Corrigé
Corrected

CR 2022/10

International Court of Justice

THE HAGUE

Cour internationale de Justice

LA HAYE

YEAR 2022

Public sitting

held on Thursday 7 April 2022, at 3 p.m., at the Peace Palace,

President Donoghue presiding,

***in the case concerning the* Dispute over the Status and Use of the Waters of the Silala (Chile *v.* Bolivia)**

VERBATIM RECORD

ANNÉE 2022

Audience publique

tenue le jeudi 7 avril 2022, à 15 heures, au Palais de la Paix,

sous la présidence de Mme Donoghue, présidente,

***en l'affaire relative au* Différend concernant le statut et l'utilisation des eaux du Silala (Chili c. Bolivie)**

COMPTE RENDU

Present:	President	Donoghue
	Vice-President	Gevorgian
	Judges	Tomka
		Abraham
		Bennouna
		Yusuf
		Xue
		Sebutinde
		Bhandari
		Robinson
		Salam
		Iwasawa
		Nolte
		Charlesworth
	Judges *ad hoc*	Daudet
		Simma
	Registrar	Gautier

Présents : Mme Donoghue, présidente
M. Gevorgian, vice-président
MM. Tomka
Abraham
Bennouna
Yusuf
Mmes Xue
Sebutinde
MM. Bhandari
Robinson
Salam
Iwasawa
Nolte
Mme Charlesworth, juges
MM. Daudet
Simma, juges *ad hoc*

M. Gautier, greffier

The Government of Chile is represented by:

H.E. Ms Ximena Fuentes Torrijo, Vice-Minister for Foreign Affairs of the Republic of Chile, Professor of Public International Law, University of Chile,

as Agent, Counsel and Advocate;

Ms Carolina Valdivia Torres, Former Vice-Minister for Foreign Affairs of the Republic of Chile,

as Co-Agent;

H.E. Ms Antonia Urrejola Noguera, Minister for Foreign Affairs of the Republic of Chile,

H.E. Mr. Hernán Salinas Burgos, Ambassador of the Republic of Chile to the Kingdom of the Netherlands,

as National Authorities;

Mr. Alan Boyle, Emeritus Professor of Public International Law, University of Edinburgh, Barrister, Essex Court Chambers, member of the Bar of England and Wales,

Ms Laurence Boisson de Chazournes, Professor of International Law and International Organization, University of Geneva, member of the Institute of International Law,

Ms Johanna Klein Kranenberg, Legal Adviser and General Co-ordinator, Ministry of Foreign Affairs of Chile,

Mr. Stephen McCaffrey, Carol Olson Endowed Professor of International Law, University of the Pacific, McGeorge School of Law, former Chair of the International Law Commission,

Mr. Samuel Wordsworth, QC, Barrister, Essex Court Chambers, member of the Bar of England and Wales, member of the Paris Bar,

as Counsel and Advocates;

Ms Mariana Durney, Professor and Head of Department of International Law, Pontificia Universidad Católica de Chile,

Mr. Andrés Jana Linetzky, Professor of Civil Law, University of Chile,

Ms Mara Tignino, Reader, University of Geneva, Lead Legal Specialist of the Platform for International Water Law at the Geneva Water Hub,

Mr. Claudio Troncoso Repetto, Professor and Head of Department of International Law, University of Chile,

Mr. Luis Winter Igualt, former Ambassador of the Republic of Chile, Professor of International Law, Pontificia Universidad Católica de Valparaíso and Universidad de Los Andes,

as Counsel;

Le Gouvernement du Chili est représenté par :

S. Exc. Mme Ximena Fuentes Torrijo, vice-ministre des affaires étrangères de la République du Chili, professeure de droit international public à l'Universidad de Chile,

comme agent, conseillère et avocate ;

Mme Carolina Valdivia Torres, ancienne vice-ministre des affaires étrangères de la République du Chili,

comme coagent ;

S. Exc. Mme Antonia Urrejola Noguera, ministre des affaires étrangères de la République du Chili,

S. Exc. M. Hernán Salinas Burgos, ambassadeur de la République du Chili auprès du Royaume des Pays-Bas,

comme représentants de l'Etat ;

M. Alan Boyle, professeur émérite de droit international public à l'Université d'Edimbourg, avocat, Essex Court Chambers, membre du barreau d'Angleterre et du pays de Galles,

Mme Laurence Boisson de Chazournes, professeure de droit international et organisation internationale à l'Université de Genève, membre de l'Institut de droit international,

Mme Johanna Klein Kranenberg, conseillère juridique et coordinatrice générale, ministère des affaires étrangères du Chili,

M. Stephen McCaffrey, professeur de droit international, titulaire de la chaire Carol Olson à la McGeorge School of Law de l'Université du Pacifique, ancien membre et ancien président de la Commission du droit international,

M. Samuel Wordsworth, QC, avocat, Essex Court Chambers, membre du barreau d'Angleterre et du pays de Galles, membre du barreau de Paris,

comme conseils et avocats ;

Mme Mariana Durney, professeure et doyenne du département de droit international à la Pontificia Universidad Católica de Chile,

M. Andrés Jana Linetzky, professeur de droit civil à l'Universidad de Chile,

Mme Mara Tignino, maître d'enseignement et de recherche à l'Université de Genève et spécialiste juridique principale de la plateforme pour le droit international de l'eau douce au Geneva Water Hub,

M. Claudio Troncoso Repetto, professeur et doyen du département de droit international à l'Universidad de Chile,

M. Luis Winter Igualt, ancien ambassadeur de la République du Chili, professeur de droit international, Pontificia Universidad Católica de Valparaíso et Universidad de los Andes,

comme conseils ;

Ms Lorraine Aboagye, Barrister, Essex Court Chambers, member of the Bar of England and Wales,

Ms Justine Bendel, Lecturer in Law, University of Exeter, Marie Curie Fellow at the University of Copenhagen,

Ms Marguerite de Chaisemartin, JSD Candidate, University of the Pacific, McGeorge School of Law,

Ms Valeria Chiappini Koscina, Legal Adviser, National Directorate for State Borders and Boundaries, Ministry of Foreign Affairs of Chile,

Ms María Trinidad Cruz Valdés, Legal Adviser, National Directorate for State Borders and Boundaries, Ministry of Foreign Affairs of Chile,

Mr. Riley Denoon, JSD Candidate, University of the Pacific, McGeorge School of Law, member of the Bars of the provinces of Alberta and British Columbia,

Mr. Marcelo Meza Peñafiel, Legal Adviser, National Directorate for State Borders and Boundaries, Ministry of Foreign Affairs of Chile,

Ms Beatriz Pais Alderete, Legal Adviser, National Directorate for State Borders and Boundaries, Ministry of Foreign Affairs of Chile,

as Legal Advisers;

Mr. Coalter G. Lathrop, Special Adviser, Sovereign Geographic, member of the Bar of the State of North Carolina,

as Scientific Adviser;

Mr. Jaime Moscoso Valenzuela, Minister Counsellor, Embassy of Chile in the Netherlands,

Mr. Hassán Zeran Ruiz-Clavijo, First Secretary, Embassy of Chile in the Netherlands,

Ms María Fernanda Vila Pierart, First Secretary, Embassy of Chile in the Netherlands,

Mr. Diego García González, Second Secretary, Embassy of Chile in the Netherlands,

Ms Josephine Schiphorst, Executive Assistant to the Ambassador, Embassy of Chile in the Netherlands,

Ms Devon Burkhalter, Farm Press Creative,

Mr. David Swanson, Swanson Land Surveying,

as Assistant Advisers.

The Government of Bolivia is represented by:

H.E. Mr. Roberto Calzadilla Sarmiento, Ambassador of the Plurinational State of Bolivia to the Kingdom of the Netherlands,

as Agent;

H.E. Mr. Rogelio Mayta Mayta, Minister for Foreign Affairs of the Plurinational State of Bolivia,

Mme Lorraine Aboagye, avocate, Essex Court Chambers, membre du barreau d'Angleterre et du pays de Galles,

Mme Justine Bendel, maître de conférences en droit à l'Université d'Exeter, chargée de recherche dans le cadre du programme Marie Curie de l'Université de Copenhague,

Mme Marguerite de Chaisemartin, doctorante en droit à la McGeorge School of Law, Université du Pacifique,

Mme Valeria Chiappini Koscina, conseillère juridique, direction nationale des frontières et limites de l'Etat, ministère des affaires étrangères du Chili,

Mme María Trinidad Cruz Valdés, conseillère juridique, direction nationale des frontières et limites de l'Etat, ministère des affaires étrangères du Chili,

M. Riley Denoon, doctorant en droit à la McGeorge School of Law, Université du Pacifique, membre des barreaux des provinces de l'Alberta et de la Colombie-Britannique,

M. Marcelo Meza Peñafiel, conseiller juridique, direction nationale des frontières et limites de l'Etat, ministère des affaires étrangères du Chili,

Mme Beatriz Pais Alderete, conseillère juridique, direction nationale des frontières et limites de l'Etat, ministère des affaires étrangères du Chili,

comme conseillers juridiques ;

M. Coalter G. Lathrop, conseiller spécial au cabinet Sovereign Geographic, membre du barreau de l'Etat de Caroline du Nord,

comme conseiller scientifique ;

M. Jaime Moscoso Valenzuela, conseiller au ministre, ambassade du Chili aux Pays-Bas,

M. Hassán Zeran Ruiz-Clavijo, premier secrétaire à l'ambassade du Chili aux Pays-Bas,

Mme María Fernanda Vila Pierart, première secrétaire à l'ambassade du Chili aux Pays-Bas,

M. Diego García González, deuxième secrétaire à l'ambassade du Chili aux Pays-Bas,

Mme Josephine Schiphorst, assistante exécutive de l'ambassadeur à l'ambassade du Chili aux Pays-Bas,

Mme Devon Burkhalter, Farm Press Creative,

M. David Swanson, Swanson Land Surveying,

comme conseillers assistants.

