Council for Development and Reconstruction

Greater Beirut Water Supply Augmentation Project Environmental and Social Impact Assessment

Final Environmental and Social Impact Assessment

Volume 1 of 2

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dar al-handasah
shair and partners

Greater Beirut Water Supply Augmentation Project
Environmental and Social Impact Assessment

Report

Greater Beirut Water Supply Augmentation Project
Environmental and Social Impact Assessment

FINAL ESIA

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ABBREVIATIONS AND ACRONYMS

AWWA	American Water Works Association
AWW	Arab Water World magazine
BMLWE	Beirut and Mount Lebanon Water Establishment
c.	circa
^{O}C	Degree Celcius
CAS	Central Administration of Statistics
CBO	Community Based Owner
CH_4	Methane
CDR	Council of Development and Reconstruction
CLO	Community Liaison Officer
CO_2	Carbon Dioxide
CoM	Council of Ministers
CN	Curve Number
DBA	Dam Break Analysis
DBO	Design Build Operate
DBOO	Design Build Own Operate
DGA	Directorate General of Antiquities
DO	Dissolved Oxygen
DoA	Directorate of Antiquities
ERP	Emergency Response Procedures
ESIA	Environmental and Social Impact Assessment
EIA	Environmental Impact Assessment
ESMP	Environmental and Social Management Plan
FS	Feasibility Study
GBA	Greater Beirut Area
GBWSAP	Greater Beirut Water Supply Augmentation Project
GBWSP	Greater Beirut Water Supply Project
GHG	Greenhouse Gas
GIS	Geographic Information System
GoL	Government of Lebanon
ha	hectares
IEE	Initial Environmental Examination
ILO	International Labour Organisation
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature
IWA	International Water Association
IWRD	Integrated Water Resources Development
km	kilometer
km^2	Square kilometer
LCWMC	Lebanon Centre for Water Management and Conservation
LRA	Litani River Authority
m.a.s.l	meter Above Sea Level

m	meter
m^3	cubic meter
MCE	Maximum Credible Earthquake
MEW	Ministry of Energy and Water
MoE	Ministry of Environment
MoF	Ministry of Finance
MoSA	Ministry of Social Affairs
MPWT	Ministry of Public Works and Transport
MSF	Multi-Stage Flash
N_2O	Nitrous Oxide
NE	North East
NERP	National Emergency Recovery Programme
NGO	Non-Governmental Organisation
NPV	Net Present Value
NWC	National Water Council
NWFP	Non-Wood Forest Product
NWSS	National Water Sector Strategy
OP	Operating Policy
O&M	Operation and Maintenance
PAP	Project Affected Person
PDESIA	Preliminary Draft ESIA
PIC	Project Information Center
PMF	Probable Maximum Flood
PMT	Project Management Team
POE	Panel of Experts
RAP	Resettlement Action Plan
RCC	Roller Compacter Concrete
RO	Reverse Osmosis
RPF	Resettlement Policy Framework
RWE	Regional Water Establishment
RWH	Rainwater Harvesting
s	second
SCS	Soil Conservation Service
SE	South East
SOW	Scope of Work
t	ton
TDS	Total Dissolved Solids
UFW	Unaccounted for Water
USBR	United States Bureau of Reclamation
WB	World Bank
WFP	Wood Forest Product

EXECUTIVE SUMMARY

ملخص تنفيذي

الخلفية

لمعالجة مشكلة النقص الحاد في إمدادات المياه، بادرت الدولة اللبنانية من خلال مجلس الإنماء والإعمار (CDR) ووزارة الطاقة والمياه(MEW) ، ومصلحة مياه بيروت وجبل لبنان (BMLWE) مشروع زيادة تغذية بيروت الكبرى بالمياه (GBWSAP) لإيجاد الحلول المقبولة بيئياً واجتماعياً، والقابلة للتطبيق تقنياً والمجدية اقتصادياً على المدى المتوسط والبعيد لتزويد منطقة بيروت الكبرى بمياه الشفة ذات الجودة المطلوبة. يأتي المشروع هذا كمكمّل لمشروع زيادة تغذية بيروت الكبرى بالمياه الجاري تنفيذه (مشروع تزويد بيروت بالمياه) لتحسين الإمدادات على المدى القصير.

ينقسم تنفيذ مشروع زيادة إمدادات المياه لبيروت الكبرى على مرحلتين: المرحلة الأولى قارنت بين الخيارات المطروحة المتعلقة بالسد والخيارات الأخرى الغير مبنية على إنشاء السدود وأوصت بسدّ بسري كمشروع ذي أولوية، في حين تم ضمن المرحلة الثانية إعداد تقييم كامل من فئة "أ" لتقييم الأثر البيئي والاجتماعي (ESIA) لسدّ بسري. يعكس هذا التقرير التغيرات المتعلقة بتصميم السد وبالمناطق التي سيتم استملاكها والتي عدّلت في كانون الثاني/يناير ٢٠١٤ الماضي.

عملية تقييم الأثر البيئي والاجتماعي

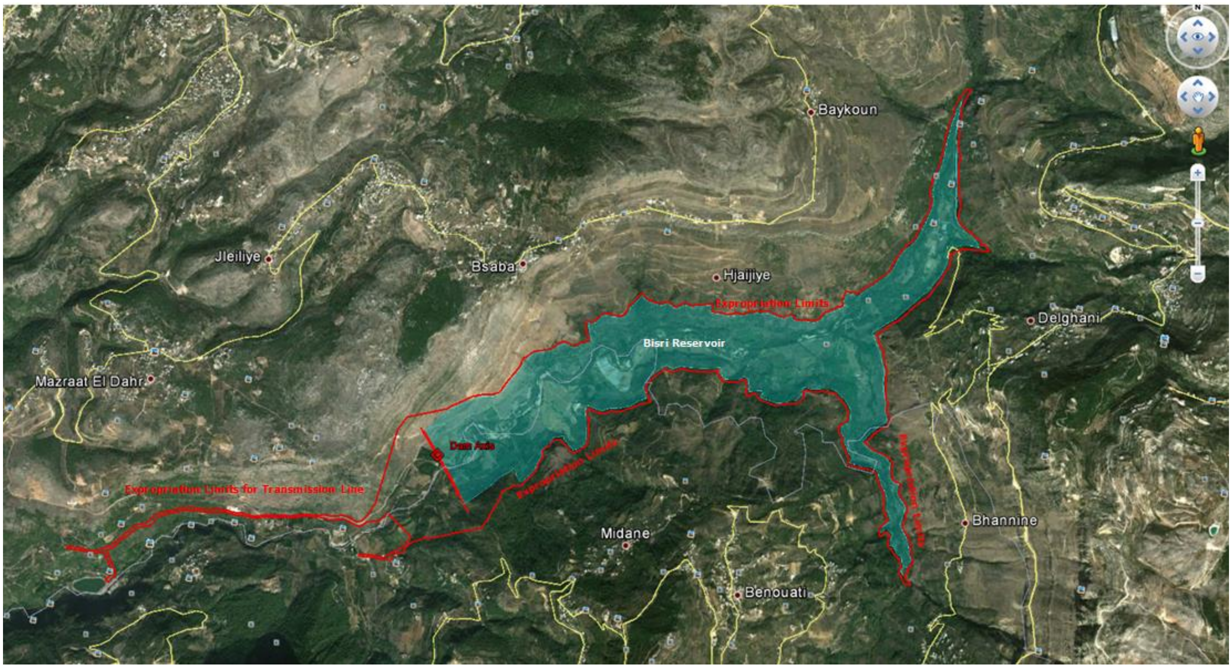
تقوم عملية تقييم بيئي واجتماعي بطرح السبل اللازمة لتجنب والتخفيف و/أو التعويض عن الآثار البيئية والاجتماعية السلبية المحتملة التي قد تنجم عن المشروع.

تم جمع كافة الأعمال التحليلية والتوصيات البيئية والاجتماعية التي صممت جميعها بطريقة شفافة وتعاونية، في مجموعتين من المستندات:

- توثيق التقييم البيئي والاجتماعي الذي يتكون من:
  ١. تقرير تقييم الأثر البيئي والاجتماعي
  ٢. الملاحق المرفقة مع التقرير
- خطة عمل إعادة الإسكان (RAP) للسد والبحيرة وخط النقل وطرق الوصول.

وصف المشروع

يقع سدّ بسري المقترح على بُعد ١٥ كيلومتر تقريباً من ساحل صيدا المتوسطي، وهو على بُعد ٣٥ كيلومتر جنوب بيروت المركزية، على ارتفاع ٣٩٥ متراً تقريباً فوق سطح البحر. يبلغ طول البحيرة المياه حوالي ٤ كيلومتر أعلى السد على نهر بسري كما هو مُبيّن في الشكل أدناه. إن الوقبتين شرقي البحيرة بسري المشكلتان من نهر الباروك من الشمال ووادي بحنين حيث يسير نهر عاريّة من الناحية الجنوبية يلتقيان في مرج بسري لتشكيل نهر بسري الذي يندمج بعد خمسة كيلومترات مع وادي خلّة إلى غربي قرية بسري ليشكل النهر الأولي ومن ثم يواصل جريانه إلى البحر. تمتد منطقة المياه السطحية للحوض المائي فوق موقع السد على نهر بسري على حوالي ٢١٥ كلم٢ .عند منسوب المياه الأقصى، تقدر سعة البحيرة الإجمالية بـ ١٢٥ مليون م٣ كما يقدر ان تكون المساحة التي يتوقع غمرها ٤٣٤ هكتار.



سدّ و بحيرة بسري المرتقبان وحدود الاستملاكات

يستلزم مشروع زيادة تغذية بيروت الكبرى بالمياه إنشاء وتشغيل سلسلة من البنى التحتية، لا سيما:

- السد والبحيرة البالغة مساحته ٢٥٦ هكتاراً (باستثناء منشآت السد الملحقة)،
- خط نقل بطول ٤ كيلومترات يربط السد بمحطة الأولي الهيدروكهربائية (HEP)، و

- إنشاء وتحسين عدة طرق وصول لمنطقة السد.

بالرغم من أن مساحة الأراضي الخاضعة للاستملاك هي ليست بالقليلة، والتي قدرت بحوالي ٥٧٠ هكتاراً، فإن الممتلكات السكنية في منطقة السد والبحيرة قليلة جداً ولا يوجد هناك أماكن تجارية أو صناعية ولا بنية تحتية او مرافق للمجتمع الأهلي تذكر. وتأوي أماكن السكن المشغولة العمال الزراعيين الموسميين، معظمهم من غير اللبنانيين الذين هناك حاجة إلى إعادة إسكانهم.

تعتبر معم الأراضي الخاضعة للاستملاك زراعية بامتياز وتقدر بحوالي ١٥٠ هكتاراً إضافة إلى غابات حرجية (٨٢ هكتاراً) والنباتات الطبيعية (١٣١ هكتاراً).

التكاليف المقدرة

قام تقرير التصميم المحدّث في سنة ٢٠١٣ بتقدير التكلفة الاجمالية للمشروع بحوالي ٣٠٠ مليون دولار أميركي تتضمن ٢٢٠ مليون دولار تكاليف المقاول، و٦٦ مليون دولار من التكاليف غير المتوقعة، و١٠ ملايين دولار للهندسة. اما كلفة إنشاء خط النقل فيقدر بـ ٢٠ مليون دولار. تقدر كلفة إنشاء المحطة الكهرمائية بـ ١٥ مليون دولار.

لقد استُثنيَ من تلك التكاليف تكلفة معالجة المياه ونقلها لاحقاً للتوزيع في بيروت الكبرى، التي ستقدم ضمن مشروع تزويد بيروت الكبرى بالمياه المُصمم سابقاً والذي سينفذه عما قريب مشروع زيادة تغذية بيروت الكبرى بالمياه.

ولقد تم تقدير التكلفة لاسمتلاك ٥٧٠ هكتاراً من الأراضي، والتي ستغطيها الحكومة اللبنانية ما يقارب الـ١٥ مليون دولاراً.

إطار العمل القانوني والنظامي والمؤسساتي

القوانين اللبنانية القائمة

بعد عملية إعادة إعمار وإنماء لبنان وبعد خمسة عشر سنة من الحرب الأهلية والغزو، ليس أمام لبنان خيار آخر سوى الاعتماد على التمويل الخارجي من المانحين الدوليين مثل المفوضية الأوروبية والبنك الدولي والمانحين الفرديين الذين يعتبرون من الضروري تقييم المشاريع بيئياً كشرط مُسبق للتمويل.

وبالتالي، حدّدت مسودة المرسوم ٤٤٤ لسنة ٢٠٠٢ المبادئ المُلزمة التي تخضع لها كافة المشاريع العامة والخاصة في تقييم آثار المشاريع على البيئة. وطبقاً للمادة ٢٣، يتوجب على كافة المشاريع إجراء تقييم بيئي تكون الهيئة النظامية بالنسبة لها وزارة البيئة (MoE). وقد تم تمرير مسودة المرسوم في آب/أغسطس ٢٠١٢ وأصبح المرسوم رقم ٨٦٣٣، *القواعد الأساسية لتقييم الأثر البيئي*.

السياسات الوقائية التي يمارسها البنك الدولي

بالتوافق مع سياسة مجلس الإنماء والإعمار، يتماشى التقييم مع الهيكلية والخطوط الإرشادية لسياسة التشغيل ٤,٠١ التابعة للبنك الدولي، *تقييم الأثر البيئي* للمشاريع من فئة "أ"، كما ومع متطلبات وزارة البيئة اللبنانية، كما صاغها مؤخراً المرسوم رقم ٨٦٣٣ الصادر في آب/أغسطس ٢٠١٢. خمسة من شروط الحماية التابعة لسياسة البنك الدولي يتبناها مشروع زيادة تغذية بيروت الكبرى بالمياه ، وهي التقييم البيئي، الموائل الطبيعية، الموارد الثقافية المادية، إعادة الإسكان القسرية وسلامة السدود.

التقييم البيئي (OP/BP 4.01): سيكون للمشروع آثار بيئية هامة. لقد تم إعداد مسودة أولية لتقييم الأثر البيئي والاجتماعي كدراسة مقاربة بين مختلف البدائل التي درست لتحديد الخيار ذي الأولوية المستند إلى تقييم بيئي واجتماعي واقتصادي وتقني. مقترح المشروع انتقى سد بسري ليكون المشروع ذي الأولوية. لقد تم إعداد تقييم للأثر البيئي والاجتماعي وخطة الإدارة البيئية والاجتماعية (ESMP) تبعاً لدليل OP/BP 4.01 للمشاريع من فئة "أ".

الموائل الطبيعية (OP/BP 4.04): سيكون للمشروع آثار هامة على الموائل الطبيعية، خلال فترة إنشاء وتشغيل السد. لقد تم إجراء تقييم تفصيلي لإيكولوجيا المنطقة، وتقييم تنوع الحياة النباتية والحيوانية، ولتحديد تلك الأجناس المعرضة للمخاطر أو المدرجة على لائحة IUCN والتي تتعرض لمخاطر مضافة جراء بناء السد.

سَيُسبّب إنشاء سد بسري وإنشاءاته المرافقة، إضافة إلى إنشاء البحيرة، تغييرات للموائل الطبيعية وبالتالي الايكولوجيا والتنوع الحيوي، وسوف يحوّل وجود البحيرة الموائل المشاطئة إلى موائل بُحيّرية مع آثار

سلبية منها وإيجابية. وسوف تحد البحيرة من موائل أجناس النباتات والحيوانات التي تتطلب مياه متدفقة ولكن ستجذب تلك المتكيفة مع المياه الهادئة أو القليلة الحركة مثل طير الماء.

سيكون للموائل الطبيعية الجديدة آثار ايجابية على بعض المجتمعات البيولوجية الجديدة التي ستقوم بالتوطين هناك مع مرور الزمن.

الموارد الثقافية المادية (OP/BP 4.11): أهمية ومدى التراث الأثري والتاريخي والثقافي في أرجاء منطقة سد بسري كانت واحدة من القضايا الأساسية لتقييم الأثر البيئي والاجتماعي. وبينما كان هناك الكثير من التراكب بين ما هو آثاري وما هو ثقافي، تم مناقشة الإجراءات الواجب اتخاذها لإنقاذ والحفاظ على هذه الآثار، بصورة منفصلة، كل واحدة تحت رقابة المديرية العامة للآثار (DGA) والأبرشية المارونية في صيدا.

من المتوقع ان تقوم المديرية العامة للآثار بتخطيط وتنفيذ تقصي آثاري وحفريات إنقاذية تماشياً مع سياساتها وإجراءاتها وذلك مع بعض المساعدة من الوكالات المُمولة مثل جامعة وارصو، التي هم في شراكة معها. تجدر الإشارة أن إجراء ما يعثر عليه بطريق الصدفة والذي سيتم تبنيه خلال الإنشاء والصيانة للأعمال الرئيسية للبنية التحتية هو مكون فرعي لخطة الإدارة البيئية والاجتماعية.

إن الحفاظ على التراث، المختلف عن إنقاذ الآثار، معني بالدرجة الأولى بنقل كنيسة مار موسى ودير القديسة صوفيا إلى مكان آخر، وإنقاذ الآثار من بعض البيوت القديمة المهدمة في أرجاء الوادي. لقد جرت اجتماعات مع أسقف الأبرشية المارونية في صيدا، والاستشاريين المعماريين للكنيسة، ورئيس بلدية مزرعة الضهر والكاهن المسؤول عن كنيسة مار موسى. وقد حدّدت الزيارات المتكررة أربعة مواقع ممكنة لنقل كنيسة مار موسى، واحد منها أوصي به لإعادة بناء كنيسة مار موسى غير انه يجب ان تمتد المسؤوليات لتقديم منطقة تخزين توضع فيها المواد المنقب عنها في مرج بسري وأماكن أخرى، كما ستحدد من قبل المديرية العامة للآثار.

إعادة الإسكان القسرية(OP/BP 4.12) : من المتوقع ان يكون لمشروع زيادة تغذية بيروت الكبرى بالمياه آثار اجتماعية مباشرة وغير مباشرة في منطقة تأثيره وما بعد. بالتناسق مع السياسات الوقائية للبنك الدولي، لقد تم حثّ OP/BP 4.12 كما وتم تحديد خطط للتخفيف من الأثر الاجتماعي. كما وتم إعداد خطة إعادة الإسكان وفقاً لعدة فئات من الأعمال (السد والبحيرة ومحطة الكهرباء وخط النقل وطرق الوصول إلى منطقة السد) لأجل التخفيف والحدّ من الآثار السلبية وتعزيز الآثار الإيجابية على المجتمعات الأهلية في منطقة المشروع. وتجري مناقشة التوصيات بخصوص إعادة الإسكان في خطة عمل إعادة الإسكان التي هي مستند مُنفصل عن تقرير تقييم الأثر البيئي والإجتماعي.

سلامة السدود (OP/BP 4.37): المساهمة الكبيرة في سلامة السدود هي صياغة خطط سلامة السدود التي تستند إلى تحاليل تشكيل انهيار وغمر السدود الذي قام به مصمم السد. يتضمن تقرير انهيار السد خطة عمل لحالات الطوارئ مع تفاصيل تتعلق بالتنفيذ. تشتمل خطط سلامة السد سواء كانت الصادرة سابقاً أو قيد الإعداد على:

- الإشراف على الإنشاء وخطة ضمان الجودة؛
- خطة استخدام الآلات؛
- خطة التشغيل والصيانة؛ و
- خطة الجهوزية لحالات الطوارئ؛

دراسة تحليلية للبدائل

تم القيام بدراسة مقارنة وتحليلية شاملة للحلول الممكنة الهادفة إلى زيادة تغذية بيروت الكبرى بالمياه على المدى البعيد وعرضت تفاصيل هذه الدراسة في المسودة التمهيدية لتقييم الأثر البيئي والاجتماعي. وقد تم دراسة عدد من البدائل منهل ما ترتكز منها ما لا ترتكز على إنشاء سدّ بالإضافة إلى بديل "عدم فعل أي شيء" أو بديل "اللا مشروع". من البدائل التي لا ترتكز على إنشاء سدود تم النظر في خيارات تحلية المياه، المياه الجوفية، تجميع مياه الأمطار، إعادة استخدام مياه الصرف الصحي، بالإضافة إلى تخفيف استهلاك المياه "غير المحتسبة". يُلخص الجدول أدناه الجوانب الإيجابية الأساسية و/أو العوائق التي قد تسهل أو تمنع هذه الحلول من التحقيق العملي لتزويد بيروت الكبرى بمياه الشفة على المدى الطويل.

ملخص المصادر للبدائل التي لا ترتكز على إنشاء سدود

المصدر	النواحي الإيجابية	النواحي السلبية	الخلاصات
عمليات المياه	• مياه وفيرة ومستدامة؛ • يمكن ان تلبي طلب منطقة بيروت الكبرى؛ • يمكن الاعتماد عليها تقنياً؛ • لا علاقة لها بالمناخ؛	• تستخدم عملية صناعية؛ • فقط ٤٠% من السحب للإمدادات؛ • تكلفة إنشاء عالية؛ • استملاكات ساحلية كبيرة؛ • تكاليف طاقة وتشغيل وصيانة عالية؛ • تضرر البيئة البحرية بسبب المياه الشديدة الملوحة؛ • سياسياً غير مرغوب بها.	عملية جداً لكن مكلفة جداً. بالنسبة للدراسة الحالية، هي "مصدر الحل الأخير"
المياه الجوفية	• معظم الكميات المستخرجة تذهب للإمدادات • ملائمة للاستخدام المتمم لمخطط آخر • جودة أفضل من المياه السطحية • مواقع منوعة للينابيع • آثار قليلة للكربون	• استخدام مستقبلي محدود بسبب الاستغلال المفرط؛ • المصادر غير محددة جيداً حالياً؛ • ربما غير كافية لوحدها لتزويد منطقة بيروت الكبرى؛ • تتوقف تجديد الموارد على المناخ؛ • تكاليف الطاقة مرتفعة	لا تزال المصادر بحاجة لتقدير حجمها لكنها ستساهم في حدها الأدنى في الاستخدام المتمم لبديل السدّ، لكن مع كميات محدودة للاستخدام في المستقبل.
جمع مياه الأمطار	• تقنية أساسية • مصادر محلية • صديقة للبيئة (بصمة كربونية منخفضة)	• موسم الأمطار في لبنان قصير؛ • غير ملائم للمناطق الحضرية ذات المباني العالية؛ • تتوقف على المناخ؛ • غير محبذة من العامة.	في أحسن الحالات، ستساهم في استخدام الأسر أو المجمّع لغير مياه الشفة
إعادة استخدام المياه المبتذلة	• تقع المصادر ضمن بيروت الكبرى • مصدر مستدام عموماً • أغلبية التكنولوجيا مطلوبة حالياً لممارسات الإدارة الفضلى	• تكاليف المعالجة عالية؛ • الافتقار إلى الخبرات التقنية؛ • موارد غير كافية لتلبية طلب منطقة بيروت الكبرى؛ • نظرة غير مؤيدة لدى العامة واعتراضات طائفية.	اعتراضات ثقافية قوية. في أحسن الحالات، يمكن تزويد كميات كبيرة من غير مياه الشفة لري المناظر الطبيعية، الخ...
التخفيف من استخدام المياه	• تقوّي إلى أقصى حد فعالية النظام الحالي واسترجاع التكلفة • تشجع ممارسات الإدارة الفضلى	• تتطلب الإرادة السياسية والإصلاح القانوني والدعم القضائي؛ • تتطلب تعاون العامة ؛ • من غير المُرجح ان يكون التسرب أقل من ٢٥%.	يجب متابعته لأنه ممكن أن يكون مجدياً اقتصادياً. لن يلغي الحاجة إلى مصادر تطوير جديدة.

استناداً إلى ما تقدم، تشكل تحلية المياه، على الرغم من كونها تقنياً واقتصادياً وسياسياً "مصدر الحل الأخير" الخيار الأخير الوحيد القادر على جعل إمدادات المياه لبيروت الكبرى مستدامة على المدى البعيد، لكن بالطبع بتكلفة أعلى.

بالإضافة إلى الخيارات غير القائمة على السدود، لقد درست مسودة تقييم الأثر البيئي والاجتماعي ثلاثة مواقع للسدود غير بسري، وهي سد الدامور على نهر الدامور (موقعين) وفي جنّة على نهر ابرهيم، واختار مجلس الإنماء والإعمار، استناداً إلى التحاليل المقارنة، سد بسري كالمشروع ذي الأولوية. ان النواحي الإيجابية والسلبية لكل من هذه المواقع ملخصة في الجدول أدناه.

المشروع	النواحي الإيجابية	النواحي السلبية	الخلاصات
بسري	• حجم تخزين عالي يلبي احتياجات طلبات منطقة بيروت الكبرى لغاية ٢٠٣٠ أو لمدة أطول: • يستخدم مرافق مشروع تزويد بيروت الكبرى بالمياه، للنقل والمعالجة والتخزين بكلفة إضافية محدودة؛ • تحتوي أرضية البحيرة على رواسب ذات نفيذية منخفضة؛ • تكاليف ضخ منخفضة أو لا وجود لها؛ • أدنى تكلفة لحجم الوحدة المسلمة إلى منطقة بيروت الكبرى؛ • عائد في حده الأعلى على الاستثمارات في مشروع تزويد بيروت الكبرى بالمياه.	• معظم استملاكات الأراضي من الأراضي المنتجة؛ • ضرورة نقل آثار تاريخية ثقافية من منطقة السد والبحيرة؛ • مخاطر ترسب كبيرة؛ • مخاطر زلزالية كبيرة.	سدّ بسري هو الموقع الوحيد الذي سيلبي طلبات منطقة بيروت الكبرى على المدى الطويل مع استثمارات منتجة تجارياً. غير ان هناك حاجة إلى دراسات إضافية تتعلق بجيولوجيا الخزان، ومحدودية المياه، والمخاطر الزلزالية والتراسبية قبل التصميم والتفصيلي. يجب توكيد تفضيل الموقع المحوري الحالي للسدّ.
الدامور الغربي	• الاستملاكات في معظمها غير مُنتجة؛ • مورفولوجيا موقع السدّ ملائمة على شكل V؛ • قد تستخدم بعض مرافق مشروع تزويد بيروت الكبرى بالمياه	• قدرة تخزين صغيرة؛ • من غير المُرجح ان يساند القدرة الكهربائية المائية؛ • مطلوب محطة معالجة جديدة وتكاليف نقل إضافية؛ • تكاليف ضخ كبيرة.	تخزين المياه أقل بكثير منه في بسري أو الدامور الشرقي كما ان جيولوجيا موقع السدّ أقل تفضيلاً. أي سدّ هنا يجب ان يكون له منسوب مياه منخفض للحد من التسرب الجانبي و/أو ان يكون جزءاً من برنامج الاستخدام الموحد مع المياه الجوفية.

الدامور الشرقي	• جيولوجيا موقع السدّ أفضل مما هي في الدامور الغربي؛ • مورفولوجيا موقع السدّ مؤاتية على شكل V؛ • حجم تخزين أكبر يلبي طلبات منطقة بيروت الكبرى لغاية ٢٠٣٠ أو لمدة أطول.	• تسرب جانبي عالٍ؛ • مطلوب محطة معالجة جديدة وإلا تسبب ذلك في تكاليف نقل إضافية؛ • تكاليف عالية لمعالجة الطبقة النفيذة J6؛ • تكاليف ضخ كبيرة؛ • معرضة لانهيار الكِتَل من منحدرات البحيرة.	بالرغم من حجم التخزين الكبير والجيولوجيا الأفضل نسبياً من الدامور الغربي، هناك هواجس جدّية حول التسرب الجانبي المُفرط المحتمل.
جنّة	• معدلات تدفق عالية، تعاد تغذية البحيرة بسرعة كل ربيع؛ • مورفولوجيا موقع السدّ ملائمة على شكل V؛ • احتمال كبير لتوليد القوة الكهربائية المائية.	• معظم الاستملاكات هي مناطق طبيعية؛ • متواجدة على طبقة نفيذة للغاية وبالتالي من المُرجح ان يكون التسرب كبيراً. • مطلوب محطة معالجة وخطوط نقل جديدة؛ • تكلفة أعلى لحجم الوحدة المُسلّمة إلى منطقة بيروت الكبرى.	بصفته سدّ مستقل، سيلبي سدّ جنّة حاجات منطقة بيروت الكبرى على المدى القصير فقط وبأعلى التكاليف المتوقعة. تحتاج الاستقصاءات اللاحقة إلى معالجة الهواجس حول جيولوجيا السدّ والبحيرة ومحدودية المياه.

استناداً إلى ما ورد أعلاه، يمكن استخلاص ما يلي:

- نظراً لحجمه ولجدواه الاقتصادية وكافة العوامل الجيولوجية المؤاتية، يعتبر سدّ بسري الخيار ذو الأولوية.
- يمكن إنشاء سدّ جنّة على مراحل مع قدرة منخفضة، تزود على المدى القصير احتياجات جبيل وكسروان.
- ستسمح السنوات الأولى لإنشاء سدّي بسري وجنّة بإجراء دراسة أعمق حول جدوى سدّ الدامور الغربي الذي ستُشير حصيلتها إلى الخطوات التالية وهي إما البدء بسدّ الدامور الغربي أو بالسير قدماً مع الدامور الشرقي انطلاقاً من دراسة جدوى إلى تصميم تفصيلي. في كافة الحالات، يمكن التعويض عن السدود المقترحة مع أحجامها المنخفضة بواسطة استخدام المياه الجوفية من مكامن المياه الأساسية.

الوصف البيئي والاجتماعي لمنطقة المشروع

المناخ

إن حرارة الهواء إضافة إلى الرطوبة النسبية والرياح هي العناصر المحدّدة الرئيسية لمعرفة إلى أي حد ستتبخر المياه من سطح السد. يقدم وجود مشروع بسري بين الشريط الساحلي والجبال الغربية كافة السمّات المناخية للمناخ الصُغري الانتقالي الذي يكشف عن مواسم صيفية حارة ورطبة في الموقع المقترح لمحور السد مقابل مواسم صيفية أقل رطوبة ومعتدلة عند أطراف مكان احتجاز المياه. تتميز أشهر الشتاء الخمسة عادة بهبوط الأمطار الوافرة مع درجات حرارة باردة عند موقع السد، ومواسم شتوية قاسية مع مزيد من هطول الأمطار على شكل ثلج، مما يساهم مع مرور الزمن في إعادة شحن الينابيع في الجبال، مع رؤوسها المائية الممتدة بين جبال الباروك وجزين.

وتحدث أعلى المتطلبات التبخرّية خلال الأشهر الستة الجافة من نيسان/إبريل إلى آب/أغسطس، مع الذروة في تموز/يوليو، عندما يتوقع ان تبلغ البحيرة طاقة تخزينها القصوى ويبدأ في إمداد المياه إلى منطقة بيروت الكبرى.

المناظر الطبيعية

تتكون المناظر الطبيعية بصورة رئيسية من مزروعات برية، وأشجار الأرز في جبال الباروك، وغابات البلوط والصنوبر في جزين وبكاسين والشوف الأعلى بالإضافة إلى أنواع الأراضي الحرجية (الغابات)، والمزارع والمزروعات الطبيعية كالشجيرات وغيرها. ويعتبر الغطاء النباتي هام للسيطرة على تآكل وانهيار التربة والصخور –الانزلاق الأرضي– ويشجع إعادة شحن المكامن المائية –aquifers– ويعزز احتجاز الكربون.

استعمال الأراضي

يبين الجدول أدناه استعمال الأراضي الخاضعة للاستملاك:

الإشغال الحالي ضمن منطقة الاستملاكات

استعمال الأراضي	المساحة التقريبية بالهكتارات	% من إجمالي الاستملاكات
حقول مُراحة	١٤٨	%٢٦
مزروعات طبيعية	١٣١	%٢٣
مزروعات قاع النهر وضفاف النهر	١٠٥	%١٨
أراضي مُشرعّة	٩٩	%١٧
غابات صنوبر	٨٢	%١٤
بيوت زراعية بلاستيكية	٤	%٠،٧
منطقة مبنية	١	%٠،٢

الجيولوجيا

تغطي منطقة تجميع مياه الأمطار سلسلة جيولوجية تمتد من الحجر الكلسي الجوراسي الكسرواني (J4) في مناطق الجبال العليا عبر التشكيلات الوسطية بين تشكيلتين رئيسيتين، إلى الرواسب الطمية والنهرية للحقبة الرابعة الحديثة على طول نهر بسري المتواصلة إلى أسفل موقع السد.

الآثار والتراث الثقافي

استناداً إلى السجلات المتوفرة لأعمال التقصي الميدانية لموسمي ٢٠٠٤ و٢٠٠٥ التي قامت بها بعثة بولندية – لبنانية، تم تحديد ما مجموعه ٧٨ موقعاً تقع ٢٧ منها في منطقة الاستملاكات لمشروع بسري، كما ان هناك ١٠ مواقع على مسافة ١٠٠ متراً من حدود الاستملاكات. تمثل المواقع المحددة في بسري الامتداد الكامل لتاريخ الإنسانية، من العصور الحجرية القديمة (الباليوليتي) قبل ٨،٣٠٠ سنة قبل الميلاد إلى أيامنا الحاضرة.

على مقربة من نقطة الالتقاء بين نهر الباروك و"عاريّة"، المعروفة أكثر حالياً بوادي بحانين، يقع معبد مرج بسري الذي يُعتقد ان له صلة بمعبد أشمون، المعروف أيضاً ببستان الشيخ، في وادي الأولي الأسفل، والذي يعود إلى القرن السابع قبل الميلاد.

اليوم، لا تتعدى البقايا الظاهرة لمرج بسري أربعة أعمدة من الغرانيت، ربما كانت المدخل إلى المعبد الرئيسي، وعدة كِتَل حجرية كبيرة واقفة معروضة على مقربة من ضفة النهر، يعتقد انها جدار تمينوس، التي هي المنطقة المقدسة المحيطة بالمعبد. وقد وجدت قطع فخارية مكسرة ذات أصول رومانية وفارسية على مقربة من المكان ومن المفترض ان يكون هناك بقايا مطمورة لمبانٍ أخرى كما ومن الممكن وجود قرية صغيرة. لم تستكمل أية مسوحات آثارية شاملة لمرج بسري ولا لأي موقع معبد آخر مشكوك فيه عند

أسفل السد علماً ان المركز البولندي لآثار البحر الأبيض المتوسط في جامعة وارصو الذي يعمل بالتعاون مع جامعة البلمند قد قام باستقصاءات أولية فقط دون القيام بأي حفريات.
ما ينطوي على أهمية خاصة وكشاهد على التراث الثقافي المكتشف حديثاً في المنطقة، هما موقعا كنيسة مار موسى الحبشي وبقايا دير القديسة صوفيا، القريبان من بعضهما البعض على مسافة قصيرة من محور السد المقترح. ويعتبر موضوع الكنيسة قضية عاطفية بالنسبة للعديد من المقيمين في مزرعة الضهر. تجدر الإشارة أنه ليس هناك من خدمة قداديس في الكنيسة إلا في يوم عيد مار موسى، في ٢٨ آب/أغسطس، وذلك بسبب الوصول المحدود إلى الكنيسة.

جودة المياه السطحية

تُظهر تحاليل جودة المياه من نهر بسري وروافده ان مستوى المعالجة المطلوب لكي تكون المياه في تساوق مع معايير مياه الشفة اللبنانية والدولية هو طريقة معالجة تقليدية. ولكن أظهرت التحاليل وجود مبيدات فوسفورية عضوية، هي اللندين والديلدرين فوق حدود الاكتشاف في عينتين من العينات المفحوصة. ولما كانت هاتين المادتين محظورتين بموجب معاهدة ستوكهولم لسنة ٢٠٠١ حول الملوثات العضوية الدائمة (POP's) التي وقعها لبنان، فان المصدر تلك المبيدات غير واضح. لذلك من الموصى به ان تشرف وزارة البيئة على برامج رصد لتوكيد الوجود المتواصل لمخلفات المبيدات والتحقق من وجود أية ترسبات من مواد إضافية مضرة للصحة. وبما انه ليس لدى وزارة البيئة القدرة على القيام بهذا العمل بنفسها، من الموصى به توكيل هذا الجانب على شكل تعاقد فرعي إلى شركة استشارية مؤهلة ترفع التقارير إلى وزارة البيئة، ويكون الهدف منها مراقبة وجود المواد الملوثة في مجرى المياه السطحية المتجهة نحو منطقة البحيرة وتقصي مصادرها الأصلية والتوصية بالإجراءات العلاجية.

الآثار البيئية والاجتماعية والإجراءات للتخفيف منها

تم تحديد منطقة تأثير مشروع زيادة تغذية بيروت الكبرى بالمياه على مستويين: المناطق المحيطة المباشرة لأعمال البنية التحتية للمشروع بالنسبة للآثار المباشرة أو المستحثة، من جهة، ومنطقة كبيرة تمتد إلى ما بعد القرب المباشر من المشروع عينه. منطقة التأثير الأساسية هي منطقة اليحيرة والحوض المائي الأسفل التي ستتأثر بنشاطات الإنشاء كما وبالتغيرات التي ستحدث جراء تشغيل السدّ سواء كانت هذه الآثار إيجابية أو سلبية، مباشرة أو غير مباشرة و التي ستؤثر على سيل عيش المجتمعات الأهلية في المنطقة. سيؤثر الحوض المائي الأعلى على جودة المياه في البحيرة. تمتد منطقة تأثير مشروع زيادة تغذية بيروت الكبرى بالمياه الكبرى الرئيسية من ينابيع نهري الباروك وعارِيّة إلى مصب نهر الأولي على الساحل، وتغطي السهول الزراعية عند أسفل السدّ والقرى القائمة في هذه المنطقة.

كما وتتبع منطقة تأثير المشروع الدورة الحياتية لمواد إنشاء السدّ التي سيؤتي بها من المقالع داخل منطقة البحيرة. سيحدد المتعاقد المُعيّن الملاءمة النهائية لكافة مناطق المقالع. سوف يتم التخلص من النفايات في مواقع مرخصة. ومن المُرجح ان أماكن إنشاء المخيمات للعمال ستكون ضمن الوادي وتتوقف على المناطق التي ستتم حمايتها مثل مرج بسري. تغطي منطقة تأثير المشروع الموقع الذي ستنقل غليه كنيسة مار موسى، وطرق هجرة الحياة البرية والتطوير المُستحثّ للوصول أخيراً إلى إمدادات المياه للمستخدمين في منطقة بيروت الكبرى (GBA).

الآثار البيئية الرئيسية

تآكل التربة والترسّب

يشكل تآكل التربة والترسب الخطر الأكبر على الانخفاض التدريجي في القدرة التخزينية للبحيرة، وان كان هذا الانخفاض بالدرجة الأولى في الإيداع الطويل بدلاً من التخزين التشغيلي. لقد صُمم الخزان لاستيعاب ٩ ملايين م^{٣} من الرسابة بعد ٥٠ سنة من التشغيل. سيُقدم هذا من قدرة "الإيداع الطويل"، أي الحجم الذي يمكن ان يمتلئ بالرسابة دون ان يؤثر على التشغيل الطبيعي للسد.

من أجل الحد قَدر الإمكان من الترسب ومن خسارة القدرة وتجمع الترسب في السد، من المهم تشجيع إعادة التشجير والحفاظ على التربة في الحوض الأعلى وحول دائرة البحيرة، وأيضاً مراقبة عمق الخزان لتقييم الترسب. ان تطوير الأراضي الرطبة عند مجاري المياه المساهمة الرئيسية كما وبرنامج إعادة التشجير عند الحوض الأعلى سيخفضان من حمولة الترسب.

التنوع الحيوي والموائل

إن إنشاء السدود سيؤدي دائماً إلى الخسارة المباشرة للموائل والمزروعات الطبيعية المشاطئة ضمن المناطق التي يعتبرها البرنامج الاقتصادي للأمم المتحدة مناطق ضعيفة وغير حصينة ايكولوجياً. لكن يجب موازنة ذلك من جديد بواسطة خطوط الضفاف الجديدة للموائل التي تناسب استيطان الأجناس في الأشجار على ضفاف البحيرة.

بالنسبة للأسماك المألوفة، تشكل الحواجز الاصطناعية عبر الأنهار إحدى العوامل الرئيسية التي تهدد أجناس الأسماك في منطقة البحر الأبيض المتوسط، إذ تصدّ أو تؤخر هجرة الأسماك القادمة من أعلى النهر. تعتبر الآثار على الأسماك معتدلة إلى خفيفة عند موقع سد بسري لكن يجب اتخاذ بعض إجراءات تخفيف الآثار للحفاظ على الأسماك عند أسفل السد وللسماح لمرور الأسماك المهاجرة بحيث تتم حماية الأماكن التي تضع فيها الأسماك بيوضها. سوف يخفض إنشاء سد بسري بصورة كبيرة تدفق المياه عند أسفل السد الذي سيؤثر بدوره لا محال على أسماك المياه العذبة البلنّي الباقية على قيد الحياة في المجرى الأسفل للنهر.

سيكون لسد بسري آثار مباشرة على موائل الزحافات والحيوانات البرمائية في الجانبين الأعلى والأسفل للسد، والذي سيشتمل على تعطل للموائل و/أو مواقع الاستيلاد، وخفض مصادر الغذاء، وزيادة حساسية الحيوانات المفترسة.

قد تصبح الأجناس ذات القدرة الضعيفة على السباحة محصورة ومحرومة من التفاعل مع الأجناس المتواجدة في البر، وعلى الأخص بالنسبة للاستيلاد، وتصبح أكثر تعرضاً للصيد اللاشرعي. وقد تكون أجناس أخرى متأثرة بصورة إيجابية جراء الموائل الناشئة حديثاً.

يتمتع المستوى الأعلى من البحيرة الذي يقترب من الأطراف السفلى لنهر المختارة بأجناس *البوفو بوفو* النادرة التي يبدو ان موئلها يتكون في معظمه من أراض صخرية وأشجار مشاطئة التي سيتم غمر بعض منها.

ان وجود مساحة كبيرة من المياه الراكدة سيزعج الطرق الجوية التي تسلكها أجناس الطيور المحلقة الكاسرة التي ستحرم من التيارات الهوائية الحرارية الضرورية للتحليق واقتصاد الطاقة خلال الهجرة.

أما الثديات فستتكيف وتصحح سلوكها على الرغم من أية عوائق دائمة على الطرق التي كانت تسلكها قبل إنشاء السد. وقد تجذب البحيرة أجناساً مثل الخفاش وكلب الماء، أما الثديات الصغرى مثل الزَّبابة والسنجاب ستميل لأن يكون لها بيوت أصغر وستكون بالتالي معرضة لخسارة وتشرذم الموائل الطبيعية. ومن غير المرجح ان تمر الأجناس الكبيرة أو المتنقلة بخسارة تذكر على الرغم من تشرذم الموائل.

وقد تم اقتراح خطة أولية لإدارة التنوع البيولوجي تتضمن تدابير للتخفيف من الآثار المذكورة أعلاه بالإضافة إلى التكاليف والمسؤوليات المعنية. وقد تم تحديد عام لخط الأساس للتنوع البيولوجي، وإجراءات إدارة المحافظة والتخفيف من الآثار وذلك ينعكس في خطة الإدارة للتنوع البيولوجي. سيقوم فريق متخصص بوضع خطة لرصد التنوع البيولوجي وإدارة الموائل، وسوف تبلغ النتائج إإى صاحب المشروع فيما يختص بمستوى تدهور الموائل الحساسة خصوصا الأنواع المهددة بالانقراض التي تم تحديدها (أي أسماك المياه العذبة blenny). لاستكمال إجراءات إدارة / التخفيف، وسوف تشمل خطة الرصد التنوع البيولوجي المسوحات التي ستجرى خلال ما قبل البناء والبناء والمراحل التنفيذية للمشروع. وتقيس هذه المسوحات المؤشرات التي تشمل على سبيل المثال: نوعية المياه، وحجم التدفق البيئي ونوعية وعدد الأنواع المستهدفة فضلا عن أعداد الأنواع المؤشر، والآثار التراكمية داخل مستجمعات المياه المنبع.

