = \frac{2 \times 12.94 \times 0.37 \times 10^{-10} \times 64.788 \times 1{,}000}{ln5.7 - ln5.6} = 3.505 \times 10^{-3}(m^3/s/km)$$
$$= 12.6(m^3/h/km)$$

(iv) Tank Model / Nash Model[1]

Tank model is a method used for estimation of temporal change of groundwater level and volume of water inflow. The procedure of this method is, firstly making bedrock into several three-dimensional blocks, then simulate temporal variation in the order of 1) volume of groundwater inflow, 2) groundwater table level and 3) surface discharge. General work flow is as follows.

1) Define the range of calculation and size of blocks
2) Prepare meteorological data
3) Prepare hydrological data
4) Prepare tunnel data
5) Prepare hydrogeological data
6) Calculate volume of tunnel inflow
7) Examination of Water balance
8) Identification

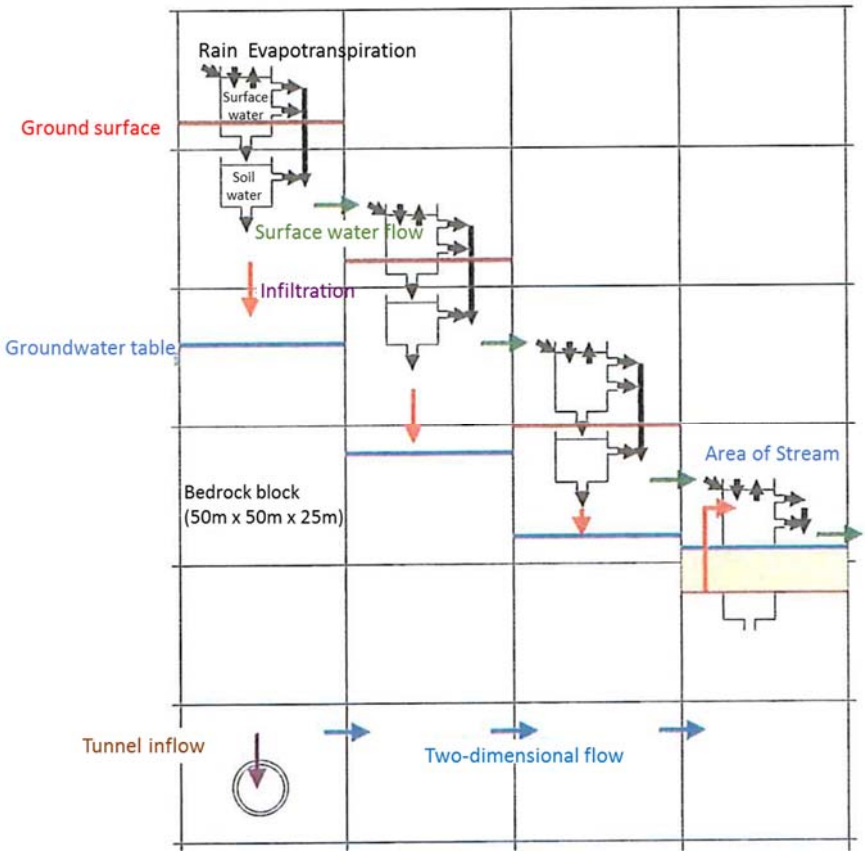


Figure C.2.9.10 Image of Tank Model Calculation Block

[1] Hiroshi Ohshima (1982),"HYDROGEOLOGICAL STUDY OF WATER INFLOW AND ASSOCIATED CHANGES OF WATER BALANCE CAUSED BY TUNNEL EXCAVATION"

(v) Hydraulic formula (Takahashi's formula)[2]

It is a method to estimate constant groundwater inflow into tunnel by using data of the area of influence and a specific discharge of a river in a low-level season. The area of influence can be calculated from Takahashi's method explained in C.9.2(3)(ii). The formula to estimate the volume of constant groundwater inflow is as follows.

$$Q = \Sigma ql (R_R + R_L) = \Sigma q A$$

Where,

Q (liter/min) : Volume of constant groundwater inflow into tunnel
q (liter/min/km^2): Specific discharge rate of a river in a low-level season per length
l (km) : unit section (divided by geological condition)
R_R (km) : Catchment range of the right side of tunnel
R_L (km) : Catchment range of the left side of tunnel
A (km^2) : Catchment area of tunnel inflow.

Specific discharge rate of a river shall be measured in the lowest level season. Generally it is measured after the rainfall event for about one week to check the temporal change to examine the base flow level.

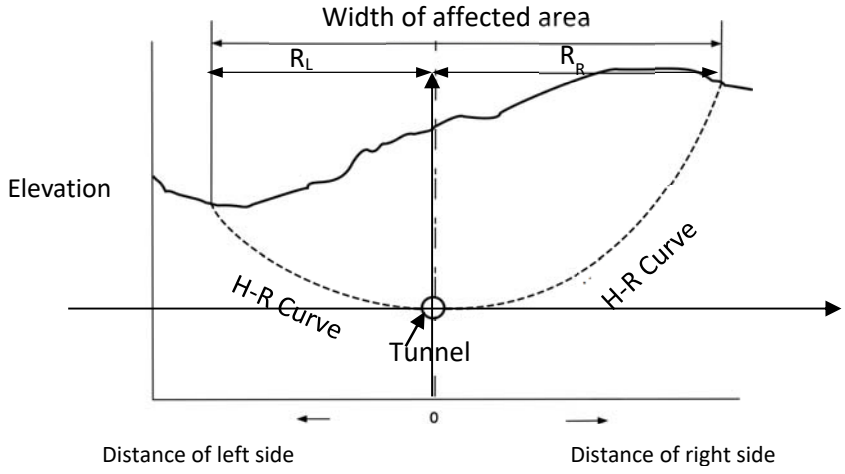


Figure C.2.9.11 Typical Section on the Takahashi's Model

(vi) Numerical modelling and simulation (Seepage flow analysis)

Seepage flow analysis is based on the governing equations combining the physical law of groundwater flow (Darcy's law) and law of conservation of mass.

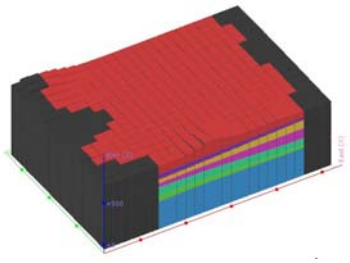
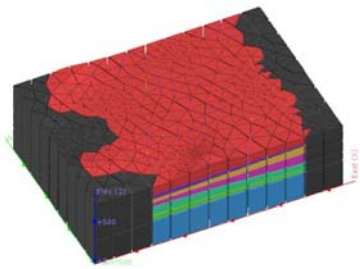
Although there are several methods for numerical modelling and simulation, "Finite Differential Method (FDM)" and "Finite Elements Method (FEM)" are commonly in these days. FDM divides the analysis area into small blocks, and calculate the storage or flow between the blocks, while FEM divides the analysis area into small elements or grid points, and calculate the value of water head (groundwater potential) which is the optimal solution satisfying the boundary conditions.

[2] Hikoji Takahasji (1964),"Characters and Some Problems on the Tunnel Water / Pre estimating methods for Amount of the Tunnel Water"

Both methods can be applied for estimation of groundwater flow, but generally FEM is more suitable for complicated geological condition than FDM as shown in the summary table below. So nowadays, FEM is used more than FDM.

On the other hand, FEM needs much more memory to calculate and takes much time for simulation. This is the reason why sometimes FDM is more convenient for general evaluation purpose such as in pre-feasibility stage.

Table C.2.9.8 FDM and FEM

Method	Element Decomposition		Model Image	Boundary Deformation	Application example
FDM	Square, Rectangle	Easy		Complex	-River flow, -Flood, -Debris flow -Groundwater
FEM	Any polygon	Complex		Easy	-Groundwater, -Debris flow, -stress analysis

(b) CLASS B (Non-Priority Area)

In the simplified area, it is not estimated significant impact, thus it is suitable to analysis by the qualitative method.

(4) Output

The result of the analysis could be organized as below and it must contain the two scenarios.

Table C.2.9.9 The result of the analysis

Scenario	The Result of the Analysis	Remarks (Condition)
Without Project	The natural state of groundwater flow direction and flow rate with seasonal variation.	
With Project	Water inflow rate and/or drawdown of groundwater table during construction by tunnel sections.	

C.2.9.5 Evaluation of the Environmental impact

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT

For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.

(The rest is omitted)

8.1 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT-FREE SCENARIO

In the analysis of the impacts prior to the project, the activities that have had the greatest impact on the changes in the areas of influence must be identified. In addition, the current state of the medium (abiotic, biotic and socioeconomic) and its environmental sensitivity should be qualified and quantified, and the analysis of trends must be made, considering the regional and local development perspective, economic dynamics, and government plans, the preservation and management of natural resources and the consequences that the anthropic and natural activities of the region have for the ecosystems.

(The rest is omitted)

8.2 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT SCENARIO

Based on the environmental assessment for the project-free scenario and the ratings obtained for each impact, the impacts generated by the project on the environment should be identified, described and qualified as a result of the interaction between the activities of said environment and the components of each medium. It is worth noting that this assessment is done without taking into account the environmental management programs, given that, according to their significance, the Environmental Management Plan is formulated.

(The rest is omitted)

(2) Other Related Technical Information

There are two methods of evaluation for the impact assessment in Japan. The first is compare the result of forecast with national standard or national goals. The second is the evaluation from efficiency of the mitigation measures conducted by project implementer. It is important to judge from the effort of project implement agency.

(3) Methodology, Process and Procedure

If national standard or local standard for hydrogeology is existed, these standards could be used for evaluation of environmental impact. In case of no official standards, it is appropriate to use inflow water rate. As an example, it is conceivable to use inflow water rate.

(4) Output

The result of the evaluation could be organized as below.

Table C.2.9.10 The result of the evaluation

The Result of the evaluation
1. The water inflow rate into the tunnel is forecasted XXm3/hour and the drainage has the capacity which can flow down the water from tunnel. 2. Environmental impact by drawdown of the groundwater table. 3. Effect of mitigation measures against water inflow and/or drawdown of groundwater table.

C.2.9.6 Mitigation and monitoring

(1) Referenced TOR

(a) Environmental Management Program

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.1 Environmental Management Program
…

An Environmental Management Plan (PMA) must be presented, structured in programs and subprograms (when required) and based on the hierarchy of management of potential identified impacts, considering as a first option measures for preventing and avoiding the occurrence of impacts; In the second option, measures to mitigate and/or minimize said impacts; Measures to correct or restore environmental conditions and, finally, compensatory measures will be considered.

For the identified impacts, environmental management measures should be considered taking into account that the same measure can be applied to the management of different impacts and that an impact can be managed through different measures.

The approach of programs, subprograms and measures should focus on comprehensive control of environmental impacts; For such purpose, it must be considered that there may be impacts that occur in different environments (for example, contamination of the surface water resource can affect elements of the abiotic, biotic and socioeconomic environments) and / or components (for example, the traditional economic activities of the population may affect the economic, demographic, cultural, etc.).

The PMA programs must specify:
17. Objective(s) of each program and subprogram.
18. Goals related to identified objectives.
Indicators that allow monitoring of the achievement of the goals proposed for each objective, as well as to determine the effectiveness of each program and subprogram.
19. Impacts to be managed by each program (based on impact assessment). Phase(s) of the project in which each program and subprogram would be implemented.
20. Application location (s) (cartographic location where possible).
21. Description of management measures (specific actions) to be developed within each program and

subprogram, specifying the type of measure (prevention, mitigation, correction and compensation).
22. List of proposed works to be implemented. The designs must be presented as documents annexed to the EIA.
23. Estimated schedule of program implementation.
24. Estimated costs of implementing each program.

(The rest is omitted)

(b) Monitoring and Tracing

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.2 Monitoring and Tracking Plan
…

a. Tracking and monitoring of plans and programs
For such purpose, the plan must precise of:

5. Actions to be developed to obtain the information and/or data to calculate the indicators proposed in the PMA.
6. Criteria used for the approach of each indicator.
7. Frequency of measurement.
8. Justification of the representativeness of the indicator raised, as well as the information used for its calculation.

b. Tracking and monitoring the trend of the medium
For the tracking and monitoring of the environmental components, the plan must include at least:

9. Objectives.
10. Environmental components to monitor.
11. Indicators (quantitative and qualitative) aimed at establishing changes in the trend of the medium, specifying what is intended to be measured and monitored with each one.
12. Location of monitoring sites, with the respective cartographic location, when applicable.
13. Identification of management measures that affect the trend of the medium.
14. Description of the procedures used to measure the trend of the medium, relating the necessary instruments.
15. Frequency and duration of the monitoring.
16. Criteria for analysis and interpretation of results.
(The rest is omitted)

(2) Other Related Technical Information

In Japan, the purpose of monitoring is adjusting the method of mitigation measures which did not have enough information for efficiency at the time of EIA study. In the case of this, contractor or implementer must collect the information about efficiency of mitigation measures and modify the method for more valid way.

(3) Methodology, Process and Procedure

(a) Environmental Management Program

Counter measures for environmental and social impact should be selected preventing or avoiding measures at first. In general, these preventing or avoiding measures could be selected at DAA study. If it is difficult to avoid or prevent the impacts at the time of EIA study, mitigation measure should be implemented as a second option.

The general process of selecting mitigation measure on hydrogeology is shown below figure.