Le Gouvernement de la Bolivie est représenté par :

S. Exc. M. Roberto Calzadilla Sarmiento, ambassadeur de l'Etat plurinational de Bolivie auprès du Royaume des Pays-Bas,

comme agent ;

S. Exc. M. Rogelio Mayta Mayta, ministre des affaires étrangères de l'Etat plurinational de Bolivie,

Mr. Freddy Mamani Laura, President of the Chamber of Deputies of Bolivia,

Ms Trinidad Rocha Robles, President of the International Policy Commission of the Chamber of Senators of Bolivia,

Mr. Antonio Colque Gabriel, President of the Commission for International Policy and Protection for Migrants of the Chamber of Deputies of Bolivia,

H.E. Mr. Freddy Mamani Machaca, Vice-Minister for Foreign Affairs of Bolivia,

Mr. Marcelo Bracamonte Dávalos, General Adviser to the Minister for Foreign Affairs of Bolivia,

as National Authorities;

Mr. Alain Pellet, Professor Emeritus of the University Paris Nanterre, former Chairman of the International Law Commission, President of the Institut de droit international,

Mr. Rodman R. Bundy, former *avocat à la Cour d'appel de Paris*, member of the Bar of the State of New York, partner, Squire Patton Boggs LLC, Singapore,

Mr. Mathias Forteau, Professor, University Paris Nanterre, member of the International Law Commission,

Mr. Gabriel Eckstein, Professor of Law, Texas A&M University, member of the Bar of the State of New York and the District of Columbia Bar,

as Counsel and Advocates;

Mr. Emerson Calderón Guzmán, Professor of Public International Law, Universidad Mayor de San Andrés and Secretary General of the Strategic Directorate for Maritime Claims, Silala and International Water Resources (DIREMAR),

Mr. Francesco Sindico, Associate Professor of International Environmental Law, University of Strathclyde Law School, Glasgow, and Chairman of the International Union for Conservation of Nature (UICN) World Commission on Environmental Law, Climate Change Law Specialist Group,

Ms Laura Movilla Pateiro, Associate Professor of Public International Law, University of Vigo,

Mr. Edgardo Sobenes, Consultant in International Law (ESILA),

Ms Héloïse Bajer-Pellet, member of the Paris Bar,

Mr. Alvin Yap, Advocate and Solicitor of the Supreme Court of Singapore, Associate, Squire Patton Boggs LLP, Singapore,

Mr. Ysam Soualhi, Researcher, Center Jean Bodin (CJB), University of Angers,

as Counsel;

Ms Alejandra Salinas Quiroga, DIREMAR,

Ms Fabiola Cruz Morena, Embassy of Bolivia in the Netherlands,

as Technical Assistants.

M. Freddy Mamani Laura, président de la chambre des députés de la Bolivie,

Mme Trinidad Rocha Robles, présidente de la commission de politique internationale de la chambre des sénateurs de la Bolivie,

M. Antonio Colque Gabriel, président de la commission de politique internationale et de protection des migrants de la chambre des députés de la Bolivie,

S. Exc. M. Freddy Mamani Machaca, vice-ministre des affaires étrangères de la Bolivie,

M. Marcelo Bracamonte Dávalos, conseiller général du ministre des affaires étrangères de la Bolivie,

comme autorités nationales ;

M. Alain Pellet, professeur émérite de l'Université Paris Nanterre, ancien président de la Commission du droit international, président de l'Institut de droit international,

M. Rodman R. Bundy, ancien avocat à la Cour d'appel de Paris, membre du barreau de l'Etat de New York, associé au cabinet Squire Patton Boggs LLC (Singapour),

M. Mathias Forteau, professeur à l'Université Paris Nanterre, membre de la Commission du droit international,

M. Gabriel Eckstein, professeur de droit à l'Université A&M du Texas, membre des barreaux de l'Etat de New York et du district de Columbia,

comme conseils et avocats ;

M. Emerson Calderón Guzmán, professeur de droit international public à l'Universidad Mayor de San Andrés, secrétaire général du bureau stratégique de reconnaissance des prétentions maritimes, du Silala et des ressources hydriques internationales (DIREMAR),

M. Francesco Sindico, professeur associé de droit international de l'environnement à la faculté de droit de l'Université de Strathclyde, Glasgow, président du groupe de spécialistes du droit relatif au changement climatique de la Commission mondiale de droit de l'environnement de l'Union internationale pour la conservation de la nature (UICN),

Mme Laura Movilla Pateiro, professeure associée de droit international public à l'Université de Vigo,

M. Edgardo Sobenes, consultant en droit international (ESILA),

Mme Héloïse Bajer-Pellet, membre du barreau de Paris,

M. Alvin Yap, avocat et *solicitor* à la Cour suprême de Singapour, avocat au cabinet Squire Patton Boggs LLP (Singapour),

M. Ysam Soualhi, chercheur au Centre Jean Bodin (CJB) de l'Université d'Angers,

comme conseils ;

Mme Alejandra Salinas Quiroga, DIREMAR,

Mme Fabiola Cruz Morena, ambassade de Bolivie aux Pays-Bas,

comme assistantes techniques.

The PRESIDENT: Please be seated. The sitting is open.

I would like to note that the following judges are present with me in the Great Hall of Justice: Vice-President Gevorgian and Judges Tomka, Abraham, Xue, Sebutinde, Iwasawa and Charlesworth; while Judges Bennouna, Yusuf, Bhandari, Robinson, Salam and Nolte and Judges *ad hoc* Daudet and Simma are participating by video link.

The Court meets this afternoon to hear the experts called by Chile, namely Dr. Howard Wheater and Dr. Denis Peach, who are participating in person in today's hearing.

Before hearing from the experts, I shall briefly explain the procedure to be followed today and tomorrow for the examination of the experts. I shall begin by inviting each expert to make the declaration set out in Article 64, paragraph *(b)*, of the Rules of Court. The Party calling the experts will then ask them to confirm their written statement, which will serve as the examination-in-chief. The other Party will then be given an opportunity to cross-examine the experts on the contents of their written statement or their earlier reports. A maximum period of 80 minutes has been allocated for this cross-examination, which will be followed by re-examination by the Party calling the experts, to be limited to matters raised in cross-examination. A maximum period of 40 minutes has been allocated for this re-examination. In cross-examination and re-examination, the questions will be addressed collectively to the group of experts being heard, and it will be up to the experts to decide which individual expert should reply to a particular question. Questions may then be put to the experts by the President on behalf of the Court, or by individual judges. The experts should reply orally, without further delay, save in exceptional cases, for example when the information requested requires verification.

I now invite Dr. Wheater and Dr. Peach to each make a solemn declaration as set out in Article 64, paragraph *(b)*, of the Rules of Court. I first call upon Dr. Wheater. Please proceed, Sir.

Mr. WHEATER: Thank you, Madam President.

> "I solemnly declare upon my honour and conscience that I will speak the truth, the whole truth and nothing but the truth, and that my statement will be in accordance with my sincere belief."

The PRESIDENT: I thank you. I now invite Dr. Peach to make his solemn declaration. Please proceed, Sir.

Mr. PEACH: Thank you, Madam President.

> "I solemnly declare upon my honour and conscience that I will speak the truth, the whole truth and nothing but the truth, and that my statement will be in accordance with my sincere belief."

The PRESIDENT: I thank you. Before beginning the cross-examination and re-examination, may I recall that, as the Court's Registrar has communicated to the Parties, the expert replying to a question should identify himself clearly, so that the statement can be properly attributed in the verbatim record. If the same expert replies to a series of consecutive questions, there is no need for him to repeatedly state his name; it will be sufficient for the record to be clear every time there is a change in the designated speaker among the experts.

I would also like to remind counsel, as well as the experts, to speak at an appropriately slow pace for the benefit of the interpreters.

I now give the floor to counsel for Chile, Mr. Samuel Wordsworth, who will ask the experts to confirm the written statement in front of them. Mr. Wordsworth, you have the floor.

Mr. WORDSWORTH: Thank you, Madam President.

Good afternoon, Mr. Wheater, Mr. Peach. You have prepared five reports in this matter, two of May 2017, two of January 2019 and one of August 2019, together with a summary report dated January 2022. Can you confirm that, subject to this short errata sheet sent yesterday to the Court, that these reports contain your true and independent expert opinions and that you consider your overriding duty in this matter to be to the Court.

Mr. WHEATER: I do so confirm.

Mr. PEACH: I do so confirm.

Mr. WORDSWORTH: Thank you very much.

The PRESIDENT: Thank you, Mr. Wordsworth. I now give the floor to counsel for Bolivia, Mr. Rodman Bundy. Mr. Bundy, you have the floor for cross-examination, for which I recall Bolivia is allocated a maximum of 80 minutes.

Mr. BUNDY: Thank you, Madam President, distinguished judges. Good afternoon, Dr. Wheater and Dr. Peach.

Dr. Wheater, we know each other from the *Kishenganga* Arbitration. Dr. Peach, it has been a great pleasure to meet you during these proceedings.

Now, this afternoon I will be asking you a series of quite specific questions relating to your reports, and I would appreciate it if you could focus on and limit your answers to those specific questions. Obviously, counsel for Chile will have an opportunity to re-examine you afterwards. I am not going to question you on your errata sheet. I actually only saw this errata sheet about two and a half hours ago. We were a little surprised on the Bolivian side to receive this errata sheet at this time. We have been here in The Hague for a week and no doubt the Parties have been preparing before that. Could I ask you why was this not submitted earlier?

Mr. WHEATER: Well, we considered —.

Mr. BUNDY: You need to identify yourself.

Mr. WHEATER: My name is Howard Wheater. The errata sheet is extremely brief, and we considered it, on the advice of counsel, appropriate to submit it immediately prior to the hearings. I am sure it did not take you two and a half hours to read it. It is just a few lines.

Mr. BUNDY: Thank you. Madam President, I just would like to state for the record that, to the extent necessary, Bolivia would like to reserve its position to comment, if any comments are due, at an appropriate stage during the second round on the errata sheet.

Excuse me one moment. I have a hard time hearing the experts.

Now, could I start by asking whether either of you have visited the Silala region?

Mr. WHEATER: Howard Wheater. Thank you, Mr. Bundy. We have not been able to visit the Bolivian side of the Silala on the advice of the Chilean Government. We understood that there was quite a lot of political tension in Bolivia over this matter, and it would not be wise for us to make a visit. We have, of course, visited the site on numerous occasions. And, in fact, from the Siloli mountain, you are able to get quite a good view over the upper Bolivian parts of the catchment.

We work as a scientific team, however. And our senior hydrologist from Chile, Professor Muñoz, was formerly a consultant to the Antofagasta Bolivia Railway Company and was able to visit —.

Mr. BUNDY: I regret to interrupt you, but my question only related to the two of you. If you could focus on my specific question, which was: have the two of you visited the Silala region; and if so, where?

Mr. WHEATER: Well, thank you, Mr. Bundy. The answer is no. But I felt that the Court should be aware that the science team as a whole had personal experience of actually carrying out fieldwork on the Bolivian side of the border.

Mr. BUNDY: Now, you say in your reports — and you just mentioned — that you were unable to visit the Bolivian wetlands. Did you or Chile ever request Bolivia to make such a visit?

Mr. WHEATER: Not as far as my knowledge, no.

Mr. BUNDY: Why not?

Mr. WHEATER: I gave a previous explanation: that the advice from Chile was that it would be inappropriate given the political tensions and feeling among the local population.

Mr. BUNDY: Just to make a site visit — just a few metres or a few hundred metres across the border? That would have caused a problem?

Mr. WHEATER: That was the advice we received and that is the advice we acted on.

Mr. BUNDY: You had requested, had you not, through Chile to receive DHI's digital data that went into their models, had you not?

Mr. WHEATER: That is correct.

Mr. BUNDY: And after a month or two delay, you received in instalments that data; is that correct?