استهلاك المواد

سيكون استهلاك المواد للإنشاء مُفرطاً لكن يتوقع ان تأتي كافة المنتجات المبرغلة والصخرية من موقع البحيرة. وقد يكون الاستثناء الحجارة الـRip Rap التي قد تكون هناك حاجة للإتيان بها من خارج المنطقة بسبب حجم الكِتَل ومواصفات جودة الصخر. ستؤخذ كافة المياه المستهلكة من أرض الموقع على الأرجح وتخضع للمعالجة المناسبة قبل استخدامها. يبين الجدول أدناه كميات الاستهلاك الأولي للمواد.

ومن المتوقع أن يستهلك بناء سد بسري ما يقرب ٦ ملايين م^{٣} من المواد، معظمها مكون من بناء الركام والرمل والطين، ومن المتوقع أن يتم استخراجها من مناطق داخل البحيرة، وبالقرب من موقع البناء.

إمدادات المياه والكهرباء

استناداً إلى المناقشات مع الاستشاري المصمم السد، ستكون إمدادات مياه سد بسري المقترحة مخصصة لضمان ٦م^{٣}/ثانية لاحتياجات بيروت الكبرى و٠،٤٥ و٠,٣ م^{٣}/ثانية للحفاظ على التدفق البيئي عند أسفل السد، في الصيف والشتاء على التوالي.

يعتبر انتاج الطاقة الهيدروكهربائية "مُنتج ثانوي" لمياه السد والتي لن تعتبر بالتالي كاستخدام استهلاكي مثل المياه التي تم ذكرها سابقاً.

تطبّق البحيرة

إن الظروف الملحوظة عند سد بسري؛ المقدار العالي من المياه الباردة الداخلة من ثلج الربيع الذائب والمقدار المتدني الدافئ من المياه الداخلة خلال الصيف والخريف، سوف ينتج عنها وجود طبقات في البحيرة. ان التخلف عن تحديد ومراقبة هذا بصورة متكررة يسبب مشاكل رئيسية لشركات خدمة المياه وقد يُعرّض للخطر كفاءة عمليات معالجة المياه، وتلبية المعايير النظامية لجودة المياه وتوقعات المستهلكين، ودقة التدفق البيئي للمياه.

ومن المتوقع ان وجود الطبقات يُصبح أكثر حِدّة خلال أشهر الصيف عندما تزداد شدة ومدة ضوء الشمس وخليطها بسبب انخفاض تدفق المياه داخل البحيرة؛ وذلك يتصادف مع الفترة الزمنية الرئيسية لعمليات بسري. وهكذا تدور نسبة كبيرة من الخزان بدون أوكسجين وبالتالي تخرج المواد المعدنية مثل المنغنيز والحديد والخام الكبريتي والزرنيخ من رسابة القاع كما يمكن ان يخرج الفوسفور والأمونيا.

سلامة السد

إن المساهمة الكبرى في سلامة السد هي صياغة خطط سلامة السد القائمة على تحاليل تشكيل انهيار السد والغمر التي قام به الاستشاري المصمم السد. ويعتبر هذا العمل التشكيلي الهيدروليكي الأولي الذي يشار إليه أحياناً بتحليل انهيار السد أو الـDBA، هو إجراء معياري في تصميم السدود، إذ يقدم (i) تقييماً لأداء التصميم، بما في ذلك حجم قنوات تصريف الفائض و(ii) تطوير خطط إقليمية وخطط للجهوزية في حالات الطوارئ للمجتمعات الأهلية.

نظراً لتكوين الوادي المنحدر بقوة على شاكلة V، في أقسامه الوسطى، بين السد والساحل، فان القرى المتأثرة أكثر في مسار انهيار السد إما بسبب حمولة زلزالية أو تخلفات فيضانية، هي قرى بسري وخربة بسري على مسافة قصيرة من أسفل السد، وعلمان وقسطني على مسافة قصيرة من الساحل.

تجدر الإشارة أن الخطط المفصلة لسلامة السدود هي في مرحلة متقدمة من التحضير. سيتم وضع اللمسات الأخيرة على خطة ضمان الجودة والإشراف على البناء عن طريق التقييم وفقاً لـOP / BP ٤,٣٧.

الهيئة الاستشارية

تتألف الهيئة الاستشارية من هيئتين: هيئة سلامة السد والهيئة البيئية والاجتماعية.

إن مهام هيئة سلامة السد هي تقديم المشورة حول كافة الجوانب الأساسية للسد؛ إنشاءاته التابعة، ومناطقه لجمع مياه الأمطار، والمناطق المحيطة ، وهي مُكلّفة أيضاً بالإشراف على صياغة المشروع، والتصميم التقني، وإجراءات الإنشاء والأعمال المرافقة مثل مرافق الكهرباء، وتحويل سير النهر خلال الإنشاء، الخ...

أما الهيئة البيئية والاجتماعية فستقدم *مراجعة مستقلة وإرشاداً حول القضايا البيئية والاجتماعية المرافقة لتخطيط وتصميم وإنشاء وتشغيل سد بسري وإنشاءاته التابعة.*

ستكون الهيئة مُجبرة على تقييم إلى أي مدى يتساوق مشروع بسري مع الإجراءات الوقائية للبنك الدولي.

الآثار الاجتماعية الرئيسية

سيؤدي إنشاء سد بسري إلى خسارة أراضٍ مُنتجة مقدرة مساحتها بحوالي ١٥٠ هكتاراً، أي حوالي ٢٥% من المنطقة الخاضعة للاستملاك. تحتل قاع النهر والنباتات الطبيعية عند جانب الضفة ١٠٥ هكتاراً، أما المناطق المبنية؛ منها مباني المزارع والمساكن والتراث، فتشكل أقل من ١%. هناك اقتراح بزرع غطاء من الأشجار الطبيعية التعويضية حول السد ما يستلزم استبدال ١:١ للغابات الرئيسية في المناطق المستملكة بما في ذلك أشجار البلوط والصنوبر والحور. أما المنطقة المتبقية هي بالدرجة الأولى غير مزروعة عند الأراضي السفلى بعيداً عن النهر وهي عادة أراضٍ عارية مع شجيرات عند منحدرات الوادي السفلي. يقدر عدد الإنشاءات المبنية التي ستغمرها المياه بـ ١٣٥ على عدد إجمالي من العقارات يبلغ

٨٨ عقاراً مع مساحة إجمالية من حوالي هكتار واحد، معظمها متروك (بعضها مهجور) أو هو فقط أماكن إقامة موسمية للعمال الزراعيين.

كما وسيتم استملاكات إضافية لنشاطات مشاريع أخرى وبنى تحتية مرافقة مثل خطوط التوزيع وطرق الوصول التي تقود إلى الناقلة.

إن إجمالي عدد العقارات هو حالياً حوالي ٩٦٦ قطعة موزعة بين مختلف المناطق العقارية كما هو مُبين في الجدول أدناه.

الاستملاكات داخل منطقة السد والبحيرة

القضاء	المنطقة العقارية	عدد العقارات	عدد العقارات المستملكة بالكامل	عدد العقارات المستملكة جزئياً	المساحة المستملكة (هكتار)	النسبة المئوية للمساحة المستملكة
الشوف	بسابا	٩	٥	٤	٦،٨	١،٣%
	مزرعة الشوف	٢٧٧	٢٢٥	٥٢	١٢٠	٢٣%
	مزرعة الضهر	٥٥	٣٦	١٩	٤٢	٨%
	عماطور	٣١٠	٢٧٩	٣١	١٦٠	٣١%
	باتر	١٤	٦	٨	٨،٨	٢%
	المجموع الفرعي	٦٦٥	٥٥١	١١٤	٣٣٨	٦٥%
جزين	بسري	٧٤	٦٢	١٢	٤٤	٩%
	بكاسين	٢	٠	٢	٠،٣	٠،١%
	بنواتي	٢٧	١٩	٨	٤	٠،٨
	غباطية	٤	١	٣	٦	١،٢%
	حرف	٦٩	٦٤	٥	٤٦	٩%
	عاريّة	١	٠	١	٠،٩٥	٠،٢%
	بحانين	٢٨	١٥	١٣	١٠	٢%
	ميدان	٨٠	٧٠	١٠	٤٨	٩%
	دير المخلص	٣	٠	٣	٢	٠،٤%
	خربة بسري	١٣	٤	٩	١٨	٣%
	المجموع الفرعي	٣٠١	٢٣٥	٦٦	١٧٩	٣٥%
مجموع الاستملاكات		٩٦٦	٧٨٦	١٨٠	٥١٧	١٠٠%
الأملاك العامة (النهر + الطرق)					٥٣	
إجمالي الاستملاكات					**٥٧٠**	

تشاطر فوائد المشروع

لضمان توزيع عادل لفوائد المشروع، يقترح تقييم الأثر البيئي والاجتماعي تأسيس برنامج تقاسم المنافع لتقديم وسائل تحسين الخدمات للمجتمع الأهلي على التلال المحيطة، وعبر منطقة تجميع مياه الأمطار والبيئة المحلية. ومن المحبذ أن يتم تنفيذ ذلك في الأساس عبر الصناديق الرأسمالية المتوفرة للمشروع، ولاحقاً عبر العائدات المتواصلة من المستفيدين الأوليين والذين هم مستهلكو منطقة بيروت الكبرى.

التطوير المُستَحثّ

نظراً للفرادة النسبية لمشروع بسري ولقربه من المراكز الحضرية مثل بيروت وصيدا، يمكن توقع بداية اجتذاب الزوار باكراً بعد البدء بمرحلة الإنشاء. ومن المتوقع أن يكونوا البادئون بالتطوير المستحث عربات الفان لبيع القهوة وشاحنات المرطبات، مع المقاهي القائمة ومحطات البنزين والخدمات الأخرى في بسري والقرى الواقعة على الطريق السريعة.

على جوانب التلال المطلة، سيكون الطلب على الأراضي لإنشاء الفيلات، ومجمعات الشقق والفنادق والمنتجعات والمطاعم على التلال، كلها مع طرق للوصول وبنى تحتية عامة، كبيراً جداً. وفي حين قد تحتل هذه النشاطات أيضاً العقارات على ضفاف البحيرة، فان الأراضي المجاورة للمياه ستستحث على الأرجح الرياضات المائية الأصغر المركزة على أماكن الإقامة والتخييم والبكنك، ومناطق السباحة، والأرصفة على الضفاف، ومسارات الدراجات الهوائية وتأجير القوارب وساحات التصليح، ونوادي اليخوت والزوارق الطويلة. علاوة على الزوار والنشاطات الترفيهية، سيقدم السد أيضاً فرصة توسع للأراضي الزراعية المحلية المَرويّة وتطوير مشاريع تجارية قائمة على المياه مثل مزارع الأسماك.

سيكون للتطوير المستحث آثار بيئية واجتماعية إيجابية فقط إذا كان متساوقاً مع مخطط رئيسي حسن الصياغة وموافق عليه. أما إذا كان التطوير غير مُخطط وتدريجي، أو إذا أتيح لبعض المصالح السياسية و/أو التجارية انتهاك المخطط، فقد تكون النتائج سلبية بالكامل.

الآثار التراكمية لـ GBSWAP

يركز تقييم الآثار التراكمية على التفاعل بين مشروع زيادة تغذية بيروت الكبرى بالمياه(GBWSAP) والمشاريع التي هي محددة في الوقت الذي يجري فيه التقييم البيئي، حيث يمكن ان تؤثر مثل هذه المشاريع والتطويرات مباشرة على منطقة تأثير المشروع. يظهر الجدول أدناه هذه الآثار التزايدية مع بعض المشاريع القائمة وغيرها المقترحة.

الآثار التراكمية

		المشاريع القائمة والمقترحة			
العناصر البيئية والإجتماعية	**المعلمات**	**مشروع تزويد بيروت بالمياه**	**محطات توليد الطاقة الكهرومائية (جون، الأولي وعنان)**	**برامج معالجة مياه الصرف**	**برامج إعادة التحريج**
المياه	*استخراج المياه*	0	0	0	0
	جودة المياه	+	0	+	+
	معدل التدفق	+	0	0	+
	إمدادات المياه المنزلية	+	0	0	0
الهواء	*غازات الانحباس الحراري*	0	−	+	+
الكهرباء	*إمدادات الكهرباء*	0	+	0	0
إشغال الأرض	*غطاء الأرض*	0	0	0	+
	ترسب الخزان	0	0	0	+
الموائل والحياة البرية	*تنوع الأجناس*	0	0	0	+
	عدد الأجناس	0	0	0	+
الصحة العامة	*تكاليف الصحة*	+	+	+	+

+ أثر تراكمي إيجابي

− أثر تراكمي سلبي

٠ لا أثر تراكمي

يلخص الجدول أدناه الآثار التي قد تحدث جراء إنشاء سدّ بسري والإجراءات التخفيفية المقترحة لكل أثر، في حين يلخص الجدول الذي يليه التكاليف المقدرة.

ملخّص للآثار البيئية والإجتماعية المتوقع حدوثها من جراء مشروع سد بسري

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
استملاك العقارات	استملاك الأرض لبناء السد و بحيرة المياه وطرق الوصول	لا محال	كبيرة	تحديد موقع الخزان بشكل يقلل من الحاجة لاستملاك العقارات وكذلك من خسارة المناظر الطبيعية.	المصمّم
	خسارة المناظر الطبيعية	متوقع	متوسطة		
	استملاك الأرض من أجل إعادة إسكان أو إنتقال الأشخاص المتأثرين بالمشروع	لا محال	صغيرة	تحديد موقع الخزان بشكل يقلل من الحاجة لإستملاك العقارات. تأمين مساكن وتعويضات مناسبة بما يتماشى مع خطة عمل إعادة الإسكان وإطار سياسة إعادة الإسكان والقانون اللبناني .	المصمّم ومطوّر خطة عمل إعادة الإسكان ومقترح المشروع
	خسارة المجتمعات الأهلية القائمة	غير متوقع	لا ينطبق		
	خسارة المنازل	لا محال	متوسطة		
	خسارة الأملاك التجارية غير الزراعية	غير متوقع	لا ينطبق		
	خسارة الأراضي المنتجة	لا محال	كبيرة		
	خسارة العمل المؤقت	لا محال	كبيرة		
	خسارة العمل الدائم	متوقع	متوسطة		
	خسارة الإرث التاريخي والثقافي	لا محال	كبيرة	المحافظة على الأملاك التراثية وإعادة البناء ضمن المناطق السكنية القائمة . تجنب غمر المواقع غير القابلة للنقل مثل المدافن . المحافظة على ما تبقى من آثار.	مقترح المشروع

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
تجميع المياه	خسارة إضافية للممرات وصعوبة الوصول إلى المناطق	متوقع	متوسطة	إنشاء طرق وصول بديلة حول بحيرة المياه.	مقترح المشروع
	إزدياد خطر الزلازل	متوقع	كبيرة	دراسة قدرة التحميل الهيدرولكية لتقييم إحتمال حدوث الزلازل ولتجنب المناطق المعرّضة لخطر الزلازل . التصميم بشكل يخفف من الحمل لتجنب حدوث الزلازل .	المصمّم
	خسارة المزروعات الطبيعية	لا محال	متوسطة	زيادة الزرع حول بحيرة المياه.	المصمّم
	تردّي جودة المياه بسبب المزروعات التي لم تتم إزالتها	لا محال	كبيرة	إزالة المزروعات والتربة قبل الغمر. ستؤمّن محطة التكرير نظام المعالجة المناسب لضمان وصول مياه الشفة إلى منطقة بيروت الكبرى .	المتعاقد
	إنتاج غازات الاحتباس الحراري بسبب عدم إزالة المزروعات	متوقع	كبيرة	إزالة الزرع والتربة قبل الغمر.	المتعاقد
	تآكل التربة على الضفاف الجديدة للبحيرة	متوقع	كبيرة	إنشاء حماية لضفاف البحيرة . زيادة الزرع حول بحيرة المياه.	المصمّم والمتعاقد
	ركود المياه في قعر الخزان	متوقع	كبيرة	تمديد المعدات للمزج بواسطة الآلات حيث تكون الوسائل الطبيعية غير كافية .	المصمّم
الترسب	خلق حالة ركود في المجاري الرافدة	متوقع	متوسطة	العمل على تنمية الأراضي الرطبة العمل على إعادة تحريج منحدرات الحوض المائي العلوي. مراقبة عمق خزان المياه لتقييم الترسب.	المصمّم ومقترح المشروع

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
				تشغيل خزان المياه لتقليل نسبة تراكم الرواسب. سماح للترسبات في التصميم البنيوي.	
	خسارة القدرة على التخزين وتراكم الرواسب في السد	متوقع	كبيرة متوسطة		
	بناء الطريق يسمح بوصول غير القاطنين إلى المنطقة	متوقع	صغيرة	منع تسوية الأراضي لزراعات جديدة . منع الولوج بوصول إلى المناطق التي كانت أساساً نائية.	مقترح المشروع
	تآكل التربة والترسب	متوقع	متوسطة	العمل على إعادة تحريج منحدرات الحوض المائي العلوي وتوسيع مساحات الأحراج القائمة	
	اضطراب اجتماعي بسبب تقييد نشاط الأشخاص	غير متوقع	لا ينطبق	ضمان العمل المحلي كأولوية في المنشآت الجديدة .	مقترح المشروع والمتعاقد
	خسارة جودة المياه بسبب التبخر	لا محال	كبيرة	تشجيع الزراعة والتشجير على طول ضفاف البحيرة .	مشغل المشروع
	تردّي جودة المياه بسبب ما يصرّف في البحيرة	متوقع	متوسطة	تبني إطار تخطيطي متكامل وخطة صارمة للإدارة البيئية والإجتماعية وتنفيذها بشكل فعّال . تنمية شبكات الصرف الصحي ونظم النفايات الصلبة في القرى الواقعة قرب حوض المياه العلوي وفقاً للمخططات الرئيسية للدولة اللبنانية	مقترح المشروع
إدارة الحوض المائي السفلي	تضاؤل موارد المياه السطحية غير الزراعية	لا محال	متوسطة	تأمين الإرشاد الزراعي وخدمات أخرى لتشجيع المحاصيل الزراعية التي لا تحتاج إلى كميات كبيرة	مقترح المشروع

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
				من المياه . الحرص على أن السكان الذين تمت إعادة اسكانهم مزودون بالموارد اللازمة من دون أن يتأثر سلبيا" على مجتمعهم الحالي .	
	تضاؤل موارد المياه المستخدمة لري المزروعات القائمة	لا محال	متوسطة		
	النزاع على إستخدام المياه	متوقع	متوسطة		
	خسارة مواقع لإرتواء الماشية	غير متوقعة	لا ينطبق	لا حاجة لها	
	تملحة السهول عند أسفل السد	متوقع	متوسطة	تأمين المجاري البديلة اللازمة لترشيح الأملاح المترسبة .	مقترح المشروع
	تضاؤل نسبة المياه في الترسبات الكميائية ومياه الصرف	متوقع	متوسطة		
	تضاؤل نسبة الأوكسجين السائل عند أسفل السد	متوقع	متوسطة	تأمين مخارج تصريف على عدة مستويات لتجنب تفريغ المياه القليلة الأوكسجين . التصميم بشكل يسمح بالتهوئة عند أسفل موقع السد.	المصمّم
	الإنجلاء بفعل قوة إندفاع المياه	متوقع	صغيرة	تأمين تبديد الطاقة من تدفق مياه السد . السماح بتوزيع مصافٍ تمنع الترسب وتخرجه بشكل منظّم .	المصمّم
المياه الجوفية	تغيير مجرى المياه الجوفية عند أعلى السد	متوقع	متوسطة	القيام بدراسة هيدروجيولوجية رقمية لتقييم الأثر على مستويات وقوة تدفق المياه الجوفية	المصمّم
	تغيّر في مستوى المياه الجوفية	متوقع	متوسطة		
	إنخفاض في إعادة تغذية الطبقة الجوفية عند أسفل السد	متوقع	متوسطة	تأمين مخارج مناسبة للسماح بإعادة التغذية . تأمين	المصمّم

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
				منشآت عند أسفل السد للسماح بإعادة التغذية السطحية .	ومشغّل المشروع
	تردّي جودة المياه الجوفية	متوقع	كبيرة	تشجيع إدارة موارد المياه الجوفية.	مقترح المشروع
التنوع الحيوي والموائل الطبيعية	خسارة النبتات المحلية	لا محال	متوسطة	تشجيع حماية الأشجار على طول ضفاف البحيرة والحفاظ عليها كمحميات. إنقاذ ونقل الأجناس البيولوجية والحيوية إلى مكان آخر . عدم الإضرار بالمزروعات غير المغمورة قدر الإمكان .	مشغل المشروع
	خسارة الموائل الطبيعية	لا محال	متوسطة	تأمين أسوار تمنع دخول الثديات . إنقاذ ونقل الأجناس البيولوجية والحيوية إلى مكان آخر. تأمين نقاط عبور آمنة للسماح بتنقل الأجناس البيولوجية والحيوية وإلتحاقها بمجموعاتها .	مشغل ومقترح المشروع
	تضاؤل التنوع الحيوي عند أسفل السد	متوقع	متوسطة	تأمين مخارج تصريف بديلة للسماح بالتنوع الحيوي عند أسفل السد .	
	تراكم الأعشاب والطحالب المائية حول مصبات المياه	متوقع	متوسطة	الحد من نمو الطحالب بإستعمال الإضافات المناسبة (مثل 22 كيلوغرام لكل هكتار من كبريتات النحاس الرباعي) . حصاد الأعشاب الضارّة والطحالب لإستعمالها كعلف وسماد أو غاز حيوي .	مشغل المشروع

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
	إعتراض ممرات الطيور	متوقع	صغيرة	. زراعة الأشجار لخلق ممرات للحيوانات . منع الصيد إلتزاماً بالقانون رقم 580/04.	مشغل المشروع
	تضاؤل الموائل المائية	متوقع	كبيرة	تأمين السلالم والجداول للأسماك وغيرها من الممرات. حماية أماكنالتي تضع فيها الأسماك بيضها. التصميم بشكل يراعي حاجة الأسماك للمساحات السطحيةلوضع البيض وغير ذلك .	المصمّم
	إعتراض ممرات هجرة الأسماك وخسارة مناطق وضع البيض	متوقع	متوسطة		
	تكوّن موائل جديدة للطيور المهاجرة	متوقع	إيجابي	تشجيع إعادة تشجير الغابات والمساحات الكثيفة بالأشجار الصغيرة.	مشغل المشروع
	وجود أنواع جديدة من سمك الأحواض	متوقع	إيجابي	منع إدخال أنواع جديدة من السمك مثل ذئب البحر والتروتة والسمك البعوضي والسمك البلطي وتشجيع الأنواع المحلية	مقترح المشروع
الزراعة	غمر الأراضي الزراعية	لا محال	كبيرة	دراسة خيار نقل التربة الخصبة من جوار البحيرةإلى أراضٍ مجاورة أقل خصوبة .	مقترح المشروع والمتعاقد
	خسارة التربة الخصبة	لا محال	كبيرة		
	خسارة المزروعات غير المحصودة بعد	لا محال	كبيرة	دراسة خيار نقل البيوت البلاستيكية الزراعية وما تحتويه من دون خسائر أو نقلها حين تكون فارغة .	مقترح المشروع

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
	انتقاص الري عند أسفل السد	لا محال	كبيرة	إستخدام الإرشاد الزراعي لتشجيع الزراعات التي لا تحتاج إلى الكثير من المياه وممارسات الري .	مشغّل المشروع
	إستعمال الأسمدة عند أعلى السد يزيد نسبة المغذيات	متوقع	متوسطة		
	زيادة نسبة الأملاح في التربة عند أسفل السد	متوقع	كبيرة	تأمين المجاري البديلة اللازمة لترشيح الأملاح المترسبة في التربة .	مشغّل المشروع
مصايد الأسماك	عدم تناسب بيئات البحيرة والا نهار	متوقع	متوسطة	إدخال أنواع أسماك أحواض مألوفة وتشجيع تربية أسماك الأحواض ضمن حدود مستدامة. الحد من إنحباس المياه للحفاظ على جودتها . ضمان ملائمة مخارج التصريف للحفاظ على الثروة السمكية عند أسفل السد .	مشغّل المشروع
	تمزّق الشبك وسنانير الصيد على المنشآت التي لم تتم إزالتها	غير متوقع	لا ينطبق	إزالة المزروعات والمنشآت قبل التعبئة .	المتعاقد ومقترح المشروع
	موت الأسماك التي تدخل إلى محطة توليد الطاقة	متوقع	صغيرة	الحد من طاقة محطة الكهرباء في موقع السدّ وضع حواجز لمنع دخول الأسماك إلى أماكن وجود التوربينات .	المصمّم والمتعاقد
الإسكان وإعادة الإسكان	إنتقال جميع السكان من المناطق المغمورة	لا محال	متوسطة	تأمين التعويضات المناسبة بما يتلائم مع إطار سياسة إعادة الإسكان وخطة عمل إعادة الإسكان والقانون اللبناني .	مقترح المشروع

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
	تفرّق المجتمعات الأهلية	غير متوقع	لا ينطبق	لا وجود لتجمعات سكانية وبالتالي لن تتعرض للتفكك. من غير المرجّح أن ينتج نزاع جراء إعادة الإسكان بما أن الأشخاص اللبنانيين المتأثرين بالمشروع من سيبقون ضمن مجتمعاتهم الأهلية .	
	التأثير على السكان الأصليين ونمط حياتهم	لا ينطبق	لا ينطبق		
	النزاع الإجتماعي بين القاطنين الحاليين والأشخاص المتأثرين بالمشروع	غير متوقع	لا ينطبق		
	التنافس على الموارد بين القاطنين الحاليين والأشخاص المتأثرين بالمشروع	غير متوقع	لا ينطبق	لا حاجة لها .	
	تأثير خاص على المجموعات الأكثر تأثراً	متوقع	متوسطة	تأمين الدعم الإجتماعي للمجموعات غير الحصينة . إعتماد إعادة الإسكان كوسيلة للتخفيف من حدة الفقر.	مقترح المشروع
الصحة العامة	إزدياد الأمراض ذات الصّلة بالماء	كبيرة	متوسطة	تنفيذ حملات توعية صحية وتأمين المساعدات الصحية المناسبة . الحفاظ على المياه من دون طحالب. تطوير وتنفيذ إجراءات الإستجابة الطارئة .	مشغّل المشروع
	إزدياد مواقع توالد البعوض	كبيرة	متوسطة	تنفيذ حملات توعية صحية وتأمين المساعدات الصحية المناسبة . رش المبيدات على أماكن توالد البعوض إذا لزم الأمر.	مشغّل المشروع
	تغيّرات مناخية مثل إزدياد الرطوبة والضباب	متوقع	متوسطة	لا حاجة لها .	

المسألة	الأثر المحتمل	إمكانية الحدوث	الحدة المحتملة	إجراءات تخفيف الأثر	الجهة المسؤولة
	قرب أسلاك كهرباء التوتر العالي من المنازل	غير متوقع	لا محال	من المرجح أن تستعمل محلياً الطاقة المائية المنتجة عند السدّ يجب وضع التربينات الجديدة لشبكة التوزيع في المحطة القائمة وسوف تستخدم الناقلات الكبلية القائمة.	
المسائل غير المباشرة	تأثيرات سلبية جراء إزدياد التنمية الحضرية	متوقع	متوسطة	الإلتزام بالتنمية المستدامة التنسيقية عبر المخطط الرئيسي لتنمية ضفاف البحيرة .	مقترح المشروع
	تحد بعض النشاطات في الحوض العلوي من فعالية السد	متوقع	متوسطة	منع القيام بنشاطات على الحوض العلوي إلا إذا كانت محدودة الأثر بيئياً وإجتماعياً .	مقترح المشروع
مسائل الإنشاء	منظر موقع البناء	متوقع	متوسطة	على متعاقدي البناء إعطاء الأولوية في التوظيف للأشخاص المتأثرين بالمشروع وغيرهم من السكان المحليين . على المتعاقد تطوير وتطبيق خطة بناء شاملة للإدارة البيئية والإجتماعية .	المتعاقد
	إزدياد حركة السير والتلوّث الذي ينجم عنها	متوقع	متوسطة		
	الضجيج والغبار الصادر عن أعمال الحفر والتنظيف في الموقع	متوقع	متوسطة		
	أعمال مؤقتة مثل تحويل وجهة تصريف المياه	لا محال	متوسطة		
	التخلص من مياه الصرف الصحي والنفايات الصلبة من موقع العمل	متوقع	متوسطة		
	الإنبعاثات من معامل الخلط ومولدات الكهرباء	متوقع	متوسطة		
	إزدياد الصيد وتجميع البيض وإفتراس الحيوانات الحية	متوقع	متوسطة		
	نزاع إجتماعي بين العمال والسكان	متوقع	صغيرة		
	نقل الأمراض المعدية	متوقع	صغيرة		
	التخلص من الزيوت وتسرّب الوقود	متوقع	متوسطة		

ملخص تكاليف الإجراءات المقترحة للتخفيف من الآثار البيئية والاجتماعية

المسألة	إجراءات التخفيف من الأثر	الجهة المسؤولة	أساس التكلفة	التكلفة المقدرة بالدولار
استملاك العقارات وإعادة الإسكان	إنقاذ الآثار والمحافظة الآمنة للآثار من صنع الإنسان	المديرية العامة للآثار ومقترح المشروع	تقديرات الاستشاري مع موقع التخزين والشراء والتوظيف والتسييج والمباني	$٥٠٠٠٠٠
	نقل كنيسة مار موسى ودير القديسة صوفيا وإنقاذ الآثار	الأبرشية المارونية في صيدا ومقترح المشروع	هدم وجمع الجدران الرئيسية وهدم وإعادة تركيب قنطرة الكنيسة الداخلية	$٢٠٠٠٠٠٠
تجميع المياه	زيادة الزرع حول البحيرة	مشغل السد ووزارة الزراعة	شريط أشجار بعرض ١٢ متر مزروع على شبكة من ٣ أمتار حول نصف محيط البحيرة	$٣٠٠٠٠٠٠
	تركيب المعدات للمرج بواسطة الآلات حيث تكون الوسائل الطبيعية غير كافية	المصمم والمتعاقد	محتسب في تكاليف الإنشاء	غير متوفر
الترسب	تشجيع تطوير المستنقعات	مشغل السد	ميزانية الترويج للمشروع فقط	$ ١٠٠٠٠
	تشجيع إعادة تشجير منحدرات الحوض المائي العلوي	وزارة الزراعة والبلديات	ميزانية الترويج للمشروع فقط	محتسب أعلاه
إدارة الحوض المائي العلوي	تشجيع إعادة تشجير منحدرات الحوض المائي العلوي وتوسعة مساحات الأحراج القائمة	وزارة الزراعة والبلديات	ميزانية الترويج للمشروع فقط	محتسب أعلاه
	تبني تخطيط متكامل، وخطة إدارية بيئية وإجتماعية صارم وتنفيذ فعال	الدولة اللبنانية، المديرية العامة للتنظيم المدني، مقترح المشروع والبلديات	ذو فائدة كبيرة للمشروع ويجب أن تأتي الموازنة من الحكومة اللبنانية	غير متوفر
	تطوير نظم الصرف الصحي والنفايات الصلبة للقرى في منطقة الحوض المائي العلوي	مقترح المشروع، وزارة الطاقة والمياه والبلديات	مستندات مختلفة زودها مجلس الإنماء والإعمار	$٢٣
إدارة الحوض	تأمين مخارج تصريف المياه على عدة مستويات لتجنّب	المصمم والمتعاقد	محتسب في تكاليف الإنشاء	غير متوفر

المسألة	إجراءات التخفيف من الأثر	الجهة المسؤولة	أساس التكلفة	التكلفة المقدرة بالدولار
المائي الأسفل	تفريغ المياه القليلة الأوكسجين والتصميم بشكل يسمح بالتهوئة عند أسفل موقع السد			
	تأمين تبديد الطاقة من تدفق مياه السد تمنع التسرب	المصمم والمتعاقد	محتسب في تكاليف الإنشاء	غير متوفر
التنوع الحيوي والموائل الطبيعية	برنامج الانقاذ الايكولوجي وبرامج المعالجة	الاستشاري الايكولوجي	اختصاصي التنوع الحيوي والأجناس للعمل بوقت جزئي قبل الانشاء ووقت الانشاء وتعبئة البحيرة	$٦٨٧٠٠٠
الزراعة	استخدام الإرشاد الزراعي لتشجيع الزراعات التي لا تتطلي كميات كبيرة من المياه، وممارسات الري الحديثة	وزارة الزراعة ووزارة الطاقة والمياه	مكتب الإرشاد لمدة سنتين مع سيارة ودعم إداري، ألخ	$٥٠٠٠٠٠
	تأمين أماكن تفريغ بديلة لترشيح الأملاح المُترسبة	مشغل السد	محتسبة ضن تكاليف الانشاء	غير متوفر
السلامة والصحة العامة	تنفيذ حملات توعية صحية وسلامة المياه	وزارة الصحة وشغل السد	حملات توعية وسلامة	$٢٠٠٠٠٠
	رش المبيدات على أماكن توالد البعوض إذا لزم الأمر	مشغل السد	مُشغل السد، ألبسة واقية، مياه خالية من المواد الكيميائية	$٢٠٠٠٠٠٠
	تأمين السلامة العامة عند موقع السد	المصمم، المتعاقد ومشغل السد	التسييج والإشارات (محتسبة في تكاليف الانشاء)	غير متوفر
	تطوير وتنفيذ إجراءات الرد الطارئ	المصمم، مشغل السد، الدفاع المدني والبلديات	محتسبة ضمن تكاليف الحكومة اللبنانية	$١٠٠٠٠٠٠
مسائل الانشاء	على المتعاقد تطوير وتنفيذ إدارة شاملة للإنشاء البيئي والاجتماعي	مقتر المشروع، المتعاقد ومدير الإنشاء	محتسبة ضمن تكاليف الانشاء فقط "افضل الممارسات" في الإنشاء	غير متوفر
	مجموع تكاليف الإجراءات التخفيفية			$٣٢٨٩٧٠٠٠

خطة الإدارة البيئية والاجتماعية

تلخّص القائمة أدناه برنامج المراقبة البيئية والإجتماعية المقترح.

متطلّبات مراقبة الجودة البيئية

الفئة	المؤشرات	الموقع	الوسيلة	المدة	الوتيرة	الهدف	الخبرة المطلوبة	المسؤولية	الكلفة المتوقعة	الكلفة الإجمالية
مراقبة الجودة البيئية قبل البناء										
جودة المياه السطحية	معايير مياه الشفة اللبنانية	أربعة مواقع هي نهر الباروك ووادي بحنين على أقصى طرفي البحيرة ومصدرين آخرين موسميين	أخذ عينات المياه وفحصها مخبرياً	مستمرة حتى انتهاء البناء	فصلية ، متنوعة لتشمل تدفق المياه القوي والخفيف	للتأكد من الظروف من أجل المقارنة أثناء مراقبة التشغيل	فاحص عينات المياه السطحية متمرس	مصلحة مياه بيروت وجبل لبنان	١٥٠٠ US $ لكل عينة	٣٣٠٠٠٠$
نسبة الترسب	حجم الترسبات المجموعة	نهر الباروك ووادي بحنين على أقصى طرفي البحيرة	تجميع الترسبات خلف سياج صغير أو في حفرة	مستمرة حتى انتهاء البناء	فصلية ، متنوعة لتشمل تدفق المياه القوي	للتأكد من مطابقة العمل مع التصميم	خبير هيدرولوجي	مصلحة مياه بيروت وجبل لبنان	١٥٠٠٠ $ لكل موقع	٦٠٠٠٠٠$

الفئة	المؤشرات	الموقع	الوسيلة	المدة	الوتيرة	الهدف	الخبرة المطلوبة	المسؤولية	الكلفة المتوقعة	الكلفة الإجمالية
			لتجميع الترسبات		والخفيف					
الحفاظ على الآثار ونقلها من مكانها	الآثار التي تم العثور عليها وتوثيقها	مرج بسري	الحفر والمراقبة والتوثيق	مستمرة حتى إنتهاء البناء	موسمية	الحرص على تطبيق إستراتيجية التنفيذ	عالم آثار	المديرية العامة للآثار	$ ١٢٠٠٠٠	$ ١٢٠٠٠٠
	المنشآت التي نقلت وأعمال إعادة بنائها	مار موسى	التفكيك وإعادة الجمع	سابقة لمرحلة البناء	شهرية	التطرق إلى قلق المجتمع الأهلي على الإرث الثقافي	خبير في ترميم المباني	المديرية العامة للآثار	$ ٢٥٠٠٠٠	$ ٢٥٠٠٠٠
إستملاك العقارات وإعادة الإسكان	تطور تنفيذ عملية إستملاك العقارات والإلتزام بتلبية مطالب الأشخاص المتأثرين بالمشروع	كل العقارات التي سيتم إستملاكها للمشروع	تحضير تقارير عن إستملاك العقارات وإعادة الإسكان	خلال فترة إستملاك العقارات	شهرية لستة أشهر وبعدها مرتين كل سنة	مراقبة التطور وضمان الشفافية	مسؤول إرتباط إجتماعي	مجلس الإنماء والإعمار	$٥٠٠٠٠٠	$٥٠٠٠٠٠
مراقبة الجودة البيئية أثناء البناء										
تقصّي	نشاط بناء	كل المواقع	نظرياً	مستمرة كل	يومية	الحرص على	خبير بيئي	مسؤول البناء	$٢٠٠٠٠٠٠	$٢٠٠٠٠٠٠

الفئة	المؤشرات	الموقع	الوسيلة	المدة	الوتيرة	الهدف	الخبرة المطلوبة	المسؤولية	الكلفة المتوقعة	الكلفة الإجمالية
الموقع	عمومي	المرتبطة ببناء سد بسري	ووصفياً حسب جدول مهام	فترة البناء		التقيّد بممارسات البناء السليمة وخطة الإدارة البيئية	متمرس في العمل الميداني في مجال البناء			
تحقيقات الشكاوى	أي إطار يتعلق بطبيعة الشكوى	داخل أو قرب المواقع التي تصدر الشكاوى حولها	ما يتناسب مع الإطار الذي تتم مراقبته	عند الضرورة	عند الضرورة	التحقيق من الشكاوى وطرح منطلق للاشحاف	خبير بيئي متمرس في المراقبة والتحليل الميداني	المتعاقد ومسؤول البناء	تعتمد على الشكاوى	غير متوفر
الصحة والسلامة	غياب العموم غير المسموح بدخولهم والإصابات وأيام العمل التي يتغيب فيها العمّال	كل مواقع البناء والأعمال المتعلقة بالمشروع	نظرياً ووصفياً بشكل خاص وحسب جدول مهام وتقارير بجدول زمني	مستمرة طوال فترة البناء	شهرياً	حماية العمّال والعامة حسب معايير الصحة والسلامة وخطة الإدارة البيئية	مشرف على الموقع متمرس في مجال الصحة والسلامة	المتعاقد ومسؤول البناء	محتسبة ضمن كلفة البناء	غير متوفر
جودة الهواء	المعايير اللبنانية المتعلقة بالتلوّث	في مواقع عمل المتعاقدين والمواقع	تقييم نظري وبواسطة معدات محمولة	تعتمد على المصدر	عند الشك بالإلتزام بالمعايير	منع تلوّث الهواء	مشرف الموقع	المتعاقد	محتسبة ضمن كلفة البناء	غير متوفر

الكلفة الإجمالية	الكلفة المتوقعة	المسؤولية	الخبرة المطلوبة	الهدف	الوتيرة	المدة	الوسيلة	الموقع	المؤشرات	الفئة
							لتقصّي جودة الهواء	الأكثر تأثّراً	الجوي من مصادر ثابتة ومتحركة	
غير متوفر	محتسبة ضمن كلفة البناء	المتعاقد	مشرف الموقع	الحد من الإزعاج الذي ينجم عن الضجيج	عند الشك بالإلتزام بالمعايير	أكثر من ساعة خلال يوم عمل	معدات مراقبة الضجيج مقبولة الصنع	في المواقع الأكثر تأثّراً	المعايير اللبنانية المتعلقة بالضجيج	الضجيج
غير متوفر	تعتمد على عدد القطع الأثرية التي يتم العثور عليها والتأخير الناجم عن ذلك	المتعاقد والمديرية العامة للآثار	مفتش من المديرية العامة للآثار	تحسين وعي اللبنانيين فيما يتعلق بالآثار والحفاظ على ما تبقّى من الآثار قدر المستطاع	كل ما يتم العثور عليه وتعتبره المديرية العامة للآثار يستحق التدوين	عند الضرورة	إجراءات عمل المديرية العامة للآثار	أي آثار يعثر عليها خلال البناء	توثيق الآثار التي يتم العثور عليها	الإرث الثقافي
	مراقبة الجودة البيئية بعد البناء									
$٥٠٠٠	$٥٠٠ لكل عينة	مصلحة مياه بيروت وجبل لبنان	مهندس ميكانيكي	منع تلوّث الهواء	كل ثلاثة أشهر خلال موسم العمل	أكثر من 12 ساعة	أدوات مراقبة محمولة	في المواقع الأكثر تأثّراً	ما يصدر عن المولّدات الكهربائية الإحتياطية	جودة الهواء

الفئة	المؤشرات	الموقع	الوسيلة	المدة	الوتيرة	الهدف	الخبرة المطلوبة	المسؤولية	الكلفة المتوقعة	الكلفة الإجمالية
	من دخان									
صحة وسلامة العمّال	عدد الحوادث والأيام التي يتغيب فيها العمّال	عند مواقع السد والبحيرة	تقارير عن الصحة والسلامة	مستمرة	مستمرة	مراقبة الإلتزام بدليل الصحة والسلامة	فاحص الصحة والسلامة	مصلحة مياه بيروت وجبل لبنان	محتسبة ضمن كلفة العمل والصيانة	غير متوفر
الصحة والسلامة العامة	عدد الإصابات والحوادث	عند السد والبحيرة والجوار	تقارير عن الحوادث	مستمرة	مستمرة	الحفاظ على السلامة والأمان والحرص على ملائمة لافتات التحذير من الخطر لإجراءات السلامة	الإلتزام بدليل الصحة والسلامة وخطة الإدارة البيئية	الإلتزام بدليل الصحة والسلامة وخطة الإدارة البيئية	محتسبة ضمن كلفة العمل والصيانة	غير متوفر
سلامة السد	تقارير لجنة تقصّي سلامة السدود	عند موقع السد	تقصّي نظري ومراجعة ملف لجنة سلامة السدود	مستمرة	كل ثلاث إلى خمس سنوات	كشف العلامات المبكرة التي تنذر بفشل محتمل	لجنة تقصّي سلامة السدود	مصلحة مياه بيروت وجبل لبنان	٢٥٠٠٠$ لكل فحص	٢٥٠٠٠$
مياه البحيرة	تقصّي ركود	موقعان	أخذ عينات	موسمية	شهرية من	التأكد من	فاحص عينات	مصلحة مياه	١٠٠٠ US$	٣٠٠٠٠$