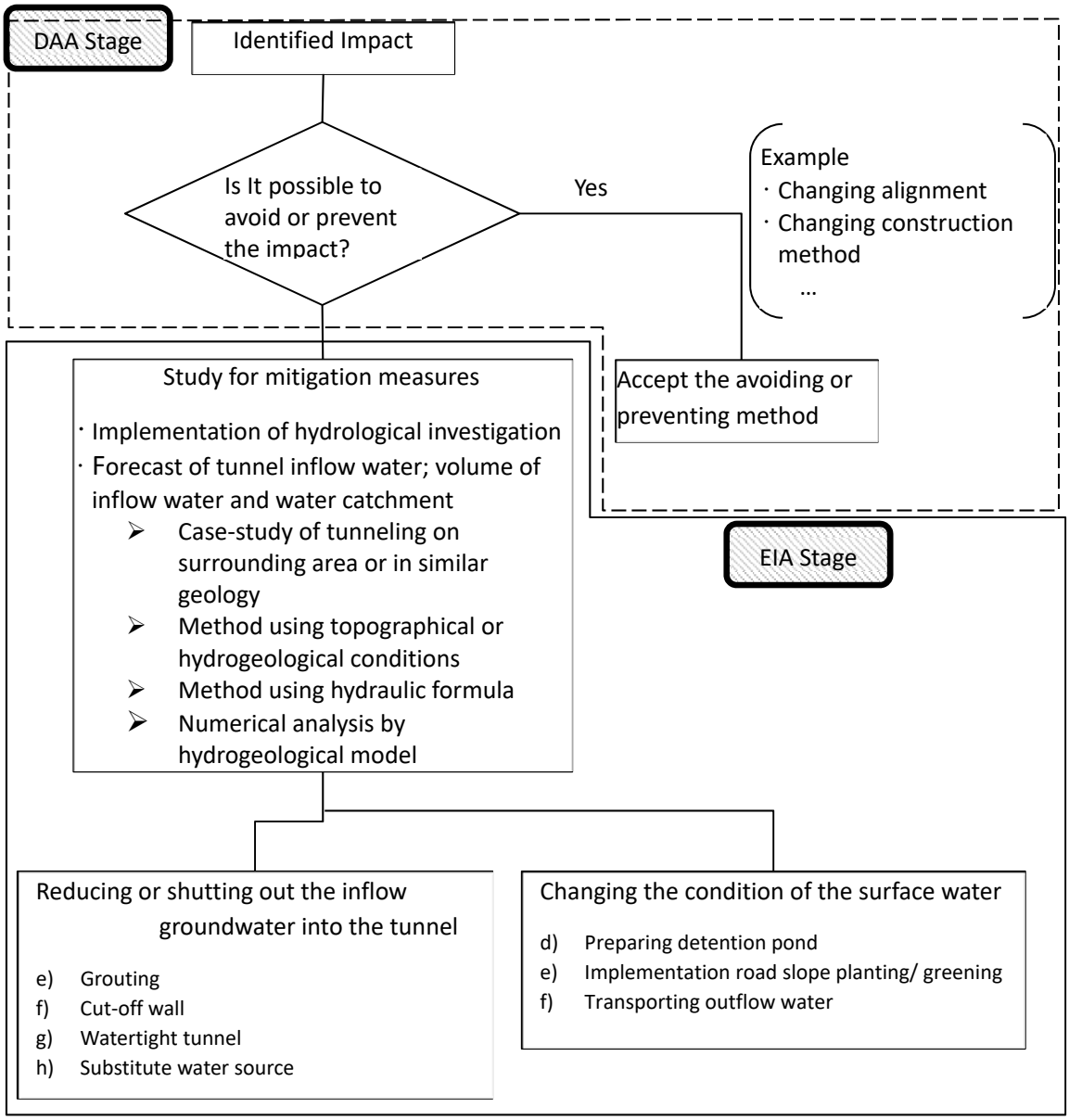


Figure C.2.9.12 Flow diagram of the mitigation measure study on Hydrogeology

The general information for mitigation measures of reducing or shutting out the inflow into the tunnel are below. (See the Subsection of the geotechnics for more detailed information)

Table C.2.9.11 General information for mitigation measures of reducing or shutting out the inflow

a) Grouting Grouting is the method of Injecting grout material into interconnected pore or void of ground to reduce water flow. b) Cut-off wall This method is the installing steel or concrete wall around the tunnel alignment to control volume of inflow. c) Watertight tunnel Waterproof is applying at entire circumference of tunnel to shut out inflow water after completion of construction d) Substitute water source: new construction of well and water supply reservoir

(4) Output

(a) Environmental Management Program

In general, some measures exist on hydrogeological field for preventing or mitigating impact from tunnel construction. On Environmental management program, the more efficient and enablable measures should be selected as countermeasures for environmental impact. The result of consideration should also contain the items which are restricted in TOR for EIA. Here is example of form on hydrological countermeasures

Table C.2.9.12 Environmental Management Program on hydrogeology

Id	Counter measure	1.Objective	2.Effectiveness/ Indicator of effect	3./7.Implementation period/ Phase	4.Implementation area / location	5./6.Management measures	8.Estimated costs	Remarks
1	Grouting							
2	Cut-off wall							
3	Watertight tunnel							
4	Substitute water source							
5								
6								
7								

(b) Monitoring and Tracing

The required information according to the TOR should be collected. Here is example form of monitoring plan.

Table C.2.9.13 PCM monitoring plan

Mitigation measure	Outline of the mitigation measure	The Index or parameter of monitoring	criteria	Frequency of the monitoring

C.2.10 Geotechnics

C.2.10.1 General

The content of this section presents the specific method of geotechnical analysis for EIA study. The Geotechnical analysis need the comprehensive information from the wide range of related field such as geology, hydrogeology, hydrology, soil and rock mechanics. The analysis should be carried out with taking account of these information.

(1) General workflow

The general workflow of geotechnical analysis shown in following diagram.

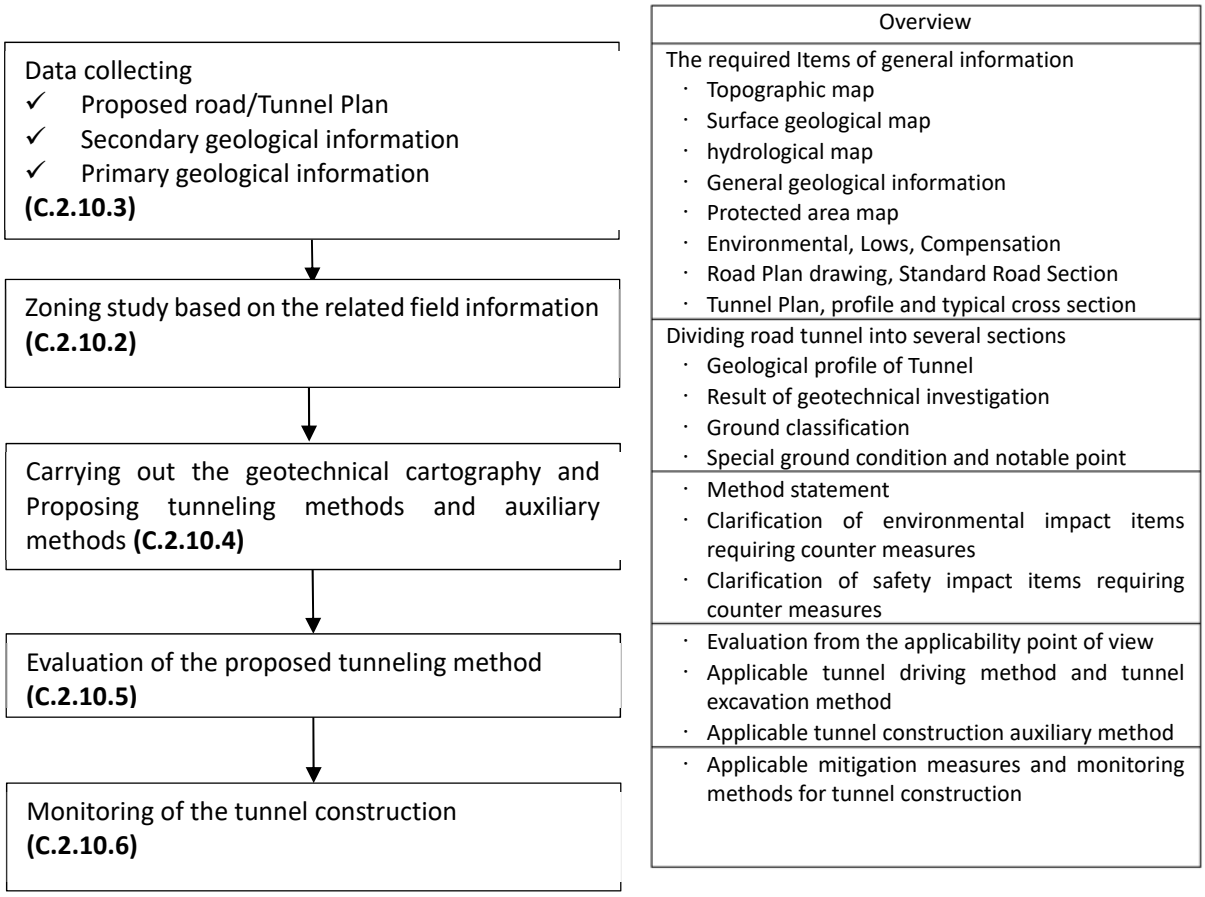


Figure C.2.10.1 Flowchart of the study on geotechnics

C.2.10.2 Zoning form the geotechnical point of view

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

5.1.9 Geotechnics

Zoning and geotechnical cartography must be carried out based on geological, soil, geomorphological, hydrogeological, hydrological, meteorological and seismic hazard information.

(2) Other Related Technical Information

The ground classification is necessary by zone with different geology for tunnel passing ground.
The ground classification is very important because it becomes an index of design of support and tunnel excavation method, farther it can show assumption the position of fault, fracture zone and aquifer.
The ground classification shall be in accordance with 'Invías 2016-Manual de Túneles para Colombia'.

(3) Methodology, Process and Procedure

The geotechnical cartography shall be prepared with following process and procedure.

(a) Method of Ground Classification

Confirm which type of method is adopted as a ground classification method such as Rock Mass Rating or Grand Classification by Elastic wave velocity.
The classification method by RMR which is in accordance with ASTM D 5868, is shown following table.
*RMR method is one of rock mass classification method by Bieniawsky.

Table C.2.10.1 Classification Parameters and Their Ratings

Parameter			Range of Values						
1	Strength of intact rock material	Point-load strength index (MPa)	＞10	4-10	2-4	1-2	For this low range Uniaxial compressive test is preferred		
		Unconfined compressive strength (MPa)	＞250	100-250	50-100	25-50	5-25	1-5	＜1
	Rating		**15**	**12**	**7**	**4**	**2**	**1**	**0**
2	RQD (%)		90-100	75-90	50-75	25-50	< 25		
	Rating		**20**	**17**	**13**	**8**	**3**		
3	Spacing of discontinuous		> 2m	0.6-2m	200-600mm	60-200mm	< 60mm		
	Rating		**20**	**15**	**10**	**8**	**5**		
4	Condition of discontinuous		Very rough surfaces Discontinuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1mm Slightly weathered walls	Slightly rough surfaces Separation < 1mm Highly weathered walls	Slickenside surfaces or Gauge < 5mm thick or Separation 1-5mm Continuous	Soft gauge > 5mm thick or Separation > 5mm Continuous		
	Rating		**30**	**25**	**20**	**10**	**0**		
5	Ground water	Inflow water per 10m of tunnel length (L/min)	なし	＜10	10-25	25-125	＞125		
		Ratio of joint water Pressure/ Major Principal stress	0	0.0-0.1	0.1-0.2	0.2-0.5	＞0.5		
		General condition	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		**15**	**10**	**7**	**4**	**0**		

Table C.2.10.2 Rock Mass Classes Determined from Total Ratings

Rating	**100 <- 81**	**80 <- 61**	**60 <- 41**	**40 <- 21**	**20 >**
Foundations	I	II	III	IV	V
Slopes	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

The elastic wave velocity evaluation method is applying in Japan as ground classification method.
This method can assume the zone where having a possibility such as a fracture zone or a fault by the elastic wave velocity. The elastic wave exploration can assume the condition of the rock and the existence position such as fracture zone. If it is used in conjunction with electric prospecting, the existence position of aquifer can also be assumed. Therefore, in the geological survey for tunnel design, the elastic wave exploration should be carried out at least along the tunnel linearity.

Table C.2.10.3 Japanese Ground Classification

Grade of Rock Mass	Rock Groups	Representative Rock Name	Elastic Wave Velocity Vp (km/s) 1.0 2.0 3.0 4.0 5.0	Condition of Rock Mass: Rock Quality, Water influence	Condition of Rock Mass: Interval of Discontinuity	Condition of Rock Mass: Condition of Discontinuity	Condition of Boring Core, RQD (%)	Competence Factor	Circumstances of Tunnel Excavation
B	H, Massive	Granite, Granodiorite, Quartz porphyry, Hornfels		-It is fresh and hard, or it show slightly tendency of denaturation due to weathering. - There is not deterioration due to water.	-The interval of joint is 50cm as mean. - Although there are influences of stratification or schistosity, it has little influence on tunnel excavation.	-There are little slickenside and inflow clay in discontinuity. -The discontinuity is almost sticking.	-Shapes of boring core are clast shape, short column shaped and rod shaped. -The length of boring core is almost 10 to 20cm, but there are a few cores of around 5cm also. - RQD is more than 70.	-	-The strength of rock is much larger than the load acting by tunnel excavation. - The state of discontinuity is also good, and looseness due to tunnel excavation hardly occurs. The excavated surface may partially occurs the fall of rocks, but the working face is self-sustaining. - At the tunnel with an excavation width (D) of about 10 m, the inner space displacement accompanying excavation is settled a minute elastic deformation of about 15mm or less.
	H, Massive	Mesozoic-Paleozoic sandstone, Chert							
	M, Massive	Andesite, Basalt, Rhyolite, Dacite							
	M, Massive	Tertiary sandstone, Conglomerate							
	L, Massive	Ophiolite, Tuff, Tuff breccia							
	M, Layered	Slate, Mesozoic-Paleozoic shale							
	L, Layered	Black schist, Greenschist							
	L, Layered	Tertiary mudstone							
C1	H, Massive	Granite, Granodiorite, Quartz porphyry, Hornfels		-It is relatively fresh and hard, or it show slightly tendency of weathering and denaturation. -Soft rock with relatively high agglomeration degree. - There is not deterioration due to water.	-The interval of joint is 30cm as mean. - Stratification or schistosity is conspicuous; it has influence on tunnel excavation.	- There is slickenside and inflow clay in a little part of discontinuity. -The discontinuity is partially open, but the opening width is small.	-The length of boring core is about 5 to 20cm, but there are a few cores of less than 5cm also. - RQD is 40 to 70.	-	-The strength of rock is larger than the load acting by tunnel excavation. - The state of discontinuity is relatively good, and looseness due to tunnel excavation is partially. The excavated surface may partially fell along the relatively slippery discontinuity, but the working face is self-sustaining. - At the tunnel with an excavation width (D) of about 10 m, the inner space displacement accompanying excavation is settled a minute elastic deformation of about 15 to 20mm or less.
	H, Massive	Mesozoic-Paleozoic sandstone, Chert							
	M, Massive	Andesite, Basalt, Rhyolite, Dacite							
	M, Massive	Tertiary sandstone, Conglomerate							
	L, Massive	Ophiolite, Tuff, Tuff breccia						more than 4	
	M, Layered	Slate, Mesozoic-Paleozoic shale							
	L, Layered	Black schist, Greenschist							
	L, Layered	Tertiary mudstone							
C2	H, Massive	Granite, Granodiorite, Quartz porphyry, Hornfels		- It is relatively fresh and hard, or it show slightly tendency of weathering and denaturation. -The rock quality is rather softened. -Soft rock with relatively high agglomeration degree. - There are deterioration and looseness due to water partially.	-The interval of joint is 20cm as mean. - Stratification or schistosity is conspicuous; it has influence on tunnel excavation.	-There is partially the slickenside and thin inflow clay in the discontinuity. -The discontinuity is partially open, and the opening width is relatively large. -Small faults with narrow width are interposed.	-The length of boring core is almost less than 10cm, and there are many cores of less than 5cm. - RQD is 10 to 40.	-	- The strength of the rock is not so large as compared with the load acting by tunnel excavation, but the deformation is almost within the range of elastic deformation. - A condition of the discontinuity is poor, and the looseness due to tunnel excavation increases along the slippery discontinuity. - The working face is almost self-sustaining. - When the rock strength is smaller than the load acting by tunnel excavation, the inner space displacement is about 30mm which is the boundary between elasticity and plasticity, in the tunnel with the excavation width (D) of about 10m, but it almost disappear at the distance of 2D.
	H, Massive	Mesozoic-Paleozoic sandstone, Chert							
	M, Massive	Andesite, Basalt, Rhyolite, Dacite							
	M, Massive	Tertiary sandstone, Conglomerate							
	L, Massive	Ophiolite, Tuff, Tuff breccia						more than 4	
	M, Layered	Slate, Mesozoic-Paleozoic shale							
	L, Layered	Black schist, Greenschist							
	L, Layered	Tertiary mudstone							
D1	H, Massive	Granite, Granodiorite, Quartz porphyry, Hornfels		-The rock quality has some hard parts, but it has intense weathering and denaturation as a whole. -Stratification or schistosity is very noticeable. -The interval of discontinuity is less than 10cm as mean, and many of them are opening. -The opening width of discontinuity is large, and the slickenside and thin inflow clay is often interposed in the discontinuity. -Small faults with narrow width are interposed. -Soils containing many boulder and talus deposit, etc. -There are striking deterioration and looseness due to water.			-The boring core is seen like fragments, and partly it is seen like angular gravelly sand or clay. - RQD is less than about 10.	4 to 2	-The strength of the rock is not large as compared with the load acting by tunnel excavation, the elastic deformation occurs, also the plastic deformation occurs at a part. - A condition of the discontinuity is very poor, and the looseness increases along the many slippery discontinuity. Because the self-sustaining of working face is difficult, ring cut method or mortar spraying works may be required. - If closing of the invert is not performed early, the inner space displacement of about 30 - 60mm occurs, in the tunnel with the excavation width (D) of about 10m, and often it does not disappear even if the distance of 2D.
	H, Massive	Mesozoic-Paleozoic sandstone, Chert							
	M, Massive	Andesite, Basalt, Rhyolite, Dacite							
	M, Massive	Tertiary sandstone, Conglomerate							
	L, Massive	Ophiolite, Tuff, Tuff breccia							
	M, Layered	Slate, Mesozoic-Paleozoic shale							
	L, Layered	Black schist, Greenschist							
	L, Layered	Tertiary mudstone							
D2	H, Massive	Granite, Granodiorite, Quartz porphyry, Hornfels						2 to 1	-The strength of the rock is little as compared with the load acting by tunnel excavation, and the large plastic deformation occurs together with the elastic deformation. - A condition of the discontinuity is very poor, and the looseness increases along the many slippery discontinuity. Because the self-sustaining of working face is difficult, ring cut method or mortar spraying works may be required. - If closing of the invert is not performed early, the inner space displacement of about 60 - 200mm occurs, in the tunnel with the excavation width (D) of about 10m, and often it does not disappear even if the distance of 2D.
	H, Massive	Mesozoic-Paleozoic sandstone, Chert							
	M, Massive	Andesite, Basalt, Rhyolite, Dacite							
	M, Massive	Tertiary sandstone, Conglomerate							
	L, Massive	Ophiolite, Tuff, Tuff breccia							
	M, Layered	Slate, Mesozoic-Paleozoic shale							
	L, Layered	Black schist, Greenschist							
	L, Layered	Tertiary mudstone							