Mr. WHEATER: February 2019 was when we received the first tranche of digital data relating to Bolivia's Counter-Memorial and I believe it was in June 2019 that we received the digital data related to Bolivia's Rejoinder.

Mr. BUNDY: Yes, that June [20]19 was related to a later request, was it not?

Mr. WHEATER: It was, yes.

Mr. BUNDY: Yes. If Bolivia was willing to turn over that data, why do you suppose they would not have let you visit the wetlands yourselves?

Mr. WHEATER: That really is not a question that I would like to go into or feel able to answer. I have already answered on two occasions that we were responding to advice from the Government of Chile.

Mr. BUNDY: Thank you. Now, as I think you were going to mention a minute ago, the annexes to Chile's Memorial do contain a number of 2017 and 2019 technical reports from a number of Chilean professors. Am I correct that both of you supervised and instructed the authors of those reports?

Mr. WHEATER: That is correct.

Mr. BUNDY: Were those studies based on field visits to the Silala in Chile?

Mr. WHEATER: They were based on extensive and, in fact, continuing to this day, field visits to the Silala in Chile.

Mr. BUNDY: Do you recall which members or which Chilean individuals that submitted technical reports made field visits in Chile?

Mr. WHEATER: I think I probably can recall that from memory, yes. Would you like me to list them?

Mr. BUNDY: Just to the best of your recollection.

Mr. WHEATER: The lead hydrologist is Professor Muñoz. He has visited personally with us several times. He is from the Catholic University. He leads a team of field technicians who visit the site approximately quarterly. His colleague, Professor Suárez, has been another senior member of the science team. He is an expert in evaporation and has installed weather stations and also some quite advanced instrumentation called Eddy Flux measurement methods which allow us to measure actual evaporation. He also installed some really quite exciting equipment. We use a fibre optic cable laid down the length of the channel to measure temperature variations in the river and, hence, can make inferences about inflows and outflows from the river. Professor Claudio Latorre is an ecologist and geologist, also from the Catholic University. He has done surveys of the vegetation, for example, in the Quebrada Negra wetland. We have had extensive geochemical analysis done, in Chile, but the results have been interpreted by a colleague from the University of Waterloo, Canada, and, to the best of my knowledge, I do not think he was personally able to visit the site.

We were interested in whether or not the river system was active — fluvially active — and so Dr. Luca Mao visited the site and made a number of observations of sediment transport and wrote a report which was cited the other day in terms of the water quality health. We have had extensive hydrogeological studies done which have involved drilling, and also geophysics, and we have had — and that was done by consultants, as far as I am aware. Dr. Peach perhaps can clarify. That may not be an exhaustive list, but is that reasonable to be going on with?

Mr. BUNDY: Yes, that is fine. Now you have referred to this extensive fieldwork: would it be correct to say that this fieldwork was important to those individuals' work and studies?

Mr. WHEATER: We were really pleased to be working with a team of very high-quality Chilean scientists, and, as I mentioned, a scientist from Canada, and they are highly regarded research scientists, and we were really very pleased to have the opportunity to work on the Silala catchment.

Mr. BUNDY: Yes, but my question was: do you consider that this extensive fieldwork they did was important for preparing their own individual studies and reports?

Mr. WHEATER: I do, yes.

Mr. BUNDY: You do? Neither of you visited the Silala in Bolivia. Would I be right then in assuming that none of these other Chilean individuals who prepared reports visited the Silala for purposes of their studies either? Would that be correct, or not?

Mr. WHEATER: I already mentioned that Professor Muñoz had visited previously, but none of the Chilean science team was able to visit the sites in Bolivia. We were able, of course, for the Memorial, to rely on remote sensing and other sources, which these days give us quite powerful insights. We can see, obviously, the visual images; we can get high-resolution digital elevation maps; we can even look at the functioning of the wetland vegetation.

Mr. BUNDY: I understand all that, Dr. Wheater, but it is not my question. I really would greatly appreciate, just because both sides are under certain time pressure, if you would focus on my question, which was not about remote sensing or satellites. I was just asking whether any of the other Chilean individuals preparing reports had done fieldwork in Bolivia. I think you mentioned Professor Muñoz. That was quite a long time ago, was it not?

Mr. WHEATER: It was in the early 1990s, when he was investigating the hydrogeology and drilling some boreholes.

Mr. BUNDY: But to your knowledge, nobody else has visited?

Mr. WHEATER: To my knowledge.

Mr. BUNDY: To your knowledge? So all of their fieldwork was undertaken in Chile; is that correct?

Mr. WHEATER: Correct.

Mr. BUNDY: Do you think that, had they visited the Silala region in Bolivia, that might have assisted them and been important for their work and for your own work?

Mr. WHEATER: It is certainly normal practice to visit a site, and we would have ideally liked to have done that. As I mentioned, Chile's Memorial was based on the available mapping

information, historical reports, remote sensing, and so on. But, of course, by the time we came to the later pleadings, we were very much aware of the fieldwork that had been done by the group led by DHI and so the data that Bolivia produced in its Counter-Memorial was most helpful to us. This included, of course, the detailed mapping of the wetland drainage system. It included measurements of the water table elevations between 10 and 45 cm below surface, descriptions of the vegetation, and, of course, the various geological studies that were done through the local drilling and mapping.

Mr. BUNDY: So would it be fair to say that a large part of DHI's reports in this case were based on field investigation in the Silala region in Bolivia?

Mr. WHEATER: I think that that the data they used was important for them to develop the model parameters and then constrain the model performance in terms of flows.

Mr. BUNDY: To your knowledge, did DHI carry out fairly extensive fieldwork in Bolivia in preparing these reports?

Mr. WHEATER: Well, a lot of the work was done by various Bolivian agencies, and I am really not aware of the contact between DHI and those agencies and the extent to which they were responsible for the products, which are of rather mixed quality. So, I am really not exactly sure to what extent the DHI staff personally were involved in the field programme, but I am, of course, aware that they used the data.

Mr. BUNDY: But have you not read one of their technical reports where they explained the fieldwork that they carried out?

Mr. WHEATER: Well, they, of course . . .

Mr. BUNDY: "They" meaning DHI.

Mr. WHEATER: I know. But "they" in the reports is a rather loose term, and I imagine that they used local staff, local consultants and local agencies. Certainly, for example, in terms of flow measurements, that was done by Senamhi, which is a Bolivian agency. The soils and the vegetation

were done by other agencies. So, I was not clear to which extent they had been involved in all aspects of the work, but it is clear that there is a broad team of Bolivian scientists involved.

Mr. BUNDY: Now, I understand that you and DHI disagree on the magnitude of the increase in surface flows that have resulted from the channelization of the waters of the Silala and Bolivia. Would it be correct to say that the channelization has increased cross-border flows to some extent?

Mr. WHEATER: We believe that the channelization has increased flows to some extent mainly due to the changes in evaporation. The drains have significantly reduced the extent of surface water in the Bolivian wetlands, and open water evaporates at a greater rate than vegetation. Because the channels are quite shallow and the water tables, as we know, quite high, the vegetation is free to evaporate. But there is a difference between the open water evaporation and the plant transpiration, and that difference results in an increase in flow. DHI and ourselves agree on the magnitude of that. It is an uncertain calculation, but we both feel it is in the region of 2 l/s or 1 per cent of the natural flow.

Mr. BUNDY: Now, am I right that both you and DHI agree that a considerable part of the waters of the Silala is constituted by groundwater, as opposed to surface flow, and that that groundwater all flows into Chile?

Mr. WHEATER: Well, the Silala River is 99 per cent fed by groundwater flows from a series of springs which arise not only in the wetlands but extensively in the ravine and then further down in the ravine in Chile. But in addition to that, there are aquifer systems which underlie the river, and those transmit groundwater downstream from Bolivia to Chile.

Mr. BUNDY: Are you able to estimate roughly what proportion of the water is surface flow and groundwater, or not?

Mr. WHEATER: I think that that is quite uncertain. I think both DHI and ourselves acknowledge that the precise amount of groundwater flowing to Bolivia is not known. We do not have any direct measurements of that. So, there are various estimates that have been made which range from a few tens of litres per second to more than a hundred litres per second.

Mr. BUNDY: But, in your opinion, do you think there is a relatively substantial amount of groundwater flow?

Mr. WHEATER: I think there is a relatively substantial flow of groundwater from Bolivia to Chile.

Mr. BUNDY: Am I right that dismantling the channel works would, to the extent it decreased the surface flow, would also perhaps over time increase the groundwater flow?

Mr. WHEATER: Yes, and fairly immediately.

Mr. BUNDY: And could Chile capture that groundwater downstream of the border?

Mr. WHEATER: It is certainly possible.

Mr. BUNDY: Now, am I right that, at least looking at records over the past fifteen to twenty years, your opinion is that the cross-border surface flow averages about 170 l/s?

Mr. WHEATER: That is correct.

Mr. BUNDY: Because I know Chile had used — and DHI had used — 160 l/s, but between 160 and 170 l/s?

Mr. WHEATER: Yes, it is a remarkably steady flow.

Mr. BUNDY: And that is the flow with the channels in place, of course?

Mr. WHEATER: Sorry?

Mr. BUNDY: That is the flow with the channels in place?

Mr. WHEATER: That is the flow with the channels in place.

Mr. BUNDY: Now, I take it you recall a paper written in 1922 before the channel works were constructed by Chief Engineer Robert Fox. It has been referred to during these proceedings. And it was produced by Chile as Annex 75 to that Memorial. Are you familiar with Engineer Fox's report?

Mr. WHEATER: I am.

Mr. BUNDY: Were you aware that it was Chile, not Bolivia, that first introduced this report into the case in its Memorial?

Mr. WHEATER: I am afraid I cannot recall exactly when it was introduced, but I know that both sides have referred to Engineer Fox.

Mr. BUNDY: Well, in Chile's Memorial, and I refer you — you do not have to look at it now — to paragraph 2.22, just for the record. Chile relied on that Fox study to identify the capacity and the flow in the pipeline that was built from the FCAB intake in Bolivia that had been installed in the 1909-1910 time period. That was just below the confluence of the two ravines in Bolivia. Chile cited the Fox article for the statement that the capacity of that pipeline was 75 l/s. Does that ring a bell? Do you recall that?

Mr. WHEATER: It does, yes.

Mr. BUNDY: Now, am I correct that in his paper, Fox identified the daily surface flow a short distance up from the boundary as equivalent to 131 l/s. He expressed it in gallons, but am I right that that converts to roughly 131 l/s?

Mr. WHEATER: You are right, it does, 131 l/s.

Mr. BUNDY: Which is significantly less than 160 or 170 l/s.

Mr. WHEATER: It is, yes.

Mr. BUNDY: Do you recall that Engineer Fox stated that that measurement of 131 l/s of daily flow had, in his words, "very slight variations"?

Mr. WHEATER: I do, yes. That is consistent with the flow régime, as we understand it, in Silala. It is fairly steady.

Mr. BUNDY: It is fairly steady. Just as the 160 to 170 l/s is fairly steady today.