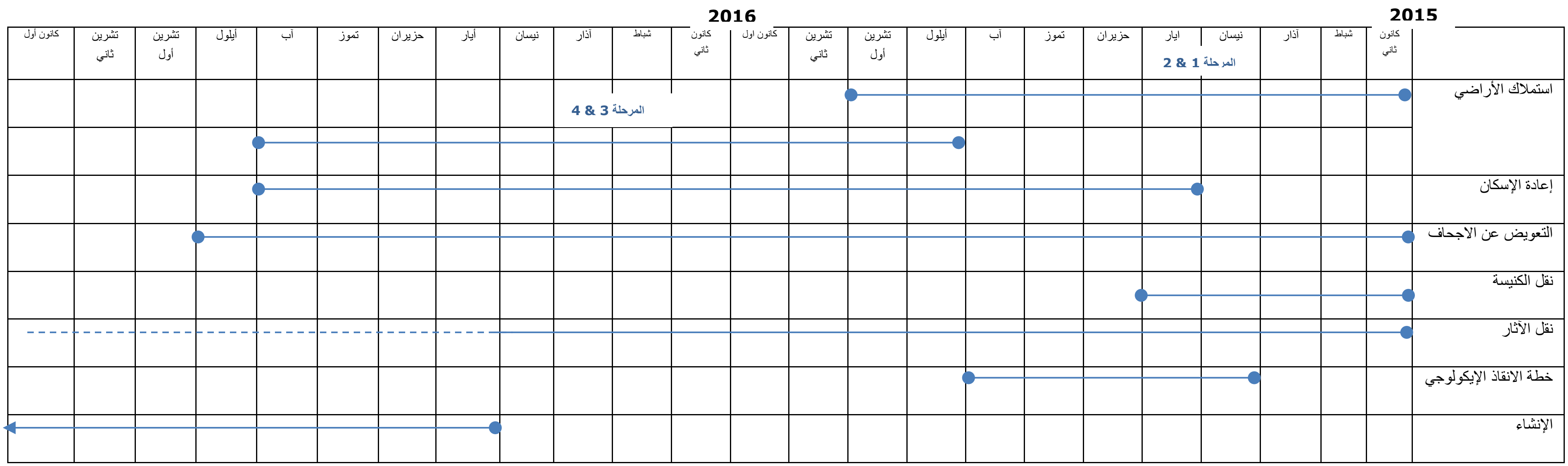
الفئة	المؤشرات	الموقع	الوسيلة	المدة	الوتيرة	الهدف	الخبرة المطلوبة	المسؤولية	الكلفة المتوقعة	الكلفة الإجمالية
	المياه في قعر البحيرة	محددان لأخذ العينات ضمن البحيرة	من عدة مستويات وتحليلها ميدانياً		أيار إلى تشرين الأول	ملائمة المزج للحد من ركود المياه	مياه متمرس وخبير قوارب	بيروت وجبل لبنان	لكل عينة	
المياه الجوفية	جودة ونسبة تدفق المياه الجوفية	ينابيع وآبار مختارة	مراقبة وأخذ عينات مستويات المياه وتقصّي التدفق	مستمرة	نصف سنوية	رصد التغيّرات في نظام المياه الجوفية	خبير هيدروجيولوجي	مصلحة مياه بيروت وجبل لبنان	US$ ٣٠٠٠ لكل عينة	$٣٠٠٠٠
التنوع الحيوي	تنوع الأجناس والموائل	السد والبحيرة والجوار	المراقبة النظرية والمسح	موسمية	سنوية لمدة ثلاث سنوات وبعدها كل خمس سنوات	تقييم هجرة الأسماك وتضاؤل التنوع الحيوي	فريق إيكولوجي	مصلحة مياه بيروت وجبل لبنان	US$٢٠٠٠٠	$٨٠٠٠٠
إستخراج المياه عند أسفل السد	ملائمة الاحتياجات البيئية	مواقع الإستخراج عند أسفل السد	مسح الاستخراج	في فصل الخريف	سنوية	تحسين إدارة الإستخراج	خبير إرشاد زراعي	وزارة الزراعة ووزارة الطاقة المياه	US$١٠٠٠٠	$٥٠٠٠٠
الترسب في البحيرة	تراكم الرواسب	البحيرة	تقصّي العمق أو	مستمرة	سنوية ، في أيار	تقصّي خسارة المخزون	مهندس ميكانيكي وخبير	مصلحة مياه بيروت وجبل	US$١٠٠٠٠	$٥٠٠٠٠

الفئة	المؤشرات	الموقع	الوسيلة	المدة	الوتيرة	الهدف	الخبرة المطلوبة	المسؤولية	الكلفة المتوقعة	الكلفة الإجمالية
			إستخدام مسبار الصدى		وحزيران	وحماية الوارد	قوارب	لبنان		
التطوير المستحثّ	الإلتزام بالمخطط الرئيسي لضفاف البحيرة	الأراضي المجاورة	تطبيق نظام التخطيط	مستمرة	مستمرة	لحماية الإستثمار في السد وموارد المياه	المشرف على التطوير	السلطات التخطيطية والبلديات	لا كلفة للمشروع	غير متوفر
مجموع تكاليف المراقبة البيئية										$٤٠٧٠٠٠٠

تنفيذ خطة الإدارة البيئية والاجتماعية

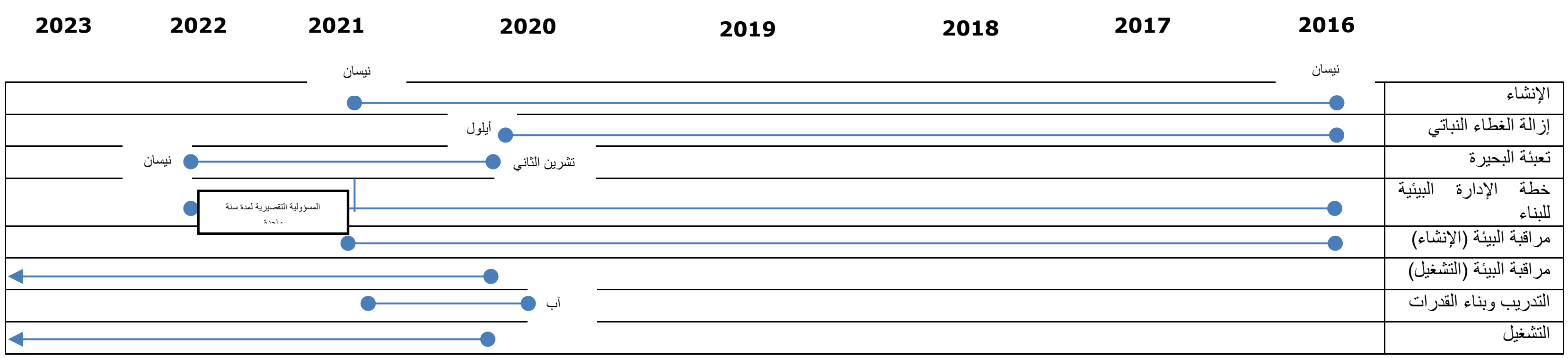
تظهر الجداول التالية الجدول الزمني المقترح لتنفيذ خطة الإدارة البيئية والاجتماعية ما قبل فترة الإنشاء، خلال مرحلة البناء، وخلال مرحلة التشغيل.

الجدول الزمني المقترح لتنفيذ خطة الإدارة البيئية والاجتماعية قبل فترة الإنشاء



* الحصول على الموافقة النهائية على المشروع (اليوم الصفر)

تنفيذ للخطة الإدارية البيئية والإجتماعية خلال فترة الإنشاء والتشغيل



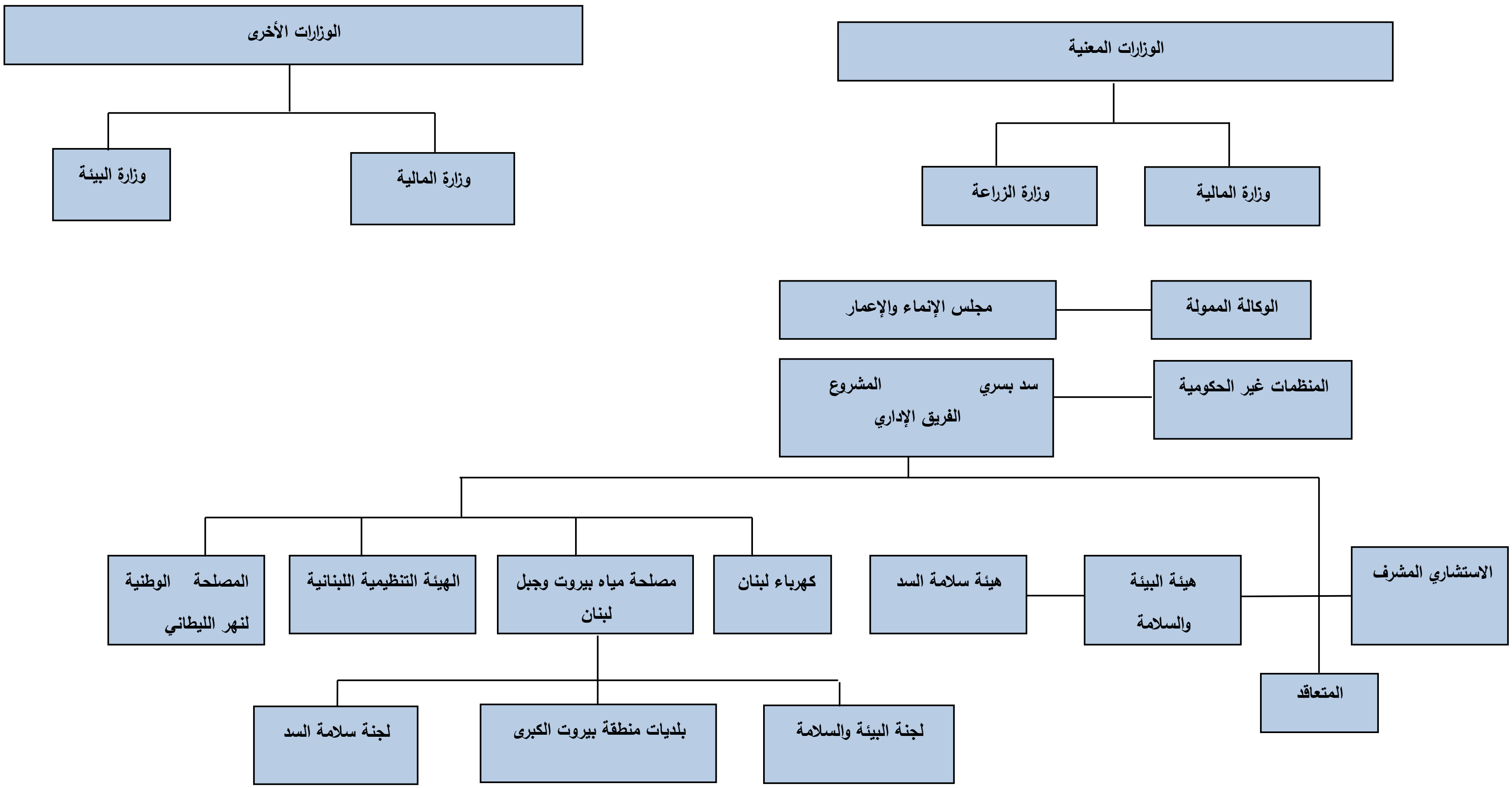
الهيئات المؤسساتية والمسؤوليات

يبينان الجدول والشكل أدناه مسؤوليات وهيكلية الهيئات المؤسساتية الفاعلة في ما يتعلق بالهيئة الإدارية للمشروع.

الهيئات المؤسساتية الأولية لإدارة سدّ بسري

المؤسسات	المسؤوليات الأولية
مجلس الإنماء والإعمار	في دوره التخطيطي، يقوم مجلس الإنماء والإعمار بتكليف إجراء استشاري لإعداد الدراسات المتخصصة وتصميم السد، ويضمن التمويل، والتأهيل المُسبق للمتعاقدين ويدير عملية المناقصة وينفذ استملاك الأراضي ويعمل بالنيابة عن الدولة اللبنانية بصفة مدير العقود.
وزارة الطاقة والمياه	صاحب السد الفعلي؛ تحدّد وزارة الطاقة والمياه السياسة التشغيلية بما في ذلك تحديد المحاصيل المتوفرة و التدفقات البيئية. تضمن قيام لجنة الفحص الرسمي لسلامة السد بعملها وفقاً للجدول الزمني المقرر.
المصلحة الوطنية لنهر الليطاني	هي الجهة المسؤولة عن الإدارة التشغيلية للمحطات الكهرمائية لتعويض أي خسارة ممكنة فب محطة شارل حلو.
مصلحة مياه بيروت وجبل لبنان	تدير المنشآت والموارد المائية عند أسفل خط السحب لمحطة جون الكهربائية المائية إلى خط الأولي الناقل، ومحطة المعالجة، والتوزيع بعد المعالجة، وخفض التسرب وفوترة التكلفة، وسوى ذلك.
وزارة البيئة	تحديد ومراقبة ما إذا كان تصريف التدفق البيئي كافياً تعتبر الوزارة المستشار القانوني للجنة سلامة السدّ. يسمح بالتطوير البيئي عند ضفاف البحيرة بقدر ما تقره القوانين القائمة.
شركة كهرباء لبنان	تشتري من مصلحة مياه بيروت وجبل لبنان ناتج القوة الكهرومائية وتبيعها إلى المستهلكين بمعدل يضمن على الأقل استعادة التكلفة.
وزارة الأشغال العامة والنقل	تعنى بتنفيذ المخطط الرئيسي لتطوير ضفاف بحيرة بسري.
وزارة الزراعة	تنظم خدمات الإرشاد الزراعي لإعطاء ممارسات الري عند أسفل السدّ مردودها الأعلى. تقدم المشورة لوزارة الطاقة والمياه حول ما يكفي من استخدام المياه للحفاظ على الكميات القانونية. تقدم المشورة لمشغلي السدّ حول السماح بتربية الأسماك تجارياً ضمن البحيرة.
المديرية العامة للآثار	جمع شظايا الفخار والزجاج وغيرها من الأعمال الفنية من التربة السطحية والضحلة وإقام الحفريات في المواقع التي تم تحديدها سابقا؛ مسح جيوفيزيائية للمواقع المحددة، حيث قد يوجد حالياً هياكل مدفونة ؛ إقام الحفريت الرئيسية وإزالة المواد في معبد المرج بسري الروماني؛ إقام الحفريات في محيط كنيسة مار موسى وبقايا دير سانت صوفيا.

	توثيق الآثار المكتشفة أثناء فترة البناء
والأبرشية المارونية في صيدا	نقل كنيسة مار موسى ودير سانت صوفيا و، استعمال مواد البناء القديمة من أنقاض المنازل التي تعود إلى القرن القرن ١٩–٢٠ لتوفير البناء الجديد المجاور لكنيسة مار موسى.
البلديات المعنية	تنفيذ الإجراءات المعنية باستملاك الأراضي
وزارة الشؤون الإجتماعية	تنفيذ خطة إعادة الإسكان خاصة فيما يتعلق باللاجئين
وكالة الامم المتحدة للاجئين	مساعدة اللاجئين المسجلين لدى الأمم المتحدة في إعادة إسكانهم في مخيمات محددة مساعدة اللاجئين غير المسجلين لدى الأمم المتحدة عبر تسجيلهم لدى المفوضية أولاً ومساعدتهم في إعادة إسكانهم في مخيمات محددة لاحقاً



الهيكلية المؤسساتية لإدارة سد بسري

بناء القدرات والتدريب

سيتطلب سد بسري برنامجاً كبيراً لبناء القدرات المقدم من خلال، (i) التوظيف الجديد لمدراء من ذوي المؤهلات المناسبة ولموظفي الصيانة، (ii) برامج تدريب للموظفين المنتقين القائمين، و(iii) التعاقد الفرعي بالنسبة لخدمات منتقاة، أو طبعاً، الإدارة العامة للسد والبحيرة المتوقفة على بناء القدرات الداخلية.

وكجزء من عقد الإنشاء، سيكون من المهم أن يتلقى موظفو وزارة الطاقة والمياه (MEW) ومصلحة مياه بيروت وجبل لبنان (BMLWE) التدريب العملي لكسب الخبرات اللازمة بالنسبة للتجهيزات المركبة. ويجب إعطاء الفرصة لموظفي المصلحة الوطنية لنهر الليطاني المقترحين لمناصب الإشراف لزيارة الموقع والاستماع إلى عروض موجزة مُفصلة، بما في ذلك تدريب عملي في سدود من نفس حجم سد بسري خارج لبنان.

من المرجح أيضاً ان يكون بناء القدرات الداخلية مطلوباً داخل الفريق القانوني للوزارة لأجل السماح لأفراده بالفهم الكامل للقضايا التي تحيط بـ "حق الحصول على الماء" في لبنان.

وسيكون من الضروري بناء قدرات موظفي وزارة الزراعة (MoA) بالنسبة لأجناس المزروعات التي لا تتطلب كميات كبيرة من المياه بالإضافة إلى معدات وممارسات ري حديثة.

تجدر الإشارة ان خطة الإدارة البيئية والاجتماعية المعدلة التي تتضمن كافة المكونات الفرعية التي نوقشت أعلاه سيتم إعدادها عند وضع اللمسات الأخيرة على التصميم ويجب ان تغطي خطة الإدارة البيئية والاجتماعية إجراءات تخفيف الآثار والرقابة.

مجموع تكاليف تنفيذ خطة الإدارة البيئية والإجتماعية

التدابير التخفيفية	$٣٢٨٩٧٠٠٠
المراقبة	$٤٠٧٠٠٠٠
بناء القدرات	$١٩٢٠٠٠
مجموع تكاليف تنفيذ خطة الإدارة البيئية والإجتماعية	$٣٧١٥٩٠٠٠

الاستشارات والاتصالات

التزاماً بسياسة مجلس الإنماء والإعمار حول المشاركة العامة، التي تتبع عادة سياسة البنك الدولي ووكالات التمويل الأخرى، تمت صياغة *برنامج الاستشارات والاتصالات* (C&CP) مع تفصيل الخطوات الواجب اتباعها خلال سير المشروع، من انتقاء الموقع إلى التشغيل الاختباري قبل التكليف.

عند بدء عملية تقييم الأثر البيئي ، عقدت سلسلة من الجلسات لعرض نطاق تقييم الأثر البيئي والإجتماعي للمشروع تلتها اجتماعات تعاونية خلال شهري أبريل ومايو ٢٠١٢، بدأت مع جلسة مع المؤسسات المعنية في مكاتب مجلس الإنماء والإعمار في وسط بيروت والذي دعي المعنيين من الوزارات والوكالات الحكومية و المنظمات غير الحكومية . وأعقب ذلك جلسة مشاورات عقدت في مزرعة بلدية ضهر في محيط سد بسري. أخيرا ، تم عقد جلستين منفصلتين لسكان بيروت ، المستفيدين من المشروع.

وقد عرض المستشار الموكل لتحضير تقييم الأثر البيئي والإجتماعي وخطة إعادة الإسكان بعرض نتائج وتوصيات الدراسة في أماكن مختلفة للمؤسسات المعنية ، والأشخاص المتأثرين بالمشروع في القرى المحيطة بسد بسري ، بالإضافة إلى المقيمين في منطقة بيروت الكبرى . تم الاتفاق على موعد وتوقيت كل الاجتماعات مع البلديات المعنية. وقد قرر عقد الجلسات الإستشارية التي تعنى بالقرى في عطلة نهاية الأسبوع و في وقت مبكر من المساء خلال أيام الأسبوع لمستهلكي المياه في منطقة بيروت الكبرى لتأمين العدد الأقصى للحضور.

وقد قام المستشار بعقد سلسلة من المشاورات العامة في نيسان ٢٠١٤، وذلك من بعد ما جرى بعض التنقيحات للتصاميم الهندسية للسد ومتطلبات استملاك الأراضي، والإنتهاء من المسح الإجتماعي– الإقتصادي. يلخص الجدول التالي جميع المشاورات العامة التي قام بها الاستشاري:

التاريخ	المنطقة	الزمان	المكان	الحضور
٢٠١٢				
٣ نيسان	بيروت	العاشرة صباحاً	مجلس الإنماء والإعمار	المؤسسات المعنية
١٠ نيسان	مزرعة الضهر	العاشرة صباحاً	بلدية مزرعة الضهر	الأشخاص المتأثرين بالمشروع
٢٤ نيسان	الحدت	العاشرة صباحاً	بلدية الحدت	المستفيدون من المشروع
٥ أيار	بيروت	العاشرة صباحاً	بلدية بيروت	المستفيدون من المشروع
٢٠١٣				
٣٠ كانون الثاني	بيروت	العاشرة صباحاً	مجلس الإنماء والإعمار	المؤسسات المعنية
٢ شباط	الميدان	العاشرة صباحاً	بلدية الميدان	الأشخاص المتأثرين بالمشروع
٢ شباط	مزرعة الضهر	الثالثة والنصف من بعد الظهر	بلدية مزرعة الضهر	الأشخاص المتأثرين بالمشروع
٦ شباط	الحدت	الخامسة من بعد الظهر	بلدية الحدت	المستفيدون من المشروع
٩ شباط	عماطور	العاشرة صباحاً	بلدية عماطور	الأشخاص المتأثرين بالمشروع
٩ شباط	مزرعة الشوف	الثانية والنصف من بعد الظهر	بلدية مزرعة الشوف	الأشخاص المتأثرين

				بالمشروع
٢٠١٤				
٢٥ نيسان	عماطور	العاشرة صباحاً	دار عماطور	الأشخاص المتأثرين بالمشروع
	مزرعة الشوف	الثالثة من بعد الظهر	قاعة البلدية	الأشخاص المتأثرين بالمشروع
٢٦ نيسان	بسري	العاشرة صباحاً	قاعة الكنيسة	الأشخاص المتأثرين بالمشروع
	مزرعة الضهر	الثالثة من بعد الظهر	قاعة البلدية	الأشخاص المتأثرين بالمشروع

وقد جاء الموقف العام من جميع الحضور في المناطق الأربعة معارض بقوة لبناء سد بسري . كما كان من المتوقع ، فإن غالبية التعليقات التي أثيرت هي استملاك الأراضي و عملية دفع التعويضات. ومن بين القضايا الرئيسية التي أثارها الأشخاص المتأثرون بالمشروع في القرى الأربعة هي: (أ) الحاجة إلى تخصيص المياه و الطاقة المولدة من سد بسري إلى القرى المجاورة بما في ذلك احتياجات الري ، (ب) يجب ان تذهب الاستفادة من المشروع الى القرويين المقيمين لتشجيعهم على البقاء في قراهم ، (ت) فقدان الأراضي المنتجة والتنوع البيولوجي، (ث) التعويض النقدي لا يكفي لا سيما أن الأرض لها قيمة معنوية لملاكي الأراضي ، (ج) مشاركة الأشخاص المتأثرين بالمشروع في تثمين العقارات ، (ح) استفادة البلديات من عائدات سد بسري والحصول على تعويض سنوي لإقامة مشاريع تنمية في القرى المجاورة ، (خ) الحاجة إلى طرق تصل السد بالقرى المجاورة ، (د) الحاجة إلى نقل الآثار التاريخية والأثرية، (ذ) دراسة تحلية مياه البحر كحل بديل ، (ر) الحاجة إلى دراسة المخاطر الزلزالية، (ز) الحاجة إلى خطط

لمعالجة مياه الصرف الصحي في القرى في الحوض الأعلى للسد، (س) جودة المياه السطحية ، (ش) الترسبات الكيماوية في المياه، (ص) انتقال الأمراض بالحشرات و الروائح الكريهة في منطقة المشروع ، (ض) زيادة ملوحة المياه وتأثيرها على الزراعة والمقيمين ، (ط) إمكانية إنشاء عدد من الأحواض الصغيرة بدلا من سد كبير ، (ظ) إمكانية إصدار قانون لإنشاء شركة لسد بسري حيث ملاكي الأراضي هم المساهمون ، (ع) نقل موقع السد المقترح إلى مكان آخر.

وسيستمر مقترح المشروع بالقيام بالاستشارات طوال فترة استملاك العقارات وبعدها من خلال مركز المعلومات المتعلقة بالمشروع (PIC).

وسوف يتم الإعلان عن تقييم الأثر البيئي والإجتماعي وخطة إعادة الإسكان داخل لبنان على موقع مجلس الإنماء والإعمار الالكتروني. وسيتم الإعلان لاحقاً عن المستندين على موقع البنك الدولي للمعلومات.

EXECUTIVE SUMMARY

Background

To overcome increasing severe shortages in public water supply, the Government of Lebanon (GoL) through the Council for Development and Reconstruction (CDR), the Ministry of Energy and Water (MEW), and the Beirut and Mount Lebanon Water Establishment (BMLWE), has initiated the Greater Beirut Water Supply Augmentation Project (GBWSAP) to identify the most significant environmentally and socially acceptable, technically viable and economically efficient solutions to the medium and long term provision of potable quality water throughout the Greater Beirut Area..

The GBWSAP ESIA has been implemented in two phases. Phase 1 compared dam and non-dam options for water supply augmentation to the Greater Beirut and Mount Lebaon area in the long term and recommended Bisri dam as the Priority Scheme, while in Phase 2 a full Category A ESIA for Bisri dam has been prepared. This report reflects the changes to dam design and area to be expropriated of January 2014. The report has been discussed with stakeholders and has been endorsed by CDR and other agencies involved in implementation of various portions of the ESMP.

ESIA Process

An environmental and social assessment process is in place to avoid, mitigate and/or compensate those identified potential negative environmental and social impacts.

The environmental and social analytical work and recommendations, all designed in a transparent and collaborative manner has been packaged into two sets of documents:

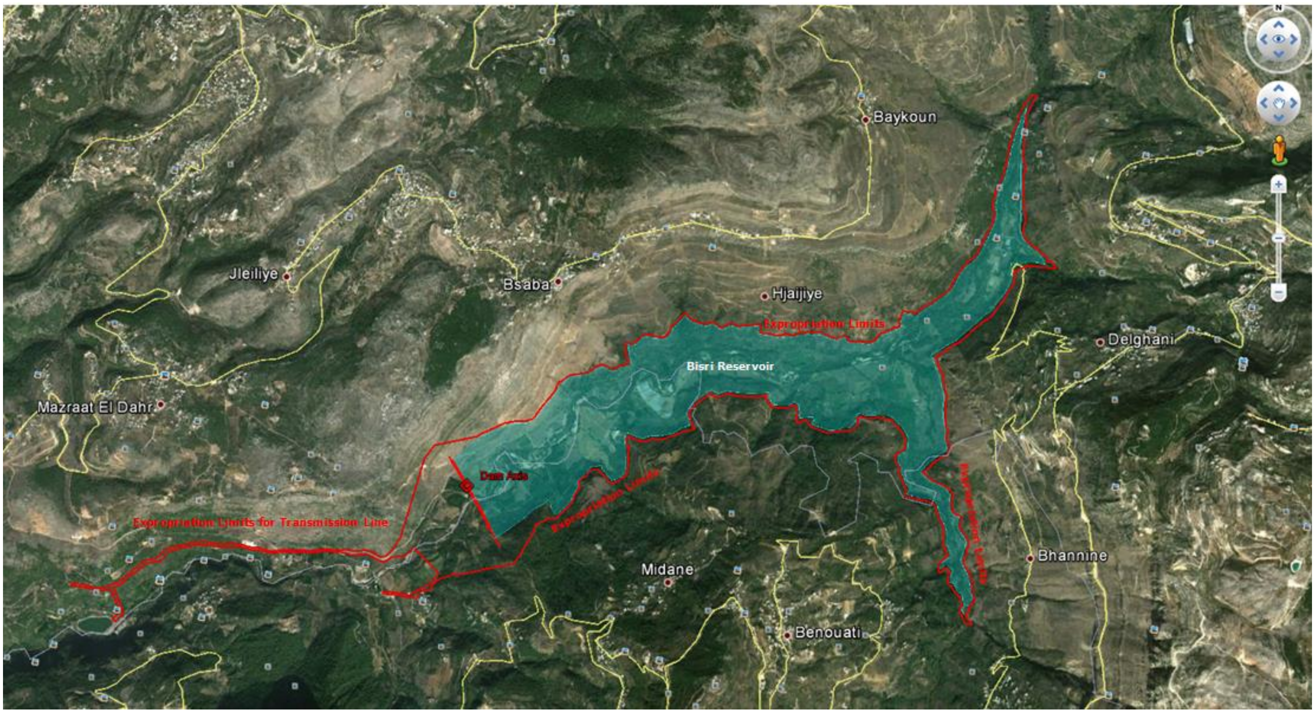
- The ESA documentation consisting of:

1. Environmental and social impact assessment (ESIA) report – i.e. the present report
2. Its accompanying appendices
    - Appendix A: Bibliography and List of References
    - Appendix B: Dam Design
    - Appendix C: Unofficial translation of Law No 8633 of August 2012, Fundamentals of Environmental Impact Assessment
    - Appendix D: 'Chance Finds' procedure
    - Appendix E: Geological and Geoechnical review report
    - Appendix F: Water quality
    - Appendix G: Biodiversity Management Plan
    - Appendix H: Preliminary report of Polish-Lebanese Expedition to the Eshmoun Valley (Wadi Bisri)
    - Appendix I: Benefit Sharing
    - Appendix J: Dam Breach report construction, supervision and quality assurance plan
    - Appendix K: ToR for consultancy services to monitor water quality entering Bisri Reservoir
    - Appendix L: Records of Public Consultations
    - Appendix M: Assessment of Quarries and Associated Environmental Management Plan

- The Resettlement Action Plan (RAP) for the dam, reservoir, transmission line, and access roads – a separate report

Project Description

The proposed Bisri Dam site on Nahr Bisri is about 15 km inland from the Mediterranean coastline at Saida and 35 km south of central Beirut, at an elevation of c.395 masl. The reservoir extends for about 4 km upstream of the dam axis on Nahr Bisri, as illustrated in the following Figure. The two easterly lobes of Bisri Reservoir formed by Nahr Barouk from the north and Wadi Bhannine where Aari'ye River runs from the south merge at Marj Bisri to form Nahr Bisri, which after a further 5 km merges with Wadi Khallet west of Bisri Village to become Nahr Awali, thereafter continuing to the sea. Above the dam site on Nahr Bisri the surface water catchment area extends to some 215 km^2. At maximum water level 467 masl, the total storage volume of the reservoir is estimated at ١٢٥ Mm^3 and the area expected to be inundated at 434 ha.



Bisri Dam, Reservoir and Expropriation Limits

GBWSAP involves the construction and operation of a series of infrastructure, notably:

- The dam and its 256 ha reservoir (excluding the dam footprint),
- A 4 km transmission line connecting the dam to the Awali HEP, and,
- The construction and improvement of several access roads.

While land take will be extensive within the proposed area to be expropriated, some 570 ha, residential properties are few and there are no commercial or industrial premises and no significant public infrastructure or community facilities within the impoundment area.

The occupied residential accommodations house seasonal farm workers, mostly non-Lebanese, that will need to be relocated.

Land to be expropriated and inundated on the completion of Bisri Dam is primarily agricultural estimated at 150 ha in addition to pine woodland (82 ha) and natural vegetation (131 ha).

Estimated Costs

The updated design report 2014 estimated the total cost of the dam and associated facilities to be some US$300 million, comprising $220 million contractors' costs, $66 million contingencies, and $10 million for engineering. The construction of the transmission line is estimated at $20 million. The construction cost of the hydropower plant is estimated at $15 million.

Specifically excluded from these costs are the cost of the expansion of the Ouardaniyeg water treatment plant (currently under construction), and onward conveyance for distribution to Greater Beirut, which will be provided under the independent Greater Beirut Water Supply project (GBWSP), currently under implementation. The estimated cost of land acquisition, to be covered by GoL, was estimated at about $150 million for around 570 ha of land (including inundation area, dam footprint and a 15 m buffer).

Legal, regulatory and institutional framework

Existing Lebanese Legislation

Following Lebanon's reconstruction and development drive after fifteen years of civil unrest and invasion, Lebanon had no alternative but to rely upon external funds granted by international donors such as the European Commission, World Bank and unilateral donors for whom projects had to be environmentally assessed as a prerequisite for funding.

Subsequently, Draft Decree No. 444 of 2002 defined the binding principles to which all public and private projects are subject in evaluating the impacts projects have on the environment. In accordance with Article 23, all projects are required to undergo an Environmental Assessment, for which the regulatory authority is the Ministry of Environment (MoE). The Draft Decree was eventually passed in August 2012, during the currency of the present project, becoming Decree No 8633, Fundamentals of Environmental Impact Assessment.

Triggered World Bank Safeguard Policies

In accordance with CDR policy, the Assessment complies with the structure and guidelines of World Bank Operating Policy 4.01 Environmental Impact Assessment for a Category A Project, as well as with the requirements of the Lebanese Ministry of Environment, as recently formalized in Decree No. 8633 of August 2012. Five of the WB Safeguard Policies are triggered by GBWSAP, these are: Environmental Assessment, Natural Habitats, Physical Cultural Resources, Involuntary Resettlement and Safety of Dams:

Environmental Assessment (OP/BP 4.01): The project will have significant and irreversible environmental impacts. Phase I of the ESIA has thus been prepared as a comparative study between the different alternatives considered to identify the priority option based on an environmental, social, economic and technical assessment. Based on the findings of the alternatives analysis, Bisri Dam was selected as the Priority Scheme for long term water supply augmentation to the Greater Beirut area. An ESIA and an ESMP have subsequently been prepared, following OP/BP 4.01 guidance for category A projects.

Natural Habitats (OP/BP 4.04): The project will have significant impacts on natural habitats, both during construction and operation of the dam. A detailed assessment has been carried out to draw the ecological profile of the area, assess flora and fauna diversity, and to identify those species endangered or IUCN-listed that are at added risk from the Project. In line with OP/BP 4.04, a Biodiversity Management Action Plan has subsequently been proposed, building on the results of the detailed ecological survey.

The construction of Bisri dam and its associated structures, in addition to the creation of the reservoir, will cause both loss and alteration of natural habitats, with resulting impacts on ecology and biodiversity. The presence of the reservoir will transform riparian riverine habitats into lacustrine habitats with both adverse and beneficial effects. The reservoir will reduce habitats for wildlife species that require flowing water but attract those adapted to still or slower-moving waters such as waterfowl.

Beneficial effects will also arise from the habitats presented by the reservoir and new biological communities will establish themselves over time.

Physical Cultural Resources (OP/BP 4.11): The significance and extent of archaeological, historic and recent cultural heritage throughout the Bisri project area is a crucial issue. While there is much overlap between the archaeological and cultural, measures to be undertaken to rescue and preserve the various cultural heritage components, each of these have been addressed separately, with the Directorate General of Antiquities (DGA) and the Maronite Diocese of Saida respectively.

The DGA will carry out archaeological investigations and rescue excavation in accordance with their policies and procedures and in collaboration with the University of Warsaw. These mitigation measures shall be funded by the project as required by OP/BP 4.01 and are included in the cost estimates of dam construction. A detailed Cultural Heritage Plan (including a Chance find Procedure to be adopted during construction and maintenance of the main infrastructure works as a sub-component of the ESMP) is further detailed in the ESIA and provided in Annex I.

Heritage preservation, as distinct from archaeological rescue, is primarily concerned with the relocation of Mar Moussa Church, St. Sophia’s Monastery and architectural salvage from some of the old ruined houses throughout the valley. Meetings have been held with the Bishop of the Maronite Archdiocese of Saida, the Church’s architectural advisors, the head of Mazraat El Dahr municipality and the priest responsible for Mar Moussa. Repeated walkovers have identified four potential Mar Moussa relocation sites four potential sites. The most appropriate site has been agreed with stakeholders (including the Maronite Church) and arrangements made for the full expropriation of the land as detailed in the RAP. Present responsibilities must, however, extend to provision of a storage area within which to retain excavated material from Marj Bisri and elsewhere pending its re-erection as and when DGA determine.

Similarly, the DGA has agreed the need for rescue archaeology and the time frame proposed in the ESIA. In accordance with its normal internal procedures, it will review the situation and make arrangements to implement its responsibilities under Lebanese law once the Loan Agreement and Project Appraisal Document have been ratified by a Decree of the Council of Ministers. CDR and DGA have agreed that DGA will appoint a team of qualified archaeology specialists to undertake the rescue archaeology, with costs of hiring these appointed experts to be borne by the project. The cost of rescue works are included in the dam works contract. A Physical Cultural Resources Plan is provided in the appendix.

Involuntary Resettlement (OP/BP 4.12): GBWSAP is expected to have direct and indirect social impacts in its area of influence and beyond. Consistent with WB safeguards policies, OP/BP 4.12 was triggered and social mitigation plans identified. A Resettlement Action Plan by broad categories of works (dam and reservoir, power plant and transmission line, access roads) was prepared to mitigate, offset, reduce negative impacts and strengthen positive impacts on the communities in the Project area. The resettlement recommendations are discussed in the RAP, which is a separate document.

Safety of Dams (OP/BP 4.37): A major contribution to dam safety is the formulation of Dam Safety Plans based on Dam Breach modelling and inundation analysis undertaken by the dam designer. The dam breach report includes an Emergency Action Plan with details of implementation. Dam Safety Plans either issued to date or under preparation include:

- Construction Supervision and Quality Assurance Plan;
- Instrumentation Plan;
- Operation and Maintenance Plan; and,
- Emergency Preparedness Plan.

ANALYSIS OF ALTERNATIVES

A comprehensive comparative analysis of the economic, social, technical and environmental aspects of potential solutions to the augmentation of Greater Beirut's long-term water supply has been carried out, the full details of which were presented in the Preliminary Draft ESIA. The GBWSAP ESIA has investigated a range of alternatives; non-dam alternatives, dam alternatives, in addition to the 'Do Nothing' or 'Without Project' alternative. Non-dam alternatives that have been considered are desalination, ground water, rainwater harvesting, wastewater reuse and reduction in 'Unaccounted for Water'. The Table below summarizes the major advantages and/or setbacks that may facilitate or deter these solutions from being realistically achieved for the long-term supply of potable water to Greater Beirut.

Summary of Potential Non-Dam Alternative Sources

Source	Advantages	Disadvantages	Conclusion
Desalination	• Plentiful and sustainable resources; • Could supply whole GBA demand; • Technically reliable; • Independent of Climate.	• Utilises an Industrial process; • Only 40% of intake to supply; • High construction cost; • Substantial coastal land take; • High energy and O&M costs; • Marine environment damaged by brine;	Highly feasible, but very expensive. For current consideration, the 'Source of Last Resort'
Ground Water	• Most discharge to supply; • Suitable for conjunctive-use; • Better quality than surface water; • Diverse source locations; • Modest carbon footprint.	• Limited future use due to over-exploitation • Resources currently ill-defined; • Probably insufficient to supply GBA alone; • Recharge climate-dependent; • Substantial energy costs.	Resources remain to be quantified but at minimum will significantly contribute to conjunctive use with a dam alternative alternative but with limited volumes to be used in the future
Rainwater Harvesting	• Basic technology; • Local sources; • Low carbon footprint.	• Short wet season; • Ill-suited to high-rise urban areas; • Climate dependent; • Poor public perception.	At best, it will contribute to household or compound non-potable water use.
Wastewater Reuse	• Source origin within GBA; • Source generally sustainable; • Majority of technology already required for best management practice.	• High treatment costs; • Lack of technical expertise; • Insufficient resources to meet GBA demand; • Very poor public perception and confessional objection.	Strong cultural objections. At best can supply substantial quantities of non-potable water for landscape irrigation, etc.
Reduction in UfW	• Optimises existing system efficiency and cost-recovery; • Promotes Best Management Practice.	• Requires political will, legal reform and judicial support; • Requires public cooperation; • Leakage unlikely to be <25%.	Should be pursued as is economically viable. Will not reduce the need for new source development.

Based on the above, desalination, albeit it technically, economically and politically the 'Source of Last Resort', is the only non-dam alternative capable of sustaining long term water supplies to Greater Beirut, but at the highest cost. The significant limitations in the Lebanese energy sector currently also impede the development of desalination as an economically feasible alternative.

The ESIA also considered three dam sites other than Bisri dam, all of which are included in the Ministry of Energy and Water's National Surface Storage Strategy; these are dam sites at Damour on Nahr Damour (two sites) and at Janneh on Nahr Ibrahim. Based on the comparative analysis, CDR has opted for Bisri dam being the priority scheme. The advantages and disadvantages of each are summarised in the following Table.

Summary of Potential Dam Alternatives

Scheme	Advantages	Disadvantages	Conclusion
Bisri	• High storage volume that meets GBA demands to 2030 or longer; • Utilises GBWSP transmission, treatment and storage facilities at limited additional cost; • Reservoir floor underlain by low permeability deposits; • Little or no pumping costs; • Lowest cost per unit volume delivered to GBA;	• Most land take is productive land; • Historic and cultural remains at risk; • High sedimentation risks to be mitigated; • High seismic risk to be mitigated.	Bisri dam is the only site that will supply GBA demand over an appreciable period of time with cost effective investment. Nevertheless; additional studies into reservoir geology, water tightness, seismic and sedimentation risks are needed prior to detailed design. Preference for the present dam axis location should be confirmed. These studies have been completed as part of the finalization of the detailed design of Bisri dam.
Damour West	• Land take mostly non-productive; • Favorable dam-site morphology in V shape; • Might utilise some GBWSP facilities.	• Small storage capacity; • Unlikely to sustain significant hydropower; • New treatment plant required otherwise additional conveyances costs; • Significant pumping costs.	Water storage is substantially less than at Bisri or Damour East, and dam site geology is less favoured. Any dam here should have a reduced water level to limit lateral leakage and/or be part of a conjunctive use scheme with ground water.
Damour East	• Dam site geology better than at Damour West; • Favorable dam-site morphology in V shape; • High storage volume that meets GBA demands to 2030 or longer.	• High lateral leakage; • New treatment plant required, otherwise additional conveyance costs; • Significant costs to treat the J6 permeable strata; • Significant pumping costs; • Subject to block collapse from reservoir cliffs.	Notwithstanding; the high storage volume and the relatively better site-dam geology than Damour West, this scheme raises serious concerns about the potential excessive lateral leakage.
Janneh	• High flow rates, reservoir readily replenished each spring. • Favorable dam-site morphology in V shape; • High Potential of hydropower generation.	• Most land take is natural landscape; • Located on highly permeable strata, hence leakage likely to be substantial; • New treatment plant and transmission line required; • Highest cost per unit volume delivered to GBA.	As a stand-alone dam Janneh will only meet GBA short term needs. Janneh dam is thus best suited to serve the northern areas of the Greater Beirut and Mount Lebanon region. Futher investigations need to be carried out to address the concerns about dam and reservoir geology and water tightness.

Based on the above, the following conclusions can be drawn:

- Given its size, cost effectiveness, and all combined favourable geological settings, Bisri Dam is considered the priority option.

- Janneh Dam could be constructed in phases, catering on short term for Jbeil and Kesrwane needs.
- The first years of construction of Bisri and Janneh Dams will allow for a more in depth study about the feasibility of Damour West Dam, the outcome of which should indicate the way forward either to proceed with Damour West Dam or to advance with the Damour East from a feasibility study into a detailed design. In all cases Damour proposed Dams with their reduced volumes could be compensated by possible conjunctive use with ground water from underlying aquifers.

Environmental and Social Baseline Conditions

Climate

Air temperature combined with relative humidity and wind are the major determinants of how much water will evaporate from the surface of the reservoir. Being topographically part of the region that lies between the coastal strip and the western mountains, the Bisri project area site affords all the climatic features of a transitional microclimate that unfolds for hot and humid summers at the proposed location for the dam axis to less humid and mild summers at the extremities of the proposed impoundment. The five winter months are generally characterized by abundant rains with cool temperatures at the dam site, and severe winters with more precipitation in form of snow, which contributes over time to the replenishment of the mountains springs, with their water heads, extending between the Barouk and Jezzine mountains.