Note: (1) The rock mass better than this classification shall be "Grade A", the inferior rock mass shall be "Grade E". (2) The classification of H, M and L of "Rock Groups" are defined by uniaxial compressive strength (qu) as follows; H: qu≧ 80N/mm², M: 20 N/mm² ≦qu < 80N/mm², L: qu < 20N/mm². (3) "Massive" and "Layered" of "Rock Groups" are defined as follows; Massive: Rock which the discontinuity is mostly joint. Layered: Rock which the discontinuity is mostly stratification or schistosity. (4) RQD stands for "Rock-quality designation", and it is a rough measure of the degree of joint or fracture in a rock mass, measured as a percentage of the boring core in lengths of 10 cm or more.

(b) General Plan of Tunnel

Confirm the longitudinal and horizontal alignment and typical cross section of tunnel.

(c) Special Ground Condition

Confirm the presence of special ground condition, if there is a special condition, check whether its position or situation is grasped. The special ground conditions are shown as following table.

Table C.2.10.4 Special Ground Conditions

Ground condition	Problem	Essential information
Ground where Landslides or slope failures are anticipated	Increase of earth pressure Unsymmetrical pressure, Slope failure Rock failure	Topography, Geology, Mechanical Strength, Groundwater level
Fault fracture zone or folded disturbance zone	Face failure, Outbreak of groundwater, Shortage of Surface water	Mechanical strength, Seismic velocity, Competence factor, Groundwater level, Distribution of fracture zone
Unconsolidated ground	Face failure, Non-sustainable tunnel floor, Outflow of ground, Subsidence of surface, Shortage of surface water	Mechanical strength, Relative density, Grain size distribution, Groundwater level, Water pressure, Hydraulic conductivity
Squeezing ground	Strong pressure on supports or lining, decrease of inner section due to squeezing of wall	Mechanical strength, Competence factor, Content of smectite, Natural water content, Degree of water immersion collapse
Ground that rock burst is anticipated	Face failure	Mechanical strength, Brittleness, Acoustic emission
Ground with hot geometry, hot spring, toxic gas, heavy metal, etc.	Eruption of high pressure and high temperature water, or toxic gas, leaching of heavy metal or acidity water	Temperature, Concentration of gas or oxygen, Content of heavy metal, Ph
Ground that high water pressure or much groundwater is anticipated	Outbreak of groundwater, Increase of earth pressure, Unsymmetrical pressure, Face failure, Shortage of surface water, Water pollution	Groundwater level, Amount and pressure of groundwater

(d) Notable Condition

Confirm the presence of notable condition in tunnel design and construction condition. The notable conditions are shown as following table.

Table C.2.10.5 Notable Design and Construction Conditions

Design and construction condition	Problem	Essential information
Small depth	Subsidence of surface, Cave-in, Unsymmetrical pressure	Topography including landslide, Mechanical strength Hydraulic, Conductivity, Location condition
Urban area	Subsidence of surface, Displacement and deformation of adjacent structure, lowering of groundwater level	Mechanical strength, Hydraulic conductivity, Location condition, Location of adjacent structure

Design and construction condition	Problem	Essential information
Large depth	High pressure groundwater, Increase of earth pressure	Mechanical strength, Hydraulic conductivity, Pressure and level of groundwater
Underwater	Large quantity of groundwater	Mechanical strength, Amount of groundwater, Hydraulic conductivity, Topography of bottom
Inclined drift or shaft	Groundwater, Inflow of surface water and soil from portal	Mechanical strength, Amount of groundwater, Hydraulic conductivity
Portal	Landslide, Slope failure, Unsymmetrical pressure, Subsidence or cave-in of surface	Mechanical strength, Topography including landslide
Neighboring construction	Unsymmetrical pressure, Deformation of adjacent structure	Mechanical strength
Large cross section	Face failure	Mechanical strength

(e) Relevant Condition

Confirm the relevant conditions which are required to prepare the tunnel geotechnical cartography such as previous design, environmental and geotechnical information from other construction experience and the result of natural condition survey.

(f) Geological Profile

Confirm the geological profile for tunnel.

(4) Output

The sample of the geotechnical cartography is shown below.

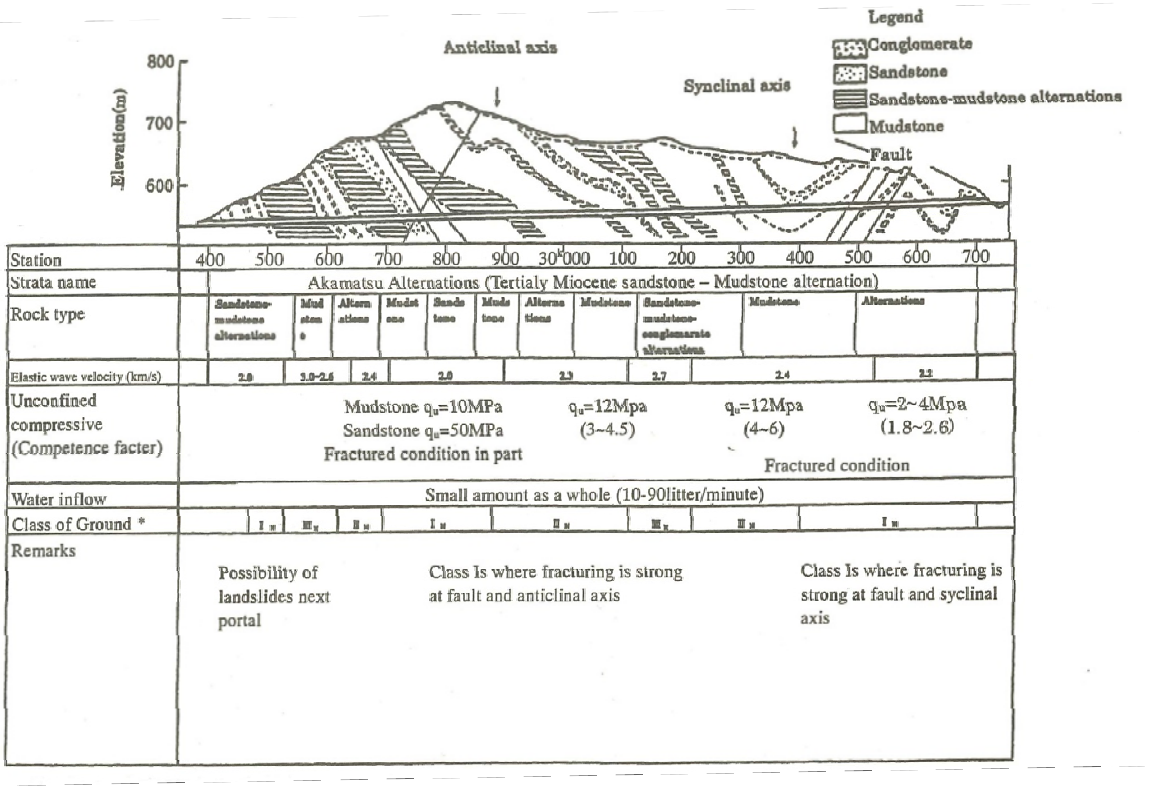


Figure C.2.10.2 Example of Geological Profile

C.2.10.3 Check list for required investigation items

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

The information should be presented on 1: 25,000 scale maps or more detailed. In any case for relevant instability processes, a more detailed scale of 1: 25,000 must be used through which adequate reading of the information is allowed.

For the roadway corridor, the geotechnical description must be carried out throughout the project. The presence of deposits with no consolidation or soil cover should be evaluated, whose geotechnical behavior is important in the stability of slopes and slopes. Such a description should be illustrated on a scale map 1: 25,000 or more detailed.

For the tunnel sections, the geotechnical sectorization must be carried out along them, focused on identifying sectors with potential geomechanically and homogeneous hydrogeological behavior and the stability of the rocky massif in each sector. The geotechnical information must be presented in plan and profile in scale 1: 10,000 or more detailed, depending on the length of the tunnel, and always considering that sufficient clarity, illustration and understanding of the geotechnical conditions of the proposed tunnel must be provided.

(2) Other Related Technical Information

It is stipulated that the preliminary design of the tunnel with primary information is performed, and counting on topographical surveys (scale 1:2.500 and 1:500 for the area of entrances) and geologic-geotechnical (scales of 1:5.000) in 'Invías 2016-Manual de Túneles para Colombia'.

On the other hand, the accuracy of survey in detailed design is stipulated as 1/1,000 to 1/100 in Standard

Specifications for Tunneling-2006: Mountain Tunnel in Japan.

(3) Methodology, Process and Procedure

The geotechnical survey must satisfy the following contents.

(i) Geology shall be researched gradually during the stage of design and construction plan in order to grasp the overall ground condition of the tunnel and to fulfill the purpose of obtaining the basic data for design and construction plan with improved accuracy.

The research of geology for design and construction plan may point out geological or topographical problems. The geotechnical investigation shall provide the information to clarify these problems, and to grasp and examine the following items:

- ✓ The overall geology, distribution and characteristics of the tunnel section.
- ✓ Ground classification with technical consideration based on the results of the investigation.
- ✓ Topography and geology of portal locations, basic references to the problems and measures.
- ✓ Evaluation of face stability, design of support selection of countermeasures, basic references to the selection of excavation method and tunnel driving method.
- ✓ Distribution and characteristics of special ground conditions, prediction of potential problems and phenomena and basic reference to possible countermeasures.

(ii) Necessary research items shall be selected and adequately investigated in consideration of the objective of the research and ground conditions.

(iii) In tunneling through special ground or under notable design and construction conditions, the most suitable investigation method shall be used for these conditions.

(4) Output

The required information for each class is shown below table. (Check list)

Table C.2.10.6 Checklist of the required information

Survey items		Required items / parameters
Detailed Information for Ground classification	1. Geological Condition	➢ Field reconnaissance results ➢ Observation result of boring core sample ➢ RQD ➢ Density, uniaxial compressive strength ➢ Water content, water permeability ➢ Elastic wave velocity, if necessary ➢ Borehole logs and in-situ investigation logs ➢ Ground classification ➢ Geological profile (1:500-1:5,000) ➢ Geological Map, if possible
	2. Topographical Condition	➢ Topographical map in detail (1:500-1:2,500) ➢ Longitudinal profile, horizontal plan ➢ Cross-section drawing ➢ Hydrological map

C.2.10.4 Proposing Tunneling Method

(1) Referenced TOR

None

(2) Other Related Technical Information

The Tunneling method and Auxiliary method shall be in accordance with 'Invías 2016-Manual de Túneles para Colombia'.

(3) Methodology, Process and Procedure

(a) Excavation Cross Section

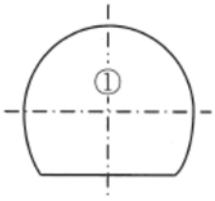
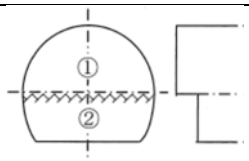
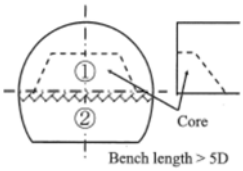
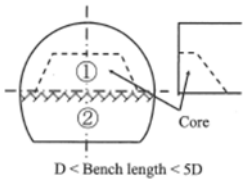
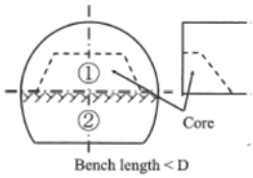
The excavation cross section should be determined taking into full consideration not only the required inner cross section, ground condition, site location, excavation method, construction procedure, supports, lining, drainage, thermal insulation, convergence after excavation, but also long-term stability of the tunnel. In bad ground condition, the excavation cross section should include the invert. In ground with a large convergence, the excavation cross section should be determined considering allowable deformation.

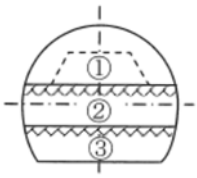
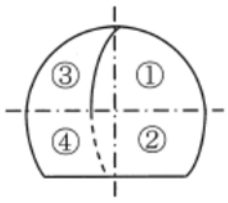
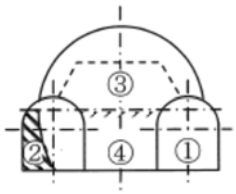
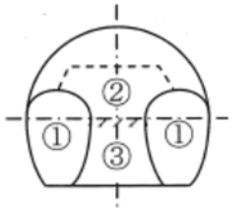
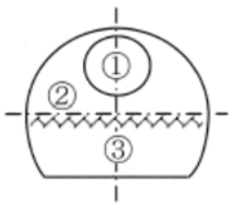
(b) Selection of Excavation Method

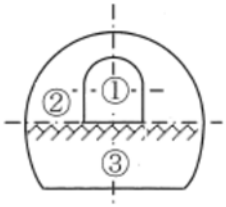
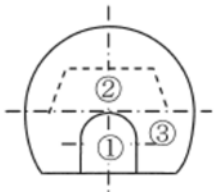
A suitable excavation method shall be selected taking into full consideration the ground conditions, shape and size of excavation cross section, tunnel driving method and impact on surrounding structures and environment. Excavation method widely used are full face method, bench cut method and drift advancing method. The center diaphragm method is also used for project of large sections and tunneling in urban areas.

The classification and characteristics of excavation method is shown in following table.