Mr. WHEATER: Indeed.

Mr. BUNDY: Yes. So, would this not suggest, when Engineer Fox so referred to only "very slight variations", would that not suggest that he had made a number of measurements to be able to make that statement at different times?

Mr. WHEATER: Possibly so, yes.

Mr. BUNDY: Yes. Now, I understand that you challenge Engineer Fox's measurement because the location and the method of the measurement is unknown and, hence, you question the accuracy and reliability of his report. Is that a fair statement?

Mr. WHEATER: Well, maybe I can comment on that.

Mr. BUNDY: Well, I am going to get into the location and measurement directly, but are those the two general areas where you challenge his methodology and the location?

Mr. WHEATER: Yes, that is correct.

Mr. BUNDY: Is that correct?

Mr. WHEATER: I would like to comment on his methodology at some point, Mr. Bundy.

Mr. BUNDY: I will come to his methodology, and if I do not, please interject and tell me. But I would like to start first with the location of his measurement. Now, do you recall how Engineer Fox described the location where he took the measurement?

Mr. WHEATER: I do not have his precise words before me, but I think it was in the vicinity of the offtake works. I do not have the precise sentence in mind. I am sorry.

Mr. BUNDY: Well, maybe I can refresh your memory. If we could perhaps display the first slide (number 1) on the screen. It is also in your tabs at number 1. This is taken from Fox's paper: "At Siloli, a small dam has been built across the stream which has a daily flow (with very slight variations) of 11,300 cubic metres or, say, 2,500,000 gallons." That is the 131 l/s, is that correct?

Mr. WHEATER: Yes.

Mr. BUNDY: Yes. Now, Fox also noted in the article that the draw-off for the main to San Pedro — this is for the pipeline from the intake to San Pedro — is carried through the dam. Do you recall that?

Mr. WHEATER: Yes.

Mr. BUNDY: Would this not be the dam that was built in ~~***2010***~~ ***1910*** for that intake purpose?

Mr. WHEATER: Quite possibly.

Mr. BUNDY: Yes. Let me just place a figure on the screen so we can get our bearings here. This is tab 2 in your folders. It is figure 6 I think from your first report in Chile's Memorial.

Now, that shows the FCAB intake just below the confluence of the Northern and Southern ravines and that is where the — would that not have been where the small dam was for the intake; is that correct?

Mr. WHEATER: Correct.

Mr. BUNDY: So does that not show that that is where Fox's measurement was taken since he refers to the measurement being taken across the small dam where the draw-off to San Pedro was?

Mr. WHEATER: No, it does not confirm that. Obviously, you are aware, as we are, that there are considerable variations in the discharge as we move down the system. I mean, the flow builds from the springs but also there are periods where it declines. And Mr. Fox would, presumably, have chosen a convenient location for his measurements, so it is not necessarily the same place as the dam. However, I do agree that it is a reasonable assumption that he was going to take a measurement there, if possible.

Mr. BUNDY: Well, the only small dam would have been the dam that was used in conjunction with the intake to have the water flow into the pipeline, is it not?

Mr. WHEATER: Yes, but to take an accurate measurement you are looking for a point where you have a well-defined section of channel, and that is the point that you would choose the measurement. It is not necessarily the same place as the dam. But I agree, it is likely that it was at the site of the dam.

Mr. BUNDY: Yes, because Engineer Fox does say: "At Siloli a small dam has been built across the stream which has a daily flow." Does that not strongly suggest that that is where he was taking the measurement?

Mr. WHEATER: Not necessarily, because he could be taking a flow at some other point and assume that the losses between the dam and the other point were small. But it is a reasonable assumption, I will agree.

Mr. BUNDY: When he measured the 75 l/s that were going in the pipeline, would that not have been measured at the entrance to the pipeline at the intake where this small dam was?

Mr. WHEATER: Not necessarily.

Mr. BUNDY: [Inaudible]

Mr. WHEATER: I am agreeing with you that it is likely that he was going to find a section of the river that was convenient for measurement somewhere near the location of that dam.

Mr. BUNDY: Now, this may get into the methodology question. I will ask you some questions and if you have points you would like to add, please do. Am I right that you have contended that little credibility can be attached to Fox's value because his method of measurement is not known?

Mr. WHEATER: I think we would like to reconsider our position on that. I made some enquiries with Ott, which is a well-known manufacturer of hydrological instruments. And roundabout the 1870s they started developing their first propeller meter, which is a normal technique that we use for measuring velocity of flow. It is certainly feasible that an engineer such as Mr. Fox might have had the opportunity to use a propeller meter in 1920.

Mr. BUNDY: His study goes into quite a few characteristics. Besides the flow rate of 131 l/s, he gives details of the chemical composition of the waters and the dimensions and the composition of the pipeline that FCAB built. Would it not be important, for purposes of the pipeline, to have accurate measures of the flow at the intake to determine if the characteristics of that FCAB pipeline were appropriate for conveying that flow, particularly since that flow is so important to the railway company?

Mr. WHEATER: I believe Mr. Fox is likely to have been a competent engineer and done his best to take an accurate measurement with the techniques available to him at that time, which may have involved a propeller meter or some other technique.

Mr. BUNDY: But do you agree that it would have been important, for purposes of the construction and the capacity of the pipeline, which was quite important to FCAB, to have accurate measurements?

Mr. WHEATER: Absolutely.

Mr. BUNDY: Yes. What concrete evidence do you have that Fox's measurements were not accurate?

Mr. WHEATER: Well, I do not have any concrete evidence. I would point out that it might be surprising to the Court that it is extremely difficult to take accurate measurements in a small stream. It seems odd that we can send people to the moon, but it is difficult to get an accurate measurement in the Silala. What is normally done, and what has been done by both Bolivia and Chile, is you build a small structure. That structure, perhaps, has a V-shape weir, that gives us a relationship between the water level and the discharge. And that is a technique, as I have said, that has been used by both sides but with considerable lack of success. In fact, the continuous records from both Bolivia and Chile have a huge amount of noise and unexplained variability. Probably due to the fact that it is a very cold site, so we can get diurnal freezing and so on. So I think that places more emphasis on the importance of manual measurements.

Mr. BUNDY: Well, we have noted that today there are relatively minor variations over time in the flow, the 160 to 170. Fox indicated there were very slight variations. Does that not suggest that the measurements all came out more or less in the same place, if there were very slight variations, that there was not a large range of error there?

Mr. WHEATER: I am sure Fox was taking his measurements at the same place for consistency. In fact, it might be appropriate to say we were quite uncertain about the location of Fox's measurements, but we do agree that it is a reasonable assumption — and we were helped in DHI's expert summary in this — that it is at the point just below the confluence. And, in fact, I understand that Bolivia undertook its own programme of manual measurements at that site, which I believe is called C-7. There is a well-established set of data in Bolivia's pleadings which relate to the manual measurements taken currently at that site by Senamhi.

Mr. BUNDY: Would it be accurate to say that the 131 l/s flow measurement referred to by Engineer Fox is the only evidence we have on the record in this case as to surface flows a short distance up from the border prior to the installation of the channels?

Mr. WHEATER: It is not a short distance up from the border. It is 650 m.

Mr. BUNDY: At the intake.

Mr. WHEATER: But that is the only measurement that we have available in the historic record, yes.

Mr. BUNDY: It is the only one. Let me turn to the effect of the channels. Would one effect of the channels in the pipes that were built in 1928 have been to drain ponding water in the wetlands and to speed up the flow towards the intake near the 600 m up from the border?

Mr. WHEATER: Yes. I mean, based on the evidence that Chile presented for the reason for constructing the channels, it seems primarily to have been to remove the surface water from the Bolivian wetlands. And to do that, a series of channels were constructed. We were grateful to DHI for providing the data on those channels, because, actually, they vary from being very shallow, of

the order of 20 to 30 cm to perhaps 40 to 50 cm. They are relatively shallow channels, and their main function is to remove surface water.

Mr. BUNDY: Now, am I right that eventually there have been three intakes for surface water: one by FCAB; another one by FCAB in 1942 just below in the Chilean territory; and then a third one a little further downstream by CODELCO. Are you aware?

Mr. WHEATER: That is correct.

Mr. BUNDY: That is correct. Does that suggest that there was considerable demand in Chile for the surface flow?

Mr. WHEATER: It does.

Mr. BUNDY: Any evidence that FCAB was tapping or using groundwater? Anything on the record that you recall to that extent?

Mr. WHEATER: Not at that stage, no.

Mr. BUNDY: No. Would you characterize the Silala as a simple or a complex hydrological system?

Mr. WHEATER: I think all hydrological systems, when it comes down to it, are relatively complex, but there are certain underlying simplicities, I think, that both sides agree. We know that it is a groundwater-dominated river system. We know that the soils have relatively high infiltration rates so that the rainfall enters the soil and that the amount of rapid run-off is extremely limited. And we know that the topography is extremely steep, from 5,700 m down to 4,200 m. And it is interesting, perhaps, sitting in Holland where the highest point, I believe, is 322 m, to reflect on this small basin which actually drops 1,500 m in elevation.

Mr. BUNDY: But, in your opinion, would it be fair to say that the hydrogeology of the Silala system is complex and difficult to understand from the limited data available?

Mr. WHEATER: I think that during the course of the study the geological understanding has improved greatly, and Dr. Peach can speak to that later. So, we have two important aquifer systems, and they tend to be based in the ignimbrite rock.

Mr. BUNDY: Well, I am just quoting from your report attached to Chile's Reply, not the Memorial: "Both we and Bolivia's experts understand that the hydrogeology of the Silala system is complex, and difficult to understand from the limited data available." Do you stand by that statement?

Mr. WHEATER: Yes. I just would add that we started looking at the Silala in 2016 and we are now in 2022, so we do feel that we have a much better understanding now than we did six years ago. But it is a complex system, I agree.

Mr. BUNDY: You have a better understanding based on — you have not carried out any field studies there. Would this be based on the field studies carried out on the Bolivian side?

Mr. WHEATER: We have done extensive geological studies. Originally, as you recall, the dispute was whether or not Chile was an international river, and so we put a lot of effort into understanding the geological development of the catchment and also the geomorphological development of the river in the ravine. So, we did a lot of work to kind of construct the history of the catchment response in its entirety across both sides. And to do that, of course, we had to put a lot of effort into reconciling different mapping and nomenclature in terms of the geology.

Mr. BUNDY: Yes, but you also had the advantage of quite a lot of on-site data that has been provided from the Bolivian side, have you not?

Mr. WHEATER: As I mentioned earlier, yes.

Mr. BUNDY: Now, am I right that in carrying out its own analysis of the effect the channels have had on the surface flow, DHI used two models — known as the MIKE-SHE and MIKE-11 — that it had developed. Do you consider that those models are widely used and respected models?