The highest evaporative demands occur during the six dry months from April to August, with a peak in July, when the reservoir is expected to reach its full storage capacity and start delivering water to GBA.

Landscape

The landscape consists mainly of wild plantations, cedar trees in Barouk Mountain, oak and pine forests in Jezzine, Bkassine, and the Upper Chouf, in addition to woodland varieties, farmland and natural scrubby bush vegetation. The plant cover is important for controlling erosion and landslip, promotes aquifer recharge and boosts carbon sequestration.

Landuse

Land to be expropriated and inundated on the completion of Bisri Dam is presently utilised as shown in the Table below.

Current Land Use within Expropriated Area

Landuse	Approximate Area - ha	% of Total Expropriation
Open Field/Fallow	148	26%
Natural Vegetation	131	23%
River Bed and Bankside Vegetation	105	18%
Open Land	99	17%
Pine Woodland	82	14%
Polytunnels	4	0.7%
Built-up Area	1	0.2%

Geology

The Bisri Dam catchment area encompasses a geological sequence extending from the Jurassic Kesrouane Limestone (J4) in the higher mountainous areas through the intervening formations to the Cretaceous Sannine Limestone (C4) and the recent Quaternary alluvial and fluvial deposits exposed along the course of the Bisri river and continuing downstream of the dam site.

Cultural Heritage

From the available records of the 2004 and 2005 field seasons carried out by a Polish-Lebanese mission, a total of 78 sites were identified, of which 27 fall within the area of expropriation for the Bisri project and a further 10 sites are within 100 m of the expropriation boundary. The sites identified at Bisri represent almost the full span of human history, from Paleolithic times prior to 8,300 years BCE through to the present day.

Close to the confluence between Nahr Barouk and 'Aariye', now more commonly known as Wadi Bhannine, lies the temple of Marj Bisri believed to be connected with the Temple of Ashmoun, also known as Bustan El Sheikh, in the Lower Awali Valley, dating back to the 7th Century BC.

Today, the visible remains of Marj Bisri are limited to four black granite columns, perhaps the entrance to the main temple, and several large dressed stone blocks exposed in the nearby river bank, believed to be the wall of the Temenos, the sacred area surrounding the temple. Pottery sherds of both Roman and Persian origin have been found in the vicinity and it is assumed the buried remains of other buildings and at least a small village will also be present. No comprehensive archaeological surveys of Marj Bisri, neither of another suspected temple site downstream, have been completed, although very preliminary investigations without excavation have been undertaken by the Polish Centre for Mediterranean Archaeology at the University of Warsaw working in conjunction with the University of Balamand.

Of particular significance as witnesses to the relatively recent cultural heritage of the area are the sites of mar Moussa El Habchi Church and the remains of St. Sophia's Monastery, located very close to each other a short distance upstream of the proposed dam axis. The future of the church is an emotive issue for many Mazraat El Dahr residents. Because access is limited to an unmetalled track that is rough and untended, services are no longer held other than on Mar Moussa Day, 28th August, each year. As a result of these critical issues pertaining to cultural heritage, a detailed Cultural Heritage Management Plan, provided in Appendix I and the ESMP reflects arrangements to address these structures, as agreed with relevant GoL counterparts.

Surface Water Quality

Water quality analyses from Nahr Bisri and its tributaries show that the level of treatment required bringing water into compliance with Lebanese and international drinking water standards is afforded by a conventional treatment stream. However, of the organophosphorous pesticides, minute quantities of Lindane and Dieldrin in concentrations marginally above the limit of detection were present in two samples.

Since both these substances are banned by the 2001 Stockholm Convention on Persistent Organic Pollutants (POPs), to which Lebanon is a signatory, the source is not immediately obvious. It is therefore recommended that the projectoversees a programme of monitoring to confirm the continued presence of pesticide residues and check for any additional substances detrimental to health that may arise. This aspect will be sub-contracted to a qualified consulting firm which will report to MoE, the objective of which will be to monitor the presence of polluting substances present in surface water courses draining to the reservoir area and to investigate their sources of origin.

ENVIRONMENTAL AND SOCIAL IMPACTS AND MITIGATION MEASURES

GBWSAP area of influence is defined at two levels: the immediate surroundings of the project's infrastructure works for direct, indirect and induced impacts on the one hand and a substantial area, that extends beyond the direct vicinity of the Project itself. The critical area of influence is the reservoir area and the lower catchment whereby it is impacted by the construction activities as well as the changes that will occur resulting from dam operation be it positive or negative, direct or indirect impacts upon which affected communities' livelihoods are dependent. The upper catchment will impact the environment mainly by what it discharges into the reservoir basin. The critical GBWSAP area of influence extends from the sources of Barouk and Aariye Rivers till the outlet of the Awali River on the coast, covering the agricultural plains downstream of the dam and the villages residing in this area.

GBSWAP area of influence also follows the life cycle of the dam construction material which will be sourced from quarries within the reservoir area. The final suitability of all borrow areas will be determined by the appointed contractor. Wastes will be disposed of at licensed sites. The location of construction camps for workers is more likely to be within the valley subject to areas to be protected such as Marj Bisri. GBWSAP area of influence also encompasses Mar Moussa Church relocation, migration routes for wildlife, and induced development, to finally reaching water supply for GBA users.

Main Environmental Impacts

Erosion and Sedimentation

A major significance of erosion and sedimentation is that it imparts a progressive decrease in reservoir storage, albeit this reduction is primarily in dead storage rather than operational storage. The reservoir has been designed to accommodate 9 million m^3 of sediment within 50 years operation. This will be provided for by 'dead storage' capacity, the volume that can fill with sediment without impacting the normal operation of the dam.

To minimize sedimentation and the loss of capacity and sediment build-up at the dam, it is important to promote reforestation and soil conservation in the upper catchment and around the periphery of the reservoir, and also to monitor reservoir depth to assess sedimentation. The development of wetland on the main contributing watercourses as well as a reforestation scheme in the upper catchment will reduce sediment load.

Biodiversity and Habitats

Dam construction will always result in the direct loss of riparian habitats and natural vegetation within recognised fragile and vulnerable ecological zones. This however, must be balanced against the new shoreline habitats that favour the colonization of tree species on the banks of the reservoir.

For native fish fauna, artificial barriers across rivers constitute one of the major factors threatening their population in the Mediterranean region, blocking or delaying upstream fish migration. Impacts on fish are considered to be moderate to minor at Bisri dam site, but some mitigation measures should be taken to maintain fish populations downstream of the dam and to allow the passage for migratory fish so to protect spawning grounds. The construction of Bisri dam will significantly reduce water flow downstream, which will definitely affect the freshwater blenny population surviving in the lower course of the river.

Bisri dam will have direct impacts on reptile and amphibian habitats, both upstream and downstream of the dam, which will include disruption to habitats and/or breeding sites, reducing sources of food, and increasing vulnerability to predators.

Species with poor swimming ability may become stranded and prevented from interacting with mainland populations, particularly for breeding, and make them more vulnerable to illegal hunting. Other species may be positively affected by newly created habitats.

The upper level of the reservoir approaches the lower reaches of the Moukhtara River where there are populations of rare *Bufo cf bufo*, whose habitat appears to consist mostly of rocky terrain and riparian trees, some of which will be inundated.

The presence of a large body of standing water may disrupt the flyways of migratory soaring raptor species, as they will be deprived of thermal air currents necessary for soaring and saving energy during migration.

Mammals will adapt and adjust their behavior, despite any permanent obstructions to their previous dispersal routes, after dam construction is completed. The reservoir may attract species such as bats and otters. Smaller mammals such as shrews and squirrels will tend to have smaller home ranges, and will therefore be susceptible to both habitat loss and fragmentation. Larger or more mobile species are less likely to experience significant habitat loss, albeit habitat fragmentation.

A preliminary Biodiversity Management Plan has been proposed and describes the mitigating measures, costs and responsibilities of the impacts described above. The biodiversity baseline, conservation management actions and mitigation have been generally identified and reflected in the Biodiversity Management Plan. The biodiversity specialist team described in the Biodiversity Management Plan section will develop a biodiversity monitoring plan to monitor biodiversity and habitat management, the results of which will inform the project on the level of degradation to the sensitive habitats and the presence of any direct or indirect activities/actions potentially degrading these habitats especially as it relates to the identified endangered species of fish (namely the blenny freshwater fish). To supplement the management/mitigation measures, the biodiversity monitoring plan will include surveys that will take place during pre-construction, construction and operational phases of the project. These surveys will measure indicators that include but are not limited to: water quality, environmental flow volume and quality, number of target species as well as numbers of indicator species, and cumulative impacts within the upstream watershed.

Consumption of Materials

The consumption of materials for construction will be significant and is estimated at approximately 6 million $m^{3.}$ However all granular materials and rock products are expected to be sourced from within the reservoir site. The exception may be riprap, which because of block size and rock quality specifications may need to be sourced externally. All water consumed on site is likely to be taken from the river and given appropriate treatment prior to use.

Nearly 6 million m^3 of earth materials are expected to be consumed in the construction of Bisri Dam. The majority of these materials – building aggregate, sand and clay, are expected to be taken from temporary borrow areas within and adjacent to the area of inundation, as near as is practically possible to the construction site, thereby significantly reducing reliance on quarries.

Water and Power Supplies

Based on discussions with the designer, the proposed Bisri dam water releases will be allocated securing 5.1 m^3/s or 5.8 m^3/s for the domestic needs to Greater Beirut and 0.3 m^3/s and 0.45 m^3/s for the environmental flow to be maintained downstream the dam, in summer and winter respectively.

The production of approximately 11.2 MW hydroelectric power, is considered a "by-product" of the dam releases and as such will not be considered as consumptive usage like the previous ones.

Reservoir Stratification

The anticipated conditions at Bisri – cold high-volume inflows from spring snow melt and warm low-volume inflows throughout the summer and autumn – are likely to result in the stratification of the reservoir. Failure to identify and control it frequently poses major problems for water service companies and may compromise the effectiveness of water treatment streams, the meeting of regulatory water quality standards and consumer expectation, and the adequacy of environmental flow releases.

Typically, and to be expected at Bisri, stratification becomes more severe during the summer months when the intensity and duration of sunlight increases and mixing due to reservoir inflow decreases; thus coinciding with the main period of Bisri operations. Hence a greater proportion of the reservoir turns anaerobic and in consequence minerals such as manganese, iron, sulphides and arsenic are released from bottom sediments, phosphorous and ammonia may be released. The downstream water treatment plant at Ouardaniyeh (currently under implementation under the parallel and independent Greater Beirut Water Supply Project), has been designed to take these issues into consideration.

Dam Safety

A major contribution to dam safety is the formulation of Dam Safety Plans based on Dam Breach modelling and inundation analysis undertaken by the dam designer. Often referred to as Dam Break Analysis or DBA, this primarily hydrological modelling exercise is standard procedure in dam design and provides for (i) the evaluation of design performance, including the sizing of emergency spillways, and (ii) the development of regional and community Emergency Preparedness Plans.

Because of the steep V-shaped configuration of the valley in its middle sections between the dam and the coast, the most affected villages in the path of a dam breach flood by either seismic loading or flood failures are Bisri and Khirbet Bisri a short distance downstream of the dam, and Aalmane and Quastani a short distance inland from the coast.

Detailed dam safety plans are in an advanced stage of preparation. The Quality Assurance and Construction Supervision (CSQA) plan will be finalized by appraisal as required by OP/BP 4.37.

Advisory Panel

The Advisory Panel is composed of two panels: the Dam Safety Panel and the Environmental and Social Panel.

The role of the Dam Safety Panel is to advise on all critical aspects of the dam; its appurtenant structures, its catchment areas, the surrounding and downstream areas. It is also usually in charge with oversight of project formulation, technical design, construction procedures, and associated works such as power facilities, river diversion during construction, fish ladders, etc. The Dam Safety Panel was appointed in early October 2013 and will remain under contract to CDR until the first fill of the reservoir.

The Environmental and Social Panel will provide independent review of, and guidance on the environmental and social issues associated with the planning, design, construction and operation of Bisri Dam and its appurtenant structures. The Panel will assess the extent to which the Bisri project complies with World Bank safeguards procedures.

Main Social Impacts

Construction will result in the loss of productive land estimated to extend to some 150 ha, about 25% of the area to be taken. The braided river bed and natural bankside vegetation occupies 105 ha, with built-up areas; farm buildings, housing and heritage, making up less than 1%. The remaining area is primarily uncultivated natural vegetation on the bottomlands away from the river and generally open land and scrub on the lower valley slopes. The number of built-up structures to be inundated is estimated at 135 over a total number of 88 plots with a total area of around 1.0 ha. The majority are already abandoned (some derelict) or only provide seasonal accommodation for agricultural labourers.

Land take will also occur for other project activities and associated infrastructure like the distribution lines and access roads leading to the conveyor. These have been incorporated into the final plans for expropriation.

The total number of individual plots of land, identified from available cadastral mapping, is currently identified to be about 966, split between the various cadastral regions as shown in the Table below.

Extent of Land Take within the Reservoir Area

Casa	Cadastral Region	No. of Plots	No. of plots totally expropriated	No. of plots partially expropriated	Expropriated Area (ha)	% Area Expropriated
CHOUF	Bsaba	9	5	4	6.8	1.3%
	Mazraat El Chouf	277	225	52	120	23%
	Mazraat El Dahr	55	36	19	42	8%
	Aamatour	310	279	31	160	31%
	Bater	14	6	8	8.8	2%
	Sub-Total	665	551	114	338	65%
JEZZINE	Bisri	74	62	12	44	9%
	Bkassine	2	0	2	0.3	0.1%
	Benouati	27	19	8	4	0.8%
	Ghbatiyeh	4	1	3	6	1.2%
	Harf	69	64	5	46	9%
	Aariye	1	0	1	0.95	0.2%
	Bhannine	28	15	13	10	2%
	Midane	80	70	10	48	9%
	Deir-el-Mkhaless	3	0	3	2	0.4%
	Khirbit Bisri	13	4	9	18	3%
	Sub-Total	301	235	66	179	35%
Expropriation Grand Total		966	786	180	517	100%
Domaine Publique (river + roads)					53	
Total Land take					**570**	

Benefit Sharing Program

To ensure an equitable distribution of Project benefits, the project will establish a Benefit Sharing Program to provide the means to improve community services on the surrounding hills and throughout the dam catchment and the local environment. This shall be carried out initially through the capital funds available for the project (as reflected in the RAP budget), later through continued revenue from primary beneficiaries which are the GBA consumers. Capacity building will be ongoing to mitigate the project's environmental and social risks and to ensure inclusive communication with all project stakeholders.

Induced Development

Given the relative uniqueness of the Bisri scheme and its proximity to urban centres such as Beirut and Saida, visitor attraction may be expected will commence soon after the start of construction. The precursor to induced development may therefore be coffee vans and refreshment trucks, with existing cafés, petrol stations and other services in Bisri and villages en-route from the highway catering for the influx.

On the overlooking hillsides the demand for land on which to construct villas, apartment blocks, hotels, hill resorts and restaurants, all with access roads and public infrastructure will be extensive. While these may also occupy shoreline plots, waterside land is more likely to induce smaller water sport focused accommodation, camping and picnic sites, bathing areas, shoreline walkways and cycle tracks, boat rental and repair yards, yacht and canoe clubs. In addition to visitor and recreational activities, the reservoir will also afford the opportunity to expand local irrigated agriculture and develop water-based commercial enterprises.

Induced development will only impart positive environmental and social impacts if it complies with a well formulated and agreed Master Plan. If development is not planned and piecemeal, or certain political and/or commercial interests are allowed to violate the Plan, the results may be entirely negative.

GBSWAP *Cumulative Impacts*

The cumulative impacts assessment focuses on the interaction of the GBWSAP Project and developments that are realistically defined at the time the environmental assessment is undertaken, where such projects and developments could directly impact on the project area of influence. The Table below is a matrix showing those incremental impacts with some existing developments and others proposed.

Cumulative Impacts on Selected VECs

		Existing and Proposed Projects			
VECs	**Parameters**	**GBWSP**	**HEPs (Joun, Awali, and Anan)**	**Sewerage Treatment Schemes**	**Reforestation Scheme**
Water	*Water Abstraction*	0	0	0	0
	Water Quality	+	0	+	+
	Flow Rate	+	0	0	+
	Domestic Water Supply	+	0	0	0
Air	*Greenhouse Gases*	0	-	+	+
Power	*Power Supply*	0	+	0	0
Land Use	*Land Cover*	0	0	0	+
	Reservoir Sedimentation	0	0	0	+
Habitats and Wildlife	*Species Diversity*	0	0	0	+
	Species Population	0	0	0	+
Public Health	*Health Costs*	+	+	+	+

+ Positive Cumulative Impact
- Negative Cumulative Impact
0 No Cumulative Impact

The Table below summarises the impacts that might accrue from Bisri dam and the mitigation measures proposed for each impact, while the table that follows summarizes the estimated costs.

Summary of Potential Impacts Arising from the Bisri Scheme

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
Land Take	Land taken for dam and reservoir, access roads	Unavoidable	Major	Locate reservoir to minimize land take and loss of natural landscape per unit volume impoundment.	Designer
	Loss of natural landscape	Expected	Moderate		
	Land take for `resettlement and/or relocation of PAPs	Unavoidable	Minor	Locate reservoir to minimize land take per unit volume impoundment. Provide adequate resettlement and compensation in accordance with RPF and RAP compliant with Lebanese Law.	Designer, RAP Developer and Project Proponent
	Loss of existing communities	Not Expected	n/a		
	Loss of individual homes	Unavoidable	Moderate		
	Loss of non-agricultural business premises	Not Expected	n/a		
	Loss of productive land	Unavoidable	Major		
	Loss of temporary employment	Unavoidable	Major		
	Loss of permanent employment	Expected	Moderate		
	Loss of historic and cultural heritage	Unavoidable	Major	Salvage cultural property and reconstruct within existing communities. Avoid inundation of immoveable sites such as burial grounds. Undertake rescue archaeology.	Project Proponent
Impoundment	Additional loss and severance of access	Expected	Moderate	Create alternative access roads around the reservoir;	Project Proponent
	Increased risk of seismicity	Expected	Major	Analyze hydraulic loading to assess seismic potential and avoid areas of high risk. Design to minimise seismic loading.	Designer
	Loss of natural vegetation	Unavoidable	Moderate	Increase planting around reservoir;	Designer
	Impaired water quality from uncleared vegetation	Unavoidable	Major	Vegetation and soil to be cleared prior to inundation. Treatment plant will provide suitable process stream to ensure water delivered to GBA of potable quality.	Contractor

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	GHGs from uncleared vegetation	Expected	Major	Vegetation and soil to be cleared prior to inundation.	Contractor
	Soil erosion along new foreshores	Expected	Major	Construct shoreline protection. Increase planting around reservoir.	Designer and Contractor
	Reservoir stratification	Expected	Major	Install provision for mechanical mixing where natural circulation insufficient.	Designer
Sedimentation	Creation of backwaters on tributary streams	Expected	Moderate	Promote development of wetlands. Promote reforestation of upper catchment slopes. Monitor reservoir depth to assess sedimentation. Operate reservoir to minimize sediment build-up. Allow for sediment loading in structural design.	Designer and Operator
	Loss of capacity and sediment build-up at dam	Expected	Moderate		
Upper Watershed Management	Road construction opens area to non-residents	Expected	Minor	Ban land clearance for new agriculture. Restrict access to previously remote areas.	Project Proponent
	Soil Erosion and Sedimentation	Expected	Moderate	Promote reforestation of upper catchment slopes and the expansion of existing forests.	Project Proponent
	Social unrest due to the restriction of human activity	Not Expected	n/a	Ensure new developments prioritize local employment.	Project Proponent and Contractor
	Loss of water quality due to evaporation	Unavoidable	Major	Promote shoreline planting and reforestation.	Operator
	Impaired water quality due to discharges above dam	Expected	Moderate	Adopt an integrated planning framework and a strict ESMP, and provide effective enforcement. Developing sewerage and solid wastes systems for villages throughout the upper watershed in accordance to GoL master Plans.	Project Proponent
Lower Watershed Management	Reduced non-agricultural surface water resources	Unavoidable	Moderate	Provide agricultural extension and other services to promote low water-use crops and irrigation practices. Ensure resettled communities are adequately resourced without detriment to existing communities.	Project Proponent
	Reduced water resources for existing agriculture	Unavoidable	Moderate		
	Water-use conflict	Expected	Moderate		
	Loss of stock watering points	Not Expected	n/a	None required	

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	Salinization of downstream floodplain	Expected	Moderate	Provide adequate compensatory flows to leach salt build-up.	Project Proponent
	Reduced dilution of chemical residues, sewage	Expected	Moderate		
	Reduced Dissolved Oxygen downstream	Expected	Moderate	Provide for multi-level releases to avoid the discharge of anoxic water. Design for aeration downstream of dam site;	Designer
	Scour by water released under increased head	Expected	Minor	Provide for energy dissipation from dam outflow; Provide for sediment trap and its orderly release.	Designer
Ground Water	Reverse ground water flow upstream of the dam	Expected	Moderate	Undertake hydrogeological study and modelling to assess impact on ground water levels and flow;	Designer
	Change in water table	Expected	Moderate		
	Reduced downstream aquifer recharge	Expected	Moderate	Provide adequate releases to maintain recharge; Provide downstream structures to induce shallow recharge.	Designer and Operator
	Deterioration in ground water quality	Expected	Major	Promote ground water resources management.	Project Proponent
Biodiversity and Habitats	Loss of indigenous flora	Unavoidable	Moderate	Promote the colonization of shoreline trees. Provide for species rescue and relocation. Minimise disturbance of non-inundated vegetation.	Operator
	Loss of terrestrial habitats	Unavoidable	Moderate	Provide mammal-resistant fencing. Provide for species rescue and relocation. Provision safe crossing points to enable dispersal and links between fragmented populations.	Operator and Project Proponent
	Reduced downstream biodiversity	Expected	Moderate	Provide compensatory discharges to maintain downstream biodiversity.	Operator
	Build-up of weed and algal mats around spillways, etc.	Expected	Moderate	Control algal blooms by using appropriate additives (e.g. 22 kg/ha $CuSO_4$). Harvest weed and algal growth for compost, fodder or biogas.	Operator

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	Disruption of flyways	Expected	Minor	Planting trees to create habitat corridors; National hunting ban to be enforced as per Law 580/04.	Operator
	Reduced aquatic habitats	Expected	Major	Provide fish leats, ladders and other by-passes. Protect spawning grounds; Incorporate sensitive design, i.e. allow shallow areas for spawning, etc.	Designer
	Barrier to fish migration and loss of spawning areas	Expected	Moderate		Designer
	New habitats for migratory bird species	Expected	Positive	Promote reforestation and areas of dense shrub.	Operator
	New farming fish species	Expected	Positive	Ban the introduction of exotic species such as trout, bass, tilapias, and mosquitofish. Promote the user of native species.	Operator
Agriculture	Inundation of agricultural land	Unavoidable	Major	Consider stripping highly fertile soils from reservoir area and spreading on adjacent less fertile land.	Project Proponent and Contractor
	Loss of fertile soils	Unavoidable	Major		
	Loss of yet-to-be-harvested crops	Unavoidable	Major	Consider relocating the poly-tunnels and their content with no actual loss, or move when fallow.	Project Proponent
	Derogation of downstream irrigation	Unavoidable	Major	Use agricultural extension to promote low water-use crops species and irrigation practices.	Operator
	Fertilizer use upstream increases nutrient load	Expected	Moderate		
	Increased soil salinity downstream	Expected	Major	Provide compensatory discharge to leach soil salts.	Operator
Settlement and Resettlement	All residents in the inundated area will be displaced	Unavoidable	Moderate	Provide adequate compensation in accordance with RPF and RAP compliant with Lebanese law.	Project Proponent
	Disaggregation of communities	Not Expected	n/a	No significant communities to disaggregate. Resettlement unlikely to result in conflict as resident Lebanese PAPs will keep within their previous communities.	
	Impact on indigenous groups/lifestyles	n/a	n/a		
	Social conflict between existing residents and PAPs	Not Expected	n/a		
	Competition for resources between residents & PAPs	Not Expected	n/a	None required.	

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	Particular impacts on vulnerable groups	Expected	Moderate	Provide social support to vulnerable groups. Use resettlement to aid poverty alleviation.	Project Proponent
Public Health	Increase in water-related diseases	Unavoidable	Moderate	Implement health awareness campaigns and provide adequate health care facilities. Maintain water free of algae. Develop and implement an Emergency Response Procedures.	Operator
	Increase in mosquito breeding sites	Unavoidable	Moderate	Implement health awareness campaigns and provide adequate health care facilities. Spray mosquito breeding sites if necessary.	Operator
	Climatic changes such as increased humidity & fogs	Expected	Moderate	None.	
	HV transmission lines in proximity to housing	Not Expected	n/a	Power generated at dam to be used at dam. New turbines for network distribution to be located at existing plant will utilise existing cableways.	
Indirect Issues	Negative impacts from increased urban development	Expected	Moderate	Adherence to coordinated sustainable development via Shoreline Development Master Plan.	Project Proponent
	Upper catchment activities limit dam efficiency	Expected	Moderate	Restrict activities on the upper watershed to those that have minimal environmental and social impact.	Project Proponent
Construction Issues	Construction site unsightliness	Expected	Moderate	Construction contractors to offer priority employment to PAPs and other local residents; Contractor to develop and implement a comprehensive Construction Environmental and Social Management Plan.	Contractor
	Increase traffic generation and exhaust emissions	Expected	Moderate		
	Noise and dust from site clearance and excavation	Expected	Moderate		
	Temporary works such as drainage diversion	Unavoidable	Moderate		
	Camp working area sewage and solid waste disposal	Expected	Moderate		
	Emissions from batching plants & power generators	Expected	Moderate		
	Increased hunting, egg collecting, live capture	Expected	Moderate		
	Social conflict between workers and residents	Expected	Minor		Contractor

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	Importation of contagious diseases	Expected	Minor		
	Fuel spillage and waste oil disposal	Expected	Moderate		

Likelihood

	Not Expected
	Expected
	Unavoidable
	Not Applicable

Likely Severity

	Minor
	Moderate
	Major
	Positive
	Not Applicable

Summary of Proposed Environmental and Social Impact Mitigation Measures Costs

Issue	Mitigation Measures	Responsible Party	Basis of Cost	Estimated Cost ($)
Land Take and Resettlement	Archaeological rescue and safe storage of artifacts	DGA and Project Proponent	Consultant's estimates with storage site acquisition, clearance, fencing and building- Included in Construction Costs	$500,000
	Relocation of Mar Moussa Church, St. Sophia's Monastery, and architectural salvage	Maronite Diocese of Saida and Project Proponent	Deconstruction and reassembly of main walls, demolition and replacement of church interior vaulting. Included in construction costs.	$2,000,000
Impoundment	Increase planting around reservoir.	Operator and MoA	Tree band 12 m wide, planted on a 3 m grid, over half the reservoir periphery	$3,000,000
	Design and install provision for mechanical mixing where natural circulation insufficient.	Designer and Contractor	Included in construction costs	n/a
Sedimentation	Promote development of wetlands.	Operator	Promotion budget only	$10,000
	Promote reforestation of upper catchment slopes	MoA and Municipalities	Promotion budget only	Included above
Upper Watershed Management	Promote reforestation of upper catchment slopes and the expansion of existing forests.	As above	Promotion budget only	Included above
	Adopt integrated planning, a strict ESMP, and effective enforcement.	GOL, DGUP, Project Proponent & Municipalities	Of wider benefit that GBWSAP and should come from GOL budget	n/a
	Develop sewerage and solid wastes systems for villages throughout the upper watershed.	Project Proponent, MEW, and Municipalities	various documents supplied by CDR	$23,000,000
Lower Watershed Management	Design and provide for multi-level releases to avoid the discharge of anoxic water, and for downstream aeration.	Designer and Contractor	Included in construction costs.	n/a
	Design and provide for energy dissipation from dam outflow and sediment trap	Designer and Contractor	Included in construction costs.	n/a
Biodiversity and Habitats	Biodiversity Management Plan	Mitigation Activities and specialist staff.	Biodiversity specialist and species specialist part-time for pre-construction, construction and reservoir filling.	$687,000

Issue	Mitigation Measures	Responsible Party	Basis of Cost	Estimated Cost ($)
Agriculture	Provide agricultural extension to promote low water-use crops species and irrigation practices.	MoA and MEW	Extension office for 2 years, with vehicle, admin support, etc.	$500,000
	Provide compensatory discharge to leach soil salts.	Operator	Included in construction costs	n/a
Public Health and Safety	Implement health awareness and water safety campaigns.	MoH and Operator	Awareness and safety campaigns	$200,000
	Spray mosquito breeding sites if necessary.	Operator	Operator, protective clothing, water-safe chemicals, labor, 3 applications/year	$2,000,000
	Provide for Public Safety at dam site	Designer, Contractor and Operator	Fencing and signage (Included in construction costs)	n/a
	Develop and implement an Emergency Response Procedures.	Designer, Operator, Civil Defense and Municipalities	Included in GOL costs	$1,000,000
Construction Issues	Contractor to develop and execute a comprehensive Construction Environmental and Social Management.	Project Proponent, Contractor and Construction Manager	Included in construction costs. 'Best Practice' construction only.	n/a
Total Costs of Mitigation beyond normal Design, Construction and Operation				$32,897,000

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The proposed programme of environmental and social monitoring is summarized in the Table below.

Environmental Quality Monitoring Requirements

Category	Indicators	Location	Method	Duration	Frequency	Purpose	Expertise Required	Responsibility	Estimated Cost	Total Estimated Costs
Pre-Construction Environmental Quality Monitoring										
Surface Water Quality	Lebanese Potable Water Standards	4 locations; Nahr Barouk and Wadi Bhannine at extremities of reservoir, two other seasonal inflows	Water sampling and full laboratory analysis	Ongoing until completion of construction and throughout operations	Quarterly, varied to include high and low flows	To confirm background conditions for comparison in operational monitoring	Experienced surface water sampler	BMLWE	$1,500 per sample	$330,000 (including staff costs)
Rate of Sedimentation	Volume and size of sediment captured	Nahr Barouk and Wadi Bhannine at extremities of reservoir	Sediment capture behind a small weir or sediment capture pit	Ongoing	Quarterly, varied to include high and low flows	To confirm design assumption	Hydrologist	BMLWE	$15,000 per site	$600,000
Rescue Archeology and Heritage Relocation	Archaeological finds unearthed and documented	Marj Bisri	Excavation, observation and documentation	Ongoing until completion of construction	Seasonally	To make sure implementation strategy is implemented	Archaeologist	DGA	$120,000	$ 120,000
	Structures removed and reconstruction	Mar Moussa	Dismantling and reassembling	Prior to construction	Monthly	To address community concern for heritage	Building conservationist	DGA	US$ 250,000	$ 250,000
Land Expropriation and Resettlement	Progress of expropriation execution. PAP satisfaction	All lands to be acquired under the project	Expropriation and resettlement reporting	Throughout expropriation	Monthly for 6-months, then bi-annually.	To monitor progress and ensure transparency	Community Liaison Office	CDR	500,000	500,000
Construction Environmental Quality Monitoring										
Site Inspection	General construction activity	All sites associated with the Bisri construction	Visual and descriptive, against check list	Ongoing throughout period of construction	Daily	To ensure compliance with good construction practice and EMP	Environmentalist with construction site experience	Construction Manager	$2,000,000	$ 2,000,000
Complaint Investigation	Any parameter relevant to the nature of the complaint	At or in the vicinity of sites for which complaints are received	As appropriate for the parameter being monitored	As necessary	As necessary	To investigate complaints and provide a basis for redress	Environmentalist with experience of field monitoring and analysis	Contractor and Construction Manager	Depends on complaints received	n/a
Health and Safety	Absence of unauthorized public. Injuries and work days lost among workers.	All sites of construction and project related activity	Primarily visual and descriptive, against a check list. Time card records	Ongoing throughout period of construction	Monthly	To protect the public and workers in accordance with H&S BMPs	Experienced H&S site supervisor	Contractor and Construction Manager	Included in construction costs	n/a

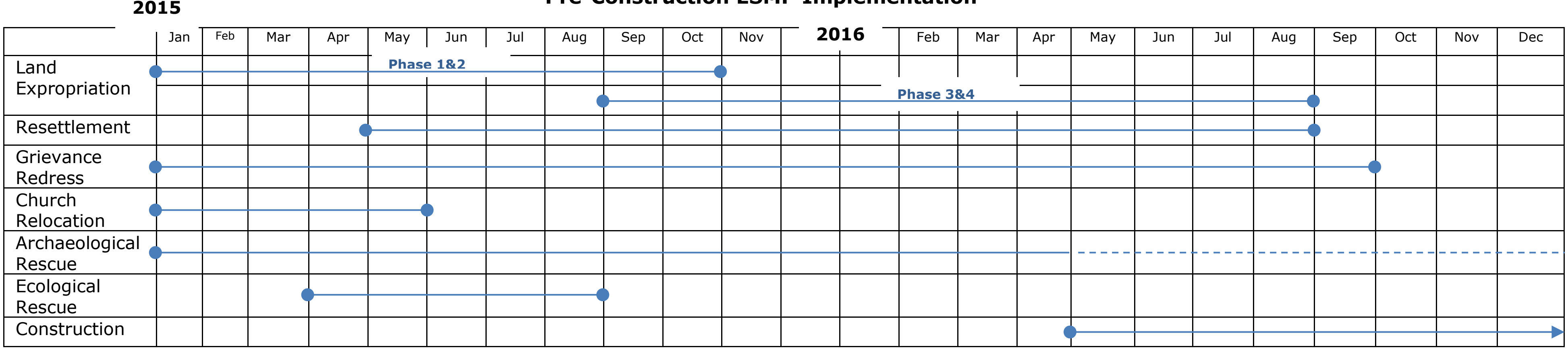
Category	Indicators	Location	Method	Duration	Frequency	Purpose	Expertise Required	Responsibility	Estimated Cost	Total Estimated Costs
Air Quality	Lebanese atmospheric emissions standards, fixed and mobile	Contractors' work sites and selected sensitive receptors	Visual assessment and portable air quality equipment	Dependent on source	On suspicion of non-compliance	To prevent air pollution	Site inspector	Contractor	Included in construction costs	n/a
Noise	Lebanese ambient noise standards	At selected sensitive receptors	Ambient noise monitoring equipment of approved manufacture	Over 1 hour during the working day	On suspicion of non-compliance	To prevent noise nuisance	Site inspector	Contractor	Included in construction costs	n/a
Cultural Heritage	Documented Chance Finds	Any unknown remains unearthed during construction	DGA standard procedures	As necessary	Every find DGA deem worthy of recording	To improve understanding of Lebanese and optimize relic recovery	DGA Inspector	Contractor and DGA	Depends on number of finds and delay caused	n/a
Post-Construction Environmental Quality Monitoring										
Air Quality	Stack emissions from stand-by generators	At stacks and sensitive receptors	Portable stack insertion monitors and other monitors	Over 12 hours	Every 3 months during the operating season	To prevent air pollution	Plant Engineer	BMLWE	US$ 500 per sample	US$ 5,000
Workers Health and Safety	No. of accidents and working days lost	On the dam and reservoir sites	H&S records	Ongoing	Ongoing	To monitor compliance with Operator's H&S Manual.	Operator's Health and Safety Inspector	BMLWE	Included in ongoing O&M	n/a
Public Health and Safety	No. of accidents and injuries.	Dam, reservoir and environs	Accident reports	Ongoing	Ongoing	Promote security and safety, and adequacy of signage.	Compliance with Operator's H&S Manual and EMP.	Compliance with Operator's H&S Manual and EMP.	Included in ongoing O&M	n/a
Dam Safety	Dam Safety Panel inspection reports	Dam site	Visual inspection and review of Dam Safety File	Ongoing	Throughout construction and every 3-5 years, post construction	To identify early warning signs of potential failure	Dam Safety Inspection Panel	BMLWE/CDR	$25,000 per inspection	$ 25,000
Reservoir water	To check development of stratification	2 fixed sampling points within reservoir	Multiple depth sampling and on-site analyses	Seasonal	Monthly from May to October	To confirm adequacy of mixing to limit stratification	Experienced water sampler and boatman	BMLWE	$1,000 per sample	$30,000
Groundwater	Groundwater flow and water quality	Selected springs and wells	- Flow gauging, water level monitoring and sampling	Ongoing	Bi-annual	To identify changes in groundwater regime	Hydrogeologist	BMLWE	$3,000 per sample	$30,000
Biodiversity	Diversity of species and habitats	Dam, reservoir and environs	Visual observation and survey	Seasonal	Annually for 3 years, then every 5 years	To assess fish migration and reduced biodiversity	Ecological team	BMLWE	$20,000	$80,000
Downstream abstraction	Adequacy of environmental flows	Downstream abstraction sites	Survey of abstractors	During Autumn	Annually	Optimize abstraction management	Agriculture extension officer	MoA/MEW	$10,000	$50,000
Reservoir Sedimentation	Sediment build up	Reservoir	Depth or Echo sounding	Ongoing	Annually, in May or June	To check loss of dead storage and protect intakes	Mechanical Engineer and Boatman	BMLWE	$10,000	$50,000
Induced Development	Adherence to Shoreline Master Plan	Surrounding lands	Enforcement of planning regulation	Ongoing	Ongoing	Safeguard investment in dam and protect water resources	Development inspector	Planning Authorities and Municipalities	No cost to project	n/a
Total Monitoring Costs										$4,070,000

Note: Total Costs are calculated for 5 years of operation

ESMP Planned Implementation

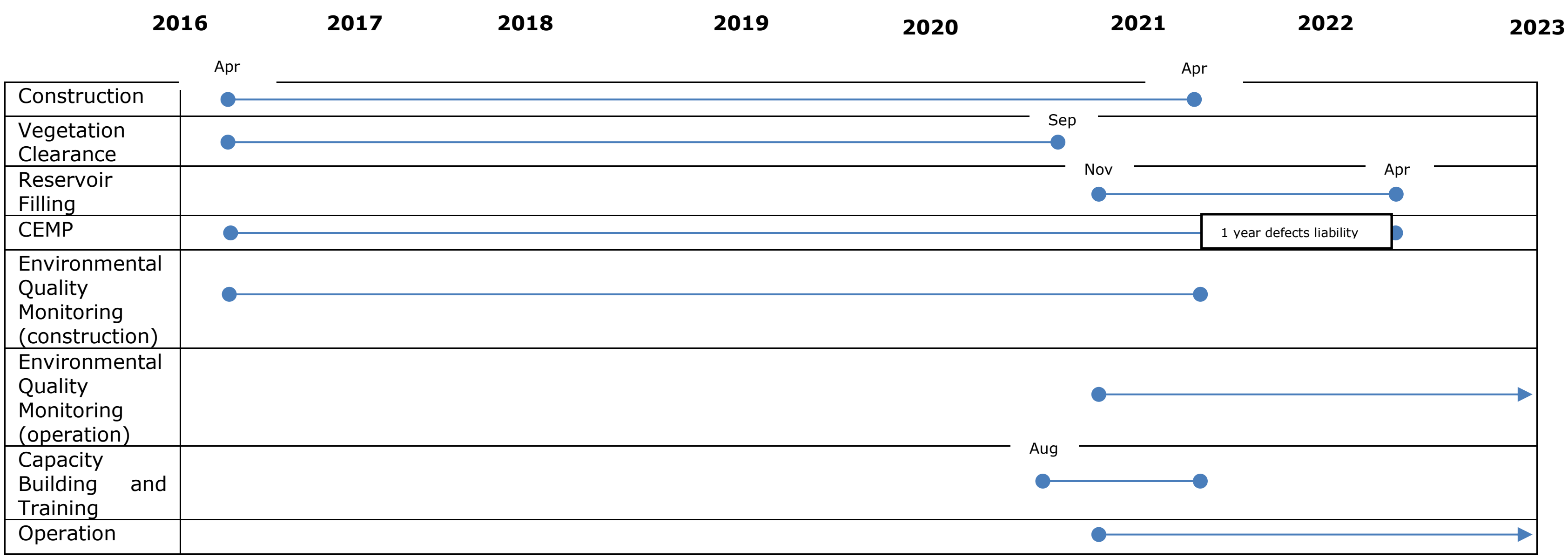
The following Tables show the proposed schedule for the implementation of the ESMP pre-construction, during construction, and during operation.

Pre-Construction ESMP Implementation



*Final Project Approval (Day Zero)

Construction and Operation ESMP Implementation



Institutional Structure and Responsibilities

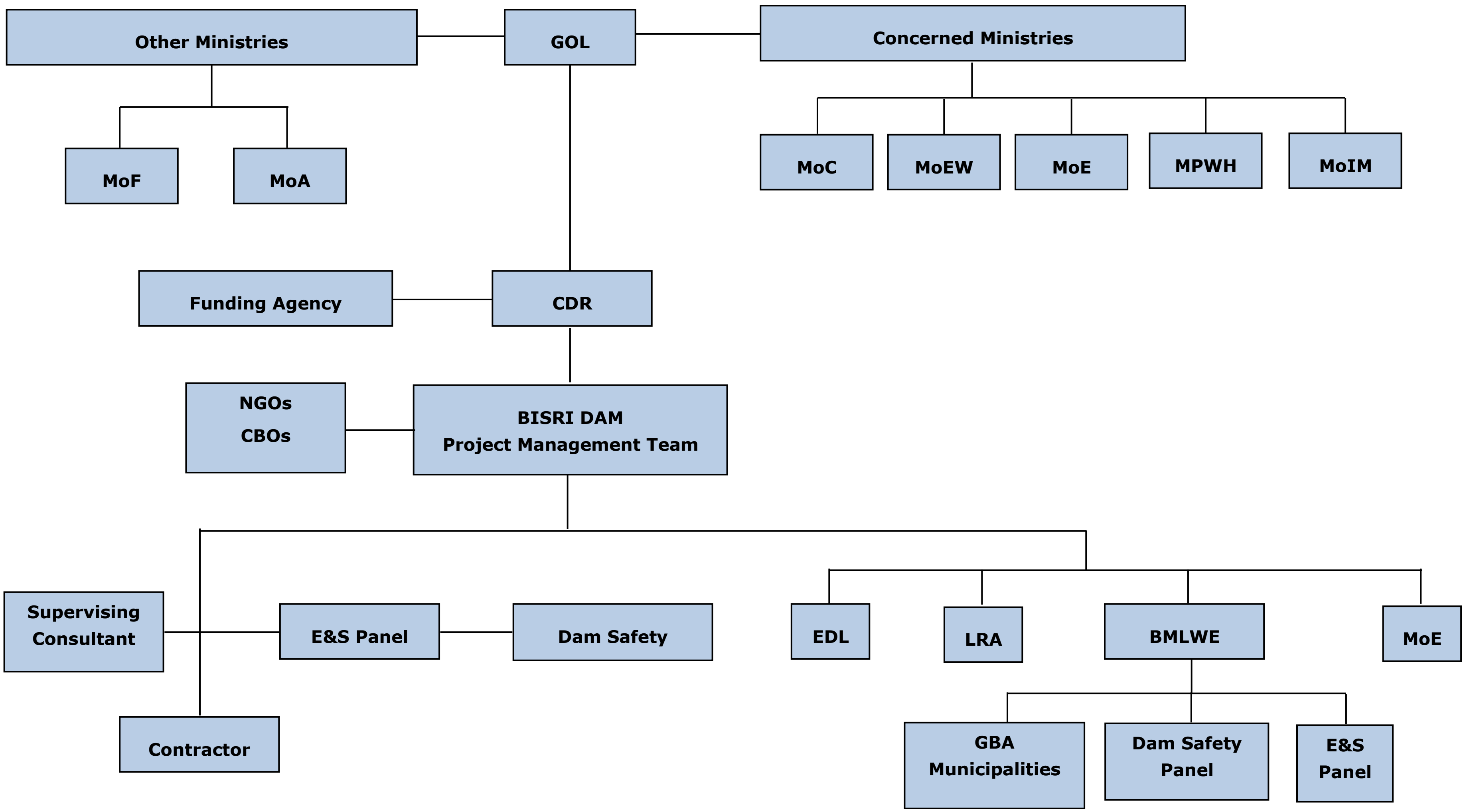
The prime institutional stakeholders in respect of expected management structure and responsibilities are shown in the Figure and Table below, respectively.