Table C.2.10.7 Classification and Characteristics of Excavation Method

Excavation Method		Division of Heading	Applicable Ground Conditions	Advantages	Disadvantages
Full face method			-Almost all ground for small section tunnels -Very stable ground for large section tunnels (A>60 m^2) - Fairly stable ground for medium section tunnels (A>30 m^2) -Unfit for relatively good ground interspersed with bad ground that may require change of the excavation method.	- Labor saving by mechanization - Construction management including safety control is easy because of the single-face excavation.	- Full tunnel length cannot necessarily be excavated by full face alone. Auxiliary bench cut will be adopted as required. -Unsteady stone from the crown may fall down with increased energy, and additional safety measures are required.
Full face method with auxiliary bench cut		 Bench length = 2- 4 m	- Fairly stable ground, but difficult to apply full face method - In case that full face method becomes difficult during construction - Relatively good ground interspersed with bad ground	- Labor saving by mechanization and parallel excavation of top heading and bench - Construction management including safety control is easy because of the single-face excavation.	- Difficult to switch to other excavation methods when the face becomes unstable.
Bench cut method	Long bench cut method		-Fairly stable ground, but difficult to apply full face method - Ring cut method is applied when the face is unstable.	- Alternate excavation of top heading and bench reduces equipment and manpower.	- Alternate excavation lengthens the construction period.
	Short bench cut method		- Ring cut method is applied when the face is unstable.	- Adaptable to changes in ground conditions - Alternate excavation of top heading and bench reduces equipment and manpower.	-Parallel excavation makes it difficult to balance the construction cycle of top heading and bench. - Alternate excavation lengthens the construction period.
	Mini bench cut method		- In case convergence needs less control than short bench cut method - Squeezing ground that requires an early closure of excavation cross section - Ring cut method is applied when the face is unstable.	- Easy to make early closure by invert -Alternate excavation of top heading and bench reduces equipment and manpower.	- Selection of construction equipment tends to be limited when they are planned to work on the top heading bed.

Excavation Method		Division of Heading	Applicable Ground Conditions	Advantages	Disadvantages
	Multiple bench cut method		- Fairly good ground for high and large section tunnel - Bad ground that requires small section of heading to stabilize the face	-Face is easily stabilized.	- Large deformation may develop if the closure is delayed in bad ground. - Each bench length is limited and working space is restricted. - Careful operation of mucking at each bench is required.
Center diaphragm method		 One method is to provide a diaphragm only for the top heading, while the other is to provide for both top heading and bench.	- Soil ground with shallow overburden where ground surface settlement is required to be kept at minimum - Relatively bad ground for large section tunnel	- Face is stabilized by dividing into small sections. - Ground surface settlement can be reduced. - Divided sections of heading are larger than those in side drift method, and larger equipment can be used.	- Displacement or settlement by removal of diaphragm should be examined. - Removal of diaphragm is added to the construction process. - The adoption of a special auxiliary method in the tunnel is difficult.
Side drift advancing method	With side wall concrete		- Ground where bearing capacity is insufficient and bearing capacity must be improved before the excavation of top heading - Soft rock ground or soil ground with shallow overburden where unsymmetrical ground pressure or landslide is anticipated	- Relatively massive concrete wall for side drift improves the bearing capacity and strengthens resistance against unsymmetrical ground pressure.	- Small equipment has to be used for drift excavation. - The upper ground may be loosened by drift excavation.
	Without side wall concrete		- Ground where bearing capacity is insufficient to apply bench cut method. - Soil ground with shallow overburden where ground surface settlement is required to be kept at a minimum.	- Ground surface settlement can be reduced. - Temporary diaphragm can be more easily removed than those in center diaphragm method.	- Small equipment has to be used for drift excavation.
Other drift advancing methods	Top drift advancing method		- Ground that requires confirmation of geology, drainage effect and the reduction in preceding displacement, and supporting pressure. - TBM may be adopted to advance drift.	- The confirmation of geology, drainage effect and the reduction in preceding displacement, and supporting pressure can be achieved by advancing drift. - Center cut is unnecessary in drill and	- Drift excavation by TBM may take time unless ground is fairly stable. - Small equipment has to be used for drift excavation.

Excavation Method		Division of Heading	Applicable Ground Conditions	Advantages	Disadvantages
				blast method. Blasting vibration and noise can be therefore reduced. -Face stability can be improved when enlarged. - Ventilation effect can be expected when drift excavation is completed.	
	Center drift advancing method		- Ground that requires the confirmation of geology, drainage effect and the reduction in preceding displacement, and supporting pressure	- The confirmation of geology, drainage effect and the reduction in preceding displacement, and supporting pressure can be achieved by advancing drift. - Center cut is unnecessary in drill and blast method. Blasting vibration and noise can be therefore reduced. -Face stability can be improved when enlarged.	- Small equipment has to be used for drift excavation.
	Bottom drift advancing method		- Ground that requires dewatering method	- Geology can be confirmed by advancing drift. -Additional face is produced from drift, and construction period can be shortened.	- Difficult to balance the construction cycle of each face - Various types of equipment are required.

(c) Selection of Tunnel Driving Method

Selection of tunnel driving method shall be based on tunnel length, ground conditions, excavation cross section, excavation method, location conditions, and impact on surrounding structure and environment.
Tunnel driving methods include drilling and blasting, mechanical excavation, and combinations of these methods. As a general rule, the main concern in the selection of the tunnel driving method is ground condition.
The drilling and blasting is typically applied for medium hard rock ground.
Mechanical excavation is usually applied to medium hard rock to soil ground. Excavation equipment should be properly selected considering the tunnel length and ground properties. TBM can be also used for relatively long tunnels in hard to medium hard rock ground. When applying TBM method, excavation efficiency and countermeasures against problem shall be studied exhaustively in advance.
A flow diagram of selection of tunnel driving method is shown in following figure.

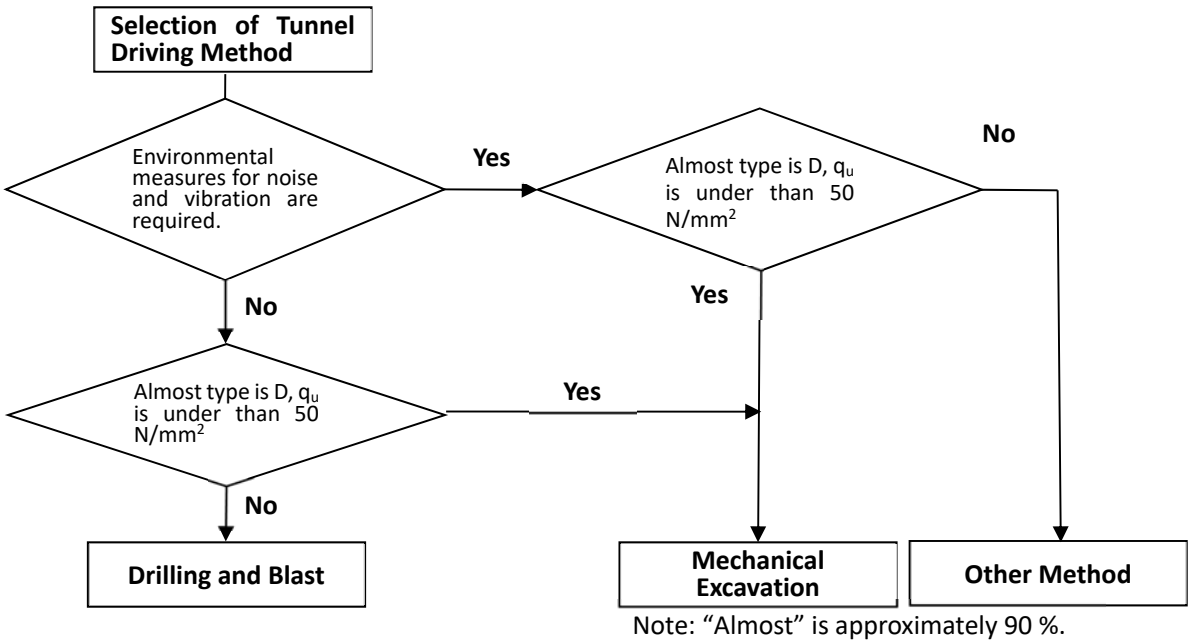


Figure C.2.10.3 Selection of Tunnel Driving Method

(d) Auxiliary Method

(i) General

An auxiliary method is a construction method of a secondary or special nature adopted to ensure face stability and tunnel safety and to preserve the environmental in cased where either conventional support patterns or division of heading section don't provide effective solution or where they are not advantageous.

Practical methods that can be used with ordinary tunneling machines and materials, which will not have a significant impact upon construction cycles, include face stabilizing techniques such as forepoling, long forepiling, face shotcrete, face bolts, foot reinforcing bolts, temporary invert, and technics for controlling groundwater such as weep holes. In contrast, method that are not very practical for use with ordinary tunneling machines and materials include measures to avoid advance impact on neighboring structures such as grouting, shielding wall, and measures against surface settlement such as long forepiling, pipe roofs, and ground water measures such as drain boring, well points, deep wells and weep holes.

(ii) Role of Auxiliary Method

Since auxiliary methods are closely related to tunnel design and construction method, it is necessary to change the excavation method and support pattern appropriately so that they will be suited for the selected auxiliary methods and its objective and type. The measure objectives of auxiliary methods are ensuring safety of tunneling (face stabilization and measures against water inflow) and preservation of the environment (groundwater measures, countermeasures against surface settlement and measures to prevent adverse impact on neighboring structures). Selection if auxiliary methods should be based on a comprehensive study to meet these objectives.

1) Auxiliary methods to be used during tunneling should be selected, considering their effects, cost efficiency and work period, correctly evaluating the construction status and measurement result, and fully studying the suitability of auxiliary method to the excavation method and support pattern.
2) In order that the auxiliary method can be employed efficiently and effectively, it is essential that the tunneling method is well suited to the auxiliary method selected. Tunnel design and construction method should be optimized to meet the field conditions by thoroughly evaluating the various design conditions. The flow of surveys, design and tunnel construction, summarized from the view point of the auxiliary method are shown following figure.

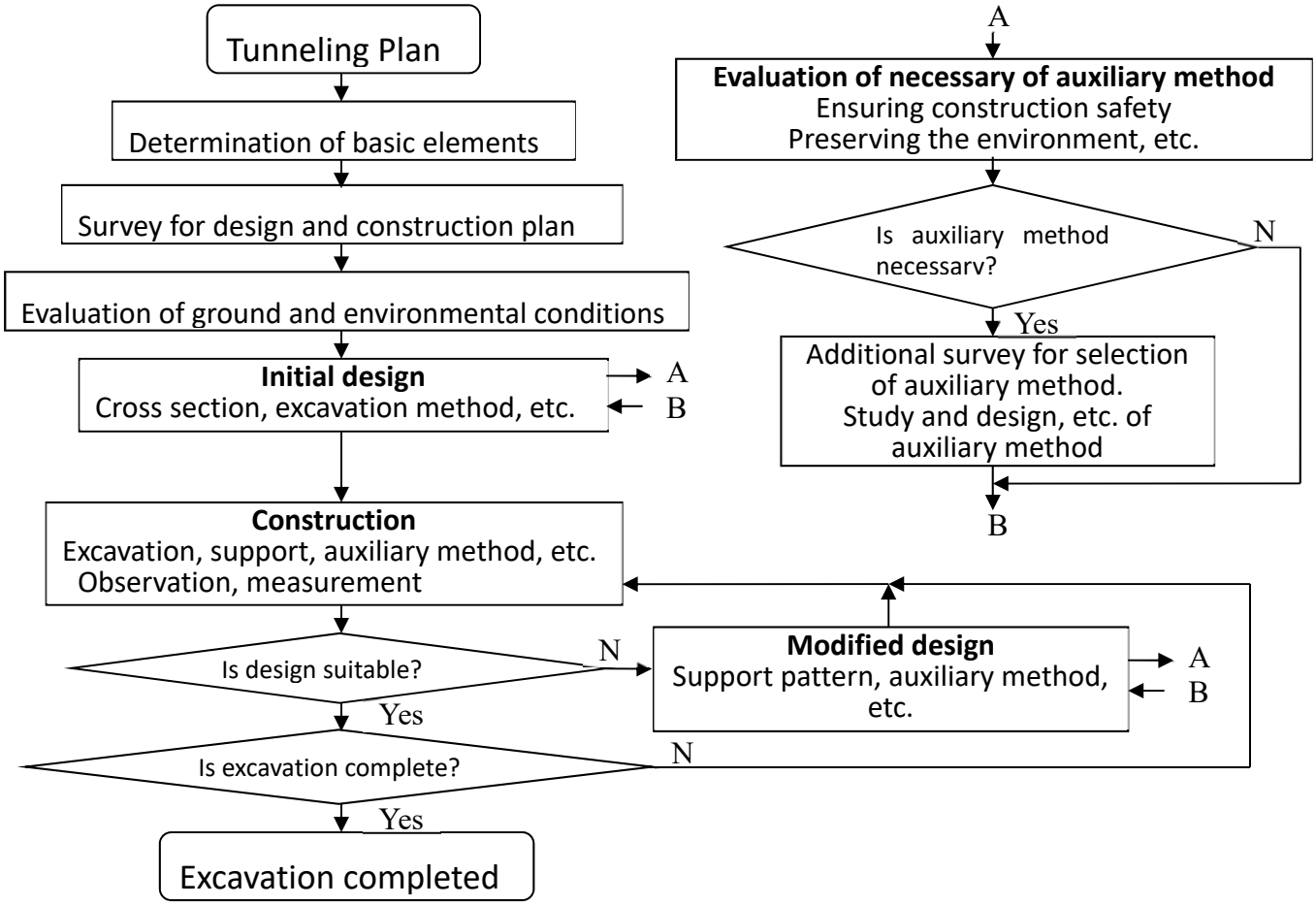


Figure C.2.10.4 Flow of Surveys, Design and Tunnel Construction Focusing on the Auxiliary Method

(4) Output

The sample of the proposed tunneling method and auxiliary method are shown below.

Table C.2.10.8 Sample of the Proposed Tunneling Method and Auxiliary Method

Item		Type of Method	Adoption
Tunneling Method	Tunnel Driving methods	➢ Drilling and Blast	X
		➢ Mechanical Excavation	
	Tunnel Excavation Method	➢ Full face method	
		➢ Full face method with auxiliary bench cut	X
		➢ Bench cut method	X
		➢ Center diaphragm method	
		➢ Side drift advancing method	
		➢ Other drift advancing methods	
Auxiliary Method	Ensuring safety of Tunneling	➢ Face stabilization	X
		➢ Against water inflow	X
	preservation of the environment	➢ groundwater measures	X
		➢ Against surface settlement	
		➢ Measures to prevent adverse impact on neighboring structures	

C.2.10.5 Evaluation of the proposed tunneling method

(1) Referenced TOR

None

(2) Other Related Technical Information

Construction methods should be selected based on investigations and studies conforming to 'Invías 2016-Manual de Túneles para Colombia'.

(3) Methodology, Process and Procedure

The design and investigation item to be checked are shown in following table.

Table C.2.10.9 The Design and Investigation Item to be Checked

Item to be Checked Results		Contents to be Checked
Research	Topographic survey	Topography of required area, scale, position of lineament or fault, position of river, stream or water resource, position of slope, position of building or structure, position of lifeline.
	Geotechnical survey	Required result of test in laboratory and in-situ test, boring log
	Hydrological research	Prediction of inflow water in tunnels, problems of design and construction, Impact on the surrounding environment
	Investigation of location conditions	Natural environment, social environment and human living environment as well as the relevant laws and regulations which are provided restrict construction projects, especially over the neighboring areas where construction of a tunnel is planned.
Design	Tunnel Plan profile, and typical cross section	Allowable alignment conditions, allowable gradient, drain during construction, required minimum inner cross section
	Geological profile, geotechnical evaluation	Geological classification, geology of the tunnel passage layer, special ground conditions, notable conditions, applied type and configuration of support
	Tunnel safety	Tunnel disaster prevention class, traffic conditions, evacuation plan, tunnel lay out, safety system
	Selection of tunnel driving method	Tunnel geology and surrounding conditions
	Selection of tunnel excavation method	Tunnel scale, tunnel geology and surrounding conditions
	Selection auxiliary method	Items requiring auxiliary method, applied auxiliary method
	Monitoring	Required observation and measurement

(4) Output

The result of the evaluation could be organized as below.