Mr. WHEATER: Yes, I have a long history of knowledge of those models. They were developed under European funding with partners in Denmark, in the UK and in France. The Système

Hydrologique Europeén (SHE) is the beginning of the SHE model. It has, of course, evolved over time and is now marketed by DHI as a family of models. But it has a long history. The models are quite complicated. They are somewhat difficult to run, require a reasonable amount of familiarization, but I would say that they are respected and quite widely used, yes.

Mr. BUNDY: Thank you.

Mr. WHEATER: I believe we said that, actually.

Mr. BUNDY: You did. In contrast, in several places in your own written reports you refer to some of the calculations you have produced as either highly simplified or textbook calculations. And in your January written statement of this year, you say they were "based on a major simplification of reality". Now, if you had been asked to determine how much effect dismantling the channels might have on the surface flows in the Silala in terms of percentages, would you have thought it right or correct or appropriate, professionally, to use a calculation that is based on a "major simplification of reality"?

Mr. WHEATER: Absolutely. Let me explain the context for this. We have quite a complicated problem where we had these catchments, as I mentioned, which is small in area but has very large elevation gradients, and then these small channels. So, to construct a physically-based model of that system is a very demanding task and not one to be undertaken lightly. You are talking at least man-months, but more like man-years, of effort. So, as a first step before getting into a problem, it is good practice to stop and think a little bit about what is actually going on and to do some simple calculations, which is in fact what we did. And those calculations are interesting, because they showed that the effect of the channels — well, we agree that there is an effect on the evaporation. So, the additional question is: what is the effect of the channels in reducing the resistance to flow? And then we had this hypothetical scenario that DHI developed of an additional resistance, because perhaps over decades and centuries and millennia there will be some further depth of peat accumulated. So our simple calculation, nevertheless, did not have to make the assumptions of the DHI model. Because it is a complicated model and a complicated system, they focused on a very small area. So, with our simple calculation, we are able to look at the small area, but also to look at

the flow, considering the entire catchment from the boundary to the springs but in a very simple way, a two-dimensional slice. We use the same gradients as DHI of water-table elevation. We use the same material properties that they use for their aquifers. And the answer we got was that the effect of the channels was 0.28 per cent, which is roughly 0.5 l/s.

Mr. BUNDY: I will come back to those models.

Mr. WHEATER: Let me finish, please.

Mr. BUNDY: Well, actually, I would like you to focus on my question, Dr. Wheater, which was if your task had been DHI's task, let's say, and had been to calculate the percentage or a range of percentage of effect that the channels have had, would it have been appropriate to use a method that was a major simplification of reality and not based on any on-site fieldwork? Would that have been the way you would have approached the problem if you had your choice?

Mr. WHEATER: Yes, as a first step, and the result of that influence is the second step. So the result of that was that this very simple method suggests that the effect of these small channels is to change the flow by 0.5 l/s. So that immediately flags up some warning signs, because it means it is an effect that it is going to be extremely difficult to simulate with a complex model. You may recall that in Bolivia's Rejoinder, the errors in their modelling, the acknowledged errors in their modelling, were, in the baseline situation, 11.7 l/s. So their model areas were 11.7 l/s, whereas our simple calculation suggests that the order of response in the catchment is more like 0.5 l/s. So that means that to proceed with modelling would need to be done with extreme caution and extreme care and extreme diligence. Of course, it would be nice to proceed to those steps. But I do not think it is necessary because we have already shown with these very simple calculations that it is a very small effect. So that could be enough to say, well, given the uncertainties in the system, we know that we have got 1 l/s from evaporation, we have got another 0.5 l/s from the channels, so why do we need to bother about going to a very large complex model which is subject to potentially very large errors, as we have, indeed, seen.

Mr. BUNDY: We will let DHI address, if counsel wishes tomorrow, their model. Could I ask you, Chile stated in its additional pleading that:

> "[Your] text-book calculation of the exaggeration factor of DHI's modelling results . . . does not purport to assess the impact of the channelization impact and does not consider, nor intend to consider, the real geology or geography of the Silala River area."

Do you agree with that, what Chile said there? Do you agree that your textbook calculations do not purport to assess the impact of the channelization and do not consider and are not intended to consider the real geology and geography of the area?

Mr. WHEATER: So, let me explain what I mean by that statement.

Mr. BUNDY: That was Chile's statement. Not yours. That was in their pleading. I was asking whether you agree with it or not.

Mr. WHEATER: Sorry, could you just repeat the statement for me?

Mr. BUNDY: Certainly. At paragraph 3.15 of their additional pleading, Chile states, referring to your reports, that:

> "[Your] text-book calculation of the exaggeration factor of DHI's modelling results . . . does not purport to assess the impact of the channelization impact and does not consider, nor intend to consider, the real geology or geography of the Silala River area."

And my question is only: do you agree with that statement or not?

Mr. WHEATER: I do not believe it is a sufficiently precise statement of what is meant. So the point about the simple calculation is, of course, that it is not intended to simulate the response, in its entirety, of a complex 3D system. It is a 2D slice. But what it does is give an indication — and actually quite a powerful indication — of the kind of order of magnitude of the effect that could be expected. So it is in no sense intended to give a precise number that could be used to predict the effect, but it is intended to give an order of magnitude. What ballpark are we in? Is it 10 per cent, 20 per cent, 40 per cent, as DHI say, or is it actually less than 1 per cent, which is what that simple calculation shows. And although you say it is simplified geology, it does represent . . .

Mr. BUNDY: I do not say. I am using Chile's words.

Mr. WHEATER: Okay.

Mr. BUNDY: Chile says it does not consider or intend to consider the real geology and geography. Those are Chile's words. Not mine.

Mr. WHEATER: It is based on the representation of the geology of the main aquifer that is represented in DHI's modelling system, but it is clearly not a detailed representation. It is a very simple abstraction of that complex system.

Mr. BUNDY: Now, earlier I think you mentioned that after a request, or actually a couple of requests, Bolivia provided you with the digital data used by DHI. This model was in February 2019, and then there was a later request in May, and you got some additional data in, I think, June 2019; is that right?

Mr. WHEATER: Correct, yes.

Mr. BUNDY: Now, the February data, that was seven months before you filed your report with Chile's additional pleading; is that correct?

Mr. WHEATER: It is.

Mr. BUNDY: Yes. Now, in your written statement of January of this year, you state:

> "we have subsequently observed that, when the DHI models are run with more realistic data with respect to topography, and when the numerical errors in the MIKE-11 model are addressed and the two models are used consistently for all scenarios, the results are in line with our [your] estimates".

Now, is the data, this more realistic data that you used to make that statement, or are the corrections of the errors that you refer to on the record anywhere?

Mr. WHEATER: They are not at this stage, no.

Mr. BUNDY: They are not? So, nobody can verify them on our side, can they, if we have not seen what you have done?

Mr. WHEATER: That is correct. I mean, the reason we did not submit that work to the Court was, it was completed after the additional pleadings. So you will recall that we received the data in February 2019, and it is quite a complex data system. We then had to purchase a licence from DHI to run the model, and we then had to carry out a detailed analysis of the data, which we reported in the additional pleading. But then to go beyond that, we had to work to fix some of the errors in the model, so we worked to improve the numerical stability, we used consistent topographies, we used consistent additions of water, and then we produced a report. But, sadly, that was beyond the time frame for the additional pleadings, so it has not been put before the Court.

Mr. BUNDY: Thank you.

Mr. WHEATER: You do have my assurance that should the results have been other than we said, I would have been duty-bound to inform the Court that that was the case.

Mr. BUNDY: I appreciate that statement, Dr. Wheater, but it would be nice to actually see the data and the so-called corrections that you made. Now, coming back to your textbook calculations. In addressing what you maintain are the erroneous boundary conditions posited by DHI in its first report, you prepared a calculation based on a single cross-section extending on one side of the Silala River.

Mr. WHEATER: That is correct.

Mr. BUNDY: I will put it on the screen.

Mr. WHEATER: Thank you.

Mr. BUNDY: It might help us get our bearings. So that was the cross-section on the left, out to 360 m, and on the right, I think out to roughly 10 km, if I recall. Now, you referred to these as an idealized two-dimensional hillslope segment; is that right?

Mr. WHEATER: Yes.

Mr. BUNDY: Am I right that the calculations based on this cross-section assume that the water flowed perpendicular in one direction, down towards the canal, down from the topography?

Mr. WHEATER: Yes, that is correct.

Mr. BUNDY: Yes. Do you agree that your calculations, based on this cross-section, assumed no vertical flow in the groundwater?

Mr. WHEATER: They approximate the flow as a horizontal system. That is part of the approximation, yes.

Mr. BUNDY: So they do not assume vertical flow?

Mr. WHEATER: They do not. On the other hand, at the scale of that transect, vertical flow is really of no significance.

Mr. BUNDY: Let's look at it. Do you dispute DHI's finding, based on their borehole drilling in the Bolivian wetlands in this area, that the groundwater does exhibit upward vertical flow? Do you dispute that?

Mr. WHEATER: In the immediate vicinity of the springs, as we learned from our Chilean Quebrada Negra wetland, there is quite a complex response. We actually find that there are a few locations of upward flow but predominantly locations of downward flow, and then additionally springs coming from the sides. So it is a complex environment which involves upwards, downwards and lateral flow.

Mr. BUNDY: Okay. Given that you are looking at the horizontal flow coming down the topography perpendicular to the channel, would it be more accurate to say that actually this model is a one-dimensional steady groundwater flow model?

Mr. WHEATER: It would, yes.

Mr. BUNDY: Yes. Now, I would like to put up two more figures from this same report of yours and the Reply. This is the cross-section we are talking about, is it not? Now, if we look at that,

on the right, that blue area, where the red arrow is pointing, is labelled “Channel”. Now, that channel there is 400 m deep on this figure. Is the actual channel 400 m deep or 0.5 m, like you said before?

Mr. WHEATER: When we were putting this diagram together, we had a problem of really trying to convey in a simple way what the boundary condition at the downstream end was. And the fact is that the water level in the channel is used to set the boundary condition for that seepage face all the way down the 400 metres. So it is an entirely conceptual representation. We were just trying to convey in simple terms that we had a fixed head lower boundary condition at the entire face of that downstream end of the aquifer.

Mr. BUNDY: You concede, I assume, that the channel is not 400 m deep?

Mr. WHEATER: We well, we all know that they are 20, 30, 40 and 50 cm deep in the main.

Mr. BUNDY: Yes, that is why I was confused when I saw 400 m there. What about if we look at the right-hand figure, you have a 400 m deep layer of peat. Are there 400 m of peat underlying there, or is it just about a metre as we saw on some of the photographs shown the other day?

Mr. WHEATER: So the calculations that I referred to initially, you remember the 0.28 per cent change, 0.5 per cent, related simply to the impact of the channel. Then there is the question of how we try, in a simple model, to represent the effect of a layer of peat. And in this case, we used a 1 m layer of peat. So what we did was to add that peat to the downstream end of our flowpath. So, of course, it is a horizontal layer, but in our simple model it is represented as a vertical slice. It represents the hydraulic resistance that DHI suggests is increased by the presence of the 1 m of peat.