Prime Institutional Stakeholders for Bisri Dam Management

Institution	Prime Responsibilities
CDR	In its planning role, commissions specialist studies and dam design, secures funding, pre-qualifies contractors and manages the tender process through to award, executes land acquisition, and on behalf of GoL acts as the contract administrator.
MEW	The effective dam owner; establishes operational policy including determining available yields and environmental releases. Ensures formal Dam Safety Panel inspections are undertaken according to pre-agreed schedules, in coordination with CDR.
BMLWE	Day-to-day operational management of the dam and its appurtenances, implements MEW policy, ensures environmental yields are delivered to riparian owners. Maintains the dam, the reservoir shoreline and operational monitoring. Facilitates dam safety and E&S panel inspection visits. Responsible for public safety including the maintenance of warning signage. Manages structures and water resources downstream of the offtake upstream of the Joun power plant to the Awali Conveyor, the treatment plant, post-treatment distribution, leakage reduction, cost billing, etc.
MoE	Setting and monitoring the adequacy of environmental flow releases to cater for non-abstraction requirements. A *statutory consultee* for the Dam Safety Panel. As existing laws, shoreline development environmental permitting.
EDL	Purchase the hydropower output and sell it on customers at a rate that at least ensures cost recovery.
MPWT	Implements the Bisri Reservoir Shoreline Development Master Plan.
MoA	Puts in place agricultural extension services to maximise the efficiency of downstream irrigation practices for minimum water use. Advises MEW on the adequacy of releases to maintain legal abstractions. Advises the dam operators on the permitting of commercial fish farming within the reservoir.
LRA	Manages the two hydropower plants ancitipated through the Bisri project to offset lost hydropower at the Charles Helou power plant.

Institution	Prime Responsibilities
DGA	Collection of pottery shards, glass and other artifacts from surface soils and shallow excavations at previously identified sites; Trial pitting and/or geophysical surveying at selected sites where buried structures may be present; Major excavation and the removal of material at Marg Bisri Roman temple; Excavations in the vicinity of Mar Moussa Church and the remains of St. Sophia's monastery. Archaeological finds unearthed and documented during construction
Diocese of Saida	Deconstruction, removal and reconstruction of Mar Moussa Church and of St. Sophia's Monastery; and, Scavenging old building materials from the ruins of 19-20th century houses to provide for new construction adjoining the relocated Mar Moussa Church.
Concerned Municipalities	Implementation of Land Expropriation Procedure
MoSA	Implementation of the RAP especially regarding refugees registered at the UNHCR
UNHCR	Assist the 79 registered UN refugees (as per the date of the project cut off date on March 20, 2014 – see RAP for details) with resettlement to UNHCR designated refugees camps if they are willing to. Facilitate the other 23 non-registered refugees to get registered with the UNHCR and eventually assist them with their resettlement to refugees' camps.

Institutional Structure for Bisri Dam Management



CAPACITY BUILDING AND TRAINING

Bisri dam will require a substantial programme of capacity building, provided through (i) the new employment of suitably qualified managers and maintenance staff, (ii) training schemes for selected existing staff, and (iii) the subcontracting of selected services, or indeed the overall management of the dam and reservoir pending the building of in-house capacity.

As part of the construction contract, it will be important for MEW and BMLWE staff to be seconded to the teams of both the contractor and construction manager to receive hands-on knowledge and experience of the equipment and apparatus installed. Selected operations staff proposed for supervisory positions should be given the opportunity to visit and receive detailed briefing, including hands-on training, at dams of similar size and purpose outside Lebanon.

While MoA already provides extension services, the consensus among agriculturalists is that it does not provide the level of expertise required to optimise farming efficiencies. Capacity building of staff in respect of modern low water-use crop species and irrigation equipment and practices is therefore likely to be required.

It is important to note that the ESMP in this document incorporating all sub-components including mitigation and monitoring measures reflects the final design. The Church relocation will be undertaken by the contractor and capacity building for chance finds will be included in general HSE briefings to staff.

Total cost of capacity building and training is estimated at $ 192,000.

Total Costs of the ESMP Implementation

The Table below summarizes the total costs of the ESMP implementation assigned for mitigation measures, monitoring, monitoring reporting, and capacity building.

Total Costs of ESMP Implementation

Mitigation Measures	$32,897,000
Monitoring	$ 4,070,000
Capacity Building	$ 192,000
Total Costs of ESMP Implementation	**$ 37,159,000**

CONSULTATION AND COMMUNICATIONS

In accordance with CDR policy on public participation, which generally follows that of the World Bank and other international funding agencies, a Consultations and Communications Programme (C&CP) detailing the steps that are to be followed throughout the project, from site selection through to commissioning has been drafted.

From the beginning of the Project and throughout the ESIA process, institutional stakeholders have been consulted at scoping and briefing levels as described below. Additional discussions have been carried out with MoE, DGA and Maronite Diocese of

Saida to reach agreement on specific issues including water quality monitoring, Mar Moussa church relocation, and archaeological recue, described in the ESIA.

At the outset of the EIA process, a series of Scoping sessions then followed by collaborative and information meetings during April and May 2012, commencing with an institutional stakeholders session at the CDR offices in Central Beirut to which stakeholder ministries, government agencies and NGOs were invited. This was followed by a consultation session held at Mazraat El Dahr Municipality in the vicinity of Bisri dam. Finally, two separate sessions were held for Beirut residents, the prime GBWSAP beneficiaries.

The safeguards (ESIA and RAP) consultant presented the results and recommendations of the ESIA study in different venues for institutional stakeholders, for local PAPs in the villages in the vicinity of the proposed Bisri dam, and for Greater Beirut residents. The date and timing of all meetings were agreed with individual municipalities. The village sessions were scheduled at weekends and early evening's week-day for Beirut Water Consumers to allow the maximum number of concerned people to attend.

Following revisions to the ESIA and RAP consequential upon changes to Dam design, land expropriations requirements, completion of the household survey and the establishment of indicative costs, further sessions of public consultation were in April 2014. The following table summarizes all public consultations carried since the beginning of the Project.

Date	Location	Time	Venue	Attendees
2012				
3 April 2012	Beirut	10am	CDR	Institutional Stakeholders
10 April	Mazraat El Dahr	10am	Mazraat El Dahr Municipality	PAPs
24 April	Hadat	10 am	Hadat Municipality	Water consumers of Greater Beirut Area
5 May	Beirut	10am	Beirut Municipality	Water Consumers of Central Beirut
2013				
30 January	Beirut	10am	CDR	Institutional Stakeholders
2 February	Midane	10am	Midane Municipality	PAPs
2 February	Mazraat El Dahr	3.30pm	Mazraat El Dahr Municipality	PAPs
6 February	Hadat	5pm	Hadat Municipality	Water consumers of Greater Beirut Area
9 February	Ammatour	10am	Ammatour Municipality	PAPs
9 February	Mazraat El Chouf	2:30pm	Mazraat El Chouf	PAPs

			Municipality	
2014				
Friday 25 April	Ammatour	10.00am	Dar Ammatour	PAPs
	Mazraat El Chouf	3.00 pm	Municipality Hall	PAPs
Saturday 26 April	Bisri	10.00am	Church Hall	PAPs
	Mazraat El Dahr	3.00 pm	Municipality Hall	PAPs

The objectives and benefits of the Project including induced development in the area and the possibility of establishing a Benefit Sharing Program have been presented and explained to the audience. Main environmental and social impacts and mitigation measures were highlighted. The details of expropriation procedure along with compensation entiltelments have also been explained. The overall attitude of all four audiences was strongly opposed to the construction of Bisri Dam. As was always anticipated, the majority of comments raised from the floor concerned land expropriation and asset compensation.

Main issues raised by PAPs in the four villages included: (i) need to allocate water and power generated by Bisri dam to neighbouring villages and account for irrigation needs, (ii) benefit of project should go to villagers not GBA residents to encourage them to stay in their villages, (iii) loss of productive land and biodiversity, (iv) cash compensation is not enough especially that land has an inheritance value to landowners, (v) PAPs want to get involved in property valuation, (vi) municipalities should benefit from Bisri dam revenues and get yearly compensation to invest in development in neighbouring villages, (vii) need for access roads to villages, (viii) need to relocate historical and archaeological remains, (ix) study desalination as an alternative, (x) need to study risk of seismicity, (xi) need for wastewater treatment schemes in villages in the upper catchment, (xii) surface water quality, (xiii) pesticide residues in water, (xix) vector-borne diseases and bad odours in the Project area, (xx) increased water salinity and impact on agriculture and residents, (xxi) possibility of creating several ponds instead of a large dam, (xxii) possibility of passing a law for the establishment of a company for Bisri dam similar to Solidere where landowners are shareholders, (xxiii) relocate the proposed dam axis.

CDR will continue consultations throughout the period of land expropriation and beyond from a Project Information Centre (PIC). The ESIA and the RAP will be disclosed in and will be followed by disclosure at the World Bank's *Infoshop.*

SECTION 1

INTRODUCTION

1. INTRODUCTION

1.1 Project Background and Rationale

Lebanon is often perceived to have relatively abundant surface and ground water resources, but while better off than its neighbours, 35th out of 186 countries[1] ranked by severity of water stress[2], annual water availability is less than 1000 m^3 per capita.

The majority of Greater Beirut's water is supplied by the karstic limestone aquifers of Mount Lebanon from the cavern outflows at Jeita and piped to the capital via the Dbaiyeh Treatment Plant. Other significant sources include wellfields at Makhada, Nahr el Kalb, Antélias and Damour, individual wells scattered among the southern Beirut suburbs, and spring sources such as Kachkouch and Ain Ed Delbe. Supplies are inadequate to meet demand; intermittent during the winter months, while during the summer many consumers receive water for just 3 hours each day or even less. The majority of households and businesses have alternative supplies, and many recently constructed buildings have no mains connection, preferring to rely upon private wells within the building plot, and to buy bottled water for drinking and cooking. In designated areas private wells are illegal as there is a long-standing moratorium on drilling, but the procedures for permitting and abstraction licensing are not implemented and there is no compliance monitoring or enforcement. There is also a well-developed and profitable trade in the delivery of tankered water, often taken from non-potable sources subject to saline intrusion and/or wastewater infiltration.

The Central Administration of Statistics (CAS) predicts the population of Greater Beirut will grow from 2 million in 2010 to 2.2 million in 2025 and 3.5 million by 2035[3]. It is projected that water shortages will become more severe and chronic starting 2020, especially during the 6 to 7 dry months due to the increasing water balance deficit.

The reasons for Lebanon's water stress include but are not limited to, the following:

- Insufficient and often inefficient source development;
- Inefficient, limited and aged transmission and distribution networks;
- Absence of volumetric metering and consumption-related tariff structure;
- Over-abstraction of ground water, resulting in saline intrusion;
- High proportion of non-revenue water and poor cost recovery;
- Poor resources allocation, abstraction licensing and monitoring;
- Uncontrolled discharges of industrial and domestic wastewater;
- Uncontrolled irrigation and over-fertilization;
- Lack of investment in modern water infrastructure;
- Lack of institutional capacity; and,
- Lack of public awareness, consultation and participation.

[1] *Maplecroft Global Risk Portfolio*, 2011. Syria 17th, Jordan 11th, Israel 8th, Egypt 9th, KSA 4th
[2] Water stress occurs when availability falls below 1,700 m^3/year/head of population. Falkenmark and Lindh, *Climate Change 2001: Working Group II: Impacts, Adaption & Vulnerability*. UNEP/WMO, 1976.
[3] Central Administration of Statistics, 2010.

Notwithstanding this, realisation that Greater Beirut and other areas face such problems is not new. Since at least the 1950's, successive governments have invested in a range of alternative sources including improved spring capture, increased ground water abstraction, small hill lakes and impoundment reservoirs.

To secure short and medium term water supplies, the Government of Lebanon (GoL) through the Council for Development and Reconstruction (CDR), MEW and Beirut and Mount Lebanon Water Establishment (BMLWE) has initiated the Greater Beirut Water Supply Project (GBWSP) under which the 50 Mm^3 of Nahr Litani water from Qaraoun Lake and Awali-Jezzine ground water currently delivered each year to the Joun hydroelectric power plant and thereafter discharged to Nahr Awali and on to the sea, are diverted to a new treatment facility at Ourdaniyah for onward distribution to consumers[4]. GBWSP comprises three prime components:

1. Bulk water infrastructure including transmission tunnels and pipelines, the treatment plant, and bulk storage reservoirs at Hadath and Hazmieh;
2. Sixteen supply reservoirs, up to 400 km of distribution pipelines, thirty bulk meters, and 200,000 household meters; and,
3. Establishment of a Project Management Unit, technical assistance, capacity building, and studies proposed by MEW's 2010 National Water Sector Strategy (NWSS).

GBWSP sets high aspirations, and while many will be met or exceeded, the lack of public confidence in government institutions and current conditions, such as high traffic loading on distribution systems in Beirut highways, will require targets for reduced leakage and other sources of non-revenue water, and consequently improved cost-recovery, to be lowered.

Notwithstanding the GBWSP benefits, it is prudent for GoL to now look forward and assess the means by which water supply may be augmented as the capital's population expands to 3 million and beyond. The present project, the *Greater Beirut Water Supply Augmentation Project* (GBWSAP) therefore evaluates options by which this might be achieved, while noting that the GBWSP is an independent project that does not require the GBWSAP to be economically or technically feasible and/or sustainable.

1.2 GBA Water Balance

Figure 1.1 simulates three water demand scenarios between the years 2011 and 2035: the first estimates gross domestic and industrial water needs assuming no reductions or savings measures are implemented, the second calculates the expected water demands once all networks leakages reduction measures are implemented, and the third quantifies those demands once all leakages are fixed and GBWSP water saving measures

[4] With the drop in Litani River flow due to increased upstream extraction and global warming, the 50 Mm^3 from Qaraoun may not be sustainable. Some losses from the 50 Mm^3 will be made up from ground water seepages to the unlined Awali Tunnel.

are implemented[5]. The Figure shows that water supply will increase with the assumption that GBWSP with its full delivery capacity will come into implementation by 2016. While other water augmentation sources are not accounted for here, they will be discussed in the section of Analysis of Alternatives of this Report.

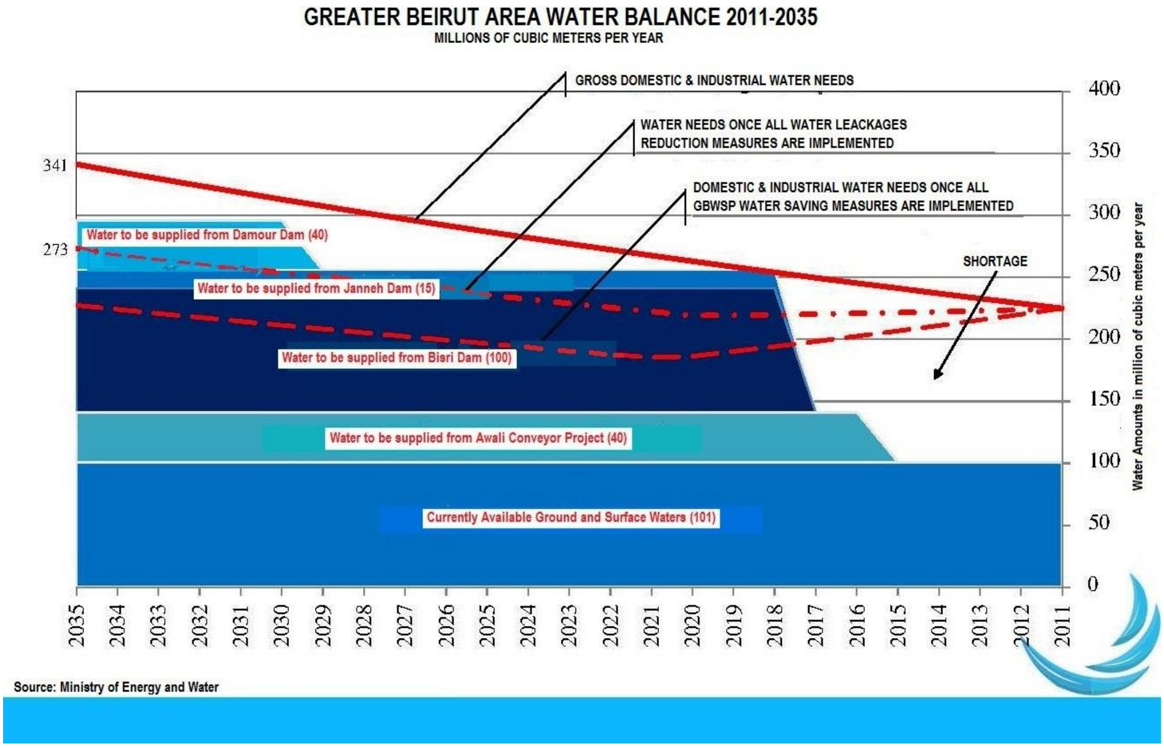


Figure 1.1: Projected Water Balance for Greater Beirut Area (MEW 2009).

Projected GBA water balance until the year 2035 (the time when GBWSP is fully operational) is summarised in Table 1.1, whereby estimates of irrigation needs have been added to domestic and industrial uses, as those were not included in the GBA water balance as suggested by MEW NWSS.

[5] The GoL National Water Strategy, in 2010, has set number of measures to be implemented towards the reduction, by 2035 down to 20%, of the excessive amounts of lost and inefficient water throughout the water supply and distribution networks. These include but not limited to: correct, rehabilitate and install of faulty, old and new networks including the installation of modern water meters; proposing optimized water layout networks and creation of water meter management areas; capacity building of WEs Personnel, the procurement of utility strengthening systems, equipment and technical advisory services, and others.

Table 1.1: GBA Domestic, Industrial and Agricultural Water Balance until they Year 2035 (MCM/year)

Water Demand & Supply for GBA		2010	2015	2020	2025	2030	2035
Demand	Domestic & Industrial Water Demands	225	240	260	290	320	340
	Reduced Domestic & Industrial demands	225	210	180	190	210	230
	Agricultural Water Demands	80	90	100	105	105	105
TOTAL DEMANDS (without losses reduction)		**305**	**330**	**360**	**395**	**425**	**445**
TOTAL DEMAND (with reduction)		**305**	**300**	**280**	**295**	**315**	**335**
Supply	Currently available water resources	100	100	100	100	100	100
	Awali Conveyor (GBWSP) future contribution	-	40	40	40	40	40
TOTAL SUPPLY		**100**	**140**	**140**	**140**	**140**	**140**
WATER BALANCE (with no losses reductions and no GBWSP)		**-205**	**-230**	**-260**	**-295**	**-325**	**-345**
WATER BALANCE (GBWSP implemented and with losses reductions)		**-205**	**-160**	**-140**	**-155**	**-175**	**-195**
Expected Water Deficit Reduction		**0%**	**30%**	**46%**	**47%**	**46%**	**43%**

As shown above, water deficit is expected to grow from 205 MCM/year in 2010 to about 345 MCM/year by 2035 in the first scenario. Water shortages will become severe as water supply can not accommodate the needs of a growing Greater Beirut population. The need to implement new projects securing additional water sources and reducing water leakages from 40% to 20%, as proposed by NWSS 2010 is therefore imperative. GBWSP will contribute to the reduction of water deficit by about 30-45% until 2035, a solution that addresses water shortages only on the short and medium terms.

Based on the above, there is no doubt that GBA water users will face serious water shortages in the next two decades. The severity of those shortages depends on a number of comprehensive initiatives to be undertaken including a proper planning, policy setting and implementation, immediate actions as foreseen under the NWSS and the integration of all components of the NWSS.

The current water imbalance in GBA, if not properly addressed will keep favouring an uncontrolled water provision and distribution practices which will further deplete water resources and degrade their quality, with a number of private water tankers companies proliferating taking the lead over BMLWE.

1.3 The GBWSAP ESIA Team

The GBWSAP Project Proponents on behalf of GoL are:

- Council for Development and Reconstruction (CDR);
- Ministry of Energy and Water (MEW); and,
- Beirut and Mount Lebanon Water Establishment (BMLWE).

The GBWSAP Project Coordinator is:

Mr. Assem Fidawi at CDR, whose registered place of business is:
PO Box 3170/11 Tallet El Serail, Riad El Solh, Beirut.

The Project Proponents have entrusted the preparation of the Environmental and Social Impact Assessment (ESIA) to:

Dar Al-Handasah (Shair and Partners), whose registered place of business is:

PO Box 11-7159, Verdun Street, Beirut. Tel: 961 1 790002.

The composition of the Dar Al-Handasah GBWSAP ESIA Team is shown in Table 1.2.

Table 1.2: Key ESIA Team Members

Name	Position
Mr. Fouad El-Khoury	Project Director
Dr. John Davey	Team Leader - Environmental Planning and Management Specialist, Hydrogeologist
Ms. Riwa Elderbas	Environmentalist and Public Consultation Specialist
Dr. Suhail Srour	Consultation Moderator and Technical Advisor
Dr. Nassim Abi Fadel	Dam Engineer
Mr. Philip Nassar	Dam Geologist
Mr. Elie Abourejaili	Water Engineer and Alternatives Benchmarking
Ms. Fay Mushantaf	Environmental Health and Safety Specialist
Dr. Naji Berri	Catchment Management Specialist
Dr. Dunia Tabet	Hydrologist and Water Management Specialist
Dr. Faten Nazzal	Water Quality Specialist
Mr. Khalid Ghannam	Coordination with Municipalities/MoF Cadastre
Dr. Mounir Abi-Said	Ecological Survey Sub-Group Leader
Ms. Alicia Obeid Jammal	Social Survey Sub-Group Leader

1.4 Project Scope

GBWSAP aims to increase the volume of water available to the Greater Beirut and Mount Lebanon area in the long term. GBWSAP is being implemented in two distinct phases:

Phase One

The technical, environmental, social and economic review of:

1. Potential non-dam water supply schemes; desalination, increased ground water exploitation, rainwater harvesting, wastewater reuse and reductions in UfW; and,
2. A comparative assessment of four previously identified dam and reservoir impoundment schemes; Bisri Dam on Nahr Bisri; Damour East and Damour West Dam on Nahr Damour, and Jannah Dam on Nahr Ibrahim.

Phase One project deliverables included:

- A Consultation and Communications Programme (February 2012);

- An Annotated ESIA (March 2012);
- Preliminary Draft ESIA and Technical & Economic Review (September 2012); and,
- Resettlement Policy Framework.

Phase Two

A full Category A ESIA of the selected Priority Scheme for Greater Beirut, and a Resettlement Action Plan are prepared.

The September 2012[6] report included a comparative study of non-dam and dam options, from which it was determined that the Phase Two ESIA should be undertaken on Bisri Dam. Following CDR policy, this is prepared in accordance with World Bank Operating Policy 4.01 *Environmental Impact Assessment* for a Category A Project, other World Bank safeguard policies, and the requirements of the Ministry of Environment, particularly Decree No. 8633 of August 2012, *Fundamentals of Environmental Impact Assessment*, which entered the statute book during GBWSAP implementation.

The results of GBWSAP Phase One afford GoL the opportunity to illustrate to GBA residents, potential funding agencies and others they have executed a wide-ranging review of all practical alternative solutions for water supply augmentation, and that the priority scheme will, subject to further investigation and engineering design, be technically feasible, environmentally responsible, socially-acceptable and cost-effective.

Phase Two Project includes:

- Draft ESIA;
- Draft Resettlement Action Plan RAP;
- Final ESIA; and,
- Final RAP.

Following design review, the present Report along with a new revision of RAP are being issued to account for those design changes including transmission lines, dam axis and expropriation area.

The GBWSAP Phase Two ESIA provides for the identification of potential environmental and social impacts arising from the design, construction and life-time operation of the Bisri scheme and presents the mechanism to ensure it is implemented without excessive environmental degradation and human suffering.

1.5 ESIA Report Structure

The structure and content of this report follows the same organization of the Final ESIA prepared in September 2013 that was drawn from the recommendations of World Bank Op.4.01, Lebanese Decree 8633 and the World Commission on Dams, amended as necessary to reflect the way issues of greater or lesser significance need to be discussed.

[6] *GBWSAP Preliminary Draft ESIA*. Dar Al-Handasah (Shair and Partners)
Doc. No. L12002-0100D-RPT-PM-01 Rev1, September 2012.

Section 2 describes the different components of the Bisri project, its location and the proposed construction, while **Section 3** outlines the policy and legislative framework within which it will be executed.

Sections 4, 5 and 6 respectively discuss the physical, biological and socio-economic conditions throughout the project site and its surroundings, while **Section 7** summarises the analysis of scheme alternatives and the reasons those less favoured than Bisri were considered unsuitable at the present time.

Section 8 identifies the potential for environmental and social impacts, be they permanent, primarily the result of scheme location and design, temporary, resulting from construction activities, or longer-term operation, occurring and/or cumulating throughout the life of the project. The same section also includes the Environmental and Social Management Plan for the project, presenting for the impacts identified previously, proposals for their avoidance, mitigation or the management of residual impacts and associated risks to environmental sustainability and human wellbeing.

Finally, **Section 9** gives details of the GBWSAP Communications and Consultation Programme and the results of public consultations undertaken during both Phases One and Two of the project.

2. PROJECT DESCRIPTION

2.1 Introduction

This chapter of the ESIA details the project location, what it is proposed to construct, the preparatory investigations that have been completed, and the expected costs.

The potential for dams in Lebanon has long been recognised, **Section 2.2** outlines the previous studies contributing to the present proposals for Bisri Dam, while **Section 2.3** summarises the reasons why the project proponents selected Bisri over other dam sites to be the GBWSAP priority Scheme.

Section 2.4 defines the location of the project and the primary characteristics such as dam and reservoir dimensions, and the storage volumes and inundated areas corresponding to the different design water levels. **Section 2.5** and **Section 2.6** summarise the proposed hydrological design and dam and reservoir construction, respectively, subject to finalization of Project design.

Finally, **Section 2.7** presents available cost information, again subject to confirmation on completion of detailed design.

2.2 Previous Studies

Prefeasibility studies and field investigations in the Awali catchment were performed during 1954, 1974 and in early 1980's. From June 1994 to April 1995, Lebanese consultants, Dar Al Handasah (Nazih Taleb and Partners) working with ECI, a division of Frederic R. Harris[7], completed feasibility studies and site investigations.

The April 1995 report was updated by Nazih Taleb in January 2011, and included a review of the hydrological basis of the Bisri scheme, reservoir sedimentation, water supply yields and cost estimates.

Bibliographical references for these studies and other sources of relevant information utilized during preparation of the ESIA are given in Appendix A.

2.3 Selection of Bisri Dam as the GBWSAP Priority Scheme

As explained in Section 1.1 above, the GBWSAP ESIA team has previously undertaken a comparative study of four dam sites, from which the project proponents concluded Bisri to be the priority scheme. While the results of this study are discussed in Chapter 8 Analysis of Alternatives, in the present context of project description it is useful to recall the prime reasons for their decision.

From the outset, Bisri had two major advantages:

- The volume of the reservoir and its annual recharge is sufficient to meet the predicted needs of Greater Beirut to 2030 and beyond; and,

[7] Frederic R. Harris has since been absorbed into the AECOM Group.

- The Bisri-Awali valley is located such that the scheme can utilise GBWSP transmission lines, treatment plant and bulk storage reservoirs, thus maximizing both water supply efficiency and the return on investment.

In addition to having the lowest cost per unit volume of water delivered to Greater Beirut, Bisri is also of a size that will allow cost-effective generation of hydroelectric power. The location of Bisri reservoir relative to GBWSP facilities is shown in Figure 2.1.

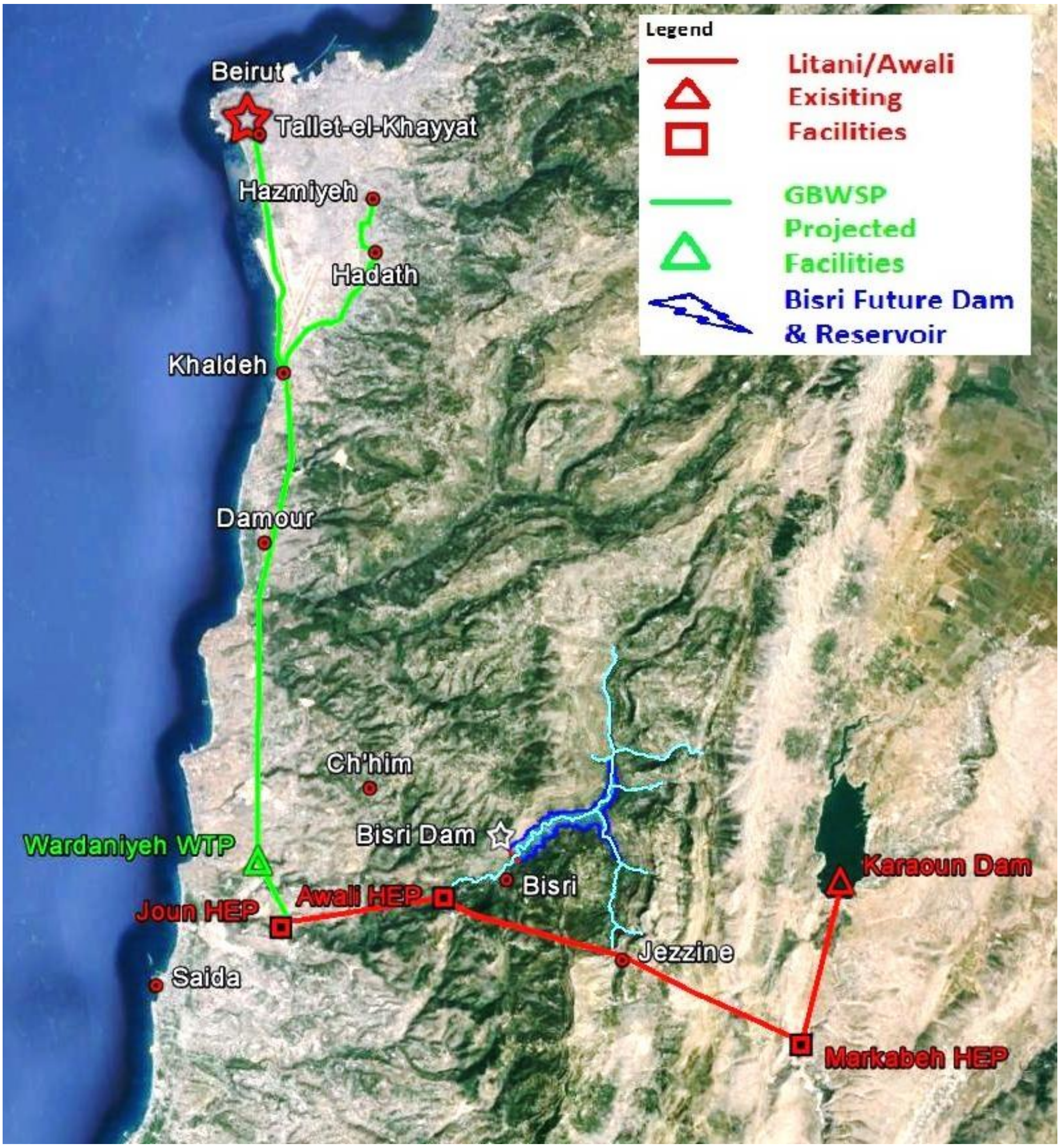


Figure 2.1: Location of the Bisri Scheme Relative to GBWSP Facilities

2.4 Project Location and Prime Characteristics

Project site as recently surveyed and shown in Figure 2.2 is in the Nahr Bisri Valley some 15 km inland from the Mediterranean coastline at Saida and 35 km[8] south of central Beirut, at an elevation of c.395 masl. The reservoir extends for about 4 km upstream of the dam axis on Nahr Bisri before forking northwards along Nahr Barouk and southwards along Wadi Bhannine. At maximum water level, 467 masl, the total storage volume of the reservoir is estimated at 125 Mm^3 and the area expected to be inundated 434 ha including dam footprint. Transmission lines extend downstream of the dam axis to GBWSP facilities, so that Bisri dam can ultize GBWSP transmission lines, treatment plant and storage reservoirs.

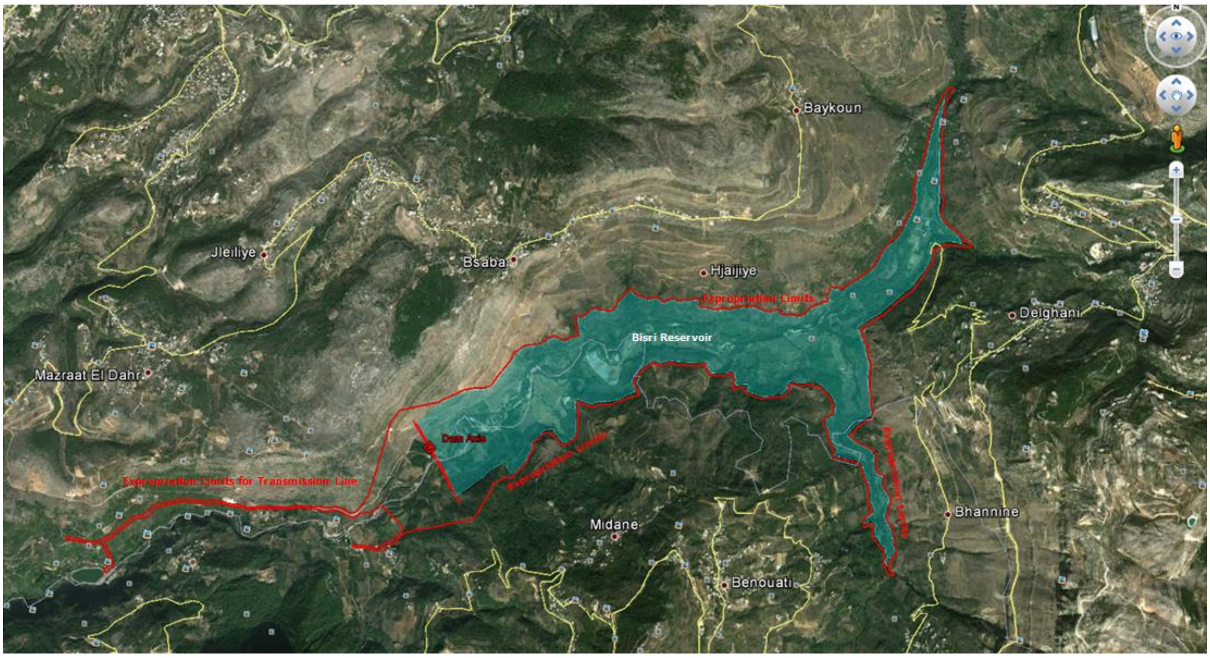


Figure 2.2: Bisri Dam and Reservoir on Nahr Bisri

Table 2.1 summarises the primary characteristics of Bisri dam and reservoir as conceived by the latest Designer's review.

[8] Measured by a straight line from Najmeh Square

Table 2.1: Primary Characteristics of Bisri Dam and Reservoir

Dam Characteristics		Elevations and Areas	
Reservoir Catchment Area[1]	Approx. 215 km^2	River Bed Elevation	392 masl
Length of Reservoir	6 km +2 km branch	Dam Crest Elevation	469 masl
Width of Reservoir	550 m	Max Water Level	466.8 masl
Type of Dam	Clay Core Rockfill Dam	Inundation at Max WL	280 ha
Maximum Height	73 m	Storage at Max WL	148 Mm^3
Crest Length	740 m	Normal Water Level	461 masl
Crest Width	12 m	Inundation at NWL	256 ha
Upstream Slope	2.5H:1V / 3.5H:1V	Storage at NWL	125 Mm^3
Downstream Slope	2.5H:1V / 3.5H:1V	Min Water Level	420 masl
Continuous Outflow	5.1 m^3/sec or 5.8 m^3/sec depending on demand	Inundation at Min WL	140 ha
Hydropower Capacity	11 MW Downstream plant 0.2 MW Upstream plant	Storage at Min WL	10 Mm^3

2.5 Proposed Hydrological Design

The proposed hydrological design based on the 2014 progress design is discussed below.

2.5.1 Climate and Meteorology

The weather stations located within and/or in the vicinity of the basin area used with respect to various climatic parameters are as follows:

Table 2.2: Weather Stations Used by the Designer

Name of Station	Weather parameter
Bhamdoun and Kfarbnabrakh	Temperatue
Bhamdoun and Kfarbnabrakh	Relative Humidity
Ksara Observatory A.U.B and College Machmoucheh	Wind
Bhamdoun and Kfarbnabrakh	Evaporation

Old and newly established stations were used in the computation and analysis of the precipitations data of Bisri site. The old stations are: Ain Zhalta (512), Kfar-Nabrakh (514), Jdeidet-ech-Chouf (516) and Jezzine (519). For more recent data, new stations

[1] While according to the ESIA Consultant estimates Bisri Dam catchment area would amount to 200 Km2, the area of 215 km2 will be adopted in the present report for consistency with the Dam Designer.

were added to the previous ones. These new stations are Jezzine (2001-2009), El-Barouk-Fraidis' Deir el-Kamar, Jbaa-el-Chouf and Mechref.

2.5.2 Precipitation

The names of the stations used for the estimation of the Basin Precipitation and the period of available records are listed below:

Table 2.3: Stations Adopted for the Estimation of the Basin Precipitation

Name of Station	Period of Available Record
Aain-Zhalta	1939-40 - 1970-71
Kfar-Nabrakh	1944-45 - 1970-71
Jdeit-ech-Chouf	1943-44 - 1970-71
Jezzine	1927-28 - 1936-37 and 1939-40 - 1970-71
Jezzine	2001-02 – 2008-09
El Barouk Fraidis	2001-02 – 2008-09
Deir El Kamar	2001-02 – 2008-09
Jbaa Ech Chouf	1964-65 – 1969-70 and 1991-92 – 2008-09
Meshref	2002-03– 2008-09

The mean annual basin precipitation calculated is 1,255 mm with an average of 1,294 mm for the old stations and 1,107 mm for the recently established stations. The average monthly precipitation varied from a minimum of zero in the month of July to a maximum of 283 mm in the month of January. Table 2.4 shows the monthly and yearly basin precipitations:

Table 2.4: Monthly and Yearly Basin Precipitations

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Total	205.77	1607.09	4538.32	8005.27	9916.19	8796.41	6712.90	3015.98	1080.53	32.79	6.99	8.39	43926.63
Av.	5.88	45.92	129.67	228.72	283.32	251.33	191.80	86.17	30.87	0.94	0.20	0.24	1255.05
Min.	0.00	0.13	0.29	52.82	53.15	42.08	41.30	7.20	0.26	0.00	0.00	0.00	715.87
Max.	97.32	127.04	354.19	571.37	688.80	514.92	451.06	441.68	236.39	7.63	2.81	3.33	2081.25
Std. Dev.	16.67	37.06	88.55	118.26	141.52	124.88	103.86	81.38	44.03	1.91	0.58	0.64	317.40

2.5.3 Evaporation

The two weather stations nearest to Bisri dam site are Jezzine, about 6 km southeast, and Kfarnabrakh, some 15 km north east. Kfarnabrakh was selected by the feasibility study over Jezzine and gave a value for evaporation of 718 mm/year. Applying the Class A Pan method to the nearer Jezzine data gave a value of 1486 mm/year, similar to the estimates using the IWMI modeling program, as shown in Table 2.5 below.

Table 2.5: Evaporation Data for Bisri Dam Site

Evaporation (mm/month)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kfarnabrakh (1955-1971)	29.5	34.5	45.7	58.0	71.0	85.2	83.5	87.6	67.2	63.3	52.2	39.9	718
IWMI*	41.4	53.7	77.4	113.7	149.4	184.5	195.0	177.9	144.0	100.5	64.2	42.3	1,344
Bisri (Class A Pan)	46	60	98	136	176	199	202	185	152	114	70	80	1,486

Source: http://www.iwmi.cgiar.org/WAtlas/Defaultaspx.

2.5.4 Hydrometric Data

The natural streamflow at Bisri Dam location characteristics are as follows:

Inter-Annual Module : 4.1 m3/s (period 1952 - 2012);

Average annual streamflow : 129.5 Mm^3;

Maximum : 434 Mm^3 year 2002;

Minimum : 55 Mm^3 year 1959.

Figure 2.3 shows the average annual streamflow between the year 1952 and 2012.

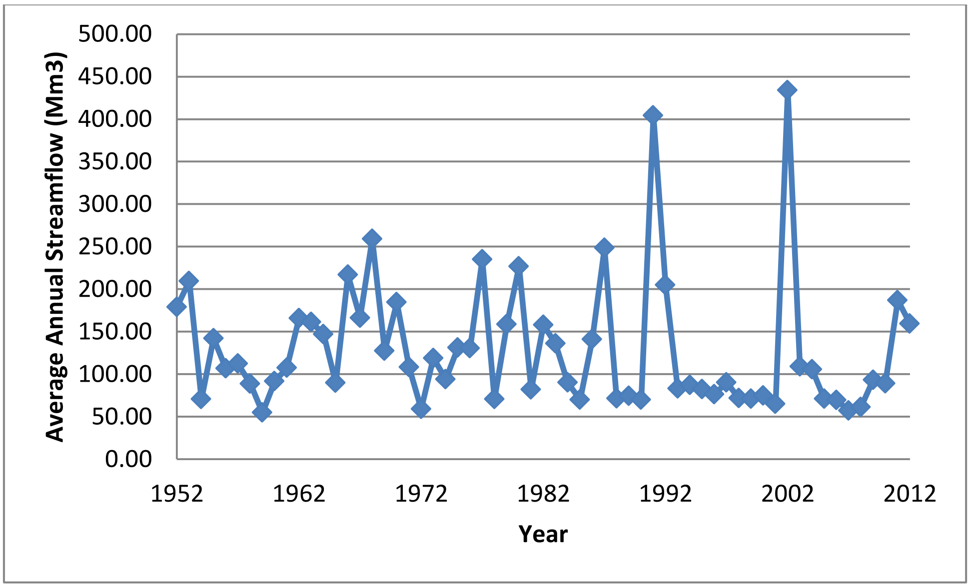


Figure 2.3: Average Annual Streamflow between the year 1952 and 2012

2.5.5 Flood Estimation

Flood hydrographs were developed for the purpose of sizing two hydraulic structures: 1) diversion facilities; and 2) spillway. By routing these inflow design flood hydrographs through available storage, either cofferdam or reservoir, the designer of each structure will thereby determine the "outflow design hydrograph". The peak of the outflow design hydrograph is the actual discharge for which the structure, tunnel, conduit, or spillway, must be designed.

The inflow flood for spillway design has a peak discharge of 2,300 m^3/s (11 $m^3/s/km^2$) and a volume of 43 Mm^3.

The inflow flood for the design of diversion facilities has a peak discharge of 600 m^3/s and a volume of 11 Mm^3.