Table C.2.10.10 The result of the evaluation

Item to be Checked Results		Evaluation result	Action
Research	Topographic survey		
	Geotechnical survey		
	Hydrological research		

Item to be Checked Results		Evaluation result	Action
	Investigation of location conditions		
Design	Tunnel Plan profile, and typical cross section		
	Geological profile, geotechnical evaluation		
	Tunnel safety		
	Selection of tunnel driving method		
	Selection of tunnel excavation method		
	Selection auxiliary method		
	Monitoring		

C.2.10.6 Monitoring of the tunnel construction

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.2 Monitoring and Tracking Plan
…
a. Tracking and monitoring of plans and programs
For such purpose, the plan must precise of:

9. **Actions to be developed to obtain the information and/or data to calculate the indicators proposed in the PMA.**
10. **Criteria used for the approach of each indicator.**
11. **Frequency of measurement.**
12. **Justification of the representativeness of the indicator raised, as well as the information used for its calculation.**

b. Tracking and monitoring the trend of the medium
For the tracking and monitoring of the environmental components, the plan must include at least:

17. **Objectives.**
18. **Environmental components to monitor.**
19. **Indicators (quantitative and qualitative) aimed at establishing changes in the trend of the medium, specifying what is intended to be measured and monitored with each one.**
20. **Location of monitoring sites, with the respective cartographic location, when applicable.**
21. **Identification of management measures that affect the trend of the medium.**
22. **Description of the procedures used to measure the trend of the medium, relating the necessary instruments.**
23. **Frequency and duration of the monitoring.**
24. **Criteria for analysis and interpretation of results.**

(The rest is omitted)

(2) Other Related Technical Information

The monitoring of the tunnel constructions shall be in accordance with 'Invías 2016-Manual de Túneles para Colombia'.

(3) Methodology, Process and Procedure

(a) Monitoring and Tracing

(i) Tracking and monitoring of plans and programs

The flow diagram of monitoring for PMA is shown below figure.

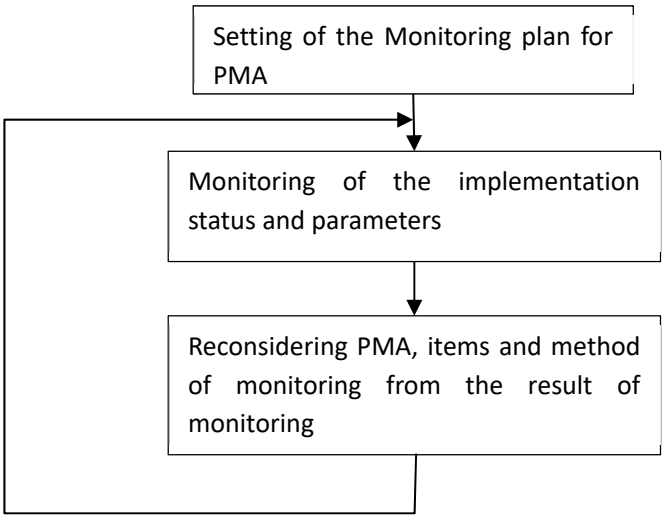


Figure C.2.10.5 Flow diagram for PMA monitoring

(ii) Objective of Monitoring works

In tunnel design stage, to obtain the sufficient information for tunnel design, such as geotechnical characteristics, is difficult because of the tunnel is constructed lineal long structure in the ground. Therefore, during tunnel construction, ungraspable information, such as the behavior of the ground around the tunnel, at design stage should be investigated and compared result of detailed design. The detailed design should be revised depending on the result of measurement. It is an extremely important matter for construction of tunnel. Recently, the tunnel, which has been in service, is deformation has occurred by variation of the ground around the tunnel. Such a problem has occurred a lot. In order to determine the countermeasure and reinforcement for deformation of these, results of the measurement in construction are very effective. The objective and function of measurement is shown following flowchart.

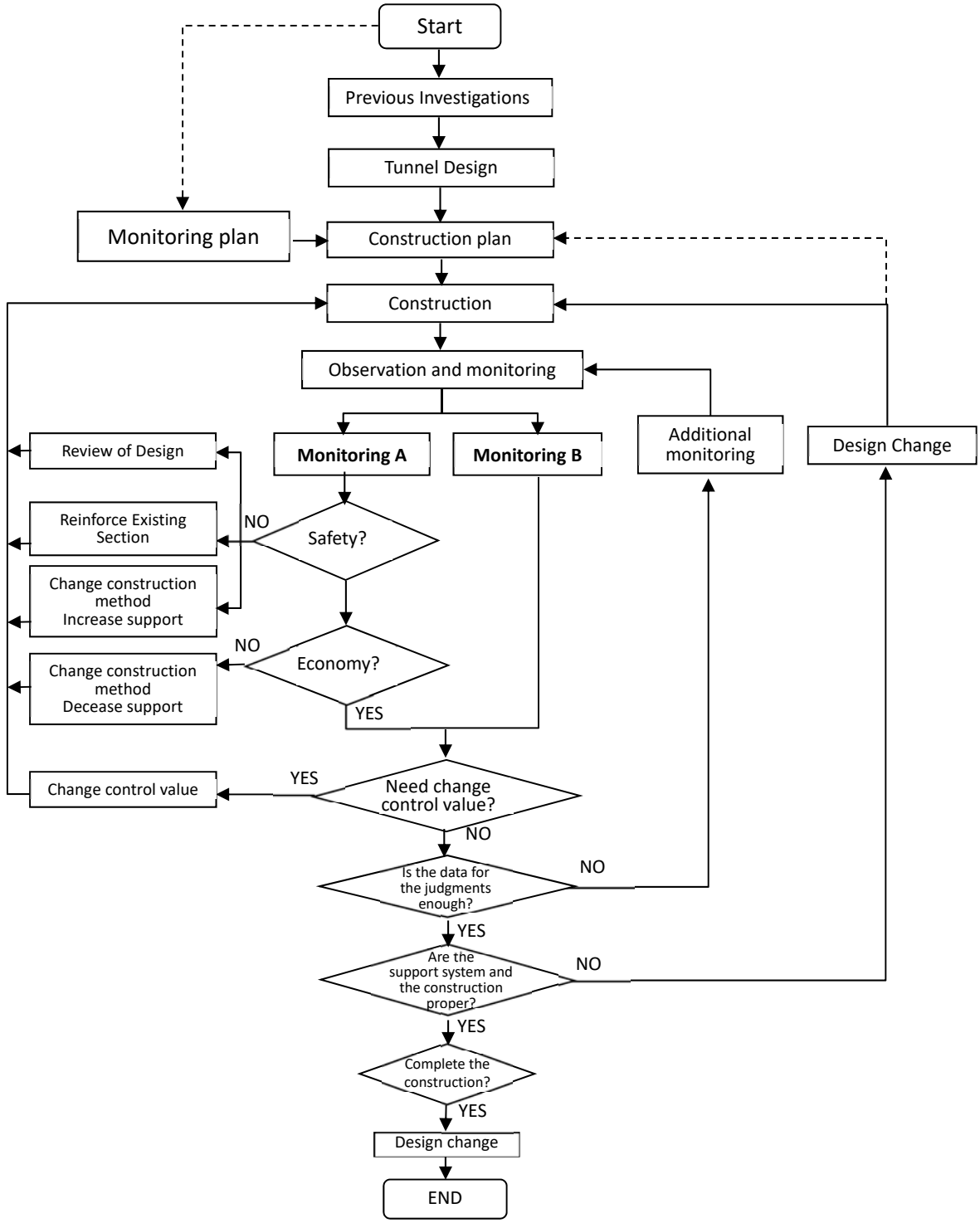


Figure C.2.10.6 Objective and Function of Observation and Measurement

(iii) Tracking and monitoring the trend of the medium

The example of the monitoring item is below table.

Table C.2.10.11 Examples of Major Observation and Measurement Items of Ground and Supports

Category	Observation / Measurement item	Position	Item to be observed	Use of results	Kind of Measurement
Observation and measurement of ground and support for stability	Observation	Inside Tunnel	- Ground Conditions of Excavation face and state of supports/lining/water inflow of constructed portion	- Evaluating the stability of excavation face Reviewing ground classification Studying relationship between ground condition and ground behavior - Prediction of future ground and groundwater conditions - Maintenance during service	A
		Surface	- Condition of surface	- Studying the range affected by excavation - Evaluating the stability of surrounding ground	A, B
Investigation/ test of ground property	Ground sample test and in-situ investigation/test	Inside Tunnel	- Ground sample test physical and mechanical properties of Ground structure	- Reviewing ground classification - Studying deformation and strength - Studying squeezing Evaluating face stability	B
		Inside Tunnel	- In-Situ investigation test: Physical and civil engineering properties of ground	- Detailed check of ground condition - Reviewing ground classification - Prediction of geology ahead of face - Studying deformation characteristics and strength characteristics	B
Measurement of ground and support behavior	Convergence measurement	Inside Tunnel	- Change in distance between walls - Displacement at measuring points	- Studying stability of surrounding ground - Studying effect of support member - Studying when to place the lining	A
	Crown Settlement measurement	Inside Tunnel	- Settlement of crown and side walls	- Studying the stability of ground around crown	A
	Measurement of settlement the foot	Inside Tunnel	- Settlement at the support foot	- Studying of bearing capability of foot	A
	Measurement of heaving	Inside Tunnel	- Status of heaving	- Studying the stability, the stability of ground around invert	B
	Measurement of ground displacement	Inside Tunnel	- Radial displacement of surrounding ground	- Understanding the nature of the loosened zone - Studying the appropriateness of rock bolt length	B
		Surface	- Settlement in surrounding ground - Horizontal displacement in surrounding ground	- Studying ground behavior before excavation - Understanding 3D behavior of ground - Studying the stability of ground ahead of face	B
	Measurement of surface displacement	Surface	- Settlement Landslide	- Studying the range affected by excavation - Studying the stability of ground ahead of face - Monitoring Landslide behavior	A, B
Measurement concerning support function	Measurement of axial force of rock bolt	Inside Tunnel	- Axial force of rock bolt	- Studying suitability of rock bolt length, number, position, anchoring method	B
	Measurement of stress in shotcrete	Inside Tunnel	- Stress in shotcrete Working load	- Studying Suitability of shotcrete thickness, strength - Studying load sharing with steel supports	B
	Measurement of stress in steel supports	Inside Tunnel	- Stress, sectional force of steel supports	- Studying suitability of dimensions, support spacing of steel support - Studying load sharing with shotcrete	B

Category	Observation / Measurement item	Position	Item to be observed	Use of results	Kind of Measurement
	Measurement of stress in lining	Inside Tunnel	- Stress in lining concrete - Stress in reinforcement	- Studying safety of lining concrete - Studying when to place the lining and whether the design is suitable - Management by long term observation of behavior	B
	Measurement of lining displacement	Inside Tunnel	- Change in inter-wall distance - Displacement at measuring points	- Studying safety of lining concrete	B
Others	Measurement of changes in nearby structure	Surface	- Settlement of the structure - Inclination of the structure - Vibration induced by explosion	- Evaluating impact on nearby structures	B
	Measurement of groundwater level	Inside tunnel	- Groundwater level - Pore water pressure	- Studying measures taken against ground water - Evaluating the water recharge - Evaluating the External water pressure acting on the lining	B

As reference, Selection of Key items for Observation / Measurement for Different Ground Condition are shown as following table. The appropriate observation or measurement shall be selected based on ground conditions and classifications.

Table C.2.10.12 Selection of Key items for Observation / Measurement for Different Ground Condition

Ground condition and classification		Phenomena	Observation / measurement item												
			Observation and investigation	Convergence	Crown settlement	Measure of settlement at the foot	Measurement of heaving	Ground sample test	In-situ investigation / test	Ground surface displacement	Ground displacement	Axial force of Rock bolt	Shotcrete stress	Steel support stress	Lining stress
Hard rock ground	A few cracks	Rock fall	○	○	○										
	Many cracks, but no clay is present	Rock fall Pressure of loosened - ground	○	○	○										
	Many cracks and fractured	Rock fall Loosening pressure Actual earth pressure Face stability	○	○	○					○	○				
Soft Rock ground	Large competence factor	Rock fall	○	○	○										
	Small competence factor	Loosening pressure Actual earth pressure	○	○	○	○	○	○		○	○				
	Extremely small competence factor	Loosening pressure Actual earth pressure Face stability	○	○	○	○	○	○	○		○	○	○	○	
Soil ground		Loosening pressure Face stability	○	○	○	○		○		○	○				
Squeezing ground		Loosening pressure Actual earth pressure	○	○	○	○	○	○	○		○	○	○	○	○

Note) - For tunnels with a small overburden (approximately, less than two times tunnel excavation width), the surface displacement shall be measured in addition to the items listed above.

- For tunnels near the structure(s), the settlement of the structure(s) and groundwater shall be measured in addition to the items listed above.

Source: Standard Specification for tunneling - 2006: Mountain Tunnels (Japan Society of Civil Engineers)

(iv) Utilization of Observation and Measurement Results

Observation and measurement results shall be promptly utilized for reasonable design and construction suitable for the ground condition. To this end, the behavior of the surrounding ground and the tunnel supports shall be determined, and then safety of construction, validity of the design and possible impact on neighboring structures shall be evaluated in accordance with pre-defined control items and control criteria.

The following list gives typical approaches for deciding control criteria:

i) To be based on similar cases in the past or records in test sections.

ii) To be based on the FEM analysis results.

iii)To be based on the critical strain method.

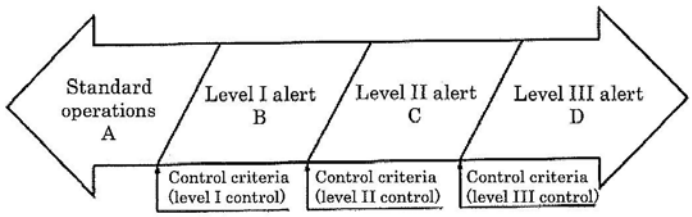
iv)To be based on the shearing index and shearing strain.

v) To be based on the expected final displacement.

vi)To be based on the maintenance criteria for neighboring structures.

vii) To use a combination of approaches i) to vi).

A general relationship between the control criteria and the safety management system is shown in following figure.



A: Standard operations – Standard measurements
B: Level I alert – Increasing measurement frequency; conducting site inspections; giving stricter instructions to workers
C: Level II alert – Strengthening the measurement system; carrying out minor control measures
D: Level III alert – Stopping construction; analyzing cause and tendency of deformation; deciding on tunnel reinforcement measures

Figure C.2.10.7 Relationship between Control Criteria and safety Control System

(4) Output

(a) Monitoring and Tracing

The required information according to the TOR should be collected. Here is example form of monitoring plan.

(i) Frequency and Interval of Measurement

The example plan of frequency and interval of measurement for Subsidence measurement of tunnel top, Deformation measurement of tunnel inner surface and Subsidence measurement of ground surface are shown as following tables.