Mr. BUNDY: I understand. You have the peat between the ignimbrite and the channel.

Mr WHEATER: Exactly.

Mr. BUNDY: But the peat you have there is 400 m deep, is that correct? On this figure.

Mr. WHEATER: Well the important factor is . . .

Mr. BUNDY: I am just asking is that correct that this model assumes 400 m of peat there for the calculation?

Mr. WHEATER: That model is representing a 1 m slice. And as depicted there, yes, it has a 400 m depth. But important factor is it is a 1 m barrier to the groundwater flow getting into the stream.

Mr. BUNDY: That goes down 400 m.

Mr. WHEATER: To provide a barrier to the groundwater flow getting into the stream. I am not claiming there is 400 m of peat. I am saying on the surface there is 400 m of peat. Potentially, at least an extensive covering of peat, and we want to try and represent that effect in a simple calculation. That is the way we do it.

Mr. BUNDY: Now, is it not correct that these figures assume that all the groundwater from the aquifer will flow into the channel?

Mr. WHEATER: That is correct.

Mr. BUNDY: Because you have got at the bottom an impermeable layer, it is not going below that, right?

Mr. WHEATER: That is correct.

Mr. BUNDY: Now, if all the groundwater is assumed to go in the channel and yet both Parties have said that there is substantial groundwater to flow to Chile, where is the groundwater that flows to Chile?

Mr. WHEATER: It is not represented in that simple calculation.

Mr. BUNDY: Well, if a substantial portion of the groundwater does, in fact, flow as groundwater into Chile and not in the channels, how can you determine how much of the groundwater actually flows into the channels?

Mr. WHEATER: What we have determined is that the change of the groundwater flow into the channels is so small that it will have negligible impact on either the surface flows or the groundwater flows, but we have not, in any way, explicitly modelled the groundwater flow downstream from Bolivia into Chile in this simple exercise. It was merely intended, as I mentioned earlier, to scope the kind of order of the effect that you would expect from putting a small channel into a system with very large topographic gradients that force the groundwater and to show that it is a small effect.

Mr. BUNDY: Madam President, I am not sure where I stand on time, because I am not sure when I started. Could you give me some guidance, please?

The PRESIDENT: Yes, Mr. Bundy. You started at seven minutes after the hour. Let's see. You have about 20 minutes to go still. Please go ahead.

Mr. BUNDY: Thank you very much. Thank you.

Let me go to Figures 3 *(a)* and *(b)* that we showed before. This was the cross-section we looked at before. This one. Now, this cross-section is only looking at one side of the ravine; is that correct?

Mr. WHEATER: Yes. The cross-section that we drew, yes.

Mr. BUNDY: It is not looking at flows coming from the other side?

Mr. WHEATER: No.

Mr. BUNDY: Now, do you consider that a single cross-section taken at just one location throughout the wetlands — or even further extensively throughout the whole catchment area — do you think that that single cross-section is representative of the flows throughout the entire wetlands?

Mr. WHEATER: Absolutely not.

Mr. BUNDY: Let me turn to geology, if I may.

Mr. WHEATER: Thank you very much, Mr. Bundy, I hand the floor to my colleague, Dr. Peach.

Mr. BUNDY: I thought Dr. Peach might be feeling lonely, so I wanted to ask a few geology questions.

Mr. PEACH: Carry on.

Mr. BUNDY: Carry on. Now am I correct, Dr. Peach, that DHI considers that there is a high permeability fault zone that approximately coincides with the ravines that has been called the Silala fault, but whatever we call it, and that increased fracturing and permeability associated with this zone facilitates discharge?

Mr. PEACH: You are correct that that is what they think.

Mr. BUNDY: That is what they think. Now, you maintain, I think, that such a fault coincident with the ravine does not exist, is that correct?

Mr. PEACH: I do maintain that.

Mr. BUNDY: Now, if I could put a slide from your geology report from the Memorial on the screen. That is Figure 3-1 to your second report to the Memorial. It is in slide 8.1.

Mr. PEACH: Yes.

Mr. BUNDY: Am I correct that on this diagram, the panels 4, 5, 6, 7 and 8, which depict the geological evolution and morphological evolution of the Silala River area, show two distinct faults next to the Silala ravine — a normal and a reverse fault — where the arrows are pointing?

Mr. PEACH: Yes, they do.

Mr. BUNDY: They do. Now, do you confirm, therefore, that this fault exists and faulting has occurred in the immediate vicinity of the Silala, regardless of whether you call it the Silala fault or something else?

Mr. PEACH: No, the major fault there, the reverse fault — the longer one on that diagram — is the Cabana fault. The Cabana fault occurs 3 to 4 km downstream of the international border.

Mr. BUNDY: That does not show it downstream. Does it magically stop before it gets into Bolivia, this fault?

Mr. PEACH: It does not. It crosses the river, the Silala River, 3 to 4 km downstream of the border in the north-north-west, south-south-east direction. There are six geological cross-sections in our reports which show the Cabana fault.

Mr. BUNDY: Yes, but where is the evidence that that fault does not extend over the border? This does not suggest — this is a cross-section really . . .

Mr. PEACH: Excuse me, you have misinterpreted what that diagram or these panels are supposed to be showing. They are showing the evolution of the geology and the geomorphology of the Silala River area, the total of it. You will notice that there is no — you see there are two mountains there, or hills. If that was anywhere near the border, it would show Cerrito de Silala and it does not. And that fault is not going down the Silala River, it is going across the Silala River, 4 km downstream of the international border.

Mr. BUNDY: Does not the border run roughly in a straight line with some variations on the right-hand or on the eastern side, in a straight line between those two volcanic peaks?

Mr. PEACH: No, we have not named those volcanic peaks. Not on that diagram. What we are trying to show there — the purpose of that diagram — is to show the geological development from approximately 5.8 or 6 million years ago to 8,500 years ago.

Mr. BUNDY: Are those volcanos there today?

Mr. PEACH: It is showing the development of the geology of the Silala basin which contains Miocene volcanics, 5.8 million years ago — and that is a Bolivian date — and it shows ignimbrite deposits, and it shows the faulting that occurred. Now, the faulting occurred in Chile. The only faults that we have ever found cross the river 3 or 4 km downstream of the international border in a north-north-west, south-south-east direction. I have said this numerous times in numerous reports.

Mr. BUNDY: And you do not believe there is any faulting on the Bolivian side in the vicinity of the ravine?

Mr. PEACH: No, I did not say I did not believe there is any faulting on the Bolivian side. I said I do not believe in the reports. I have said I do not believe that there is any evidence in Chile for the Silala fault as defined, if you like, or described by DHI.

Mr. BUNDY: Would you agree that the ignimbrite is fairly permeable in this area? Fractured?

Mr. PEACH: I think the ignimbrite is permeable. I think — let me just qualify that. There are two ignimbrites that we found in Chile: the Silala ignimbrite, which — that is the Chilean name — which overlies something called the Cabana ignimbrite. The Cabana ignimbrite, we think, is pretty permeable actually, there is no doubt about that. And in between the two, we have a clastic sedimentary deposit — it is a debris flow in fact — which is 12.6 m, more or less at the border where we have drilled through it, and that also adds to the permeability flowing down underground.

Mr. BUNDY: Thank you. Now can I put up the next figure.

Mr. PEACH: By all means.

Mr. BUNDY: If it is what I think it is. It should be Figure 3 — well, this figure taken from a later report of yours.

Mr. PEACH: That figure, okay.

Mr. BUNDY: That figure. Where have those faults gone?

Mr. PEACH: I have just told you, had you been listening, that they are not in the same.

Mr. BUNDY: I assure you I am listening, Dr. Peach.

Mr. PEACH: I am sorry. But I have just told you that those sections are not at the same point. This is what we believe to be going on at the border. Cerro Inacaliri is named, the Silala River is named, Cerrito de Silala — these are all Chilean names of course — and Volcán Apagado, are

named. At the base of that you have got Miocene volcanics between 5.8 and 6.6 million years ago. There are dates to show that in what you might call the valley between the base of Cerro Inacaliri and Cerrito de Silala you have Cabana ignimbrite. Cut into that, you have a little green patch, you notice, which is the clastic deposits I talked about. And then above that, a sort of darker brown, that is the Silala ignimbrite. That is 1.1 million years old. The Cabana ignimbrite is 4.2 million years old.

Mr. BUNDY: So this looks at the situation at the border, hence no fault, and you say the previous figure was not looking at the situation at the border. It was looking at the situation in Chile?

Mr. PEACH: Yes, it was looking at the situation that we believed at the time, and this was in the Memorial, so it is when we wrote it, it is quite a long time ago, and we have done an updated report, which you will be aware of, since then. That was what we thought was going on. We updated the geology subsequent to that, and we looked at all the documents provided by Bolivia concerning their geological survey information and so on, and they are available in that information. This comes from our Reply. That information is available in the Reply — our analysis of that — and in Chile's additional pleading.

Mr. BUNDY: Good. Thank you very much, Dr. Peach. Can I turn to the wetlands or the *bofedales* for a moment. Just a couple more minutes. Do I understand . . .

Mr. WHEATER: Sorry, Your Honour, I am on my feet again, and it is Howard Wheater.

Mr. BUNDY: Thank you, Dr. Wheater. Do I understand that the principle hydrological effect of the drainage channels is to reduce the elevation of the groundwater water table in the vicinity of the channels and so that instead of groundwater emerging at the wetlands surface it will flow into the canals? Is that . . .

Mr. WHEATER: Yes, Mr. Eckstein showed us quite a nice picture of that the other day.

Mr. BUNDY: Okay. So, in effect, the channels act as drains allowing ingress of water from the wetlands and a corresponding loss of water to the adjacent soils?

Mr. WHEATER: Yes. I mean, the channels are earth channels but they are in places lined with stone, but not in any way to restrict the flow. The flow can enter and leave the channels.

Mr. BUNDY: Except, I suppose, in the pipes.

Mr. WHEATER: Except where there are pipes, yes.

Mr. BUNDY: And this started happening some 90 years or so ago after they were installed in 1928; would that be correct?

Mr. WHEATER: Yes.

Mr. BUNDY: Do you accept that the drainage of the wetlands may have had some effect on the wetlands' spatial extent and ecosystem health?

Mr. WHEATER: I certainly agree that it may have had some effect on the ecosystem health in the sense that we have lost the surface water ponding. What we have retained, though, are shallow water tables. So they still maintain wetland conditions. It is interesting that the water tables that you have measured in Bolivia range between 10 cm below the surface and 45 cm, so that is still quite shallow. It is actually very consistent with the sort of behaviour we have in our undisturbed wetland in the Quebrada Negra and that is enough to maintain plenty of moisture for the plants to transpire. But I do agree that there may have been some change to the ecosystem. What we have shown in our pleading is that there is really very little change to the hydrological behaviour of the vegetation. We believe that the vegetation, both in the two Bolivian systems and in the Chilean system that we have studied is at a high rate and unconstrained by a lack of water. But we do see a very strong seasonal variability in the wetland area, and at one point in our pleadings we produced a time series from Landsat imagery from about the 1980s to near current time, which shows a very large variability between widespread functioning wetlands in the wet season and very small effective wetland areas in the dry season. There is a big seasonal expansion and contraction of the wet system. And I am not convinced that the channels have had any significant effect on that functioning. There is no evidence from our analysis to show that.