2.5.6 Sediment Yield

Only two years' data are available for calculating river sediment load. This is 800t/km^2/yr, to which 200t/km^2/yr has been added to represent the estimated bed load. Over a 215 km^2 basin area, a total of 8 Mm^3 of sediments are therefore expected to accumulate in 50-year-reservoir operation.

In his updated report, the Designer has noted that the 1.5 g/l of sediment seems too low. He recommends, as such, an increase of 20% over the previously estimated sediments load bringing it up to 9 Mm^3 in 50-year-reservoir operation.

2.6 Proposed Dam and Reservoir Construction

Feasibility Study geotechnical investigations show the Bisri dam site to be underlain by up to 30 m of recent alluvial clastics over some 90 m of plastic clays with occasional coarser lenses. The clays are lacustrine in origin, the lake forming behind an ancient landslip that once blocked the valley below Anane. As the lake filled the blockage was eventually overtopped, leaving the present valley profile.

The flanks of the dam site comprise different materials. To the left, the dam will abut the fine-grained and friable sandstones of the Chouf Formation (C1), while the right abutment will be on the fractured and well jointed limestones and marls of the Abieh Formation (C2a). The active Roum Fault passes beneath or in close proximity to the dam site beneath the alluvium and clays. As a result of differences in geology between the two abutments and the risk of seismic activity, the ESIA recommended the dam design consultant review the present dam site relative to others upstream offering potentially more equable conditions.

Bisri dam as presently conceived is a Clay Core Rockfill Dam comprises an earth embankment with a rolled compacted concrete (RCC) section for the spillway, as illustrated in Appendix B.

2.7 Estimated Costs

The updated design report 2013 estimated the total cost of the project to be some US$300 million, comprising $220 million contractors' costs, $66 million contingencies, and $10 million for engineering, the latter including design, tendering, contract supervision and administration. The construction of the transmission line is estimated at $20 million, while the construction costs of the hydropower plan is estimated at $15 million.

Specifically excluded from these costs are the cost of water treatment, and onward conveyance for distribution to Greater Beirut, which will be provided under the independent Greater Beirut Water Supply project (GBWSP). Also excluded from the Bisri costs but outside the scope of the GBWSP are land clearance prior to filling, additional site investigations and studies prior to the issuing of final design drawings, and reservoir slope protection. Construction costs are distributed over 3-years; 10, 46 and 44%.

The estimated cost of land acquisition, to be covered by GoL, was estimated, by the ESIA Consultant to about $150,228,686 for around 570 ha of land (including inundation area, dam footprint and a 15 m buffer).

3. POLICY AND LEGISLATIVE FRAMEWORK

3.1 Introduction

This section provides an outline of the existing policy and legislative framework under which the Greater Beirut Water Supply Augmentation Project (GBWSAP) will be implemented.

Section 3.2 provides a brief overview of the general framework related to environmental law; while **Section 3.3** reviews with the institutional framework under which the GBWSAP is being pursued. From these, **Section 3.4** outlines the approach adopted in the preparation of the present Environmental and Social Assessment in the context of existing legislative and institutional framework, including the expected application of World Bank Safeguard Policies. **Section 3.5** explains the main responsibilities of the Dam Safety and Environmental and Social Advisory Panels.

3.2 Legislative Framework

3.2.1 Existing Lebanese Legislation

When Lebanon initiated its reconstruction and development drive after fifteen years of civil unrest and invasion, the majority of the projects were evaluated on the basis of technical and economic feasibility with little consideration of potential environmental and social impacts. Without adequate economic resources to finance the entire reconstruction and rehabilitation process, Lebanon had no alternative but to rely upon external funds granted by international donors such as the European Commission, World Bank and unilateral donors for whom projects had to be environmentally assessed as a prerequisite for funding.

Subsequently, Draft Decree No. 444 of 2002 defined the binding principles to which all public and private projects are subject in evaluating the impacts projects have on the environment. In accordance with Article 23, all projects are required to undergo an Environmental Assessment, for which the regulatory authority is the Ministry of Environment (MoE). Although the Draft Decree was for many years not passed by the Council of Ministers (CoM), the Ministry influenced project proponents to abide by its requirements. It was eventually passed in August 2012, during the currency of the present project, becoming Decree No 8633, Fundamentals of Environmental Impact Assessment. The EIA Procedure under Decree No 8633 is illustrated in Figure 3.1 and an unofficial English language translation is given in Appendix C. As in most other countries, Lebanese EIA procedures offer projects three paths to approval:

- Those that are small in scale, socially beneficial and impart no significant environmental impact may be approved without further assessment;
- Those expected to impart significant impact, such as traffic congestion, energy and water consumption, solid or liquid waste discharge, and noise or air pollution, are required to undergo EIA against a Scope of Work and Terms of Reference set

out in a Scoping Report, itself approved by the Ministry prior to EIA commencement; and,

- Projects for which the nature or scale of impacts is uncertain undergo Initial Environmental Examination (IEE) upon review of which MoE decides whether or not to call for a full EIA.

For GBWSAP, a comparative study between the different alternatives considered to identify the priority option based on an environmental, social, economic and technical assessment was undertaken in a first phase. Based on this analysis, Bisri Dam was selected to be the Priority Scheme which is the subject of the present ESIA.

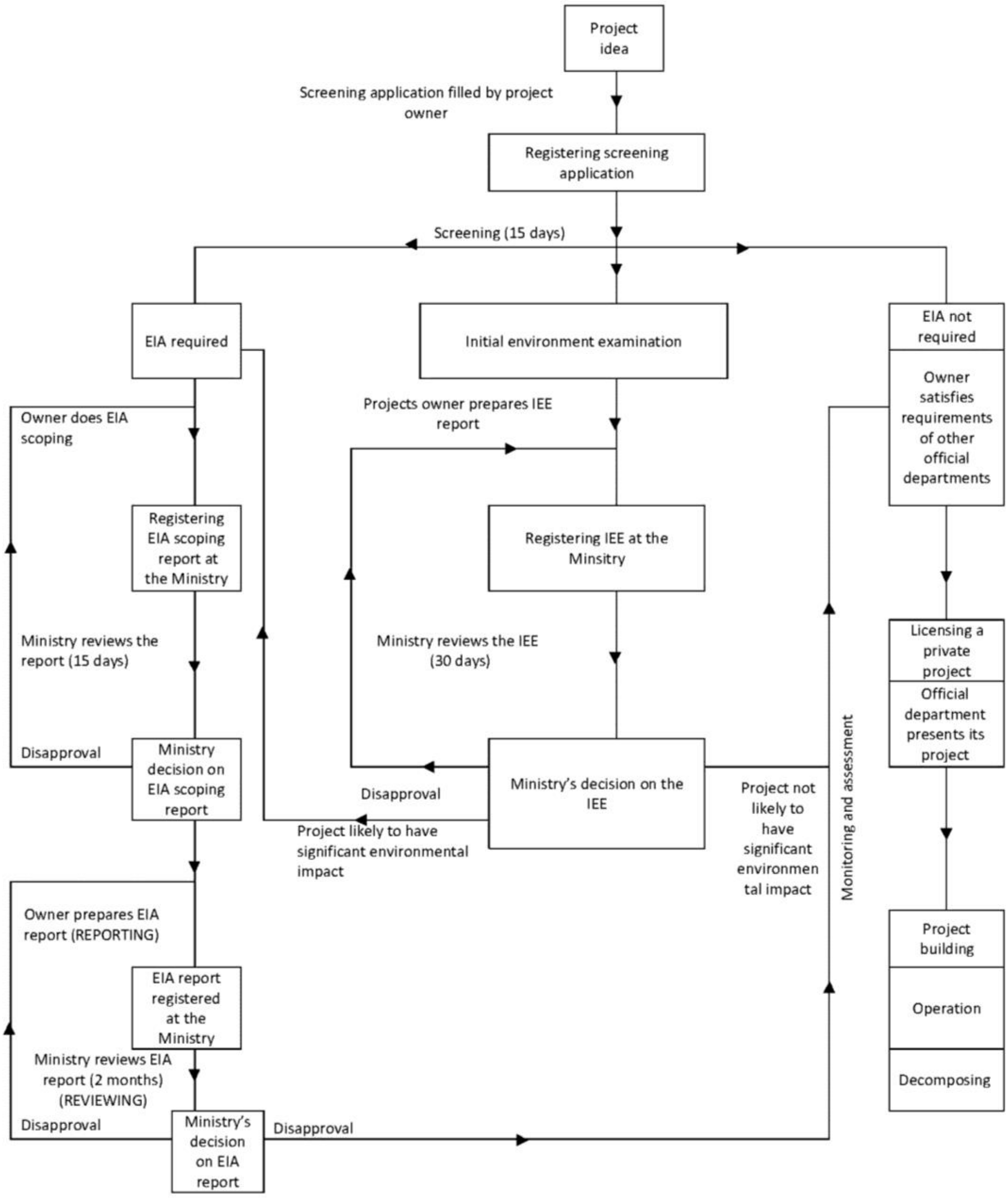


Figure 3.1: Environmental Assessment Procedure in Lebanon

The need for environmental protection has long been recognized by the Lebanese authorities and a large number of parliamentary Laws, Council of Ministers' Decrees and

Ministerial Decisions and Orders are available for enforcement. Those most pertinent to GBWSAP are listed in Table 3.1

Table 3.1: Selected Lebanese Environmental and Water Resources Legislation

Protection through Planning, Land Use and General Exploitation

Document	Date	Subject	Responsible Ministry
Law	07.01.1949	Forest Protection	Agriculture/Environment
Law	09.11.1951	Soil Preservation	Agriculture
Order No. 69	09.09.1983	Urban Development	Public Works
Order No. 2/89	05.01.1989	Urban Development	Public Works
Law No. 85	07.09.1991	Flora and Fauna Protection (Forest Code)	Agriculture/Environment
Decision No. 1/42	01.03.1993	Tree Cutting and Felling	Agriculture/Environment
Decision No. 108/1	12.09.1995	Cedar Seeds and Plants	Agriculture
Decision No. 92/1	27.02.1996	Medicinal and Aromatic Plants	Agriculture
Law No. 558	24.07.1996	Forest Code	Agriculture/Environment
Decision No. 90/1	19.11.2000	Construction in River Basins, etc.	Environment
Law No. 444	29.07.2002	Environmental Code	Environment
Decree No. 8633	August 2012	Fundamentals for EIA	Environment

Protection from Pollution

Document	Date	Subject	Responsible Ministry
Decree No. 8735	23.08.1974	Pollution by Solid & Liquid Wastes	Industry/Environment
Law No. 64	18.08.1988	Pollution from Hazardous Wastes	Industry/Environment
Decision No. 52/1	29.07.1996	Air, Water and Soil Pollution	E&W/Environment
Decision No. 8/1	01.03.2001	National Standards for Environmental Quality	E&W/Environment
Law No. 341	06.08.2001	Transport Exhaust Emissions	Transport

Laws Pertaining to Water Resources

Document	Subject	Content
Order No. 144 of 1925	Protection of Surface & Ground Water Resources	
Decision No. 144/S of 1925	Public Property	Defines publically-owned water resources
Decision No. 320 of 1926	Water Usage	Defines water usage and allocation
Decision No. 3339 of 1930	The Law of Real Estate	Water springs that cannot be used for the public benefit can be owned by individuals.
Decree No. 2761 of 1933	Protection and Use of Public Water Properties	Prohibits of waste and wastewater discharge to watercourses and the sea.
Decision No. 6/1/T of 1936	General Industrial Health Criteria	States that all water supplies should be taken from piped water networks or springs.

Document	Subject	Content
Legislative Decree No. 227 of 1942	Drinking Water Abstraction Projects	Authorises the use of water resources for drinking and identifies protection zones.
Legislative Decrees No. 340 of 1943	The Law of Penalties	Penalties for illegal activities such as unauthorized drilling and water pollution.
Decree No. 10276 of 1962, Decree No. 7007 of 1967	Water Sources Protection Zone Delineation	Identification of protection zones for water resources, based on geological studies.
Decree No. 14438 of 1970	Water Abstraction Management and Use	Defines the permitting requirements for well and spring abstraction.
Decree No. 14438 of 1970	Water Abstraction Management and Use	Indicates the annual abstraction limits and charges for private and public consumption
Decree No. 14438 of 1970	Water Abstraction Management and Use	Indicates the annual abstraction limits and charges for irrigation and industrial use.
Decree No. 14522 of 1970	Allocation of Nahr Litani and other water resources	Sets distribution to South Bekaa, the Western Foothills, and between industrial and potable water
Decision No. 182/1 to 186/1 of 1997	Criteria for the Use of Sand and Rock Quarries	Conducting EIA studies for proposed quarries to protect the water resources
Decree No. 680 of 1998	The Preservation and Protection of Boreholes	Source protection
Decree No. 1039 of 1999	National Drinking Water Standards	Potable water quality
Law No. 221 of 2000	Water Management	Indicates the responsibility of MEW in water quality assessment.
Law No. 221 of 2000	Water Management	Indicates the responsibility of LRA in all irrigation schemes in South Bekaa and South Lebanon.
Law No. 221 of 2000	Water Management	Need for a new tariff structure for drinking and irrigation based on socio-economics.
Decision No. 75/1 of 2000	Environmental Permitting of Tanneries	Emphasizes rationalizing water use and reuse
Decision No. 90/1 of 2000	Environmental permitting of construction in river basins	Emphasizes on rationalizing water use
MOE, Decision 8/1 of 2001	WWTP Effluent and Atmospheric Emissions	Defines the standards of effluent and air pollutants discharged from a wastewater treatment plant
Decisions Nos. 3/1, 5/1 of 2000 and 16/1, 29/1, 61/1 of 2001	Permitting of Farm, Dairy Plastics and Fruit Processing	Defines methods to limit water consumption in production and cleaning in industrial settings.
Decree No. 8018 of 2002	Environmental Permitting of Industries	Defines distances of industrial zones from surface and groundwater bodies.
Draft Decree No. 444 of 2002	Environmental Protection	Defines an integrated approach for the management of natural resources and sets the criteria for implementing and supervising waste disposal practices, and the penalties for non-compliance.

Notwithstanding the large number of laws that govern the water sector, Lebanon suffers from significant legislative weaknesses leading to the mismanagement of the sector. Most of the laws, decrees, and regulations are at best only poorly implemented due to the lack of institutional capacity and enforcement mechanisms. Many laws have been promulgated without accounting for significant environmental and social factors. Political instability, conflict between institutions and the lack of financial resources have aggravated the situation.

The recently drafted Water Code and National Water Sector Strategy attempt to address long-standing institutional shortcomings and improve water sector governance and its technical approach to an Integrated Water Resources Management Plan. Included in the Code are:

- Establishment of a National Water Council (NWC), to oversee sustainable development policy throughout the water sector;
- Preparation of a six-year Water Sector Development Plan;
- Consistent application of the "user pays" and "polluter pays" principles; and,
- Restriction of government subsidies to financing of capital investments with high social or environmental benefit.

But according to the World Bank[9], the Water Code is un-likely to deliver the expected gains unless there is a strong political will to address the challenges facing the sector. With weak accountability between policy-makers and service providers, the NWC risks become an additional institutional layer with limited ability to improve coordination and align incentives.

3.2.2 International Legislation

Internationally, Lebanon is a signatory to a variety of environment-related international and regional conventions and protocols, of which the most significant to the present project are listed in Table 3.2.

9 Republic of Lebanon Water Sector: Public Expenditure Review. World Bank, Report 52024-LB, May 17 2010

Table 3.2: International and Regional Conventions and Protocols

Date	Title
1954	International Convention for the prevention of Pollution of the Sea by Oil Covered by Law no. 68/66 dated 16th November 1966
1972	Convention on the prevention of marine pollution by Dumping of Wastes and other Matter Signed 15th May 1973
1976	Convention for the Protection of the Mediterranean Sea against Pollution. Barcelona. Signed 16th February 1976. Covered by Law No. 126 dated 30th June 1977.
1980	Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources. Athens. Signed 17th May 1980. Accession: 27th December 1994.
1982	Protocol Concerning Mediterranean Specially Protected Areas. Accession: 27/12/1994.
1985	Convention for the Protection of the Ozone Layer. Vienna. Covered by Law No. 253 dated 30th March 1993.
1987	Protocol on Substances that deplete the Ozone Layer. Montreal. Covered by Law No. 253 dated 30th March 1993.
1989	Convention on the Control of Transboundary Movement of hazardous Wastes and their Disposal. Basel. Ratified 21st December 1994. Covered by Law No. 387
1990	Amendment to the Montreal Protocol on Substances that deplete the Ozone Layer. London. Covered by Law No. 253 dated 30th March 1993.
1992	United Nations Framework Convention on Climate Change. Rio de Janeiro. Ratified 11th August 1994. Covered by Law No. 359.
1992	Convention on Biological Diversity. Rio de Janeiro. Ratified 11th August 1994. Covered by Law No. 360.
1992	Amendment to the Montreal Protocol on Substances that deplete the Ozone Layer. Copenhagen. Covered by Law No. 120 dated 3rd November 1999.
1994	United Nations Convention to Combat Desertification. Paris. Ratifications: 21/12/1994 by the law number 469.
1999	Convention on Wetlands of International Importance especially as Waterfowl Habitat-Ramsar. Accession: 1/3/1999 by the law number 23.
2001	Convention on Persistent Organic Pollutants. Stockholm Signed 22nd May 2001.

The design, construction and operation of the GBWSAP will comply with all applicable Lebanese Standards and guidelines, including but not necessary limited to:

- Water Supply for Public and Commercial Facilities;
- Drinking Water Quality Standards 1999;
- Wastewater Discharged into the Sea 2001;
- Stack Emission Standards 2001;
- Recommended Noise Emission Limits for Outdoor Areas;
- Draft Ordinance on the Use and Disposal of Sewage Sludge;
- National Environmental Action Plan; and,
- National Biodiversity Strategy and Action Plan.

3.3 Institutional Framework

Institutional capacity for environmental management and monitoring in Lebanon is weak, thus the potential range and effectiveness of policy options for environmental management is severely constrained. Law enforcement in Lebanon is also weak, particularly so in respect of environment and social legislation. While much has improved in recent years, particularly with the creation of the MoE and the consequential strengthening of institutional framework for the design and implementation of environmental policy, much remains to be achieved. For GBWSAP, the prime institutional stakeholders and their particular roles are listed in Table 3.3.

Table 3.3: Roles and Responsibilities of the Prime GBWSAP Stakeholders

Institution	Role and Responsibilities
Council for Development and Reconstruction (CDR)	Accountable to CoM for sectorial investment planning and international donor funding. GBWSAP Project Proponent.
Ministry of Energy and Water (MEW)	Water policy, national budgeting, oversight of RWEs, water legislation and enforcement. GBWSAP Project Proponent.
Beirut and Mount Lebanon Water Establishment (BMLWE)	Water supply and treatment operations, distribution to consumers, billing and cost recovery for the Beirut and Mount Lebanon service area. GBWSAP Project Proponent.
Ministry of Environment (MoE)	The national regulatory authority for environmental protection, permitting, monitoring and enforcement
Concerned municipalities	Organized into Federations where projects are too large for a single municipality. Responsibilities include local roads and buildings, community facilities, wastewater and drainage.
Directorate General for Antiquities (DGA)	Part of the Ministry of Culture, responsible for execution, monitoring and enforcement of the Antiquities law and for archaeological remains, antiques, traditional and historical monuments
Other institutions agencies, academia and NGOs	As appropriate to the relevant organization

3.4 World Bank Safeguards Policies

In accordance with CDR policy, and while simultaneously complying with MoE procedures and the Decree No 8633, *Fundamentals of Environmental Impact Assessment*, the present Assessment also follows the requirements of World Bank Operating Policy OP 4.01 for a Category A Project, thus rendering it acceptable for any future funding by the Bank or other international funding agencies, most of which follow World Bank requirements for environmental and social assessment. In consequence, GBWSAP followed World Bank safeguard policies. Impacts on project affected persons (PAPs) and their environment are identified and mitigation measures are proposed. WB safeguard policies allow for the participation of stakeholders including PAPs in project design. There are 10 WB environmental, social, and legal Safeguard Policies. These are Environmental Assessment (OP/BP 4.01), Natural Habitats (OP/BP 4.04), Forests (OP/BP 4.36), Pest Management (OP/BP 4.09), Physical Cultural Resources (OP/BP 4.11), Indigenous People (OP/BP 4.12), Involuntary Resettlement (OP/BP 4.12), Safety of Dams (OP/BP 4.37), Projects in International Waterways (OP/BP 7.50), and Project on Disputed Areas (OP/BP

7.70). Only 5 of the 10 safeguard policies will be triggered by the construction of the GBWSAP, which are:

1. **Environmental Assessment (OP/BP 4.01):**

   This policy is considered to be the umbrella policy of the WB Safeguard Policies. Environmental Assessment aims at identifying, avoiding, and mitigating the potential negative environmental impacts accruing from the Project during design, construction and operation. The policy ensures that the Project is environmentally sound and sustainable and that PAPs are properly consulted. EA also studies project alternatives and suggests methods to improve Project design, siting and planning. EA studies the social and natural baseline, the legislative and regulatory framework of the country and institutional capabilities related to the environment and social aspects, in addition to international environmental treaties and agreements the country is signatory to. EA should be initiated as early as possible during project design and should be integrated with all Project components.

   GBWSAP is classified as category A project, as it is likely to have significant adverse environmental and social impacts especially that the proposed dam is considered to be a large dam. As described above, an Analysis of Alternatives (preliminary draft ESIA) has been already prepared as a comparative study between the different alternatives considered to identify the priority option based on an environmental, social, economic and technical assessment. The Project Proponent has selected Bisri Dam to be the Priority Scheme. An ESIA and an ESMP have been prepared, following OP/BP 4.01 guidance for a category A project.

2. **Natural Habitats (OP/BP 4.04):**

   This policy ensures that the Project takes into consideration biodiversity conservation and aims at protecting natural habitats in the Project area that are legally protected, officially proposed for protection, or unprotected but of known high conservation value. Appropriate mitigation measures should be adopted to ensure environmentally sustainable development.

   The project will have significant impacts on natural habitats, both during construction and operation of the dam. A detailed assessment has been carried out to draw the ecological profile of the area, assess flora and fauna diversity, and to identify those species endangered or IUCN-listed that are at added risk from the Project.

   The construction of Bisri dam and its associated structures, in addition to the creation of the reservoir, will cause both loss and alteration of natural habitats, with resulting impacts on ecology and biodiversity. The presence of the reservoir will transform riparian riverine habitats into lacustrine habitats with both adverse and beneficial effects. The reservoir will reduce habitats for wildlife species that require flowing water but attract those adapted to still or slower-moving waters such as waterfowl.

Beneficial effects will arise from the habitats presented by the reservoir and new biological communities will establish themselves over time.

A preliminary ecological survey has already been undertaken on Bisri dam site. Being the priority option, Bisri underwent a detailed ecological survey, the results of which are presented in Section 5 and the full report is found in Appendix G.

A preliminary Biodiversity Management Plan has been proposed and describes the mitigating measures, costs and responsibilities of the impacts described above. The biodiversity baseline, conservation management actions and mitigation have been generally identified and reflected in the Biodiversity Management Plan. The biodiversity specialist team described in the Biodiversity Management Plan section will develop a biodiversity monitoring plan to monitor biodiversity and habitat management, the results of which will inform the project on the level of degradation to the sensitive habitats and the presence of any direct or indirect activities/actions potentially degrading these habitats especially as it relates to the identified endangered species of fish (namely the blenny freshwater fish). To supplement the management/mitigation measures, the biodiversity monitoring plan will include surveys that will take place during pre-construction, construction and operational phases of the project. These surveys will measure indicators that include but are not limited to: water quality, environmental flow volume and quality, number of target species as well as numbers of indicator species, and cumulative impacts within the upstream watershed. Supplemental details to the biodiversity management plan will be included in a revised version of the ESIA.

Physical Cultural Resources (OP/BP 4.11):

This policy addresses any adverse impacts on physical cultural resources as a result of the Project activities. Physical cultural resources include movable or immovable sites, structures, and natural features that have archaeological or cultural value. The policy aims at avoiding and/or mitigating the negative impacts on cultural or archaeological remains to ensure their preservation.

Reconnaissance sites visits to Bisri dam site have identified various sites physical cultural resources within the reservoir limits including archaeological remains at Marj Bisri, historic remnants of St. Sophia Monastery, and the almost contemporary Mar Moussa Church. GBWSAP thus triggers OP 4.11 and agreement has been reached with the Directorate General for Antiquities and the Diocese of Saida, as to the necessary measures to be undertaken to plan and execute archaeological investigations and rescue excavation and to preserve cultural heritage.

The Maronite Church, pending archive research at Bkirki into the historical significance of Mar Moussa Church, favours the proposed relocation site for which land expropriation procedures arrangements have been reflected in the project.

Similarly, the DGA has agreed the need for rescue archaeology and the time frame proposed in the ESIA. In accordance with its normal internal procedures, it will review the situation and make arrangements to implement its responsibilities under

Lebanese law once the Loan Agreement and Project Appraisal Document have been ratified by a Decree of the Council of Ministers.

A Cultural Heritage Plan is presented in Appendix D and comprises a 'Chance Find' procedure has been incorporated included in the construction documents should any physical remains be unearthed.

Involuntary Resettlement (OP/BP 4.12):

This policy is triggered when the development project involves the involuntary land take and displacement of PAPs. It aims at assisting displaced people to restore their living standards after displacement. Particular attention is given to vulnerable groups including the elderly, women and children and the infirm. Resettlement planning includes provision of compensation and/or any other assistance that may be required during and after resettlement.

GBWSAP is expected to have direct and indirect social impacts in its area of influence and beyond. Consistent with WB safeguards policies, OP/BP 4.12 was triggered and social mitigation plans identified. A Resettlement Action Plan by broad categories of works (dam and reservoir, power plant and transmission line, access roads) was prepared to mitigate, offset, reduce negative impacts and strengthen positive impacts on the communities in the Project area. The resettlement recommendations are discussed in the RAP, which is a separate document.

3. Safety of Dams (OP/BP 4.37):

Dams funded by the World Bank or another of the international financing agencies, are expected to adhere to the provisions of World Bank Operational Policy, *OP.4.37, Safety of Dams*. Most developed countries such as the US, UK and most EU countries already have equivalent provisions for dam safety incorporated within national water supply and/or Health and Safety legislation.

Both the Bank and the World Commission on Dams considers *Large Dams* to be those over 15 m in height, and treats smaller dams as large dams if located in areas of high seismic risk, have large flood-handling requirements, or require complex foundations. On both counts, Bisri is a large dam.

A major contribution to dam safety is the formulation of Dam Safety Plans based on Dam Breach modelling and inundation analysis undertaken by the dam designer. The dam breach report includes an Emergency Action Plan with details of implementation. Dam Safety Plans either issued to date or under preparation include:

- Construction Supervision and Quality Assurance Plan;
- Instrumentation Plan;
- Operation and Maintenance Plan; and,
- Emergency Preparedness Plan.

3.5 Advisory Panel

A dam safety panel and Environmental and Social Advisory Panel have been established by CDR to advise on dam safety, safeguards and other technical studies during dam design, construction, impoundment, and dam monitoring. These panels are expected to meet twice a year during construction and once a year during operation, and their reports will be published.

3.5.1 Dam Safety Panel

CDR has appointed a Dam Safety Panel of Experts that will undertake the following reviews:

- Review site investigations, design, construction and commissioning;
- Review all dam safety plants including (i) Construction Supervision and Quality Assurance Plan; (ii) Instrumentation Plan; (iii) Operational and maintenance Plan; and, (iv) Emergency preparedness Plan.
- Review of prequalification of construction and procurement contractors prior to tendering; and
- Undertake Periodic safety inspections throughout the operational life of the dam.

The Panel usually consists of three eminent persons with a wealth of practical experience of dam design, construction and operation. Their role will be to advise on all critical aspects of the dam; its appurtenant structures, its catchment areas, the surrounding and downstream areas. They are also usually in charge with oversight of project formulation, technical design, construction procedures, and associated works such as power facilities, river diversion during construction, fish ladders, etc. Initial agreement to fund a dam project and any staged loan or grant payments are usually dependent upon the approval of progress status by the Panel.

In the case of the GBWSAP, a panel of 4 internationally recognized dam experts has been established. The Panel has undertaken review of the detailed design of the dam, and will remain under contract throughout the implementation of the works and first filling of the reservoir. The TOR’s of the various Panel members were reviewed by the Bank.

3.5.2 Environmental and Social Advisory Panel

The project proponent will appoint an Environmental and Social Advisory Panel that will provide independent review of, and guidance on the environmental and social issues associated with the planning, design, construction and operation of Bisri Dam and its appurtenant structures.

The Panel will comprise three eminent persons with a wealth of practical experience of the environmental and social issues concerned with dam design, construction and operation. The Panel will also assess the extent to which the Bisri project complies with World Bank safeguards procedures.

The Panel will remain in place throughout the period of construction and for a period of three (3) years operation, or whatever alternative period as appropriate.

4. PHYSICAL BASELINE CONDITIONS

4.1 Introduction

This section of the ESIA is the first of three to describe and discuss the environmental and social baseline conditions pertaining within the project area and its region. In this, Section 4, the physical conditions are presented, in Section 5 the biological conditions, and in Section 6 the social conditions.

Herein under **Section 4.2** the prevailing climatic regime is discussed, while **Section 4.3** describes the landscape and topography. The geology and soils on which Bisri Dam and Reservoir will be founded are detailed in **Section 4.4**, while the risk of seismicity is presented in **Section 4.5**.

The surface water hydrology is described in **Section 4.6**, and the ground water hydrology summarized in **Section 4.7**. The likely tightness of the reservoir is discussed in **Section 4.8**, and the prevailing water quality in **Section 4.9**.

Section 4.10 assesses the impact of the presumed climatic change over Bisri basin water resources while **Section 4.11** examines the impact of the dam project over possible sensitive receivers with respect to air and noise pollution.

4.2 Climate

4.2.1 Prevailing Regime

Lebanon enjoys a Mediterranean climate characterized by a hot dry season extending from May to October, and a cool, wet season between November and April. Although only a little over 10,500 km^2 in area, its wide topographical variation gives rise to a wide variety of microclimates.

Being topographically part of the region that lies between the coastal strip and the western mountains, the Bisri project area site affords all the climatic features of a transitional microclimate that unfolds for hot and humid summers at the proposed location for the dam axis to less humid and mild summers at the extremities of the proposed impoundment. The five winter-months are generally characterized by abundant rains with cool temperatures at the dam-site, and severe winters with more precipitation in form of snow, which contributes over time to the replenishment of the mountains springs, with their water heads, extending between the Barouk and Jezzine mountains.

The climatic parameters of most concern to dam studies are those having direct or indirect impact on the state of water being impounded. Among others, rainfall and evaporation will affect directly the water balance in terms of inflow and outflow to and from the reservoir. The indirect effect of temperature, relative humidity and prevailing wind is expressed in term of how much water will evaporate from the surface of the impoundment. These parameters also impact on the occurrence of ecosystems and natural habitats, and levels of biodiversity.

The following discussion of the prevailing climate at Bisri draws heavily on the National Climatic Atlas for Lebanon[10].

4.2.2 Rainfall

The southwesterly winds bring humid air masses to the Eastern Mediterranean coast, which on reaching the high Lebanese mountains intensifies and triggers precipitation on the Lebanese western mountain chain. The Bisri dam site extends in a moderately steep-sided valley, nested between the Iklim-el-Kharoub, Barouk-Niha and Jezzine mountains, with a part of the Valley axis in a north-east direction, exposing the site to southwesterly winds. The physiological features of the site explain why the Nahr Bisri catchment receives rainfall totaling 1250 mm/yr compared to the 70-year national average of 877 mm/yr. Table 4.1 shows the distribution of Rainfall throughout the year at Bisri site.

Table 4.1: Distribution of Rainfall at Bisri

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
297	260	175	84	27	3	0	0	2	38	127	237	**1,250**

Figures in mm. Source: Atlas Climatique du Liban.

The considerable rainfall falling at Bisri is not distributed equally throughout the year. Almost 95% of rain falls between November and April, leaving the other six months almost dry. Such unequal rainfall distribution will have a decisive impact not only on the annual yield of the river, and as such on the water storage and delivery patterns of the dam, but also on natural habitats and biodiversity.

4.2.3 Temperature

As a general rule, the increase in altitude and latitude across the Lebanon western mountains produces milder weather. As such, the more eastward we move from the coast, the lower will be the air temperatures throughout the various seasons of the year. Bisri dam site is no exception to this rule, where the annual and monthly temperatures are lower than those on the coast at Saida, as shown in Table 4.2.

Table 4.2: Mean Monthly and Annual Temperatures for Bisri and Saida

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Mean**
Bisri	7.5	7.8	11.1	14.3	18.3	20.3	21.5	22.5	20.3	18.8	14.4	9.1	**15.5**
Saida	12.5	13.6	15.1	17.8	20.1	22.9	24.7	26.0	24.8	21.6	18.7	19.6	**19.8**

Figures in °C *Source: Atlas Climatique du Liban.*

4.2.4 Relative Humidity

The key factor ruling the variation in relative humidity in Lebanon is the proximity and remoteness of the site from the Mediterranean Sea, where the humid south-westerly winds off the sea saturate the air during the summer months and the more the air masses move inland the less humidity they will bear. The annual mean relative humidity may drop from 72% on the Beirut coast during summer, to 40% at Baalbek in the Bekaa

10Atlas Climatique du Liban, 1977 Publié par le Service Météorologique du Liban avec l'aide de l'Observatoire de Ksara Deuxième Edition.

Valley, for the same period. As mentioned above, since the Bisri site is in a transitional zone between the wet and humid coast and the dry hinterland, one could predict that Bisri dam site may record values for relative humidity in between these two extremes, as shown in Table 4.3.

Table 4.3: Relative Humidity for Bisri

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Mean**
72	69	66	60	56	59	57	57	63	65	57	60	**62**

Figures as % Source: Atlas Climatique du Liban.

The lowest humidity levels are generally recorded during the summer months, the highest in January and February.

4.2.5 Prevailing Wind

Across Lebanon, southwesterly (SW) and westerly (W) winds predominate on the coast and in the mountains while northeasterly (NE) prevail in the north of the country and in some inland areas during the winter. Being within the coast-mountain transitional zone and considering the Bisri valley's orientation, the prevailing wind at the dam site is southwesterly. While these winds are active all year, the months of October and November witness relative calm. During the period from December to April, the SW winds bring maritime air masses that trigger rainfall all along the coast and over the mountains.

During the period from May to September these winds carry humid air that accumulates as fog on the flanks of the Lebanese western mountains where, during nighttime they are swept away by the local breezes blowing down from the surrounding mountain tops.

Variations in the degree of windiness relative to average wind throughout the year are shown in Table 4.4. Not surprisingly, January to March are the windiest months, while October and November are the calmest.

Table 4.4: Relative Monthly Windiness at Bisri

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
113	110	109	102	102	102	103	93	91	86	87	97	**100**

Figures in % Source: The National Wind Atlas of Lebanon, 2011.

4.2.6 Evaporation

As mentioned above, air temperature combined with relative humidity and wind are the major determinants of how much water will evaporate from the surface of the reservoir. The nearest and within basin climate station to the Bisri site is Jezzine, station, from which data have been used to estimate evaporation, given in Table 4.5 ,for the project site.

Table 4.5: Evaporation at Bisri

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
46	60	98	136	176	199	202	185	152	114	70	48	**1486**

Figures in mm Source: Atlas Climatique du Liban.

As shown above, the highest evaporative demands occur during the six dry months from April to August, with a peak in July, when the reservoir is expected to reach its full storage capacity and start delivering water to GBA[11]. While the estimated evaporative demands are not expected to exceed 5% of the full storage capacity, these losses have to be accounted for in any reservoir yield-capacity analysis because 60% of these losses will occur during the months June to November when the reservoir will be delivering to Greater Beirut.

Moreover, the occurrence of the highest reservoir evaporative losses are expected to coincide with the lowest recorded air relative humidity levels for the months May to September. This will have a decisive impact on altering the humidity of the air surrounding the reservoir. High relative humidity coupled with warm temperatures favour fauna and flora species proliferation, while the same conditions are ill-suited to the thermal comfort of humans.

4.3 Landscape and Topography

The two easterly lobes of Bisri Reservoir formed by Nahr Barouk from the north and Wadi Bhannine where Aari'ye River runs from the south together drain a substantial portion of the southern Chouf Mountains. These two watercourses merge at Marj Bisri to form Nahr Bisri, which after a further 5 km merges with Wadi Khallet west of Bisri Village to become Nahr Awali, thereafter continuing to the sea. Above the dam site on Nahr Bisri the surface water catchment area extends to some 215 km^2. The dam site is at an elevation of 395 m and its catchment rises to a height in excess of 1,900 m. Typical scenery throughout the Bisri reservoir site and adjacent areas is shown in Figure 4.1.

The upper catchment area is characterized by the steep slopes and cliffs, with small traditional villages comprising red-tiled houses perched on hilltops and at cliff edges. The landscape consists mainly of wild plantations, cedar trees in Barouk Mountain, oak and pine forests in Jezzine, Bkassine, and the Upper Chouf, in addition to woodland varieties, farmland and natural scrubby bush vegetation. The plant cover is important for controlling erosion and landslip, promotes aquifer recharge and boosts carbon sequestration. The natural beauty of the mountains is an important resource but the lack of landscape management and the absence of planning control have resulted in severe degradation over the last two decades. Typical upper catchment scenery is shown in Figure 4.2.

The Awali Valley south of the dam site is moderately steep sided and largely under natural vegetation. Downstream of Bisri Village, beyond the area of ancient landslip that gave rise to form the lake that subsequently silted-up to give the dam site its float and fertile character, the valley again occupies a steep generally-V-shaped valley in which the bottom lands are narrow and agriculture is largely limited to tree-crops grown on terraced slopes. The nature of the lower catchment is also shown in Figure 4.2.

11Design of Bisri Dam: Updated Feasibility Report. Dar Al-Handasah (Nazih Taleb and Partners), 2011.

Looking E from the dam site

Pine woodland on the left bank

Looking W from above Wadi Bhannine

Rocky hillside and scrub on the right bank

Looking E towards of Wadi Bhannine

Looking N towards the far end of the reservoir

Figure 4.1: Typical Landscape and Scenery of the Bisri Area

Upper Catchment Landscape at Bater

Upper Catchment Landscape at Niha

Nahr Awali 3km below the Bisri Dam Site

Awali Hydropower Plant downstream the dam

Figure 4.2: Landscape and Scenery Above and Below the Project Area

4.4 Geology and Soils

4.4.1 Geology of Catchment Area

The Bisri Dam catchment area encompasses a geological sequence extending from the Jurassic Kesrouane Limestone (J4) in the higher mountainous areas through the intervening formations to the Cretaceous Sannine Limestone (C4) and the recent Quaternary alluvial and fluvial deposits exposed along the course of the Bisri river and continuing downstream of the dam site. This sequence presence in the catchment and its primary lithologies are shown in Table 4.6, the blue shaded formations being those falling within the area of the dam and reservoir.

Table 4.6: Stratigraphic Succession in the Bisri Catchment Area

Age	Formation		Lithology
Middle Cretaceous	C4	Sannine Limestone	Finely bedded limestones and marly limestones, c.600+ m in thickness, highly fractured and karsified.
	C3	Hammana Formation	Varied limestones overlain by clays marls and sands, c.140 m.
Lower Cretaceous	C2b2	(Now part of C3)	Marls with limestone and sandstone intercalations.
	C2b1	Mdairej Limestone	Massive cliff limestone unit, generally confined at depth, 40-50 m.
	C2a	Abeih Formation	Variable limestones, marls and sandstones, fractured, karstic at depth. Clays near the top give landslips. c.170 m thick.
	C1	Chouf Sandstone	Friable quartzitic sandstones with subordinate clays, shales, lignites and marine basalts. Fractured. Up to 300 m.
Upper Jurassic	J7	Salima Formation	Mostly thin-medium bedded ferruginous oolitic limestones with marly and sandy beds, 80-180 m in thickness.
	J6	Bikfaya Formation	Massive fine-grained micritic limestones, highly fractured and karstic, 60-80 m thick.
	J5	Bhannes Formation	Limestones, basalts, pyroclastics and shales, 50-150 m thick.
Middle Jurassic	J4	Kesrouane Limestone	Massive grey cliff limestones with chert, 1000+ m in thickness, heavily fractured and karsified

4.4.2 Geology of Bisri Dam and Reservoir

The proposed dam will stretch to nearly 800 m across the valley and stand about 74 m high. The present floodplain and active river deposits have a maximum thickness of some 30 m in the main channel but overlie up to 90 m of mainly fine grained lacustrine material deposited in an ancient lake that formed behind a landslip downstream of the dam site. The left abutment primarily comprises the fine grained and friable Chouf Sandstone (C1), where two adits were excavated in 1982 and during the previous investigations, for distances of 210 and 215 m respectively. Both encountered friable rock and evidence of past land sliding. Close to the dam axis the depth of slide was less than 10 m, while elsewhere larger slides were reported. The right abutment presents a sequence of strata covering the period between the Basal Cretaceous up to the Middle Cretaceous going through C1 to C4.

The stratigraphy in the reservoir consists mainly of Chouf Sandstone. Close to the dam site, a sequence of interbedded limestones and marls representing the sequence from C2a to C3 extends from the dam axis upstream about 1.7 km along the right abutment. The right wall of the reservoir also contains areas of landslip. The Quaternary and Recent alluvial and lacustrine deposits comprise sands, silts, gravels, and cobbles, overlying highly plastic clayey silts and silty clays interstratified with sandy lenses.

The limestone rocks exposed along the right side of the dam reservoir are highly fractured and show evidence of developing karstification, as shown in Figure 4.3. This secondary permeability will ultimately affect water tightness and make the exposed rocks prone to leakage from the reservoir. In this respect, it was noticed during the previous investigations, that all the boreholes drilled along the right bank of the dam showed evidence of water loss down to a depth of 18m, where the complete loss of drilling fluid was reported.

Figure 4.3: Highly Fractured and Jointed Mdairej Limestones on the Right Bank of the Reservoir

Further upstream, the transition from the limestone rocks to the sandstones of the clastic Chouf Formation (C1) can be traced along the right bank. However, further detailed mapping is needed to establish the precise boundary/contact between the carbonate rocks of the Abeih Formation (C2a) and the basal sandstone of the C1 formation because landslide material and eboulis are masking the exact location of the contact. At close proximity to the eboulis, the sandstone strata show variable dip direction and higher degrees of systematic jointing. In addition, greyish clayey/shale intercalations are not uncommon within the sandy strata, as shown in Figure 4.4.

Figure 4.4: Altered and Jointed Chouf Sandstone and Eboulis.

Further upstream on the same right bank, another massive mass movement feature is encountered; large blocks originating from the Mdairej cliff at the topmost right wall of the valley have become detached and moved downslope under gravity, intermixed with smaller and finer debris, as shown in Figure 4.5. Any dam axis relocation should be upstream of the eboulis, bypassing fractured Middle Cretaceous strata and unstable slopes

Figure 4.5: Old Landslide on the Right Bank of the Valley.

Given the highly jointed nature of the C2b Formation, as shown in Figure 4.6, and the presence of already detached blocks resting at the toe of the cliff, it is probable that sizeable limestone blocks will completely detach themselves and move downslope during the lifetime of the project.

Figure 4.6: Well Jointed Mdairej Limestone with Fallen Blocks on Underlying Abeih Formation

Agricultural terracing along the slopes of Nahr Bisri act to stabilise slopes, especially in the softer and friable sandstone layers.