Table C.2.10.13 Example of Measurement Frequencies of Convergence/ Crown Settlement/ Ground Surface

Frequency	Distance from face to measuring point	Rate of displacement
2 times / 1 day	Under 0 – 0.5 D	Over 10 mm / day
1 time / 1 day	Under 0.5 – 2.0 D	5 – 10 mm / day
1 time / 2 days	Under 2.0 – 5.0 D	1 – 5 mm / day
1 time / 1 week	Over 5.0 D	Under 1 mm / day

1) D=tunnel Excavation width
2) The measurement frequency to be selected is the frequency determined by the rate of displacement, or the frequency by the distance from the face, whichever is the higher.
3) After observing for about two consecutive weeks that the displacement rate is under 1 mm/week, measurements may be terminated.
4) Tunnel term "face" here refers to an excavation location such as the top heading, bench, invert, etc.
The typical measurement intervals of convergence and crown settlement of a road tunnel is shown as following table.

Table C.2.10.14 Typical Measurement intervals of Crown Settlement and Convergence

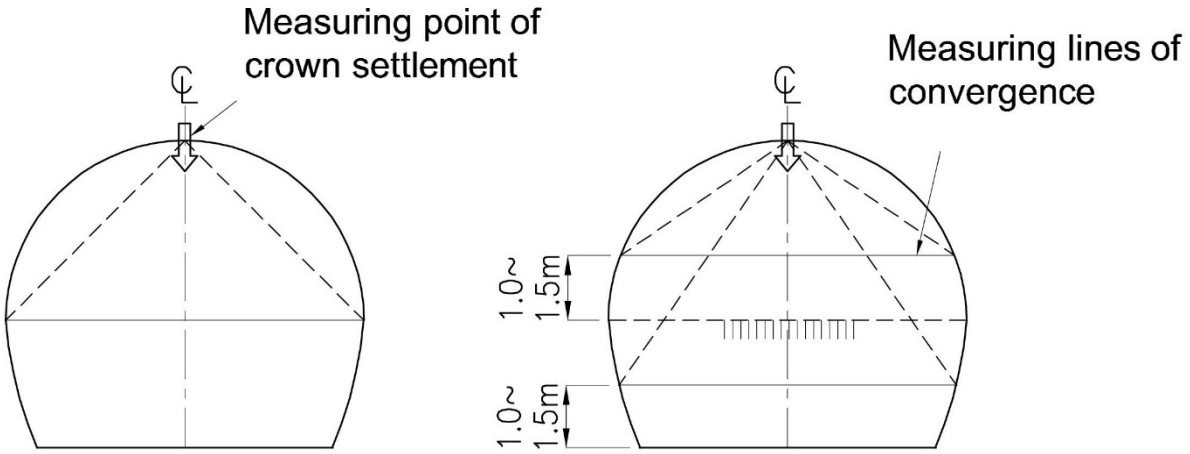
Zone / Ground Classification	Near the portal (50 m from the portal)	Earth covering 2D or Less	Initial stage of construction: phase up to about 200 m tunneling advance	Steps After some advancement: Standard
B, C	10 m	10 m	20 m	30 m
D	10 m	10 m	20 m	20 m
E	10 m	10 m	10 m	10 m

(ii) Arrangement of Crown Settlement / Convergence Measure lines

Measuring line layout shall be set out with consideration for the excavation method and foreseeable ground behavior. Example of measuring lines is shown as following.

1) Subsidence measurement of tunnel top
a) Basically, survey point should be placed on the tunnel centerline.
b) In the special zone with unsymmetrical pressure, leg subsidence, and ground heaving, survey point should be added depending on the following conditions:
- In case of large ground deformation or sharp unsymmetrical pressure, subsidence measurement should be carried out at survey points at both sides of the arch;
- In cases where steel arch support is used and subsidence is dominant, subsidence measurement should be carried out at survey points at the feet of the arch; and
- In cases where ground heaving occurs, survey points should be added depending on the condition.

2) Deformation measurement of tunnel inner surface
a) Basically, in case of full face method, the survey line is one horizontal line. In case of bench cut method, survey line is one horizontal line each for the top heading and bench.
b) In zone DIII, near the portal, the overburden is less than 2 D. It is shown same as bench cut method. However, in cases when unsymmetrical pressure is forecasted, survey lines should be six lines.



Full face method
Example of 1 or 3 measuring lines

Bench cut method
Example of 2,4 or 6 measuring lines

Note) Measurement shown by horizontal lines (solid lines) are mandatory, whereas diagonal lines (dotted lines) are measured if necessary.

Figure C.2.10.8 Example of Arrangement of Crown Settlement/ Convergence measuring Lines - 1 (excavation width D is about 10 m)

3) Displacement measurement of ground surface and under ground

Basically, the interval of displacement measurement from ground surface in the vicinity of the portal is shown in **Table C.2.10.15**. The measuring interval for measurement of ground surface subsidence shall be 5 to 10 m longitudinally, and 3 to 5 m in the cross direction, reducing the interval toward the center of the tunnel, and also for lesser overburden. The measuring range in the cross direction is given in **Figure C.2.10.10**, which corresponds to the range affected by the excavation.

Table C.2.10.15 Guidelines for Measurement of Displacement for Ground surface and Underground

Overburden	Importance of Measurement	Necessity of Measuring	Interval of Subsidence Measurement
Less than 1D	Very important	Necessary	5 m
Over 1D less than 2D	Important	To be measured preferably	10 m
Over 2D	Less important	To be measured if necessary	If necessary

Note) D: tunnel excavation width, h: overburden

a) If overburden is over 2D, in case where subsidence of ground surface is expected depending on condition of geology, groundwater, and unsymmetrical pressure.

b) The interval of measurement is the axis direction of the tunnel.

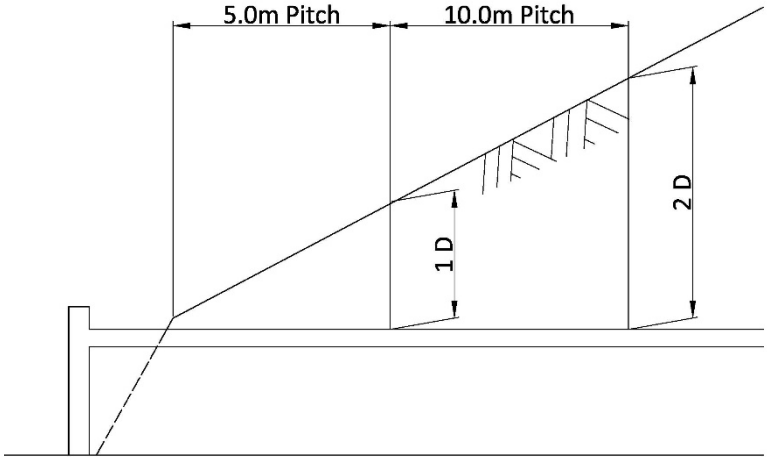


Figure C.2.10.9 Interval of Subsidence Measurement on Ground Surface

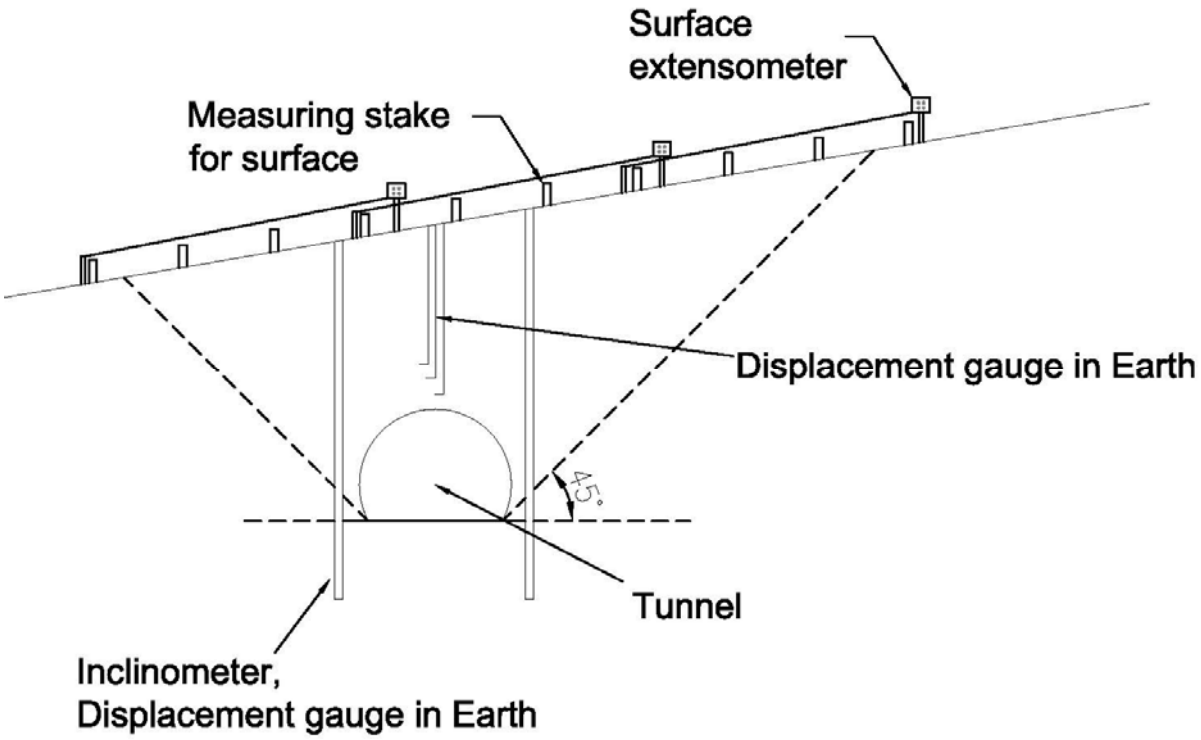


Figure C.2.10.10 Example of Arrangement of Measuring Points for Ground Surface Displacement and Underground Displacement

(iii) Measurement of Groundwater Level

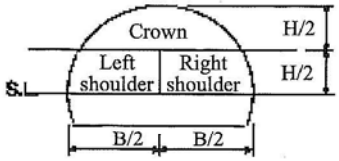
If it should a drop of groundwater level accompanying tunnel excavation be an issue, groundwater level shall be measured. In that case, an opening for groundwater level observation is provided as needed. An existing well may be used for this purpose.

(iv) Processing of Observation and Measurement Result

All observation and measurement results shall be processed in a timely manner so as to determine the present condition of the tunnel and to utilize the findings in subsequent predictions and in the design and construction of the tunnel.

The example of processing of observation and measurement result for road tunnel is shown in following figure.

Tunnel name		Observation date:	
Measuring station +	Distance from portal: m	Cross section: No.	Supporting pattern:
Overburden: m	Rock name/Geological age:	Rock group (1-5):	Rock code:
Specifications of auxiliary method (inc. face shotcrete and bolts)	Specifications of additional supports	Measurement A / B Specify A or B if it is the closest cross section	



Special conditions, status, etc. _____

_____

Presence/absence and status of collapse _____

Presence/absence of early invert closure _____

Observation item		Rating						Enter the ratings here		
								Left	Center	Right
A. Compressive strength (N/mm²)	Unconfined compressive strength	100 or more	100 - 50	50 - 25	25 - 10	10 - 3	3 or less			
	Point load	4 or more	4 - 2	2 - 1	1 – 0.4	0.4 or less				
	Rough guide for strength in hammering	Hard to break when placed on the ground and strongly hammered	Breakable when placed on the ground and strongly hammered	Breakable when held by hand and hammered	Breakable when hit with another rock of the same type	Partially breakable using two hands	Crushable when force is applied with a fingertip			
	Rating	1	2	3	4	5	6			
B. Weathering and alteration	Rough guide for weathering	Generally fresh		Weathered or altered along the crack		Weathered or altered to the rock core	Weathered into soil or unconsolidated soil			
	Rough guide for hydrothermal alteration	No alteration observed		Clay observed in the crack due to alteration		Decreased strength observed at the rock core due to alteration	Remarkable alteration into soil or clay			
	Rating	1		2		3	4			
C. Crack intervals	Crack intervals	d ≥ 1 m	1 m > d ≥ 50 cm	50 cm > d ≥ 20 cm	20 cm > d ≥ 5 cm	5 cm > d				
	RQD	80 or more	80 - 50	60 - 30	40 - 10	20 or less				
	Rating	1	2	3	4	5				
D. Crack conditions	Crack opening	Tightly closed	Some of the cracks open (less than 1 mm wide)	Many of the cracks open (less than 1 mm wide)	Open (1-5 mm wide)	Open to the width of 5mm or more				
	Substance in cracks	None	None	None	Thin clay (5 mm or less)	Thick clay (5 mm or more)				
	Crack roughness and slickenside	Rough	Smooth	A limited slickenside	A highly polished slickenside					
	Rating	1	2	3	4	5				
E. Strike and dip	Strike perpendicular to tunnel axis	1. Reverse dip of 45 to 90 degrees	2. Reverse dip of 20 to 45 degrees	3. Regular/reverse dip of 0 to 20 degrees	4. Regular dip of 20 to 45 degrees	5. Regular dip of 45 to 90 degrees				
	Parallel with tunnel axis			1. Dip of 0 to 20 degrees	2. Dip of 20 to 45 degrees	3. Dip of 45 to 90 degrees				

Evaluation by water inflow and water-induced deterioration within 10 m from the face
(Deterioration shall be evaluated considering existing and possible future deterioration.)

F. Water inflow	Status	No inflow or water seeping not exceeding 1 liter/min.		Water dripping at 1 to 20 liters/min		Water locally inflowing at 20 to 100 liters/min.	Water extensively inflowing at 100 liters or more per min.		
	Rating	1		2		3	4		
G. Water-induced deterioration	Water-induced deterioration	None		Loosened		Weakened	Washed out		
	Rating	1		2		3	4		

Figure C.2.10.11 Example of Face Observation Records in Road Tunnel

C.2.11 Atmosphere

C.2.11.1 Meteorology

C.2.11.2 Identification of emission sources

C.2.11.3 Air Quality

C.2.11.4 Noise

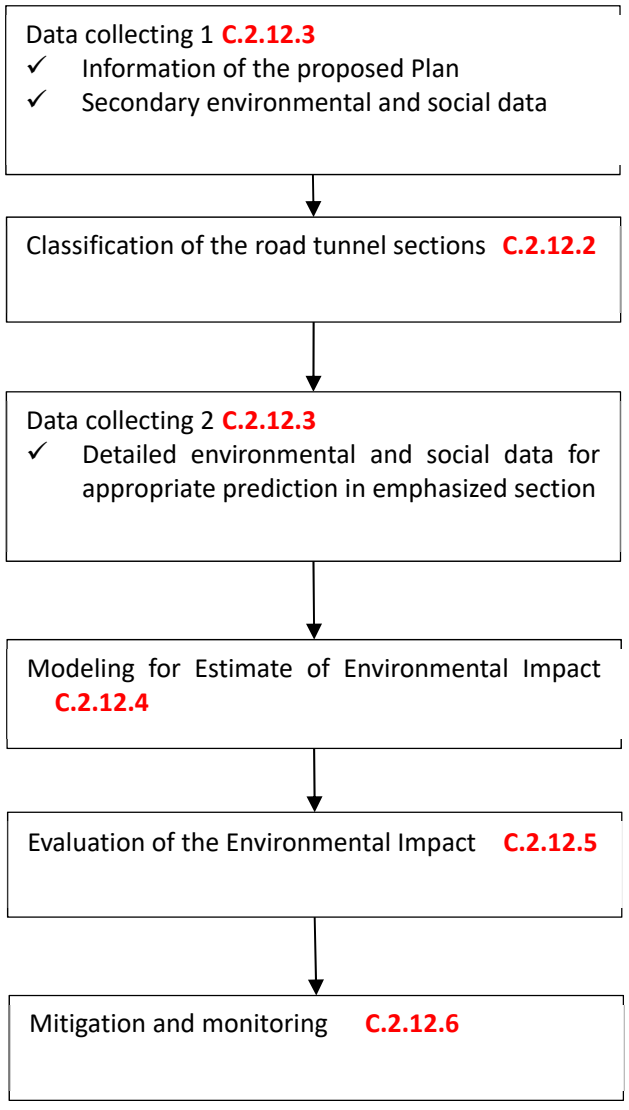
C.2.12 Vibration

C.2.12.1 General

The content of this section presents the specific method of collecting and analysis on vibration for EIA study. This section also introduces the countermeasures for environmental effect caused by road tunnel project and monitoring method on vibration during constructing.