Mr. BUNDY: Well, wetlands, or the definition, at least used by Ramsar, is wetlands, amongst other things, have water-loving plants. Now, I know you have not been to the *bofedales* in Bolivia, but are you aware that in the areas where there are drainage canals and pipes, they do not display this water-loving vegetation. They have these drier-type grassy shrubs. And in the areas where there is no dense collection of channels, you still have the true *bofedal* vegetation which gives off, as you said, your infrared or ultraviolet, whatever it was, higher transevaporation rates. Have you not seen a correlation?

Mr. WHEATER: We have a survey of the vegetation in our Quebrada Negra wetlands by a colleague, Claudio Lattore, and he has 12 taxa present there which includes all the major species that we see in the Bolivian *bofedales*, and that is an undisturbed wetland. So we certainly see cushion bog, as you do, and we also see quite extensive areas of tussock grass. But I am not, I am afraid, in a position to make comments on the special distribution of the vegetation within the Bolivian wetlands as I have not been there.

Mr. BUNDY: Do you consider the Quebrada Negra wetland in Chile to be similar to the Bolivian wetlands?

Mr. WHEATER: I do, actually. I mean, clearly every site is unique. The major difference is that although over most of the wetland — well, I should say we have got a very similar climate, it is 3 km away, and we have also got very similar vegetation. In fact, the vegetation is slightly impoverished compared to the vegetation that FUNDECO have reported in the Bolivian wetlands. So, slightly impoverished vegetation at an undisturbed site. But the functioning of the system — we have got shallow water tables, very similar except that in about 20 per cent of the area we have got water tables at the surface. And, of course, in the areas that are drained in the Chilean wetlands we do not have water at the surface. But as you have shown in some of your nice photographs, there are clearly areas within the Bolivian wetland system where you still have standing surface water.

Mr. BUNDY: Well the Quebrada has much less water feeding it, doesn't it? The Quebrada Negra, it has not perennial flow down to the Silala, does it? None has been seen since 2016 according to your reports.

Mr. WHEATER: We have perennial flows in the wetlands, but then they disappear downstream. The wetland has a perennial flow, but further downstream the flow disappears and then it reappears, as groundwater flow, when the Quebrada Negra joins the main river Silala.

Mr. BUNDY: Well, I think that Professors Muñoz and Suárez whom you referred to earlier say that no flow from the Quebrada Negra has reached the Silala since at least 2016; that is six years.

Mr. WHEATER: No surface flow, yes.

Mr. BUNDY: Yes, surface flow. That is quite a big difference from the *bofedales* where there is a 160-170 l/s.

Mr. WHEATER: Well, the difference occurs downstream of the wetland, so the wetland is functioning in a very similar way. But as the water leaves the wetland, then it infiltrates.

Mr. BUNDY: ~~***No***~~ ***I know that*** extensive fieldwork was carried out in the Quebrada Negra — you mentioned some of it at the very beginning of your responses. But if there has not been anything comparable fieldwork done in the *bofedales* by the Chilean team, how can you allege that they are similar?

Mr. WHEATER: As I have just explained we have got the same climate; we have got the same vegetation; over 80 per cent of the area, we have the same water table depths. So that is quite a lot of similarity.

Mr. BUNDY: But the supply of water is very different. One produces a surface flow of 170 l/s. The other produces none. That seems like quite a big difference.

Mr. WHEATER: The water is supplied by the springs, and the Quebrada Negra has springs which emerge both within the wetlands and adjacent to the wetlands. And then we have a flow from the outlet of the wetland; but then as the water moves downstream, it disappears into the riverbed, but that is once it has left the main wetland area.

Mr. BUNDY: I think I better stop there, Madam President. Thank you both, Dr. Peach, Dr. Wheater. Thank you for your patience.

The PRESIDENT: Thank you, Mr. Bundy. Before I give the opportunity to counsel for Chile to conduct a re-examination, the Court will observe a coffee break of 15 minutes. The sitting is adjourned.

The Court adjourned from 4.25 to 4.40 p.m.

The PRESIDENT: Please be seated. The sitting is resumed. Mr. Wordsworth, could you please return to the podium? If you wish to conduct a re-examination of the experts, please go ahead now.

Mr. WORDSWORTH: Thank you very much, Madam President. I have got four questions for Dr. Wheater and one for Dr. Peach. First of all, Dr. Wheater, you were asked various questions about not having visited the Silala on the Bolivian side of the border. Do you feel that your expert views in this matter have been in any way rendered unreliable by neither you nor Dr. Peach visiting the site on the Bolivian side?

Mr. WHEATER: I do not. I think that the original question in the case was whether or not the Silala was an international watercourse, and at the time of our Memorial, we had adequate information to comment fairly definitively on that. And then by the time we came to our later work, we had extensive data available from the Bolivian side which was very helpful in allowing us to confirm our opinions about the impact of the channelization.

Mr. WORDSWORTH: Thank you very much. Second question. You were taken to various figures, which are at tabs 5.1 and 5.2 of the judges' folder, and these show the calculations that you undertook to try and find the impact of the channels on the surface water flow. Maybe those can be put up on the screen, please: tab 5.1 of the judges' folder. This is the one that deals with the impact on surface water in the channel alone. And the next one, of course, you were looking at —

Mr. WHEATER: So that is the one with the peat layer.

Mr. WORDSWORTH: That is peat layer? Okay. I think it will do for present purposes. You were asked various questions about the fact that the channel was depicted as going down 400 m, and likewise the layer of peat was depicted as going down 400 m. And the question is whether that impacts on the reliability of your calculation, given that the figures do show this 400 m . . . apparent depth of water or peat?

Mr. WHEATER: Yes. In our report, this is all explained with the aid of further diagrams. But as I explained to Mr. Bundy, we are considering a layer of 1 m deep peat, a larger assumption than Bolivia have made. But to represent that within a simplified model, we had to put it on the end of the groundwater flow path, and hence it sits adjacent to our boundary where we fixed the water level as that of the channel.

Mr. WORDSWORTH: And what were these calculations? What are you actually modelling? Is it the impact of 1 m of peat?

Mr. WHEATER: Yes.

Mr. WORDSWORTH: Or 400 m of peat?

Mr. WHEATER: 1 m of peat.

Mr. WORDSWORTH: And the same question in relation to the surface water in the channel. What is the depth of surface water that is being modelled there?

Mr. WHEATER: We dropped the elevation of the surface water by half a metre.

Mr. WORDSWORTH: So the same question again. What is being modelled? Is it the impact of half a metre?

Mr. WHEATER: The impact of half a metre. I did not, I think, have the chance to say what the impact of the peat layer was, but it was a 1.2 per cent effect on the flow.

Mr. WORDSWORTH: And can we see that on this particular figure?

Mr. WHEATER: If you could read it, it would say that, yes.

Mr. WORDSWORTH: Right. And 1.2 per cent, what is that?

Mr. WHEATER: 2 to 3 l/s.

Mr. WORDSWORTH: 2 to 3 l/s.

Mr. WHEATER: That is the combined effect of dropping the channel and the peat layer, but it excludes the effect of the evaporation, which provides an extra 1 l/s difference.

Mr. WORDSWORTH: So if you were to add this peat layer together with your impact on the surface water, how many litres per second is the impact?

Mr. WHEATER: We are talking about a 2 to 3 l/s impact, including the peat.

Mr. WORDSWORTH: And that compares with what sort of impact that has been modelled by DHI?

Mr. WHEATER: 40 per cent.

Mr. WORDSWORTH: How many?

Mr. WHEATER: 40 —4-0.

Mr. WORDSWORTH: Four-zero. Now that leads to my next question. You were asked questions about the groundwater and how the groundwater is apparently not taken into account in this calculation. I think we can just leave it up on the screen, please. Does the fact that the groundwater is not catered for in this calculation undermine its validity or value?

Mr. WHEATER: Not at all. It is merely to demonstrate the magnitude of the effect of 0.5 m drop in water level in the channel and the 1 m accumulation of the peat on the surface flows.

Mr. WORDSWORTH: And what do you deduce with respect to groundwater flows from what this calculation tells you about the surface water?

Mr. WHEATER: Both sides have acknowledged that all of the flow, be it surface water or groundwater, flows to Chile. So if we are changing the surface flows by 2 to 3 l/s, we have a corresponding change in the groundwater flows, of 1 to 2 l/s because we have lost a litre a second in evaporation.

Mr. WORDSWORTH: Thank you. Now, related to this, you were asked a question as to whether a single cross-section was representative of flows through the wetland, and you said absolutely not. And the figure you were taken to . . . I think we can put it up as it is, in fact, in your report: that is the one, yes. I believe that is the one you were taken to in the judges' folder. And in your report, you also have these further figures underneath. So to recall, in answer to Mr. Bundy's question whether a single cross-section was representative of flows through the wetland, you said absolutely not. And the question is: how does that answer impact on your assessment of the value of the exercise that you carried out with this calculation or, indeed, your ability to question the validity of DHI's modelling exercise by reference to that calculation?

Mr. WHEATER: So we showed with our simple calculation that the effect of the channels was of the order of 0.5 m/s and we used that by using one representative cross-section. We could do that for many cross-sections, and the results would essentially show the same thing, because the change in the channel elevation is so small — everywhere in the catchment, it is so small, compared to the pressure gradient — the water table elevation difference that is driving the groundwater flow. So in your presentation on Friday, you showed the very small decrease. In fact, it is barely discernible. On the long flow path of a drop of rain moving from the mountains, 5,600–5,700 m through to the wetlands, so a 1,500 m drop in elevation. In terms of the groundwater gradient: we think it is 160, DHI think it is 150 m. That is a big gradient pushing the water through, and just a little — I mean, this is putting a spade in the soil kind of depth of change. So there is a common-sense argument that this is — to put the spade in the soil and get a 40 per cent increase in flow is just bizarre.

Mr. WORDSWORTH: Thank you very much. And then, in fact, those are all the questions that I have for you. Thank you very much, Dr. Wheater. I am sorry, I said only four questions.

Mr. WHEATER: Thank you.

Mr. WORDSWORTH: Dr. Peach, you were asked a question as to where the evidence is that the fault that we were looking at in tab 8 of the judges' folder — I think we can put this on the screen, slide 21 — so, you were taken to this figure 3.1, outlining the geological and morphologic evolution of the Silala river area, and you were asked a question as to whether evidence is that the fault that is being depicted there does not extend across the border.

Mr. PEACH: Yes.

Mr. WORDSWORTH: Is there evidence to that effect in your reports?