4.4.3 Structural Geology

The geological structure at Bisri comprises a complex interaction of faults, folds and mass movements. The faults appear to be high angle to vertical normal faults that essentially trend generally north-south and east-west. Two major faults pass close to the dam axis; the Roum Fault and the Qalaat El Hambra Fault. The major landslide that caused the lake to be formed that resulted in the lacustrine deposit is believed to have occurred along the latter fault.

Boreholes along the dam axis encountered a succession of older beds of J5-J7 abruptly displaced against the C2a, for which the Jurassic succession must have been uplifted along a major fault. The report interprets this fault to be the subsurface extension of the Roum Fault, although this remains somewhat speculative and must be investigated during detailed dam design.

In addition, other faults can be seen intersecting the upstream area of the reservoir. One fault cuts the upper part of the reservoir area, near Marj Bisri and along the Bhannine valley. Where this intersects the dam reservoir along the northern bifurcation, its trace is masked by the floodplain and fluviatile sediments. The faulted cliff can above Wadi Bhannine is shown in Figure 4.7, with the fault trace marked by shattered rock.

Figure 4.7: The Faulted and Fractured Mdairej Limestone above Mar Bisri

Most of the faults are local and of limited extent, although their effect can be clearly seen in jointing and fracturing in addition to displacement, as shown in Figure 4.8 , in which the line of trees highlights the availability of water within the zone of fracturing.

Previous reports have helped define the geological structure within the vicinity of the dam, but not to the extent detailed design can proceed without further investigation. Little work has been undertaken on the reservoir, where the impact of the old landslips or the potential for new movements, and fracture and joint surveys are still required. The detailed design phase should map/study in detail the slides and their effect on the reservoir, banks stability and dam safety. The presence of faults below the lacustrine deposits remains speculative and should be confirmed by exploratory drilling, perhaps backed up by geophysical exploration.

Figure 4.8: The Limestone Cliff Displaced above Wadi Bhannine

Further details of the geology and geotechnical aspects of Bisri Dam are presented in Appendix E. The Dam Safety Panel of Experts comprises a Geology Expert that has reviewed all aspects of project design as they relate to geological conditions and required mitigation measures.

4.5 Seismicity

4.5.1 Regional Seismicity

Given its location on a major tectonic plate boundary it is of little surprise that Lebanon and adjacent regions suffer frequent structural movements. Fortunately, only a small number of the several hundred tremors recorded each year by seismograph are felt by residents. Figure 4.9 illustrates the epicentres of those recorded over just a three year period, 2006 to 2009. Features to consider in the context of the present ESIA are primarily:

- The large number of events (all dots) and their widespread occurrence;
- The widespread occurrence of deeper (black dots) and potentially more catastrophic events;
- The distribution of events around the Bisri site.

4.5.2 Seismic Risk

Given the structural and tectonic setting of Lebanon, the main structures likely to affect the dam site are the Roum Fault and the Yammouneh Fault. The closest surface expression of the Roum Fault is about 2 km SW of the dam site, but its subsurface trace or an offshoot of it appears to continue into the Awali valley and beneath the proposed dam site. The Yammouneh Fault is approximately 10 km east of the dam site, and two other faults of regional significance, the Rachaya and the Serghaya Faults, 28 and 40 km east, respectively. While the Yammouneh Fault, the extension of the Dead Sea Fault System, appears not to have moved for several thousand years, more recent movements, including the 1956 Chhim Earthquake, have taken place on the Roum Fault. It is thought by some seismologists that this lineation, running from Marjayoun towards Beirut, is now the effective plate margin.

Two notable earthquakes with a magnitude of 8.3 were recorded in 1201 and 1759. Both epicenters were within a radius of 75 km from Bisri and resulted in a high level of destruction and loss of life. On March 16 1956, a magnitude 6.0 earthquake occurred 4 km east of the proposed dam site causing 136 deaths and destroying 6,000 houses. This event is thought to have occurred along the Roum Fault.

The widespread faulting and fracturing has caused secondary discontinuities that further dislocate and decrease structural integrity. The permeability of the rock mass is thus increased and the potential for leakage from the reservoir enhanced. That the Roum Fault, known to be significantly active, may pass under the dam and reservoir site presents a major risk to the viability of the Bisri project.

The Earthquake Design has recently been reviewed. The earthquake resistant design criteria prepared for the Bisri Dam (ECIDAH, 1997) essentially refer to the Operating Basis Earthquake (OBE), probabilistically associated with a return period of 144 years, and the Maximum Credible Earthquake (MCE), 84-percentile ground motion deterministically obtained from the MCE scenarios. The deterministic OBE and MCE scenarios provided by ECIDAH (1997) are respectively M7.3 and M5.7 on Roum Fault both at 2km distance from the Bisri Dam. Under the Subsection 5.1 of the Dam Review Board (DRB) Report No.1 (November 2013), it has been requested to "Perform a seismic hazard study to define the characteristics of the earthquakes that may be encountered at the site (design basis ground motion levels)". Three sets of ground motion have been provided, compatible with the MCE response spectra originally presented in ECIDAH (1997). These time domain ground motion sets are used by the engineer for the earthquake response analysis of the Bisri Dam.

Current approach for the earthquake resistant design of dams relies on the "performance based design" based on the guidelines of the Committee on Seismic Aspects of Dam Design of the International Commission on Large Dams (ICOLD, 2010). ICOLD guidelines call for a two level design based on the Operating Basis Earthquake (OBE) and the Safety Evaluation Earthquake (SEE), and also provides the associated performance objectives. In line with these requirements, the earthquake resistant design criteria were reviewed and the design basis response spectra associated with the OBE and SEE level ground motions recomputed based on the current data, knowledge and state-of –the-art methodologies. An assessment of the location, characteristics and capability of the Roum Fault, or any other neo-tectonic feature at the dam site, including the OBE and SEE fault offsets if the neo-tectonic feature crosses the dam body, through a site-specific neo-tectonic investigation was undertaken. This included an assessment of the structural and seismic characteristics of the Roum Fault in the dam site area based on existing literature and tectonic knowledge and was combined with additional field visits. This includes reviewing the mapping, OBE, SEE and offsets associated with this fault.

Information about possible existence of the active fault under the dam site and assessment of its structural and seismic characteristics presented in the reports (location, type, offsets) was also reviewed by comparing report results with ground-based observations during field visits where the existence and mapping of such structures were verified.

Preliminary findings of the neo-tectonic study are summarized below (*Report on the Assessment of the Neo-Tectonic Setting and Seismic Sources for the Seismic Hazard Assessment of the Bisri Dam Site, Elias Ata, May 2014*). These are currently under review by the Dam Safety Panel of Experts and will be reflected in the final detailed design as appropriate:

- Some of the parameters used for characterizing the major faults were reviewed based on recent understanding of the geology and tectonics of the region. The Length of the Yammouneh Fault was originally considered equal to the length of the entire transform plate boundary between the Red Sea and Anatolia. Given the widely accepted standards and rules in Seismotectonics, this is an exaggeration of the possible rupture length. This resulted in a reduction of the MCE for the Yammouneh Fault to 7.9 in compliance with the definitions set by ICOLD 2010 guidelines.
- The MLT ramp was identified as a new seismic source that can affect the Dam site and characterized its hazard. This is a blind sub-surface thrust ramp that lies below the northern part of the Dam site and is capable of generating MCE of 7.8. Special care should be given when considering the GMPEs of this source because of its special geometry (a thrust).
- No proof of active faulting related to the inferred fault below the Dam site was found in the geomorphology or geology of the site. Neither was any convincing evidence found for the continuation of the Roum Fault under the sedimentary cover of the Bisri valley.

Given the important erosion/deposition rates within the valley, the surface expression of active, deep-seated faults may have been smoothed and covered, cannot be totally ruled out. It is suggested that a geophysical investigation of the subsurface using seismic refraction methods be undertaken in order to image the subsurface structure and check for any buried faults.

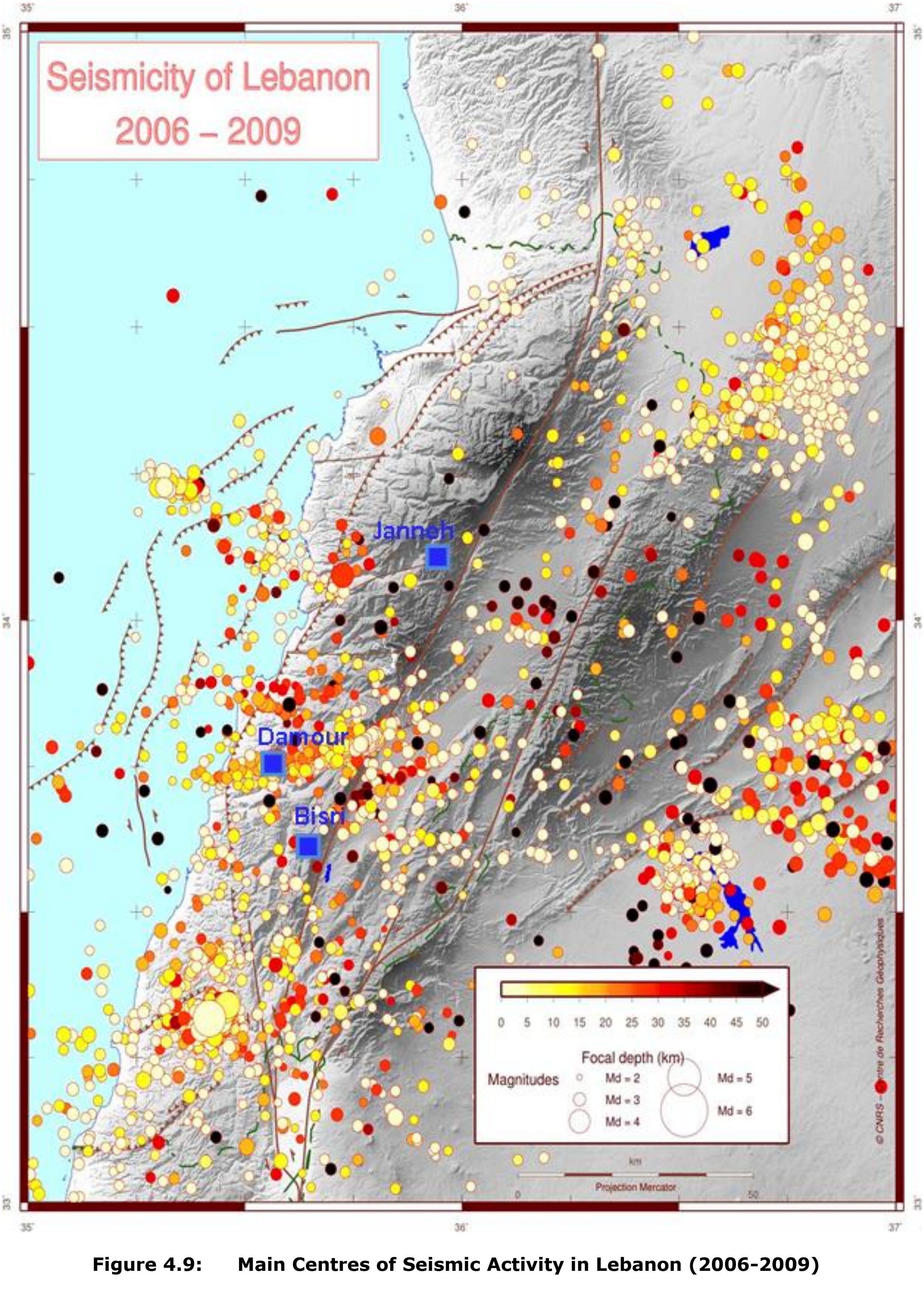


Figure 4.9: Main Centres of Seismic Activity in Lebanon (2006-2009)

4.6 Surface Water Hydrology

Nahr Bisri above the dam site has a 215 km^2 catchment area that receives water from various perennial and seasonal spring issues as shown in Figure 4.10. The headwaters of most perennial springs are at elevations varying between 1000 and 1900 masl along the western rims of the Al-Barouk, Toumat-Niha and Jezzine mountains, while those of seasonal tributaries generally have headwaters at elevations below 1000 masl.

The two main influents of Nahr Bisri are Nahr Barouk, running in southerly direction, and Aa'rye-Jezzine watercourse running in northern direction into Wadi Bhannine, converging at Marj Bisri, some 3 km west of Bater village. Nahr Bisri then meanders down through the project area until south of Bisri Village, after taking in minor tributaries, it becomes Nahr Awali. The watercourse provides both the physical and administrative boundary between the Chouf and Jezzine Cazas. The lower reaches of Nahr Awali has an abundant flow even during the summer months because of the Litani-Awali scheme that transfers water from Qaraoun Lake and intermediate springs to the Joun hydropower plant that discharges ultimately into that final stretch of the river.

The rainy season across the catchment is from October to April, with the peak monthly precipitation of around 300 mm in January. Almost no rain falls during the other months. The average annual precipitation, recorded for the period of 8 years from 2001 to 2009 is 1107 mm.

The nearest river gauging station to the proposed dam axis is located 1.3 km downstream of the dam site at Bisri road bridge, where the recorded average annual yield is about 135 Mm^3 (4.2 m^3/s) for a recording period of 30 years, extended up to 65 years for the purpose of the feasibility study. The minimum average monthly stream flow for the same period, 1.31 Mm^3 (0.5 m^3/s), occurs during the month of September, whereas the maximum average monthly stream flow recorded in February was 30.44 Mm^3 (12.0 m^3/s). Comparing the most recent 20-years' worth of records with those from the period 1944 to 1974, a 22% reduction in recent average annual river yield is apparent.

The monthly flow-duration analysis for Nahr Bisri shows that the base monthly flow is about 0.6 m^3/s, with 90% chance of exceedance. The slope of the flow-duration curve (Figure 4.11)[12] is considerably flattened in its low flow portion, indicative of significant ground water inflow. Moreover; the curve shows that Nahr Bisri flows are reliable about 40% of the time, corresponding very well to the wet rainy season of 5-6 months.

As part of project preparation, a detailed assessment of the hydrology relating to Bisri and the associated detailed design was undertaken. This assessment reviewed in detail the quality of the runoff records at the Marj Bisri gauging station, and the methodologies used for computation of average inflow and extreme floods. The assessment indicated that that while low flows may be correctly estimated, high flows estimates are highly uncertain. The assessment therefore triggered additional parallel hydrological modeling

12 Bisri Dam Feasibility Report, Dar Al-Handassah (Nazih Taleb & Partners), 1995.

exercises, leading to new more robust hydrological characteristics that have been incorporated into the final detailed design.

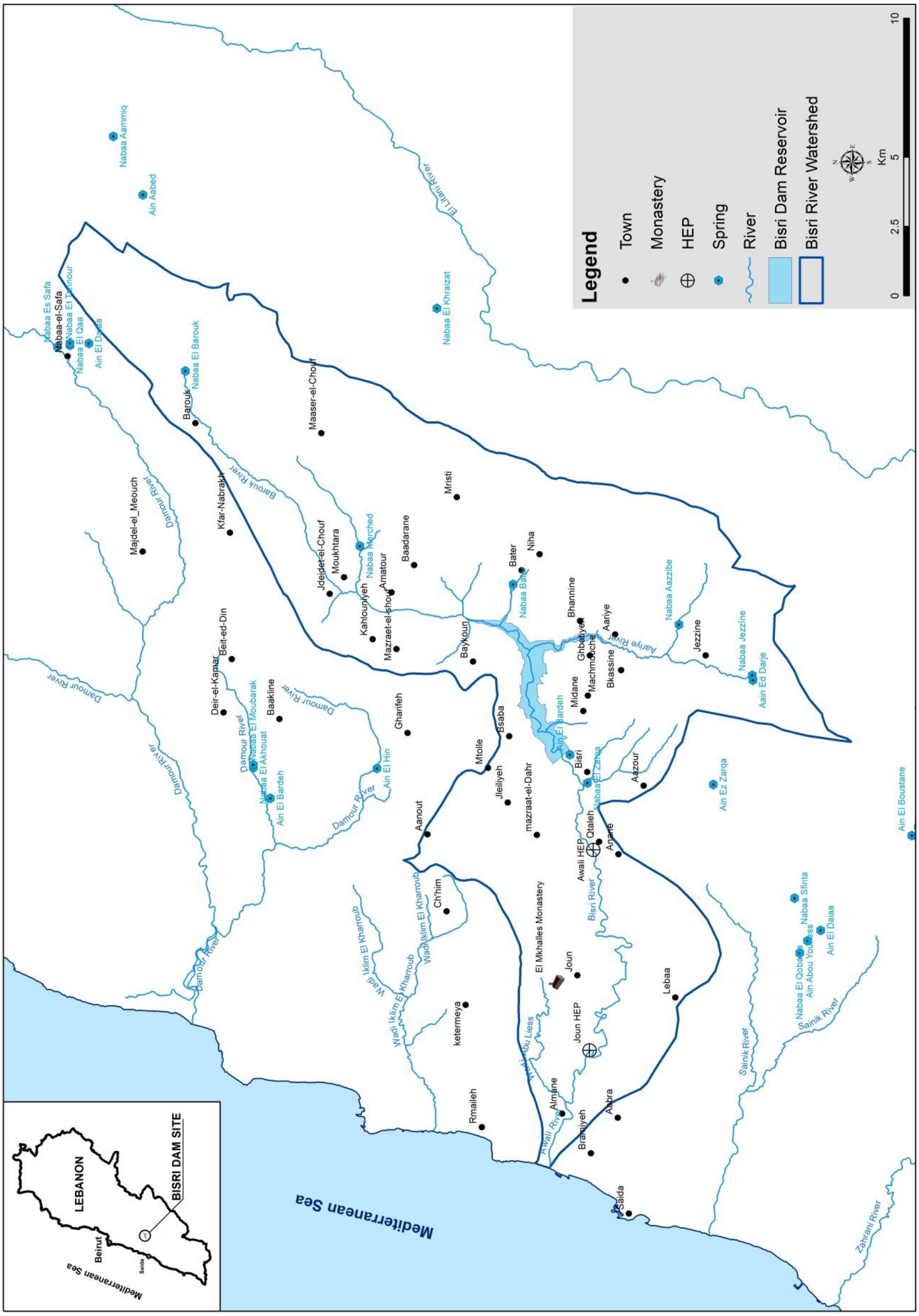


Figure 4.10: Bisri-Awali Surface Water Catchment Area

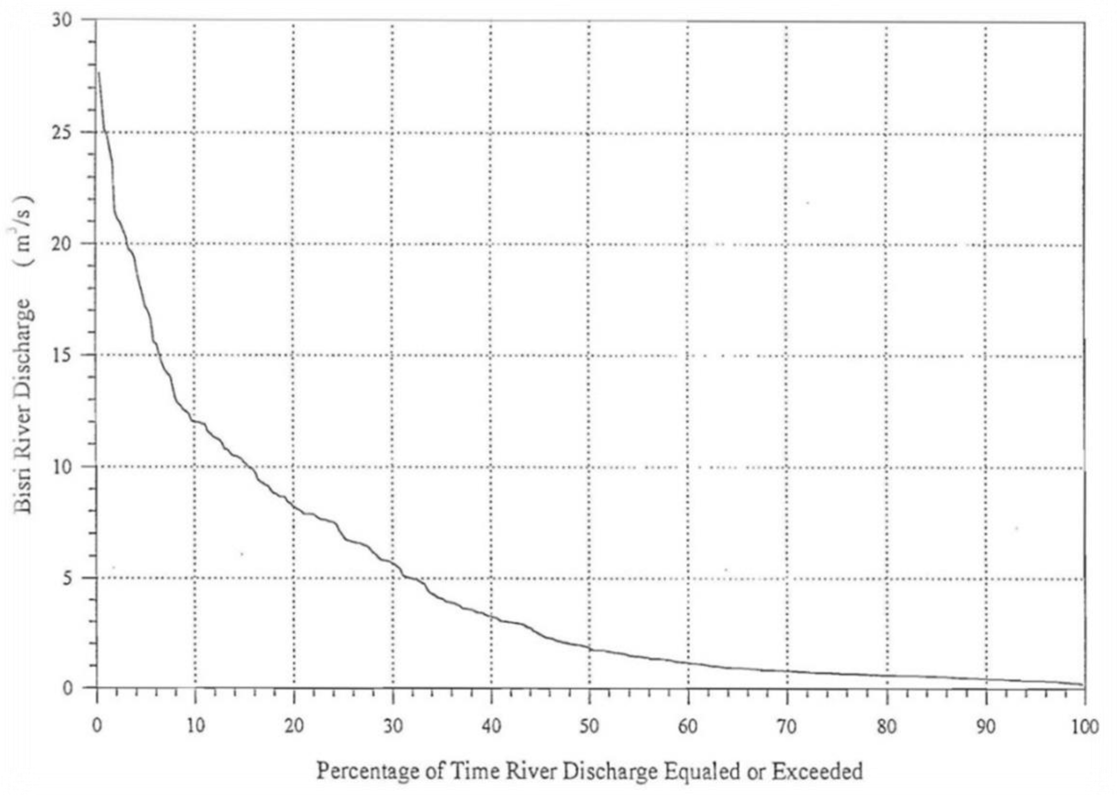


Figure 4.11: Nahr Bisri Flow-Duration Curve

A summary of the key hydrological parameters pertaining to the Bisri dam site taken from the 1995 and 2011 feasibility studies are listed in Table 4.7.

Table 4.7: Bisri Dam Site Hydrology

Parameter	Quantity
Catchment area	215 km^2
Site elevation	395 masl
Average Precipitation	1,107 mm/year
Average annual yield	135 Mm^3
Annual dry year yield	60 Mm^3
Annual evaporation	718 mm
Spillway design discharge	3,000 m^3/s (for PMF)
PMF estimate and safety check discharge for spillway	3,000 m^3/s
Diversion during construction (25-year return flow)	550 m^3/s
Annual sediment yield	1,000 $t/km^2/yr$
Water release	6 -7 m^3/s (June-Nov)
Dam storage	125 Mm^3

4.7 Ground Water Hydrology

As discussed previously, Lebanon had access to plentiful ground water resources but while those of the aquifers underlying the coastal plain and adjacent foothills are generally over-exploited and increasingly subject to saline intrusion, those in the upper hills and mountains, despite affording a potentially valuable resource, remain not only largely unexploited but also unexplored.

The geological sequence discussed in Section 4.4 comprises a series of permeable aquifers separated by poorly permeable aquicludes[13], as illustrated in Table 4.8. The Kesrouane Formation (J4) and the Sannine Formation (C4) comprise hard, fractured and karstic limestones and are Lebanon's major ground water aquifers.

Table 4.8: Aquifer Units within the Geological Sequence

Age	Formation		Hydrogeological Significance
Middle Cretaceous	C4	Sannine Limestone	Major Aquifer
	C3	Hammana Formation	Aquiclude
Lower Cretaceous	C2b2		
	C2b1	Mdairej Limestone	Minor Aquifer
	C2a	Abeih Formation	Aquiclude
	C1	Chouf Sandstone	Minor Aquifer
Upper Jurassic	J7	Salima Formation	Aquiclude
	J6	Bikfaya Formation	Minor Aquifer
	J5	Bhannes Formation	Aquiclude
Middle Jurassic	J4	Kesrouane Limestone	Major Aquifer

The occurrence of these formations across the Bisri project areas has been discussed previously. In the absence of a national geological survey to which well drillers' and site investigation contractors' records are routinely submitted, neither modern field mapping, nor specialisations such as hydrogeology and engineering geology have been developed for the public good. Even basic concepts such as the definition of fractured and karstic aquifer catchment areas, which unlike granular aquifers do not mirror surface water catchments, are very poorly understood. This is equally true of the Bisri dam and reservoir site as for elsewhere.

The 1995 feasibility studies for Bisri makes almost no mention of hydrogeology, although it seems that the main ground water level beneath the dam and reservoir are within the coarser alluvium beneath the lacustrine clays, with near-surface ground water limited to existing and old river channel deposits with hydraulic continuity to Nahr Bisri and Wadi Bhannine.

13 The terms aquifer and aquiclude relate to a formation's relative ability to accept recharge, store and move water and yield usable quantities economically. Formations classified as aquicludes may have ground water passing through them, often via discrete fissures, but cannot productively yield it in usable quantities.

The most significant formation for ground water within the project area will be the Chouf Sandstone, which while only a minor aquifer, crops out over much of the reservoir slopes. While the geological investigations at the dam site show up to 90 m of low permeability clays and other generally fine clastic material, these lacustrine deposits may be expected to coarsen and perhaps also thin northwards, and with increased hydraulic head due to the depth of inundation, reservoir water may penetrate the courser horizons to seep into the underlying faulted bedrock.

These issues were reviewed in detail by the Dam Safety Panel of Experts (which includes a dam geology specialist) and by a series of additional borehole investigations, financed by CDR as part of project preparation. Findings were reflected in the final detailed design.

4.8 Reservoir Water Tightness

For a dam to be successful, the water impounded behind it should not infiltrate through the valley floor or walls into the underlying bedrock, flow beneath the dam, or issue as spring discharge downstream. There are numerous examples in many parts of the world where such leakages occur and reservoir areas remain almost dry years after dam construction. Leakage is already a major problem at the 63 m high Chabrouh Dam in North Lebanon. Completed in 2007 with a design storage of 8 Mm^3, leakage has always been a problem and the reservoir design water level has never met. Current losses reported by different sources, vary from 22,000 to 33,000 m^3 each day.

While hydraulic continuity between river flow and shallow ground water in superficial alluvial aquifers is common, the raising of water levels during reservoir filling increases hydraulic pressure, allowing the water to exploit open fissures and fractures in the underlying bedrock. In large dams, the increase in hydraulic head may be sufficient to prise open previously closed fractures or to clear those previously clogged with sediment.

The ideal dam site will therefore be one located on solid, poorly fractured bedrock. While ground improvement, such as injection grouting or the use of geosynthetic membranes, may be practical for a broken and permeable dam site, both quickly become prohibitively expensive if the whole area inundated by the impoundment has to be treated to render it watertight.

For Bisri Dam, the site is mainly formed by permeable karstic limestones. New boreholes are being undertaken to enrich existing and provide new data for the design of the appropriate sealing measures.

In the left abutment, the presence of the comprehensive sandstone formation C1, of overall low permeability, will not allow lateral leakages from the karstic limestones that appear at the lower part of the abutment. The water table with a gradient towards the valley is an assuring fact. The leakages through these limestones will take place only under the dam, and these leakages may be stopped or significantly reduced by the grout curtain under the embankment.

In the right abutment, leakages can take place under the dam and also by passing it "au large". Those leakages have to be stopped or controlled by a grout curtain under the dam and its extension inside the abutment. In this abutment, the water table is recognized to be under the riverbed elevation. This means there is a possibility for lateral leakages towards a distant exit. The area where these limestones will be inundated in the reservoir zone extends about 600m upstream of the axis, including the more karstic "Falaise Blanche". From there on, the sandstone formation of low permeability appears and seems to persist.

A positive feature is the presence of interlayers of marlylimestones or marls inside the main limestone mass. They should intercept the potential lateral leakages. The structural orientation of these interlayers with a strike almost parallel to the valley slopes is a contributing factor, provided they are fairly persistent. This is one of the purposes of the proposed investigations together with the inspection of the piezometry and its fluctuations.

Even after the results from the additional boreholes are available, there will be some uncertainty about the water tightness of the right bank. Therefore, consideration should be given to the construction of gallery/galleries that could be used for post-construction grouting, if that should prove to be required.

4.9 Surface Water Quality

4.9.1 General

This section discusses the water quality aspects of the water source considered for augmenting Greater Beirut water supply, including the expected requirements for water treatment prior to distribution.

Two process streams are commonly used for treating natural surface waters:

- Conventional treatment including clarification (coagulation, flocculation and sedimentation), filtration and disinfection; and,
- Advanced treatment to remove pollutants that cannot be removed by conventional treatment.

The objective is therefore to assess Nahr Bisri water and its suitability for potable use after conventional treatment. In order to achieve this, water quality sampling and analysis have been undertaken within Nahr Bisri and its tributary springs and watercourses.

One of the prime advantages of the Bisri scheme option over other dam alternatives, discussed further in Section 8 below, is that it can technically and economically benefit from and give benefit to, the regional water infrastructure already agreed upon for the Awali basin, with water coming from various sources including Qaraoun Lake, springs at Ain Zarqa and near Jezzine, ground water seepage into the unlined transmission tunnel, and Nahr Awali.

The purpose of the ESIA is therefore to show that water impounded behind Bisri Dam is of at least equivalent quality, is free from potentially harmful contaminants, and can also be rendered suitable for consumption by Greater Beirut through the same conventional treatment stream. Figure 4.12 illustrates schematically how the Bisri Dam interfaces with the GBWSP scheme and feeds into the Ouardaniye treatment plant.

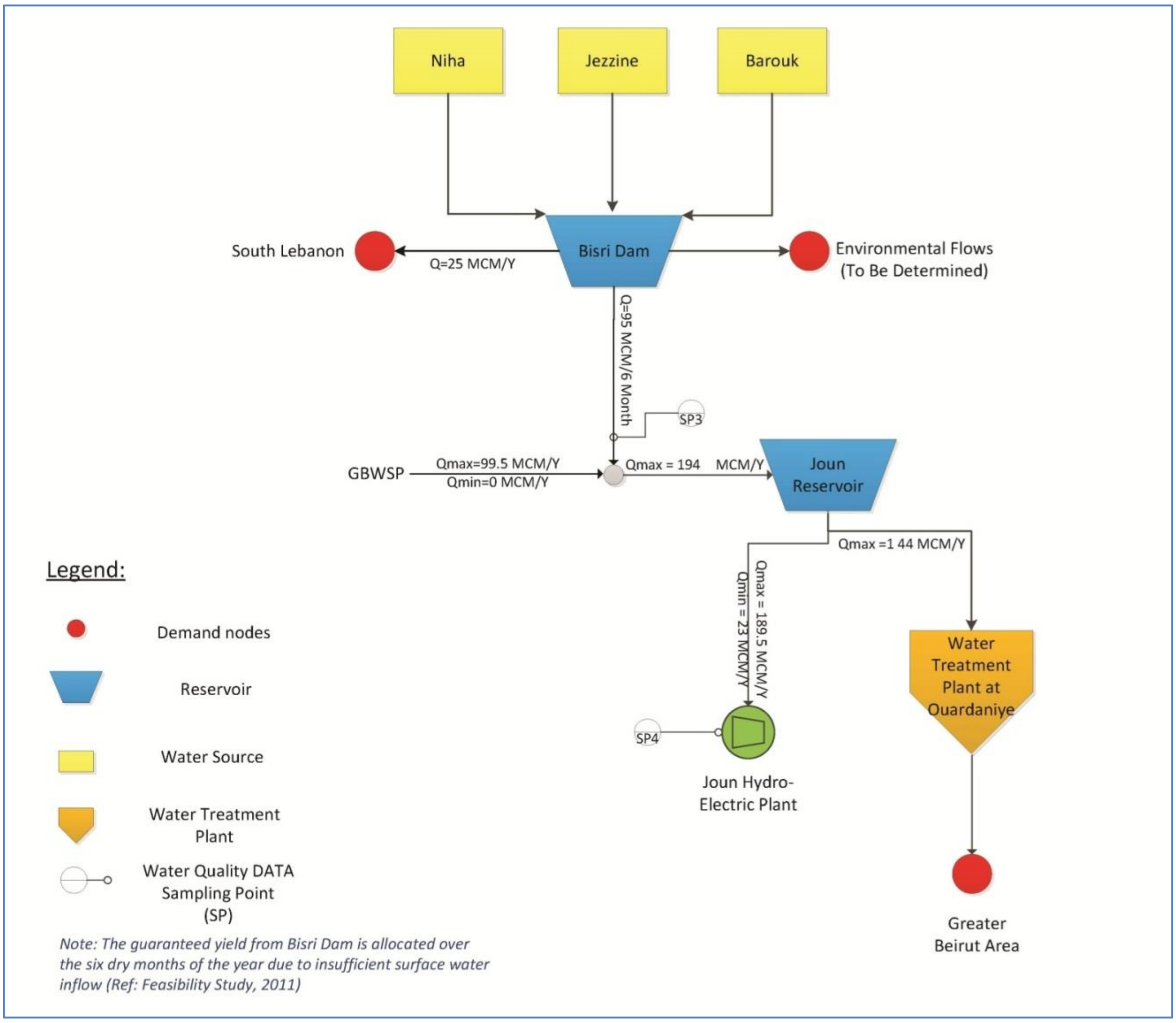


Figure 4.12: The Bisri Scheme within the Awali/GBWP Scheme

The criteria against which to assessing Bisri water quality are the Lebanese Standards and WHO Guidelines for drinking water. Table 4.9 lists the primary and secondary standards, while Table 4.10 lists additional parameters generally used in water quality assessment.

Table 4.9: Primary and Secondary Potable Water Standards and Guidelines

	Parameter	Lebanese MOE Standards[14]	LIBNOR Standards[15]	WHO Guidelines	EU Standards	US EPA Standards
Primary Standards	Turbidity	<4 NTU	<10 NTU	<5 NTU	Not Mentioned	-
	Nitrate/Nitrate-nitrogen	50 mg/l	45 mg/l	-	50 mg/l	10 mg/l
	Nitrite/Nitrite-nitrogen	0	0.05 mg/l	-	0.5 mg/l	1 mg/l
	Cyanide	0.05 mg/l	0.05 mg/l	0.07 mg/l	0.05 mg/l	0.2 mg/l
	Fluorides	0.7 mg/l at 25-30°C	0.7 mg/l at 25-30°C	1.5 mg/l	1.5 mg/l	4 mg/l
	Arsenic	0.05 mg/l	0.05 mg/l	0.01 mg/l	0.01 mg/l	0.05 mg/l
	Cadmium	0.005 mg/l	0.005 mg/l	0.003 mg/l	0.005 mg/l	0.005 mg/l
	Chromium	0.05 mg/l	0.05 mg/l	0.05 mg/l	0.05 mg/l	0.1 mg/l
	Copper	-	1 mg/l	2 mg/l	2 mg/l	1.3 mg/l
	Lead	0.05 mg/l in flowing water	0.01 mg/l	0.01 mg/l	0.01 mg/l	0.015 mg/l
	Selenium	0.01 mg/l	0.01 mg/l	0.01 mg/l	0.01 mg/l	0.05 mg/l
	Faecal Coliforms	0	0 in 250 ml	-	0	0
	Total Coliforms	0	0 in 100 ml	-	0	0
	Antimony	0.01 mg/l	-	0.005 mg/l	0.005 mg/l	0.006 mg/l
	Beryllium	-	-	-	-	0.004 mg/l
	Barium	-	0.5 mg/l	0.3 mg/l	-	2 mg/l
	Mercury	0.001 mg/l	0.001 mg/l	0.001 mg/l	0.001 mg/l	0.002 mg/l
	Thallium	-	-	-	-	0.0005 mg/l
Secondary Standards	pH	9	6.5 – 8.5	6.5-8.5	-	6.5-8.5
	Color	15 mg/l Pt-Co	20 mg/l Pt-Co	15 mg/l Pt-Co	-	15 mg/l Pt-Co
	Total Dissolved Solids	1500 mg/l	500 mg/l	-	-	500 mg/l
	Sulfates	250 mg/l	250 mg/l	500 mg/l	250 mg/l	250 mg/l
	Chlorides	200 mg/l	200 mg/l	250 mg/l	250 mg/l	-
	Iron	0.2 mg/l	0.3 mg/l	0.3 mg/l	0.2 mg/l	0.3 mg/l
	Manganese	0.5 mg/l	0.05 mg/l	0.5 mg/l	0.05 mg/l	0.05 mg/l

14 Ministry of Environment Decree No. 52/1- Standards for Minimization of Pollution of Air, Water and Soil 1996"
15 LIBNOR Standard 161; 1999.

Table 4.10: Additional Conventional Water Quality Parameters

Parameter	Limiting value	Remarks
Electrical Conductivity	250 µS/cm [1-2]	-
Total suspended solids	-	Guideline value linked to Turbidity
Hydroxide Alkalinity	-	Guideline value linked to pH
Bicarbonate Alkalinity	-	Guideline value linked to pH
Carbonate Alkalinity	-	Guideline value linked to pH
Total Hardness	150-500 mg/l [1]	-
Calcium Hardness	150-500 mg/l [1]	-
Magnesium Hardness	50 mg/l [3]	-
Ammonia Ammonia-nitrogen	0.5 $(NH)_4$ mg/l [3] 50 mg/l [2]	-
Total Phosphorus	0.015 mg/l [5]	-
Orthophosphates	0.05 mg/l [5]	-
Chemical Oxygen Demand	10 mg/l [5]	-
Biochemical Oxygen Demand	5 mg/l [2]	-
Total Organic Carbon	2 mg/l [4]	-
Volatile Organic Compounds	-	VOC compounds identified if VOCs detected
Organochlorinated Pesticides	N/A	-
Organophosphorus pesticides	N/A	-

Limiting values are reported by different sources [1]WHO Guidelines [2]EU Standards [3]Lebanese Standards [4]US EPA [5]General practice

Water analyses reviewed by the ESIA have come from the following studies:

- GBWSP studies for the Awali Scheme;
- AUB study for BMLWE, *Long Term Water Quality Assessment: Litani, Qaraoun Lake and Bisri/Awali River*, Quarterly Reports 1 and 2;
- Analyses for GBWSAP PD ESIA; and,
- Analyses for the GBWSAP ESIA for Bisri Dam.

During the present ESIA samples were taken in June 2012 from Nahr Bisri at the proposed dam site, and in September 2012 from the sites shown in Figure 4.13 and listed in Table 4.11, this later round approximating the lowest 2012 flow in the river.

The results of all Bisri water analyses are given in Appendix F.

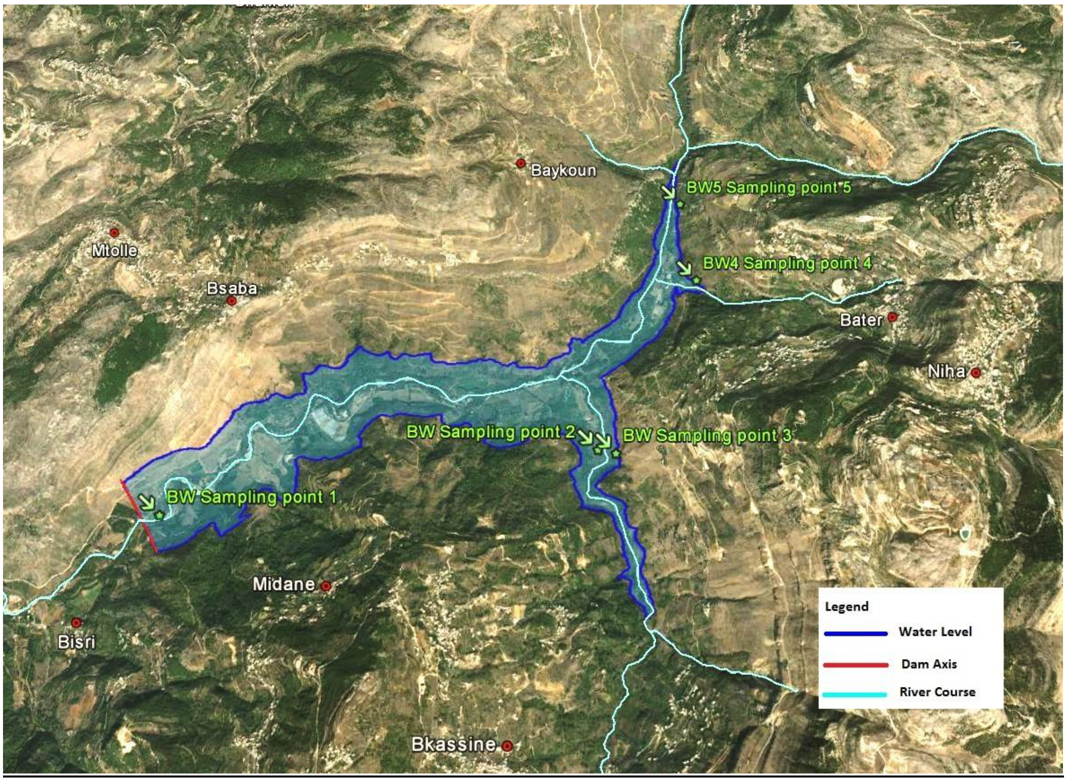


Figure 4.13: September 2012 Water Quality Sampling Locations

Table 4.11: September 2012 Water Sampling Locations

Site	X-Y-Z	Stream	Description
BW1	35°32'45"N 33°35'12"E 402 masl	Main	On Nahr Bisri at the proposed dam axis
BW2	35°35'17"N 33°35'29"E 441 masl	Tributary	On a tributary a few meters downstream of an abundant spring. The tributary branches out upstream from Wadi Bhannine and follows a sub-parallel course before discharging into Nahr Bisri. The water had a turbid and soapy appearance
BW3	35°35'23"N 33°35'27"E 446 masl	Tributary	On Wadi Bhannine, to which water drains Aazibe and Ain-el-Darjeh springs from Jezzine. The water had a dark appearance and a sewage odour.
BW4	35°35'56"N 33°36'23"E 473 masl	Tributary	On the tributary from Bater spring, draining Bater Village. fall ends up into this tributary. The water had a dark appearance.
BW5	35°35'52"N 33°36'50"E 463 masl	Tributary	On a tributary that rises at Nabaa el-Barouk and receives many spring issues before reaching the Bisri Valley, most importantly Nabaa Mershed in Moukhtara. The water was generally clearer than other sampling points but still turbid.

The results of recent analyses show Nahr Bisri water quality conforms to the Lebanese and International Standards and Guidelines for potable use with respect to pollutants that would otherwise require advanced treatment.

In respect of specific pollutants, neither volatile organic compounds (VOCs), nor any organochlorine pesticides were present in quantities that could be detected. Of the Organophosphorus pesticides, minute quantities of Lindane and Dieldrin in concentrations marginally above the limit of detection were present in two samples. Since both these substances are banned by the 2001 Stockholm Convention on Persistent Organic Pollutants (POPs), to which Lebanon is a signatory, the source is not immediately obvious.

The project will thus oversee a program of monitoring to confirm the continued presence of pesticide residues and check for any additional substances detrimental to health that may arise. Because MOE does not have the capacity to undertake this work itself, this aspect be sub-contracted to a qualified consulting firm which will report to MoE. The objective is to monitor the presence of polluting substances present in surface water courses draining to the reservoir area and to investigate their sources of origin. To this end, a Terms of Reference for Consultancy Services to Monitor Water Quality Entering Bisri Reservoir is given herein as Appendix K. current proposals are for the contract to run until such time as the dam and reservoir are commissioned and routine operational monitoring commences.

The majority of heavy metals (As, Cd, Cr, Cu, Fe, Pb, Mn, Se, Tl, Hg, Be, Sb) were not detected in any of the recent samples. While Barium, present in most common sedimentary rocks, was identified in all samples, its presence was well below the limits given for any of the standards listed in Table 4.10 above.

With the October 2012 sampling round undertaken when surface water flow was near its lowest level for the year, and hence the dilution of sewage discharges from surrounding villages at its minimum, it is surprising BOD, COD and TOC are also below the level of detection, confirming minimum organic pollution. One reason for this may be that by the time the samples were taken many summer residents had already departed, and that despite low flows, the contributions of high-volume high-nutrient discharges are limited. Another reason might be that the influence of sewage discharges is less than anticipated, which is supported by the absence of ammonia and ammoniacal nitrogen except in the sample from the dam site. Opposing this thesis however are the high concentrations of total and faecal coliforms.

Nahr Bisri does not appear to suffer the high concentrations of nitrate common in intensely agricultural catchments, with all samples recording concentrations well below potable water standards, and nitrate only marginally exceeding the standard in one sample. While NPK (nitrogen-phosphorous-potassium) fertilisers are commonly applied throughout Lebanon to citrus and other tree crops, the nitrogen content is often low while the potassium content is higher, hence the greater concentrations of phosphate.