(1) General workflow

The general workflow for impact study of vibration shown in following diagram.



Overview	
The required Items of general information · Surface geological map · distribution of residence · Road Plan drawing, Standard Road Section	
Setting the target village or residence which could be assumed that the impact of vibration would be affected.	
CLASS A Priority Area	CLASS B N/A
More detailed data for numerical analysis · Geological data · Tunneling method · Quantity of explosive · The structure of the target house	N/A
· Blast-induced vibration estimation model of	N/A
· Evaluation based on the particle velocity of the vibration	
· Controlling amount of explosive for blast of using delay detonator · Measuring blast vibration	N/A

Figure C.2.12.1 Flowchart of the study on hydrological impact

(2) Estimated environmental impact

It is important to clarify the environmental and social impact caused by construction and operation of the

tunnel for classification of the divided sections. The assumed environmental impact on vibration is shown below.

Table C.2.12.1 Estimated Impact on hydrology

From the daily life or livelihood point of view
・ Damage to the houses and buildings ・
From the precious or protected nature point of view
・
From the Occupational health and safety point of view
・

C.2.12.2 Classification of the investigation methods

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

4.AREAS OF INFLUENCE
4.2 DEFINITION, IDENTIFICATION, AND DELIMITATION OF THE AREA OF INFLUENCE
…

It is important to clarify that the result of the delimitation can be reflected in one or several polygons, by identifying the area of influence for each component, group of components or media.

The area of influence by component, group of components or medium should be based on units of analysis such as: watersheds, ecosystems, territorial units, and those identified by the applicant within the EIA. Each area of influence per component, group of components or medium, must have a minimum unit of analysis which must be properly supported.

(The rest is omitted)

(2) Other Related Technical Information

THE PRINCIPLES of ENVIRONMENTAL IMPACT ASSESSMENT BEST PRACTICE say that Environmental Impact Assessment should be focused. (INTERNATIONAL ASSOCIATION FOR IMPACT ASSESSMENT, 1996) The process of the EIA study should be concentrated on significant environmental effects and key issues. Therefore, it is recommended to identify the possible area or section of significant environmental effect.

(3) Methodology, Process and Procedure

(a) Target of the study

For effective study of EIA, it is important to make a concentrate on important area for environment and society. It is well known that the energy of blasting is smaller than the energy of earthquake and actual impact of blast vibration would propagate only several hundred meters distance from the blasting point. Therefore, it would be enough to set the nearest target house/building within the 200m from the tunnel alignment (as the following figure) for effective EIA study.

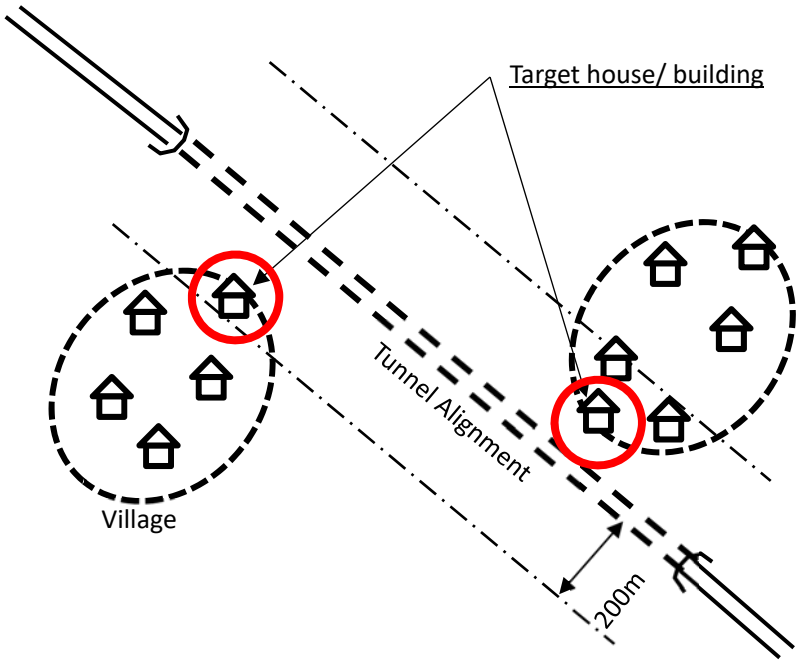


Figure C.2.12.2 Conceptual Image of the EIA study area dividing on vibration

(b) Data collecting range

On analysis of the blast vibration on EIA study, the analysis should be limit as the target house or building. Therefore, the range of data collection should also be limit as the peripheral of the target house/building.

(c) Classification

It is not necessary to set the several classes of analysis because the environmental impact analysis on blast vibration has the determined house or building as a study target.

(4) Output

On analysis of the blast vibration on EIA study, there is only one class should be set. The conditions for analysis, class and the reason of classification are described as below.

Table C.2.12.2 Classification of Environmental Impact

Study Area	Conditions on vibration analysis		Class A	-	Remarks
	Distance between alignment and house/building	Tunneling method			
I	✓(Within 200m)	✓(blasting)	○	-	

C.2.12.3 Check list for required investigation items

(1) Referenced TOR

There is no description of blast vibration in TOR for EIA (Resolution 0751, 26 March 2015).

(2) Other Related Technical Information

For the detailed analysis on blast vibration, it is basically required to collect following items for impact analysis.

(a) Tunnel blasting method

(i) Blasting type

It is necessary to identify the blasting type whether blasting cap or electric detonator from the construction planning.

(ii) Amount of the blasting powder

For analyzing blast vibration, information of the type and amount of the blasting powder per single blasting will be required.

(iii) Delay patterns

In addition, delay pattern of the blasting will be required from the construction design.

(b) Geological conditions

The information of geology will be required for analysis.

(3) Methodology, Process and Procedure

(a) Tunnel blasting method

Basically, the information of the tunnel blasting method is based on the construction design. Therefore, required information will gathered from the result of construction design.

(b) Geological conditions

Geological data in peripheral area of the target house/building will be required.

(4) Output

The required information for each class is shown below table. (Check list)

Table C.2.12.3 Checklist of the required information

Survey items		Required items / parameters
Information for detailed analysis	Tunnel blasting method	Blasting type
		Amount of the blasting powder
		Delay patterns
	Geological conditions	Types of the foundation rock

C.2.12.4 Modeling for Estimate of Environmental Impact

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT
For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.
(The rest is omitted)

On study of the blast vibration, the case of without the blasting is not necessary to consider. However, if other tunneling method could be applicable except blasting, the impact caused by that method should be considered.

(2) Other Related Technical Information

(3) Methodology, Process and Procedure

(a) CLASS A (Priority Area)

A blast of tunnel construction generates ground shock and vibration which may cause damage to the surrounding houses or buildings. Various experimental site-specific studies have been performed to predict and control blasting effects. The parameters associated with the vibration are displacement, velocity and acceleration with their respective frequencies. It has been inferred from result of many studies that peak particle velocity (PPV) is generally a good index of damage to structure.
The relationship between PPV and distance(D) can be written as

$$\mathrm{V} = \mathrm{k} \times W^m \times D^n$$

Where
V is the PPV(cm/sec);
D(m) is the distance from blasting point to the observed point
W(kg) is the amount of the blast powder per one delayed explosion
k is the site constants.
The parameter “m” is generally 0.5 to 1.0 and “n” is approximately -2.

The following table shows the proposed value of the parameter from Japanese blast powder manufacturers.

Table C.2.12.4 Analytic method on Hydrology

Proposing blast powder manufacturer in Japan	Estimation formula	Type of the blasting	K value
Company A	$V = k \times W^{0.75} \times D^{-2}$	Reliving cut (Center cut)	400 to 900
		Side slash	200 to 500
		Lower berth cut	300 to 700
Company B	$V = k \times W^{2/3} \times D^{-2}$	Reliving cut (Center cut)	500 to 1000
		Side slash	200 to 500
		Open cast blasting	200 to 500
Company C	$V = k \times W^{0.75} \times D^{-1.5}$	Blasting in the Tunnel	80±40
		Open cast blasting	50±30

Source: Japan explosive society

It is difficult to fix the site constants K before the construction works. On the time of EIA study, it is better to refer the literatures or to use observed K value of the near site.
On the actual construction stage, it is important to measure PPV and k value with test blasting on the site before the main construction works.

(b) CLASS B (Non Priority Area)

Not available

(4) Output

The result of the analysis could be organized as below and it must contain the two scenarios.

Table C.2.12.5 The result of the analysis

Scenario	The Result of the Analysis	Remarks (Condition)
Without Project	Not available	
With Project	The peak particle velocity(PPV) is forecasted as ** m/sec in the target house/building.	

C.2.12.5 Evaluation of the Environmental impact

(1) Referenced TOR

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

8.ENVIRONMENTAL ASSESSMENT

For the identification and evaluation of environmental impacts, it is necessary to characterize the areas of influence by component, group of components or medium. This characterization expresses the general conditions of the area without the effects of the project and constitutes the basis for analyzing how the project will modify them. This indicates that two scenarios must be analyzed, namely: the determination of environmental impacts with and without project.

(The rest is omitted)

8.1 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT-FREE SCENARIO

In the analysis of the impacts prior to the project, the activities that have had the greatest impact on the changes in the areas of influence must be identified. In addition, the current state of the medium (abiotic, biotic and socioeconomic) and its environmental sensitivity should be qualified and quantified, and the analysis of trends must be made, considering the regional and local development perspective, economic dynamics, and government plans, The preservation and management of natural resources and the consequences that the anthropic and natural activities of the region have for the ecosystems.

(The rest is omitted)

8.2 IDENTIFICATION AND EVALUATION OF IMPACT FOR THE PROJECT SCENARIO

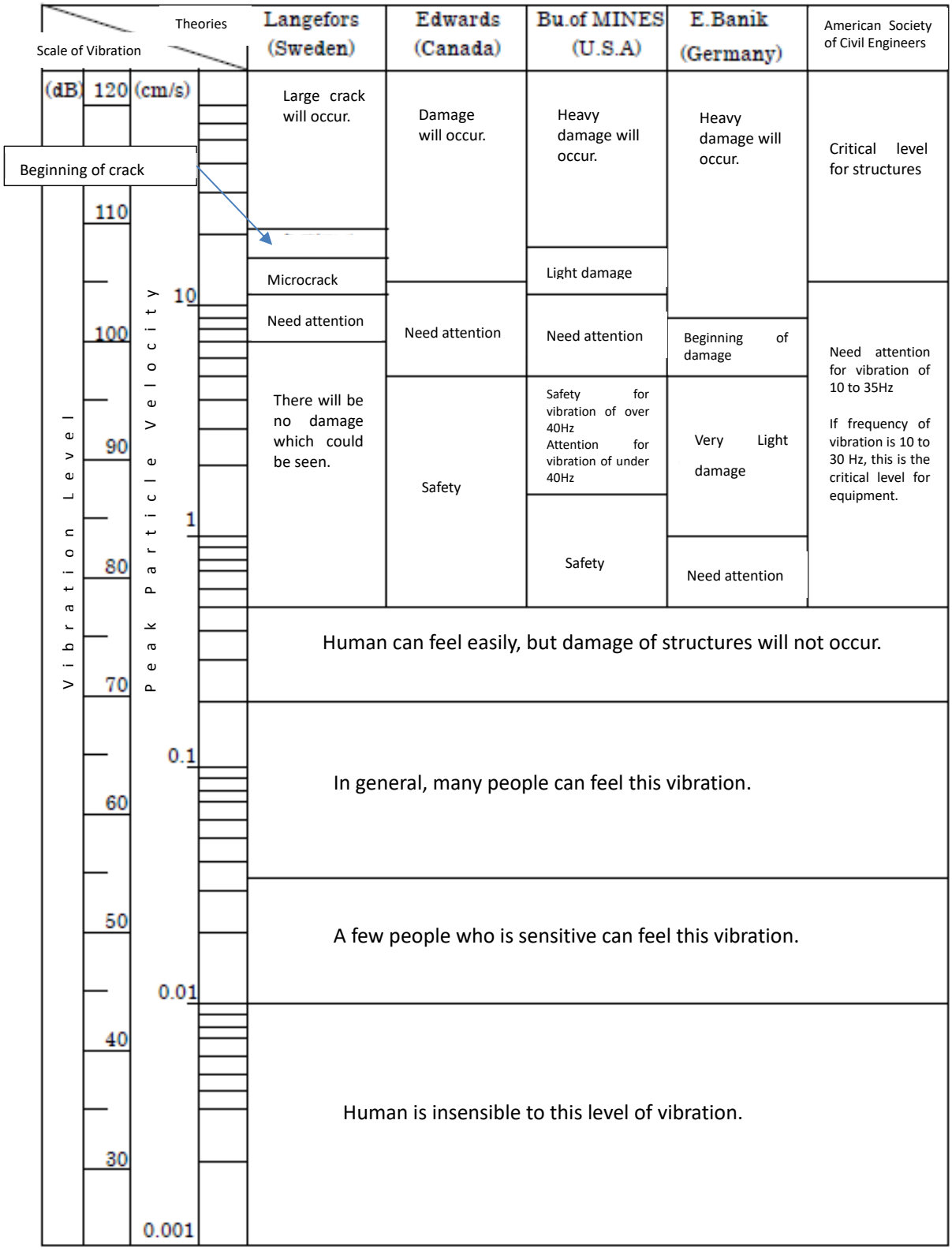
Based on the environmental assessment for the project-free scenario and the ratings obtained for each impact, the impacts generated by the project on the environment should be identified, described and qualified as a result of the interaction between the activities of said environment and the components of each medium. It is worth noting that this assessment is done without taking into account the environmental management programs, given that, according to their significance, the Environmental Management Plan is formulated.

(The rest is omitted)

(2) Other Related Technical Information

There are many scientific literature of blast vibration globally. The relation between level of blast vibration and damage of houses/building is summarized as following table.

Table C.2.12.6 Relation between level of blast vibration and damage of houses/building



Source: Japan explosive society

On the blast caused vibration, PPV is commonly used for standard value of assessing effect of the structures or houses.

Japan explosive society recommends the standard value of blast vibration value as following table. This standard has two targets. (Human and Structures) The standard value for human is using vibration level (dB). On the other hand, the standard value of structure use PPV (cm/s).

Table C.2.12.7 Vibration standard recommended by Japan Explosive Society

		Frequency of the blast vibration		
Target＼Frequency(Hz)		Less than 10Hz	10 to 50 Hz	More than 50Hz
Human (dB)	Day time	73	79	85
	Night time	58	64	70
Structures (cm/s)	Strength Clarified structures	1.25	2.5	5.0
	Dwellings	0.5	1.0	2.0
	Important structure (More sensitive structure)	0.25	0.5	1.0

German Standard DIN 4150–3:1999–02 Vibration in buildings—Part 3: effects on structures provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration.