Mr. PEACH: Yes. In the map, at the end of the Reply, Chile's Reply, on the geological map there, you can see clearly, because they are marked on the map, the Cabana fault and the two accommodating faults crossing the river about 4 km downstream of the border. They cross the river in a north-north-west, south-Ssouth-east direction. That fault is the Cabana fault.

Mr. WORDSWORTH: Could we put up on the screen, then, the map that I understand Dr. Peach to be referring to. Is that the right map?

Mr. PEACH: That is the right one, yes.

Mr. WORDSWORTH: So, can you talk the Court through what that map shows us?

Mr. PEACH: Yes, if you look at the section, or the line which goes from A to A-1 (I think, or A-dash) and you go along it for a short distance just before the yellow outcrop of Cabana ignimbrite, you can see a dotted line. And then a bit further on, you can see another dotted line and then a more solid line.

Mr. WORDSWORTH: Yes.

Mr. PEACH: The dotted line by the yellow outcrop of Cabana ignimbrite is the Cabana fault. Now, you can see where this is, and you can see it crosses it in a north north-west, south south-east direction, and the other ones do as well, the accommodating faults. And if you look at the border,

where we have — we were asked — I was asked the question about, well, where has the fault gone. Well, there is no fault down the Silala river crossing the border because the Silala fault does not exist.

Mr. WORDSWORTH: Now, when you refer to the border there, am I right in thinking that is the diagonal line going up towards the right to left?

Mr. PEACH: Yes, the dotted — well, I do not know whether it is dotted or not.

Mr. WORDSWORTH: The dashed.

Mr. PEACH: The dotted line that you can see, and then there is a blank area, which is Bolivia.

Mr. WORDSWORTH: And I do not know whether it is possible to help with the cursor. Am I right in thinking that the Silala river is moving down from, roughly, from that point exactly —

Mr. PEACH: Yes. And down to the south-west, from there to about 2 km and a bit, and then it bends to the right. That is right. And then it bends again to the left and comes down to the — and that is the outcrop of Cabana ignimbrite, and *that* is the fault: *there*.

Mr. WORDSWORTH: And you say that fault is how far away from the boundary?

Mr. PEACH: Well, it is 4 km — I have not actually measured it, but it is about 4 km downstream, and there is no fault running *down* the Silala river.

Mr. WORDSWORTH: And just to complete this. Am I right in thinking — well, can we move on? I believe there is a profile . . .

Mr. PEACH: Yes.

Mr. WORDSWORTH: — which shows this as well.

Mr. PEACH: A geological cross-section.

Mr. WORDSWORTH: Perhaps you could explain this to the Court as well.

Mr. PEACH: There we are.

Mr. WORDSWORTH: That is also in your reports; correct?

Mr. PEACH: Yes. This is in — I think it is in the Reply.

Mr. WORDSWORTH: Yes.

Mr. PEACH: So, if you look at the cross-section at the top, on the right, you have got the international border. And then it runs in a south-west direction into Chile. It is not in Bolivia at all there. And if you come down, to about 4 km down, you see these solid lines. One is at that angle, and two are at that sort of angle. Those, the furthest one to the south-west, is the Cabana fault and the other two are the accommodating normal faults. And I apologize for all the geological terms, but I cannot think of anyhow else to describe them. But you can see where they are. They cross the river in the north-north-west, south-south-east direction. They are nowhere near the border and they do not run down the river.

Mr. WORDSWORTH: Thank you very much, Dr. Peach. I only had one question for you.

Mr. PEACH: Yes, okay. Thank you very much.

Mr. WORDSWORTH: And now, I believe, Madam President, re-examination is complete, and the judges may have questions.

The PRESIDENT: Thank you, Mr. Wordsworth. Yes, I shall now see whether there are judges who would like to put questions to the experts. Our practice is for judges who are on the Bench to pass a note to the President if they wish to ask a question. ***~~It~~ This*** is a little more difficult for the judges on the screen. They have a different way of asking for the floor, if they wish to do so.

I am not seeing any***one*** asking for the floor, but I do have a question. It relates to the comment that was made earlier regarding the seasons — the rainy seasons. I think that is probably a question that is properly directed to Dr. Wheater. I understand that the Silala is located in a very arid area but that there is also a rainy season. That is mentioned in Chile's Memorial. My question is whether the time of year when the flow rate is measured has an impact on the results that could have implications for the comparison of one measurement with another measurement. That is my first question.

Mr. WHEATER: Thank you, Madam President. The fact that it is a groundwater-dominated stream means that the water that is reaching the stream has travelled through the ground various distances from the catchment boundary and it smooths out the seasonal variations. So, we have a remarkably consistent flow. When it rains, you see a little peak because, obviously, there is a bit of runoff from the riparian wetlands. But basically, it is a flat response, so you would not expect to see seasonality in the flow.

The PRESIDENT: Thank you, Dr. Wheater. I have a related question. Do you have in front of you the Written Statement of the experts submitted by Bolivia by any chance?

Mr. WHEATER: I regret, I do not.

The PRESIDENT: Well, I ***can*** explain to you my question. In that document, there is a picture of the northern wetland canal surrounded by drain soils, in comparison to what is described as a natural *bofedal* with surface flow across the valleys. In the latter picture, there is much more greenery and it gives the impression, at least to a layperson, of what I would describe as maybe a more vibrant or healthier looking system. So my question ~~***also***~~ is***:*** does the season at which such a photograph is taken have an impact or is the answer similar to the answer you just gave me?

Mr. WHEATER: No, it has a huge impact. In Chile's Memorial, we present a long time series of Landsat images that show the aerial that extends to the wetlands. And the variability — and so we have the rainy season and winter data — there is a huge variation. So it can be as little from that image as one hectare or as big as 26 ha. The vegetation is there but it is only really active at its fullest extent in the wet period.

The PRESIDENT: Thank you, Dr. Wheater. I now have a question from Judge Iwasawa, so I will give him the floor, please.

Judge IWASAWA: Thank you, Madam President. I have a question for Dr. Wheater. My question is about methods adopted by Mr. Fox in 1922. You stated that you now believe that it is likely that he may have used the propeller meter which was developed in 1870. Does this affect your assessment of the result produced by Mr. Fox? Thank you.

Mr. WHEATER: Thank you. I think our uncertainties about Mr. Fox have always been, primarily, where the measurement was taken. And we have had a long discussion today which seems to strongly suggest it was taken some 600–650 m above, which is at a site that is called C-7 on some of Bolivia's pleadings. The way we take a measurement, manually, using this classical approach is that you — the propeller meter measures the velocity of water, and so you put it in the water at different depths and different special locations, you integrate the velocity with the area, and that gives you your measurement of discharge. If you do it carefully, it might be a plus or minus 5 per cent effect. Normally, if we want precise data, we use a little structure, as I explained, where you put a weir in the stream and you measure the relationship between the water level above the weir — sorry, a measurement of the water level gives you a measurement of a discharge. And in the case of the Silala, both Bolivia and Chile have these installations, but they have been extremely variable in the terms of the quality of the responses. I think that the manual data are actually quite important. Of course, normally you use the manual data to correct the continuous flow measurement. The continuous flow measurement depends on a relationship between the water level and discharge, which is called a rating curve, and you normally come along with your current meter [inaudible], and then you correct your rating curve so that the weir reading is reflecting the manual measurements. Does that adequately answer?

Judge IWASAWA: Yes, thank you very much.

Mr. WHEATER: Thank you.

The PRESIDENT: Thank you, Judge Iwasawa and thank you Dr. Wheater. I also have a question from Judge Tomka, so go ahead, Judge Tomka.

Judge TOMKA: Thank you very much, Madam President. Good afternoon, Dr. Wheater. A pleasure to see you. I hope you remember that you appeared first time 25 years ago.

Mr. WHEATER: 25 years ago, nearly to the day. There was a very fierce Agent for Slovakia at that occasion.

Judge TOMKA: Thank you, Dr. Wheater. I would like to ask you a question in order to reassure me that I understand well your submission. Is your submission, and the submission of your colleague, Dr. Peach, that this historical channelization has not had any major environmental impact in the area? Because at least you have written that your results show that both Bolivian and Chilean wetlands continue to fully occupy the valley floor, and that channelization in Bolivia has not affected the area of active wetlands in the valley floors.

Mr. WHEATER: Yes.

Judge TOMKA: So is my understanding correct that the submission is that there has been no major negative environmental impact of this channelization?

Mr. WHEATER: That would really be beyond our expertise, to give an opinion on the ecosystem response. I think, what we have seen is that the drainage clearly removes the surface water and so obviously, there is vegetation that particularly thrives in that environment with a lot of surface water and that will decline and be replaced by other vegetation. The main point that we have been have trying to make is the hydrological one. Because, when we look at the — we can use satellite imagery to estimate the functioning of the wetland. There is an index called normalized difference vegetation index — NDVI — that shows how actively the vegetation is transpiring. And we see that the results from the undisturbed wetland in Chile are very similar to the disturbed wetlands in Bolivia. We also see that even close to the drainage works, there is very strong vegetation transpiration. So hydrologically, it does not seem to make much difference.

Interestingly, downstream, there has been channelization in Chile and that has been looked at. And what we see from looking at soil pits, is that the effect of the channelization has been to change a riparian wetland system into something that is more like a *bofedal*. So these systems do change their functional form according to the drainage channels, so we would not at all wish to say there is no ecological effect. I think an important point, though, which we did not have an opportunity to address in the questions, was the extent to which the channels have caused this supposed degradation. And Bolivia's evidence is really quite confused on this, because they say changes were observed from 1908 — before the channels; changes were observed from 1950; changes were observed

earlier . . . There is no clear-cut evidence, in my opinion, to link the channels with the degradation. But that does not mean to say that there is degradation. What it does mean is that if Bolivia wishes to restore the wetlands, they really need to take care and take account of all the factors, particularly climate variability, which is a very — we've seen from our satellite imagery, the seasonal change and the interannual change in wetland extent depending on a seasonal precipitation.

Judge TOMKA: And as a follow-up, if I may ask: from your scientific point of view, or environmental point of view, leaving aside economic aspects, what would be your recommendation to restore the environment, to remove the channels, or ...? Thank you.

Mr. WHEATER: In my opinion, it would be great to restore the wetlands and remove the channels. And I think, in my professional opinion, Chile would see very little impact downstream of that.

Judge TOMKA: Thank you very much. I have no more questions.

The PRESIDENT: Thank you, Judge Tomka. And thank you, Dr. Wheater. I do not have any other judges on the Bench asking for the floor, nor do I see an indication that the judges who are joining us via video link are asking for the floor. So that means that we have come to the close of the questioning of Dr. Wheater and Dr. Peach. I thank both of you for appearing before the Court today, and I recall that tomorrow, Friday, 8 April, between 3 p.m. and 6 p.m., the experts called by Bolivia will be invited to address the Court. The sitting is adjourned.

The Court rose at 5.05 p.m.

_____