Table C.2.12.8 Vibration standards for buildings, DIN 4150–3

Group	Type of structure	Peak vibration velocity, cm/s			
		At foundation at a frequency of			Plane of uppermost story
		Less than 10 Hz	10 Hz to 50 Hz	to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	2.0	2.0 to 4.0	4.0 to 5.0	4.0
2	Dwellings and buildings of similar design and/or use	0.5	0.5 to 1.5	1.5 to 2.0	1.5
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	0.3	0.3 to 0.8	0.8 to 1.0	0.8

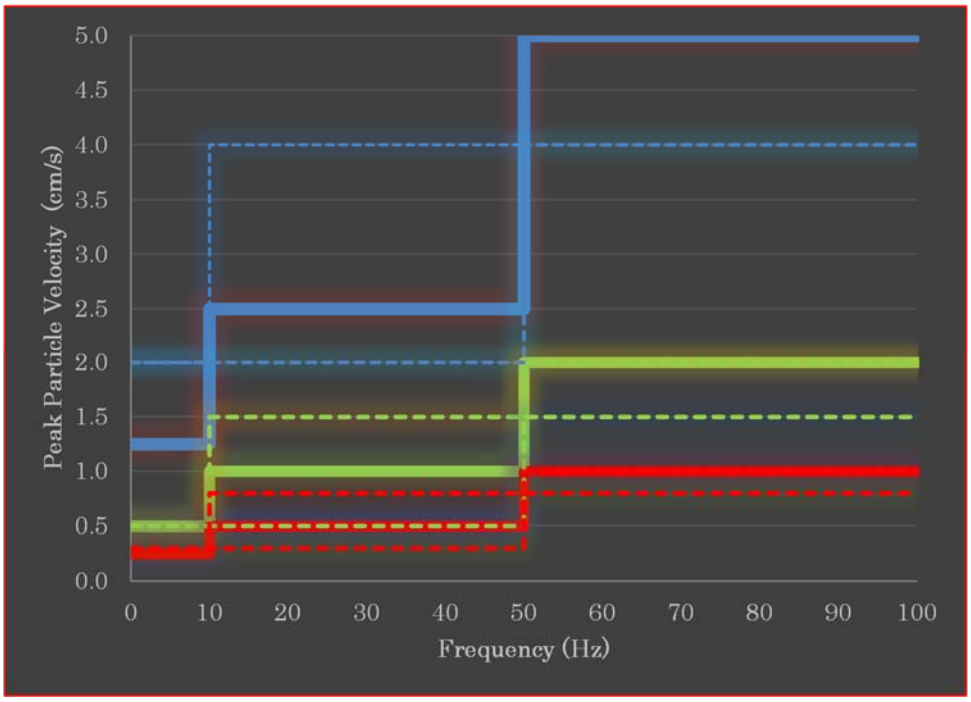


Figure C.2.12.3 Comparison of the standard Japan and Germany

(3) Methodology, Process and Procedure

If national standard or local standard for vibration is existed, these standards could be used for evaluation of environmental impact. In case of no official standards, it is appropriate to use knowledge from scientific literature widely used in the world. Most of the vibration standard have the several values corresponding to the frequency and types of the structure. Therefore, it is important to identify the frequency of the blast vibration and status of the target structure. On the stage of EIA study, it is difficult to fix the frequency of the blast vibration. From the safety side point of view, the smallest value on the known table can be used for evaluation of the result of prediction. Japan explosive society propose the PPV which will not damage to the houses/building is 0.25 cm/sec on less than 10 Hz according to the previous table. This value is the lowest value of the table. To compare with this standard value is the one method for evaluation of forecasted value.

(4) Output

The result of the evaluation could be organized as below.

Table C.2.12.9 The result of the evaluation

The Result of the evaluation
Example-1 The result of prediction at target dwelling is 0.2cm/sec (PPV). The target house is seemed having enough strength. Therefore, the damage of house would not be assumed. Example-2 The result of prediction at target house is 0.3cm/sec (PPV). The target house is fragile. Therefore, the damage of house would be assumed. It is required to consider counter measure to the blast vibration.

C.2.12.6 Mitigation and monitoring

(1) Referenced TOR

(a) Environmental Management Program

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS
11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.1 Environmental Management Program
…

An Environmental Management Plan (PMA) must be presented, structured in programs and subprograms (when required) and based on the hierarchy of management of potential identified impacts, considering as a first option measures for preventing and avoiding the occurrence of impacts; In the second option, measures to mitigate and/or minimize said impacts; Measures to correct or restore environmental conditions and, finally, compensatory measures will be considered.

For the identified impacts, environmental management measures should be considered taking into account that the same measure can be applied to the management of different impacts and that an impact can be managed through different measures.

The approach of programs, subprograms and measures should focus on comprehensive control of environmental impacts; For such purpose, it must be considered that there may be impacts that occur in different environments (for example, contamination of the surface water resource can affect elements of the abiotic, biotic and socioeconomic environments) and / or components (for example, the traditional economic activities of the population may affect the economic, demographic, cultural, etc.).

The PMA programs must specify:
25. Objective(s) of each program and subprogram.
26. Goals related to identified objectives.
Indicators that allow monitoring of the achievement of the goals proposed for each objective, as well as to determine the effectiveness of each program and subprogram.
27. Impacts to be managed by each program (based on impact assessment). Phase(s) of the project in which each program and subprogram would be implemented.
28. Application location (s) (cartographic location where possible).
29. Description of management measures (specific actions) to be developed within each program and subprogram, specifying the type of measure (prevention, mitigation, correction and compensation).
30. List of proposed works to be implemented. The designs must be presented as documents annexed to the EIA.
31. Estimated schedule of program implementation.
32. Estimated costs of implementing each program.

(The rest is omitted)

(b) Monitoring and Tracing

The inside of the below box is quotation from the TOR for EIA (Resolution 0751, 26 March 2015).

11.PLANS AND PROGRAMS

11.1 ENVIRONMENTAL MANAGEMENT PLAN
11.1.2 Monitoring and Tracking Plan
…

a. Tracking and monitoring of plans and programs
For such purpose, the plan must precise of:

13. **Actions to be developed to obtain the information and/or data to calculate the indicators proposed in the PMA.**
14. **Criteria used for the approach of each indicator.**
15. **Frequency of measurement.**
16. **Justification of the representativeness of the indicator raised, as well as the information used for its calculation.**

b. Tracking and monitoring the trend of the medium
For the tracking and monitoring of the environmental components, the plan must include at least:

25. **Objectives.**
26. **Environmental components to monitor.**
27. **Indicators (quantitative and qualitative) aimed at establishing changes in the trend of the medium, specifying what is intended to be measured and monitored with each one.**
28. **Location of monitoring sites, with the respective cartographic location, when applicable.**
29. **Identification of management measures that affect the trend of the medium.**
30. **Description of the procedures used to measure the trend of the medium, relating the necessary instruments.**
31. **Frequency and duration of the monitoring.**
32. **Criteria for analysis and interpretation of results.**

(The rest is omitted)

(2) Other Related Technical Information

In Japan, the purpose of monitoring is adjusting the method of mitigation measures which did not have enough information for efficiency at the time of EIA study. In the case of this, contractor or implementer must collect the information about efficiency of mitigation measures and modify the method for more valid way.

(3) Methodology, Process and Procedure

(a) Environmental Management Program

Counter measures for environmental and social impact should be selected preventing or avoiding measures at first. In general, these preventing or avoiding measures could be selected at DAA study. If it is difficult to avoid or prevent the impacts at the time of EIA study, mitigation measure should be implemented as a second option.
The general process of selecting mitigation measure on vibration is shown below figure.

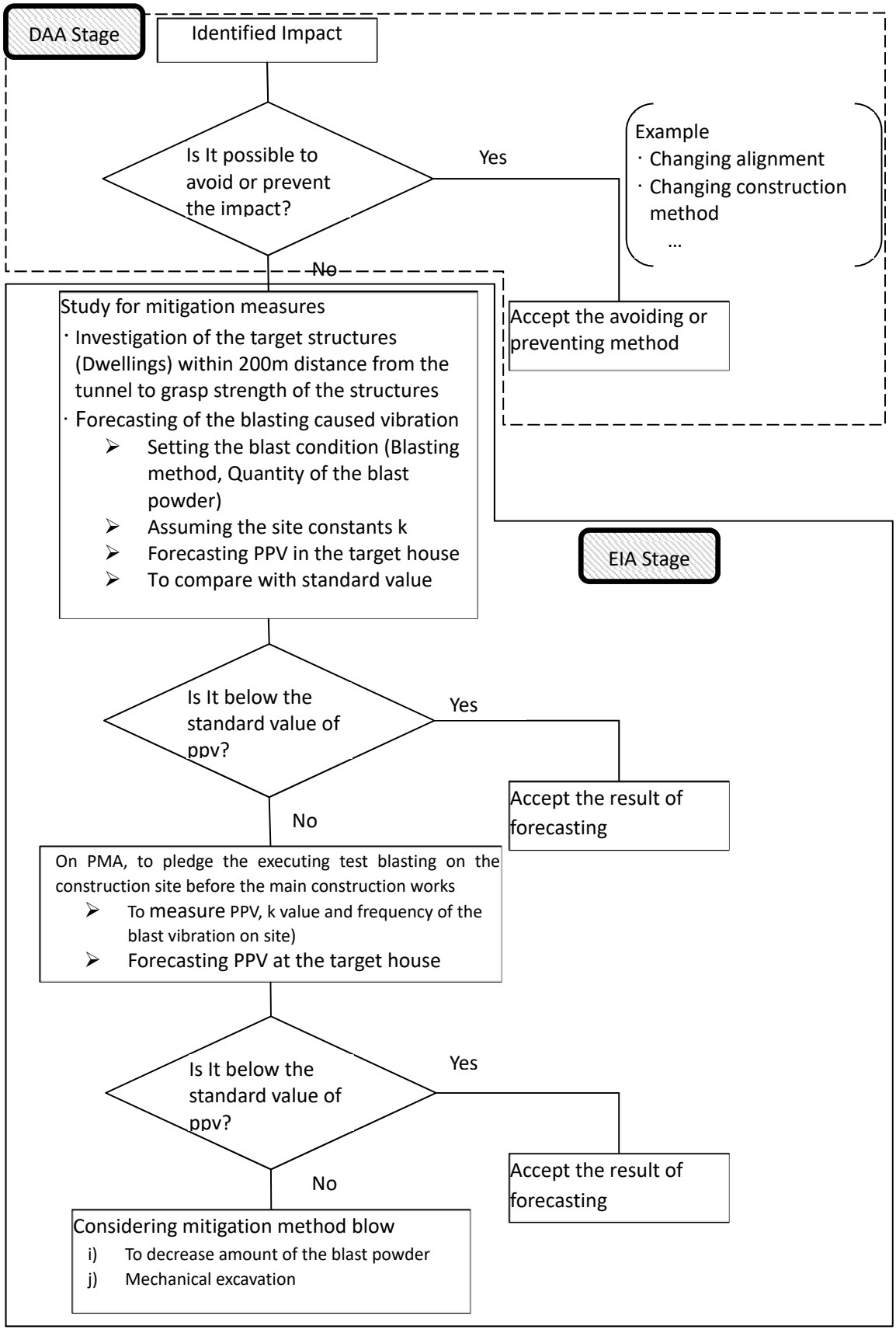


Figure C.2.12.4 Flow diagram of the mitigation measure study on Vibration

The general information for mitigation measures are below.

Table C.2.12.10 General information for mitigation measures

e) To decrease amount of the blast powder To decrease amount of blasting powder by using delay detonator, applying double plough wedge V cut or reducing tunnel production rate f) Mechanical excavation Applying mechanical excavating such as partial tunnel face excavation machine.

(b) Monitoring and Tracing

(i) Tracking and monitoring of plans and programs

The flow diagram of monitoring for PMA is shown below figure.

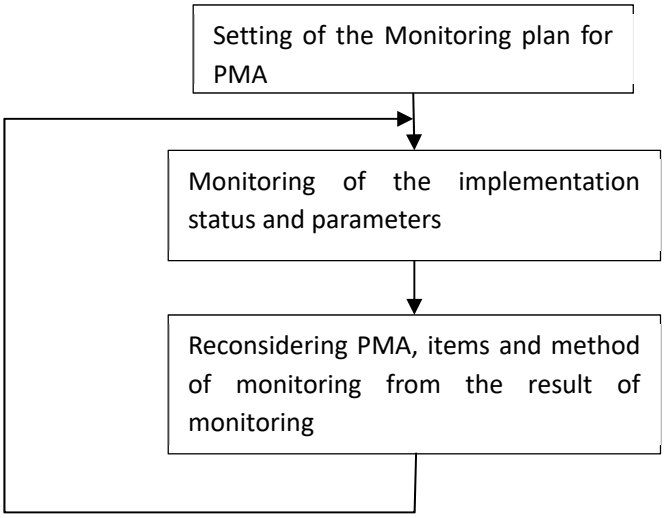


Figure C.2.12.5 Flow diagram for PMA monitoring

(ii) Tracking and monitoring the trend of the medium

On the blast caused vibration, it is not only important to monitor the parameters of vibration, but also the record of rock blasting works. In addition, it is recommended to record of the structural situation on target dwelling. The example of the monitoring item is below table.

Table C.2.12.11 Monitoring Item

Monitoring item	Parameter	Monitoring Method
Vibration	· Peak Particle Velocity(cm/s) · Frequency (Hz) · k-value	Location: Target house, Dwelling. Method: Vibration meter, Recorder
Working record of the rock blasting	· Amount of the blasting powder(kg/delay) · Position of the blast powder	Location: The working face of the tunnel Method: Blasting work record
Structural situation of the target house	· The situation of below Foundation Wall Column Window, Door	Location: Target house, Dwelling. Method: Taking photos of the situation before construction

(4) Output

(a) Environmental Management Program

In general, some measures exist on hydrological field for preventing or mitigating impact from tunnel construction. On Environmental management program, the more efficient and enablable measures should be selected as countermeasures for environmental impact. The result of consideration should also contain the items which are restricted in TOR for EIA. Here is example of form on vibration countermeasures.

Table C.2.12.12 Environmental Management Program on hydrology

Id	Counter measure	1.Objective	2.Effectiveness/ Indicator of effect	3./7.Implementation period/ Phase	4.Implementation area / location	5./6.Management measures	8.Estimated costs	Remarks
1								
2								
3								
4								
5								
6								
7								

(b) Monitoring and Tracing

(i) Tracking and monitoring of plans and programs

The required information according to the TOR should be collected. Here is example form of monitoring plan.

Table C.2.12.13 PCM monitoring plan

Mitigation measure	Outline of the mitigation measure	The Index or parameter of monitoring	criteria	Frequency of the monitoring

(ii) Tracking and monitoring the trend of the medium

C.3 Biotic environment

C.3.1 Ecosystems

C.3.1.1 Terrestrial ecosystems

C.3.1.2 Aquatic ecosystems

C.3.1.3 Strategic, sensible, and/or protected areas ecosystems

C.4 Socio economic environment

C.4.1 General

C.4.2 Participation and socialization with the communities

C.4.2.1 Demographic component

C.4.2.2 Spatial component

C.4.2.3 Economic component

C.4.3 Cultural component

C.4.3.1 Non-ethnic communities

C.4.3.2 Ethnic communities

C.4.3.3 Archeological component

C.4.4 Political-organizational component

C.4.4.1 Political-administrative component

C.4.4.2 Institutional presence and community organization

C.4.5 Development Trends

C.4.6 Information on population to be resettled