A BMLWE study reviewed water quality data from Joun, Bisri (Awali River), Anane and Qaraoun (Karoun) Reservoirs. Samples were collected from December 2011 to November 2012 and includes 24 rounds of physical, chemical and microbiological data; 3 rounds of metals and organics. Results are summarized as follows:

- Qaraoun Reservoir has the highest values of COD and TOC, followed by Anane and then Joun Reservoir with Bisri having the lowest level. The organic analysis also followed this trend.
- Nitrite at Joun, Anane and Qaraoun Reservoirs are elevated and is a contaminant of concern. However, ozone followed by GAC filtration should be able to treat this. Bisri has low nitrite but is elevated for bacterial load (total and fecal coliform and E coli). While bacterial loads are high, conventional water treatment followed by chlorine disinfection should provide 4 log removal and inactivation.
- For metal analysis, only barium and beryllium were detected with regularity and these were at very low levels.
- Organics analyses detected polynuclear aromatic hydrocarbons (PAH), phthalates (plasticizers), pesticides, chloro-benzenes, trihalomethanes and xylenes. Of these compounds, typically Qaraoun Reservoir shows the highest concentration of detects and has more compounds detected. These chemicals are indicative of farming and industrial contamination.

Details of this study are included in Appendix F.

From the results of recent water sampling, the need for conventional and advanced water treatment to provide Greater Beirut consumers with high quality potable water is shown in Table 4.12 [16].

Table 4.12: Treatment Requirements for Bisri Reservoir Water

Parameter	Conventional Treatment	Advanced Treatment
Temperature (°C)	No	No
Color (mg/l Pt-Co)	Yes	No
Turbidity (NTU)	No	No
Conductivity (microS/cm)	Yes	No
Acidity $CaCO_3$ (mg/l)	Yes	No
Total Alkalinity $CaCO_3$(mg/l)	Yes	No
pH (units)	No	No
Calcium hardness $CaCO_3$ (mg/l)	No	No
Magnesium hardness $CaCO_3$ (mg/l)	No	No
Total hardness $CaCO_3$ (mg/l)	No	No
Chlorides Cl^- (mg/l)	No	No
Sulphates SO_4^{2-} (mg/l)	No	No
Phosphates P (mg/l)	Yes	No
Phosphorus P_2O_5 (mg/l)	Yes	No
Dissolved Iron Fe^{2+} (mg/l)	No	No
Ammonia Nitrogen NH_4^+(mg/l)	No	No

16 Assuming no extraordinary adverse change in water quality during reservoir storage.

Parameter	Conventional Treatment	Advanced Treatment
Nitrites NO_2^- (mg/l)	Yes	No
Nitrate Nitrogen (mg/l NO_3^-N)	No	No
Nitrite Nitrogen (mg/l NO_2^-N)	No	No
Nitrates NO_3^- (mg/l)	No	No
Dissolved Oxygen (mg/l)	No	No
TDS as NaCl (mg/l)	No	No
Total Organic Carbon (mg/l)	No	No
Mineralization Virtual (mg/l)	Yes	No
CO_2	No	No
Fluorides	No	No
Manganese Total (mg/l)	No	No
Sulphide (mg/l)	No	No
COD/%S. Humic (mg/l)	No	No
BOD_5 (mg/l)	Yes	No
Coliform Bacteria at 37°C	Yes	No
Thermotolerant Coliform at 44°C	Yes	No
Escherichia Coli at 44°C	Yes	No
Citrobacter Freundi at 44°	Yes	No
Entrebacter Cloacae at 44°C	Yes	No
Kleb. Pneum. Ozaenae at 37°C	Yes	No
Chryseomonas Luteola at 37°C	Yes	No
Non fermenter spp at 37°C	Yes	No
Pseudomonas Aeruginosa at 44°C	Yes	No
Flavi. Oryzihabitans at 37°C	Yes	No
Salmonella typhimurium or *Proteus mirabilis* at 37°C	Yes	No
Alpha-BHC	No	No
Arsenic (µg/l)	No	No
Cyanide (mg/l)	No	No
Gumma-BHC (Lindane) (µg/l)	No	No
Beta-BHC (µg/l)	No	No
Heptachlor(µg/l)	No	No
Delta-BHC (µg/l)	No	No
Aldrin (µg/l)	No	No
Heptachlor Epoxide (µg/l)	No	No
Endosulfan I (µg/l)	No	No
4,4 DDE (µg/l)	No	No
Dieldrin (µg/l)	No	No

Parameter	Conventional Treatment	Advanced Treatment
Endrin (µg/l)	No	No
4,4 DDD (µg/l)	No	No
Endosulfan II (µg/l)	No	No
4,4 DDT (µg/l)	No	No
Endrin Aldehyde (µg/l)	No	No
Endosulfan Sulfate (µg/l)	No	No
Chromium (mg/l)	No	No
Manganese (mg/l)	No	No
Iron (mg/l)	No	No
Copper (mg/l)	No	No
Zinc (mg/l)	No	No
Cadmium (mg/l)	No	No
Lead (mg/l)	No	No
Mercury (mg/l)	No	No
Selenium (µg/l)	No	No

Notwithstanding the results show no advanced treatment may be required, the Ouardaniye Water Treatment Plant includes oxidation and Granular Activated Carbon Filtration. Both will be incorporated into the design of the water treatment plant, currently in advances stages of preparation for tendering.

During public consultation, the issue of *cyanobacteria* was raised, suggesting its presence in Qaraoun Lake and elsewhere in the GBA supply system would render the water unfit for human consumption. Cyanobacteria, more commonly known as blue-green algae, are often a problem in reservoirs with high nutrient loadings, causing algal blooms. Sources of high nutrient loadings may be vegetation uncleared prior to inundation, the discharge of sewage effluent, and soil organic matter washed in during high river flow. Some strains of the bacteria may contain toxins, *cyanotoxins*, of concern to human health. The general occurrence of these is low and exposure through drinking water or during water-based activities such as swimming or canoeing is largely unknown[17]. While there are some recorded poisonings of livestock and wildlife, it is considered unlikely that humans would ingest sufficient amounts to impart a lethal dose.

Measures to reduce the build-up of nutrients, such as the clearance of vegetation prior to inundation and the implementation of sewerage systems for villages draining to the reservoir are planned. In any case, any algae that get through to the treatment plant can be readily taken out by coagulation and filtration within the type of conventional treatment stream proposed for Greater Beirut.

17 All human deaths accorded to cyanobacteria have been due to intravenous exposure during renal dialysis.

A conventional water treatment plant, which comprises the treatment processes included in the Ouardaniye treatment plant, will treat the water from Joun Reservoir to international drinking water standards. Granular Activated Carbon (GAC) has been substituted for anthracite in the filtration step. Ozonation followed by GAC filtration will help to lower nitrite levels and mitigate against the low levels of organics. An optimum pH for residual disinfection and to minimize calcium scale formation potential should also be investigated during the design phase. Every effort should be made to protect the watershed from further contamination.

In conclusion, water quality analyses from Nahr Bisri and its tributaries show that while the water is not immediately of potable quality, the level of treatment required to bring it into compliance with Lebanese and international standards is only that afforded by a conventional treatment stream. No special or advanced water treatment will be required. Treatment for physical parameters including colour, alkalinity and conductivity are primarily for aesthetic reasons, such as appearance and taste, to improve consumer acceptance, while that for chemical and bacteriological parameters, such as coliforms, is required to safeguard public health and prevent gastro-digestive ailments. The treatment stream expected to be provided at Ouardaniye is expected to include coagulation/flocculation, sedimentation, filtration, Granular Activated Carbon and disinfection.

4.10 Climate Change and Water Resources

4.10.1 Introduction

The world over the last few decades has been witnessing number of unusual and more frequent weather extreme events. Among these events are: i) spectacular floods and extended drought in many regions; ii) an increase of +0.6°C in average global temperature; iii) a decrease of the snow cover worldwide of about 10%; iv) a mean sea water level rise of 10-20 cm; and v) more frequent, severe and long-lasting Nino events.

The increasing pace of these events triggered a number of researches and studies in the attempt to elucidate their origin. While the various studies may disagree about the impacts and extent of these phenomena, they do all seem to attribute these events to anthropogenic activities such as Greenhouse Gas (GHG) emissions that contribute to global warming. A number of mathematical models have been developed to simulate climate conditions under increased GHGs emissions. Despite the inherent limitations in these models they remain the primary only tool to predict in a simple mathematical way future events within a complex and uncertain science.

Over the last few years there were several attempts in the Mediterranean Basin to observe closely the likelihood of climate change using mathematical models. While some models used worldwide were applied to the Mediterranean Basin to probe the future trends in the region average temperatures, more region-specific models such as HADCM3, ECHAM4, CISRO-MK2, etc were developed to predict the regional change in precipitation. If the models predicting the future precipitation trends remain inconclusive due to intrinsic limitations, the predicted temperatures increase seem better aligning with the last 50 years global temperatures increase (EUWI 2009). For Lebanon, climate change scenarios have been developed through the application of the PRECIS model (MoE/UNDP, 2011)[18].

Water resources are a main component of natural systems that might be affected by climate change [19] . Key climatic parameters like precipitation, temperature and evaporation are the controlling factors of freshwater availability and quality, surface water runoff and ground water recharge. The recharge of natural and/or artificial water bodies, like Bisri Dam, are governed by these hydrological parameters.

A recent collaborative work on climate change impact on Bisri reservoir yield between CDR and an independent hydrology expert has shown an average decrease of flow of about 3.5% for the precipitation change and an additional 0.5% for the temperature increase. Mitigation measures are in place to meet water demand in the GBA during periods of increased drought as a result of climate change. These include diversion of a limited volume of water from the Litani River (as per Presidential decree 14522) and the use of other sources of water supply in the GBA region.

4.10.2 Temperature

An increase in average air temperature in Lebanon of 1.3-1.8°C for the period 1961-1990 was reported by IPCC-DCC (1999)[20]. By the same trend it is believed Lebanon will witness, in the coming four decades, further increase in average temperature. Such increase in temperature will have an impact on reducing the availability of water, be it the source aquifer, spring, lake or river. Additional 2°C by 2050 and 4°C by 2090 will cause the snow/rain limit line to rise from 1500 m to 1700 and 1900m respectively, affecting the recharge of Lebanese mountain springs from where the coastal rivers originate (MoE-UNDP 2011).

A water balance model WATBAL[21] applied to two locations in Lebanon used to assess the significance of climate changes over the water resources, showed a potential of 5-15% reduction in water resources in Lebanon. In the same line, Bakalowicz (2009) [22] revealed that a reduction of 6-8% of the total volume of water resources is expected with an increase of 1°C, and 12-16% for an increase of 2°C. Therefore, the national annual water resources currently estimated to be between 2800 and 4700 MCM, are expected to drop to 2500-4400 MCM with a temperature rise of 1°C and to 2350-4100 MCM for a 2°C of temperature rise (EUWI, 2009).

As previously mentioned, and according to the hydrology assessment described above, temperature rise will result in an average decrease of Bisri flow of about 0.5%.

18 Lebanon’s Second National Communication to the United Nations Framework Convention on Climate Change.MoE, Gefand UNDP, 2011.
19Climate Change and Water Resources in Lebanon and the Middle East E. Bou-Zeid and M. El-Fadel, 2002.
20Intergovernmental Panel for Climate Change, Data Distribution Center (IPCC-DCC), 1999.
21 WATBAL: a model for estimating monthly water balance components including soil water fluxes. “ Proc., 8th Annual Report, UN ECE ICP 1999.
22M. Bakalowicz, Assessment and Management of Water Resources with an emphasis on prospects of climate change, 2009.

4.10.3 Precipitations

Using the available data and analytical means, Bakalowicz (2009) has demonstrated that precipitation over the Mediterranean Basin, most specifically the eastern part, have not experienced any particular increasing or decreasing trends over the past century. Long-term rainfall records, however, do reveal wide multiannual variations, where lengthy humid periods follow lengthy dryer periods. These variations are often mistakenly perceived as climatic changes. The MoE/UNDP National Communication 2011 reached to the same conclusion.

On the other hand Shaban 2009[23] argues that Lebanon is witnessing signs of decreasing precipitation and increasing drought and desertification. His study relied on a disparate number of gauging stations during three periods of time. From 1966 to 1978 rainfall data were collected for 70 gauging stations while for the period from 1978 to 1997 there were just 11 stations available. For the period from 1998 to 2005 the number of gauging stations was 24.

While various sources may disagree about the decreasing trends in precipitation over Lebanon, they all confirm that seasonal variability and changing precipitations patterns will be experienced. Some months of the year (December and January) will receive less water than now, while other months (November to September) will become rainier[24]. Noda and Tokiota (1989) noted that in some situations, changes in variability and distribution are potentially more significant and detrimental than changes in mean levels[25].

Climate Change impact on Bisri reservoir yield previously discussed has estimated an average decrease of flow of about 3.5% for the precipitation change. Resulting indices and their variations will be ultimately discussed when the hydrology model is rerun with the revised allowance for climate change.

4.10.4 Evapotranspiration

The evapotranspiration is the losses of water to the atmosphere from the ground and vegetation cover. The key climatic factors that govern the rate of evapotranspiration are precipitation and air temperature. The volume of water not absorbed or evaporated otherwise runs off or infiltrates to recharge surface and groundwater resources.

At the scale of Lebanon, Bakalowicz (2009)[26], using the Turc equation model, predicted future evapotranspiration trends, assuming that +1°C and +2°C temperature rise scenarios over three Lebanese mountain altitudes. He concluded the evapotranspiration

[23] Indicator and Aspects of Hydrological Drought in Lebanon, Water ResourcesManagement, Shaban A. 2009.

[24] Climate Risks Vulnerabilityand Adaptation Assessment, Final Report ELARD 2010.

[25] Noda, A., and Tokiota, T., "The effect of doubling the CO2 concentration on convective and non-convective precipitation in a general circulation model coupled with a simple mixed layer ocean model." 1989.

[26] M. Bakalowicz, Assessment and Management of Water Resources with an emphasis on prospects of climate change, 2009.

rate will increase by an average of 4.6% for an increase of 1°C, while 2°C will cause an average increase of 10% of the currently recorded rate.

4.10.5 Surface Water

A direct impact of global warming will be the change in the patterns of precipitation, with more rain than snow, hence more water running off as soon as it falls and less being held in snow that will only melt slowly and better percolate the karstic aquifers.

River flow regimes will therefore be greatly impacted. Peak flow is expected to move backwards, from the end of April to the end of February, and will increase between December and February. With snow melt decreasing from April to June, flows during this period, one of high demand for irrigation water (MoE/UNDP 2011) will dramatically decrease.

Under such conditions, surface water will be less easy to exploit without retention, and with rainfall concentrated in time, the risk of flooding may dramatically increase.

4.10.6 Ground Water

As discussed above, the shift of snow-rainfall balance towards greater rainfall will cause more run off with proportionally less recharge to Lebanon's karstic aquifers. According to Shaban study (2009) in which 193 Cenomanian and 122 Jurassic wells were monitored between 1987 and 2005; there was clear evidence of water table decline. The Cenomanian and Jurassic aquifers in the Litani River basin (Bekaa) dropped 20-25 m and 5-10 m respectively. Furthermore, many wells and boreholes in the coastal cities have experienced irreversible saltwater intrusion.

4.10.7 Bisri Basin and Climate Change

Under any climate change regime, the hydrological parameters should be handled carefully in designing any water supply scheme. While the sections above presented detail about how the hydrologic regimes of water resources may be affected by changing climate, those below address the likely impact on Bisri dam design parameters.

There are four major parameters for which final dam design must take account of climate changes. The design must ensure that there will be sufficient safe yield to fill the reservoir with least shortage. There should be provision for predicting any change in flood flow by appropriately sizing spillways and other diversion structures. The increase in evapotranspiration rates will have a decisive impact on Bisri reservoir, with more water loss during the hot summer months. Finally global warming will impact reservoir water quality, since there will be less water to dilute any contamination present. Hence, the implementation of comprehensive waste water collection and treatment, and solid waste management schemes throughout the dam catchment area will be a major contribution to the success of the Bisri project.

Dam Safe Yield

In the latest update of hydrometric data the dam designer highlights a decrease in the river flows of 5% over the last twenty years of record compared to the previous 59 years.

In proposing the 125Mm^3 reservoir capacity, the designer has assumed that the historical data showing decreasing trends are more representative of future river flows.

Two basic monthly water demand scenarios were evaluated in the water supply yield analyses:
- 6-month delivery period between June and November at constant releases of 5.1 m^3/s. No release in other months.
- 6-month delivery period between June and November at constant releases of 5.8 m^3/s. No release in other months.

The above flow rates are based on the Master Plan of the Awali Water Project. Flow covers the following areas:

1. Zone A (area situated to the East of Beirut City, extending from Wadi Chahrour Village in the south to Hazmieh Village to the North and ranging in elevation from 40m and rising to approximately 400m above sea level. The main villages included in the project are: Haret El Fghaliye, Haret Es Sitt, Wadi Chahrour, Merdash, Boutchai, Louaize, Baabda, Hadath, Hazmieh, Chiah, Furn El Chebbek). The demand for this zone is estimated at 3.3 m^3/s.

2. Zone B (The works cover an area situated to the East of Beirut City, extending from Wadi Chahrour Village in the south to Hazmieh Village to the North and ranging in elevation from 40m and rising to approximately 400m above sea level. The main villages included in the project are: Haret El Fghaliye, Haret Es Sitt, Wadi Chahrour, Merdash, Boutchai, Louaize, Baabda, Hadath, Hazmieh, Chiah, Furn El Chebbek). The demand for this zone is estimated at 0.6 m^3/s.

3. Zone C (coastal area situated to the south of Beirut City, extending from Damour Village in the south to Kfarshima Village to the North and ranging in elevation from sea level and rising to approximately 250m. above sea level. The main villages included in the project are: Damour, Naameh, Choueifet (including Aaramoun and Khaldeh) and Kfarshima). The demand for this zone is estimated at 0.8 m^3/s.

4. Zone D (The works cover an area situated to the East of Beirut City, extending from Jisr El Basha Village in the south (North of Hazmieh) to Jdeideh Village in the North and ranging in elevation from 50m and rising to approximately 300m above sea level. The main villages included in the project are: Mkalles, Jisr el Bacha, Mar Roukoz, Cap Sur Ville, Sabtiyeh, El-Aamariyeh, Fanar). The demand for this zone is estimated at 1.1 m^3/s.

It should be noted that Zone D is divided into two subzones Upper and Lower with respective demands of 0.4 m^3/s and 0.7 m^3/s. The lower zone will be connected to the Awali system as a back-up source and not as a primary source.

Design Flood Flow

As discussed above, under climate change conditions it is expected that river peak flows will be altered. The peak flows might be shifted from spring to winter months with the reduced snow cover period. The seasonal stream flow regime will be modified where snowfall and snowmelt contributions are significant (Impacts 1999)[27]. Snow makes a significant contribution to the Bisri Basin resources and as such any change in snow/rain amounts and seasonality will impact reservoir performance.

The most devastating flood recorded at Bisri was on 13 April 1971, when 620 m^3/s swept away the gauging station at Bisri Bridge and disrupted the operation of Awali and Joun Hydro-Power plants. While the 3000 m^3/s design flow of the dam spillway is sufficient to accommodate such a large flood event, the 550 m^3/s design flow of the diversion structures may be of concern given the tendency of global warming to increase climatic extremes. Moreover, any shift in the timing of floods must be well considered by the designer and contractor when preparing the schedule for construction works.

Evaporating Water

Climate change will result in higher evaporation losses from the reservoir surface and consequently, reduced storage. At the normal water level of 461 m the water surface will be some 398 ha. Using the figures cited in Section 4 above, the annual loss will be about 4 Mm^3 from the total volume of 125 Mm^3 stored. With evapotranspiration expected to increase by between 4% and 10% due to global warming, as discussed above, losses may be expected to increase significantly.

Water Quality

The water sampling and analyses for Nahr Bisri conducted during October 2012, showed that while river water is not immediately of potable quality, it requires only conventional treatment to render it so. Thus Bisri river quality conforms to the Lebanese and international standards for pre-treated source water for potable use.

Of no surprise in a predominantly agricultural catchment there was some presence of pesticide residues. That, these were lindane and dieldrin, was of a surprise as both are classified as POPs (persistent-organic pollutants) and as such banned under the Stockholm convention, which Lebanon signed in 2001 and came into force in 2004, although lindane has a partial exemption for use as a pharmaceutical for the treatment of lice and scabies. As part of the environmental management of Bisri dam, this and other aspects of water quality will be monitored and action taken to reduce the use of polluting substances.

In respect of other undesirable water quality parameters, nitrate was slightly above acceptable potable water limits, but the majority of heavy metals were not detected. While other studies have shown traditionally high organic and bacteriological contaminations of Bisri River due to sewage discharges from the surrounding villages, the October 2012 gave only low concentration. One reason for this may be that by the time the samples were taken the summer residents of surrounding villages had already departed contributing less to nutrients discharges into the river.

[27] Impacts of climate change and climate variability on hydrological regimes. J. C. Van Dam, eds., Cambridge University Press, Cambridge, U.K - 1999.

With global warming expected to reduce the natural inflow to the reservoir, waste water discharges, which will increase with population growth, will be less diluted and hence enhance water quality problems such as eutrophication within the reservoir.

4.11 Air Quality and Noise

The Bisri project area is entirely rural with anthropogenic activity predominantly agricultural. Site walkovers, meetings with municipalities and on-site investigations have revealed no industrial, non-agricultural commercial or significant construction activities within the project area and its vicinity. There is therefore an absence of potentially significant sources of atmospheric pollutant or noise emissions.

Given the sparse population and the absence of community facilities, there is also an absence of sensitive receivers. Mar Moussa Church, used only on Mar Moussa day in August each year, is some 1,400 m from the nearest metalled public road, more than 400 m from the nearest occupied house, 200 m from the nearest seasonal farm workers shelters, and over 100 m from the nearest site where farm machinery is used.

Notwithstanding this, short periods of particulate matter emissions due to the movement of agricultural vehicles moving on unsurfaced tracks are evident. Although such periods are rare, they are concentrated in the summer months, when there is greatest tendency to generate dust.

With no public water or power supplies, a number of generators and water pumps are scattered across the project area, but given the openness of the area and the spacing of buildings the emission of SO_x, NO_x and CO are much less of an issue than the impacts posed to those working and living in their immediate vicinity, which is itself primarily seasonal.

Similarly, noise emissions are also deemed to be of little concern given the sparse population and extremely low per capita exposure.

The chances that the level of atmospheric emissions and noise generated in the valley carry up the hillsides to surrounding villages such as Bsaba (850 m distant and 400 m higher), Midane (900 m distant and 350 m higher), or down the valley to Bisri (over 1 km distant and hidden from line-of-sight behind a hill) is almost inconceivable.

5. BIOLOGICAL BASELINE CONDITIONS

5.1 Introduction

This section of the ESIA discusses the biological conditions pertaining within the project area and its region. A detailed assessment has been carried out to draw the ecological profile of the area, assess flora and fauna diversity, and to identify those species endangered or IUCN-listed that are at added risk from the project proposed for Bisri. A preliminary Biodiversity Management Plan was also produced to mitigate the impacts on the natural environment as described below.

Herein under **Section 5.2** the flora of the area is discussed, while **Section 5.3** describes its fauna including fish and macro-invertebrates, amphibians and reptiles, avifauna, and mammals.

5.2 Flora

A rapid flora inventory was conducted to identify existing species and their status (rare, endangered, iconic, etc). Walking transects were identified to obtain an understanding of the vegetation communities in the area, identify community boundaries, record existing species, and determine the potential distribution of threatened species. Vegetation communities were randomly assessed in both the thermo-Mediterranean (0-500 m) and part of the Eu-Mediterranean in Bisri.

The area reflects mosaics of ecological niches for various vegetation formations and agricultural fields with various hedges type such as Cyprus and Casuarinas trees. The composition of the vegetation is typical to South/South East and North/North East plants associations. The former represents bushy type vegetation reflecting past uses of the forests with agricultural terraces. The latter mingles trees association of Calabrian pine, stone pine, oak, hawthorn, laurel, pistachio, juniper, carob, etc. with bush formations and herbaceous vegetation. The valley is home to agricultural fields, riverside plant formations and islands of patches of natural vegetation and alien tree species such as willow, alder, tamarisk, oriental plane, Cyprus, stone pine and Casuarinas. Three types of vegetation are identified:

Type 1 River course vegetation as shown in Figure 5.1, including *Platanus orientalis* L., *Salix libani* Bornm, and *Alnus orientalis* Decne with associated shrubs and herbaceous plants.

Figure 5.1: Riverside Vegetation along Nahr Bisri

Type 2. Hillside North/North East dominated by associations of *Pinus brutia* Ten., *Pinus pinea*, *Quercus calliprinos* Oliv., Quercus infectoria, *Laurus nobilis L. and Pistacia paleastina* Boissm as shown in Figure 5.2.

Figure 5.2: Associations of Plant Populations

Type 3. South/South East similar to the previous type but formed by denser bush-like formations.

Approximately 50 plants were identified, the most important species including *Ricotia lunaria* (L.) DC. (endemic), *Orchis anatolica* Boiss., *Orchis morio* L., *Orchis papilionaceae* L., *Orchis pyramidalis* M. Bieb., *Orchis romana* subsp. *libanotica* Mt., *Orchis tridentata* Scop., *Ornithogalum umbellatum* L. and *Fritillaria libanotica* (Boiss.) Baker, some of which are illustrated Figure 5.3.

Orchis papilionaceae L.

Orchis morio L.

Orchis romana subsp. *libanotica* Mt.

Orchis tridentata Scop.

Fritillaria libanotica (Boiss.) Baker

Figure 5.3: Examples of Plant Species in the Bisri Area

In addition to its wild plant species, Marj Bisri is rich in fruit trees mainly citrus, roses and strawberry grown in polytunnels, and commercial grass plots for turf.

5.3 Fauna

5.3.1 Fish and Macro Invertebrates

Electro-fishing was used to survey fish and macro invertebrates. It is a non-selective method that provides a broad overview of the fish fauna living in the surveyed water body. Figure 5.4 shows electro-fishing for ichthyofauna at Bisri site.

Figure 5.4: Survey of Ichthyofauna using Electro-Fishing on Nahr Bisri.

Five fish species and one crab were identified in Nahr Bisri, as listed in Table 5.1.

Table 5.1: Fish Species Recorded from the Awali Basin

Species	Family
Salaria fluviatilis (Asso, 1801)	Blenniidae
Anguilla anguilla (Linnaeus, 1758)	Anguillidae
Capoeta damascina (Valenciennes, 1842)	Cyprinidae
Pseudophoxinus kervillei (Pellegrin, 1911)	Cyprinidae
Oxynoemacheilus leontinae (Lortet, 1883)	Balitoridae
Potamon potamios (Olivier, 1804)	Potamidae

Three of the above fish species deserve special mention. These are the Freshwater blenny, the European eel, and the Middle Eastern Green carp. No exotic fish or macro invertebrates were captured.

Freshwater blenny or Salaria fluviatilis

Freshwater blenny shown in Figure 5.5 resides in lakes and streams with moderate current and has a clear preference to stony bottoms. It is a territorial species that can live up to 5 years. It feeds on insects, crustaceans, and fry. In Lebanon, it reproduces during spring.

Figure 5.5: The Freshwater Blenny *Salaria Fluviatilis*

According to IUCN, the Freshwater blenny is not currently considered threatened around the Mediterranean. However, populations have declined considerably in recent years and the fish has completely disappeared from most rivers in Lebanon. This is mainly because of habitat alteration, rivers drying up, drought, and pollution. Two small populations seem to be confined in the lower parts of Nahr Awali and Nahr Damour, living only in the last few hundred meters of freshwater close to the estuary. Thus these two populations each thought to be less than 100 individuals, critically endangered. While they are downstream of the Bisri project, the curtailment and control the project will impose of seasonal flow may put their survival in peril.

European eel or Anguilla Anguilla

The European eel shown in Figure 5.6 is a *catadromous* fish that resides in freshwater most of its life and migrates to the sea for spawning. The species lives in all types of habitats from small streams to large lakes. It reproduces between March and July in the Atlantic Ocean (Sargasso Sea) and feeds on a wide variety of benthic organisms. The species has a high commercial value in Europe and around the Mediterranean. European eel has been recently considered as critically endangered by IUCN. In Lebanon, Eel is found in all rivers connected to the sea with running waters.

Figure 5.6: The European eel Anguilla Anguilla; adult (left) and Larvae (right)

The decline in its population is mainly due to water diversion for agricultural, industrial, and domestic use and heavy chemical pollution.

Middle Eastern Green carp or Capoeta damascina

Middle Eastern Green carp shown in Figure 5.7 is a very common carp that lives in all rivers of Lebanon, as well as the Qaraoun and the Chouan lakes. It is a bottom fish, feeding mainly on algae, invertebrates and detritus. It reproduces in small streams where it deposits its eggs on gravel.

Figure 5.7: The Middle Eastern Green Carp Capoeta Damascina

The fish can withstand poor water conditions and high levels of pollution. It is commonly targeted by Lebanese anglers for consumption and has a local commercial importance.

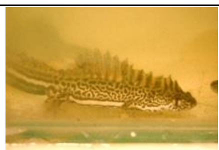
5.3.2 Amphibians and Reptiles

Survey of amphibians and reptiles in the Bisri area was conducted during the day and the night. In addition to field visits and surveys, identifying active animals was based on inventories and bibliographic reviews. Emphasis was made on species richness, areas of activity and breeding habitats.

Various species of reptiles were identified in the proposed dam and reservoir site. None of them are known to be endangered or endemic. Table 5.2 shows the species that might be impacted directly or indirectly by dam construction and inundation. The impact on the species could be in terms of changes in habitat, breeding sites or food sources.

Table 5.2: List of Reptiles and Amphibians in the Bisri Area.

Species	Common Name	Picture	Status				Type of Impact		
			T	E	R	C	HT	BR	FD
Natrix tessellata	Water snake					+	+		?
Pelophylax bedriagae	Marsh frog					+	+	+	?

Pelobates syriacus	Eastern or Syrian spadefoot				+		+	+	?
Bufo viridis	Green toad					+		+	?
Bufo cf. *bufo*	European common toad			+	+		+	+	?
Hyla savignyi	Tree frog					+	+	+	?
Salamandra infraimmaculata	salamander					+	+	+	?
Triturus vittatus	Newt				+				

T = Threatened, E = Endemic, R = Rare, and C = Common.
HT= general habitat, BR=breeding habitat, FD=food requirements.

5.3.3 Avifauna

The 20-minute point-count method was used to identify the existing avian species in the Bisri reservoir area. Species were recorded at different places and times in the most characteristic habitats. This method is semi-quantitative and changes in abundance of a species are estimated by changes in the frequency of this species over a series of point counts. Other information about species status and trends was retrieved from past experience literature when available.

Thirty two species were identified as shown in Table 5.3, four of which are forest dependent and may reappear in the riparian areas above and below the Bisri dam site. These are the Wren, Jay, Chaffinch and Blackbird. Species that tolerate high disturbance were found across the site. These include the Graceful Prinia, Sparrow, Hooded Crow and Bulbul. Several birds common to the region were spotted in the site including Graceful Prinia (*Prinia gracilis*), Jay (*Garrulus glandarius*), Hooded Crow (*Corvus cornix*), Wren (*Troglodytes troglodytes*), and Sparrow (*Passer domesticus*),

Swift (*Apus apus*) and Lesser White Throat (*Sylvia curruca*) were frequently spotted. A few other bird species were reported by villagers, such as Lesser Kestrel (*Falco naumannii*), Black Redstart (*Phoenicurus ochruros*), Masked Shrike (*Lanius collurio*), and Barn Owl (*Tyto alba*). Field visits during October increased the total number of birds from 28 to 32 species, 24 of which are common, and none are endemic. Four bird species are threatened as shown in Figure 5.8. These are White storks, Lesser Spotted Eagle, White Pelicans that are of passage only, and Short-toed Eagle that is of wide range of action.

Table 5.3: Birds Identified in the Vicinity of Bisri Dam Site.

	Species	*Scientific name*	Status	T	E	R	C
1	Bulbul	*Pycnonotus xanthopygos*	R				+
2	Graceful Warbler	*Prinia gracilis*	R				+
3	Common Chiffchaff	*Phylloscopus collybita*	SB, PM, WV				+
4	Chaffinch	*Fringilla coelebs*	R, PM, WV				+
5	Winter Wren	*Troglodytes troglodytes*	R				+
6	Blackbird	*Turdus merula*	R				+
7	Eurasian Jay	*Garrulus glandarius*	R				+
8	Great Tit	*Parus major*	R				+
9	European Greenfinch	*Carduelis chloris*	R				+
10	Blackcap	*Sylvia atricapilla*	SB, PM, WV				+
11	Sardinian Warbler	*Sylvia melanocephala*	R, PM, WV				+
12	Lesser Whitethroat	*Sylvia curruca*	SB, PM, ?wv				+
13	White Storks	*Ciconia ciconia*	PM	+			+
14	Pelican	*Pelecanus onocrotalus*	PM	+			+
15	Short-toed Snake Eagle	*Circaetus gallicus*	SB, PM	+		+	
16	Long-legged Buzzard	*Buteo rufinus*	R, PM, WV				+
17	Hooded Crow	*Corvus cornix*	R				+
18	Palestine Sunbird	*Cinnyris osea*	R, wv			+	
19	European Goldfinch	*Carduelis carduelis*	R, WV, pm				+
20	House Sparrow	*Passer domesticus*	R				+
21	Swift	*Apus apus*	SB, PM				+
22	Lesser Spotted Eagle	*Aquila pomarina*	PM				+
23	Black headed Bunting	*Emberiza melanocephala*	SB				+
24	Corncrake	*Crex crex*	pm	+		+	
25	Black Kite	*Milvus milvus*	PM				+
26	Steppe Buzzard	*Buteo vulpinus*	PM				+
27	Hoopoe	*Upupa epops*	R, SB			+	
28	White Wagtail	*Motacilla alba*	PM, WV				+
29	Steppe Buzzard	*Aquila nipalensis*	pm			+	
30	Levant Sparrowhawk	*Accipiter brevipes*	PM				+
31	European Sparrowhawk	*Accipiter niseus*	PM			+	
32	Marsh Harrier	*Circus aeroginosus*	PM			+	


White Storks


Lesser Spotted Eagle


White Pelican


Short-toed Eagle

Figure 5.8: Threatened Bird Species in the Bisri Area

5.3.4 Mammals

Two approaches, direct and indirect were used to monitor mammals. The indirect approach was conducted during day time through diurnal walking surveys where opportunistic observations of secondary signs such as tracks, footprints, fur and scats were recorded. Caves and dens were inspected for bats, animal signs and animal remains. The direct approach was conducted in two ways night surveys and photo trapping to obtain data on the more secretive and nocturnal species.

Photo-trapping equipment to survey mammals consisted of seven pre-baited active and passive remote camera traps, as shown in Figure 5.9.

Figure 5.9: Camera Traps and Bait being Laid for the Mammal Survey at Bisri.

The rapid field survey on mammals at the proposed dam site revealed the presence of 17 mammal species belonging to 14 families, as shown in Table 5.4.

Table 5.4: List of Mammalian Species at Bisri

Family	Species	Scientific Name	Nahr Bisri
Erinaceidae	Hedgehog	*Erinaceus concolor*	R, r
Miniopteridae	European Free-tailed bat	*Tadarida teniotis*	R, r
Vespertilionidae	Common pipistrelli	*Pipistrellus Pipistrellus*	R, c
	Khul's pipistrelle	*Pipistrellus kuhli ikhawanius*	R, c
Rhinolophidae	Lesser horseshoe	*Rhinolophus hipposideros*	R, c
	Greater horseshoe bat	*Rihnolophus ferrumequinum*	R, c
Canidae	Jackal	*Canis aureus syriacus*	R, c
	Fox	*Vulpus vulpus palaestina*	R, c
Mustelidae	Pine Martin	*Martes foina syriaca*	R, c
	Badger	*Meles meles canescens*	E, r
	Otter	*Lutra lutra*	E, r
Hyaenidae	Striped hyaena	*Hyaena hyaena syriaca*	R, c
Felidae	Wild cat	*Felis silvestris tristrami*	R, r
Suidae	Wild boar	*Sus scrofa lybicus*	R, c
Sciuridae	Squirrel	*Sciurus anomalus syriacus*	E, c
Hystricidae	Porcupine	*Hystrix indica indica*	R, c
Spalacidae	Moles	*Spalax leucodon ehrenbergi*	R, c
Muridae	House mouse	*Mus musculus praetextus*	R, c
	Rats	*Rattus rattus*	R, c
	Field mouse	*Apodemous mystacinus*	R, c
Microtinae (Subfam.)	Voles	*Microtus sp.*	E, c

R= recorded, E= Expected, c= common, r= rare, endemic or endangered at National level

In addition to wild mammals domestic mammals like goats, cows, dogs and cats were also encountered. Moreover, within the dam site there is a private menagerie that houses lions, tigers, lamas, deer, hyaenas, a fox, some farm animals, and a chimp.

Out of the 17 species of mammals, one species, the hedgehog is dependent on forests, farmlands, gardens and orchards. In addition, 3 bat species: the European free tailed bat, lesser horseshoe, and greater horseshoe, hunt along open woodland, woodland edges and paths as well as hedgerows.

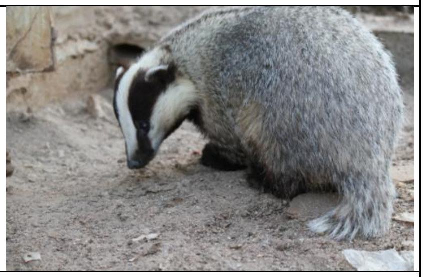
Most other species can tolerate high disturbance and are referred to as urban wildlife; these included the common pipistrelle, Khul's pipistrelle, jackals, foxes, pine martins, wild boar, house mice, rats, and field mice.

Several mammals which are common to the region were spotted in the site, such as wild cats, striped hyaenas, porcupine, and moles.

Finally, two other mammal species which are dependent on the riparian ecosystem are expected to be present: the otter *Lutra lutra* an amphibian mammal that was reportedly recorded in Moukhtara, and voles, which are other riparian ecosystem inhabitants that usually live in river banks.

Only five species are considered to be rare species, as shown in Table 5.5.

Table 5.5: Five 'Rare' Mammal Species at Bisri

English name	**Hedgehog**	
Scientific name	*Erinaceus europaeus concolor*	
Status	This species was common in Lebanon, especially in the coastal plain. However, at present the species is endangered due to excessive use of pesticide, unintentional killing during hibernation and road kills.	
English name	**European Free-Tailed bat**	
Scientific name	*Tadarida teniotis*	
Status	This species is threatened in Lebanon due to habitat destruction excessive use of pesticide.	
English name	**Eurasian Badger**	
Scientific name	*Meles meles canescens*	
Status	Badgers are endangered in Lebanon due to persecution by human.	
English name	**Wild cat**	
Scientific name	*Felis silvestris tristrami*	
Status	Endangered species due to cross breeding with domestic cats	
English name	**Common Otter**	
Scientific name	*Lutra lutra seistanica*	
Status	This species is endangered in Lebanon due to hunting and drying of wetlands.	

Details of a Biodiversity Management Plan are discussed in Section 9.2.3.

6. SOCIO-ECONOMIC BASELINE CONDITIONS

6.1 Introduction

Lebanon has long suffered the lack of accurate comprehensive socio-economic analysis because no national census has been undertaken since 1932, and while sample surveys in selected areas and communities have been carried out, no such survey is available for the very sparsely populated Nahr Barouk/Nahr Bisri valley. In addition, there is a lack of accurate cadastral and land ownership data. The area is not included in the priority areas of the Department of Real Estate at the Ministry of Finance, for which UNDP has financed surveys and developed land ownership records. Data available for the ESIA issued back in September 2013 has therefore primarily been derived from the following:

- Desk study and publicly available information from previous studies;
- Maps and plans from municipalities, the MoF Real Estate Department (*Cadastre*) and the Directorate General of Urban Planning;
- Repeated site walkovers in the dam site, the area expected to be inundated and the anticipated shoreline;
- Visits and walkovers within the upper and lower dam catchment areas;
- Photography for visual documentation; and,
- Informal meetings with elected members of affected municipalities, muktars, local residents, seasonal farm workers, and others.

The ESIA has undertaken a full socio-economic survey on which proposals for land expropriation and the development of a Resettlement Action Plan have been based.

Cadastral information along with topo maps showing cadastral plots have been provided by the Design Consultant, based on which a revised version of the Resettlement Action Plan has been prepared as a separate document.

The cadastral regions within which land will be expropriated are listed in Table 6.1 hereafter.

Table 6.1: Cadastral Regions in the Vicinity of Bisri Reservoir

Caza	Cadastral Regions
Chouf	Mazraat El Dahr, Bsaba, Mazraat El Chouf, Aamatour, Bater ,and Khirbit Bisri and Deir El Mkhalles.
Jezzine	Bisri, Harf, Midane, Ghbatiye, Benouati, Aariye, Bkassine, and Bhannine

Section 6.2 outlines the key social indicators, while **Sections 6.3 & 6.4** discusses population and employment. **Section 6.5** discusses household structure and tenure; **Section 6.6** education and health, and **Section 6.7** access to public utilities and community services. **Section 6.8** identifies and discusses vulnerable groups within the community that may require special attention during the execution of the Bisri project.

Section 6.9 discusses land utilization, with **Section 6.10** summarises the cadastral information collected to date.

Finally, **Section 6.11** discusses in some detail the interesting archaeological, historical and recent cultural heritage findings in the Bisri reservoir and its environs.

6.2 Key Social Indicators

The key social indicators for most projects in Lebanon include demographic profile (the representation within the population of different age groups and genders), access to public utility services (roads, power, telecoms, water, wastewater and drainage), to community services (schools, health centers, recreational facilities, NGOs and public open space), land ownership and utilization, standards of public health, educational attainment, and employment and income-generating activities. Of particular relevance to the present project, is the seasonality of residence and place of work.

By international standards, Lebanon scores relatively high in terms of social indicators such as educational attainment, life expectancy, and income. It is ranked 71 out of 187 countries in UN Human Development Index (HDI)[28] with a score of 0.739, greater than the World average of 0.682 and also higher than the average for all Arab States, 0.641.

6.3 Population

The population of Lebanon in 2011 was estimated[29] to be 4.2 million, of which 87% are urban and 13% rural[1]. The population of the Greater Beirut conurbation, the prime recipient beneficiaries of the Bisri project, is currently estimated at 2 million and is expected to reach 2.2 million by 2025 and 3.5 million by 2035[30]. Growth rates vary between organizations undertaking the survey, but generally the urban population is increasing at twice the rate of the rural population. As always, real growth in Lebanon is difficult to determine due to the high level of emigration and the absence of a national census.

In 2005, the total population of Lebanon was estimated to comprise 49% males and 51% females, of which 28% were minors under 16 years of age, 65% adults between 16 and 64, and 7% 65 years or older. Such a composition mirrors those of adjacent Arab countries. The age-sex distribution represented in the population pyramids in Figure 6.1 illustrates the youth bulge in 2005 and its predicted transition by 2050[31].

28 UNDP (2011). Lebanon: HDI values and rank change in 2011, Human development Report
29 The government of Lebanon has not held a national Census since 1932
30 Central Administration of Statistics, 2010.
31 ESCWA, UN. Population Information Network. Lebanon Demographic Profile.

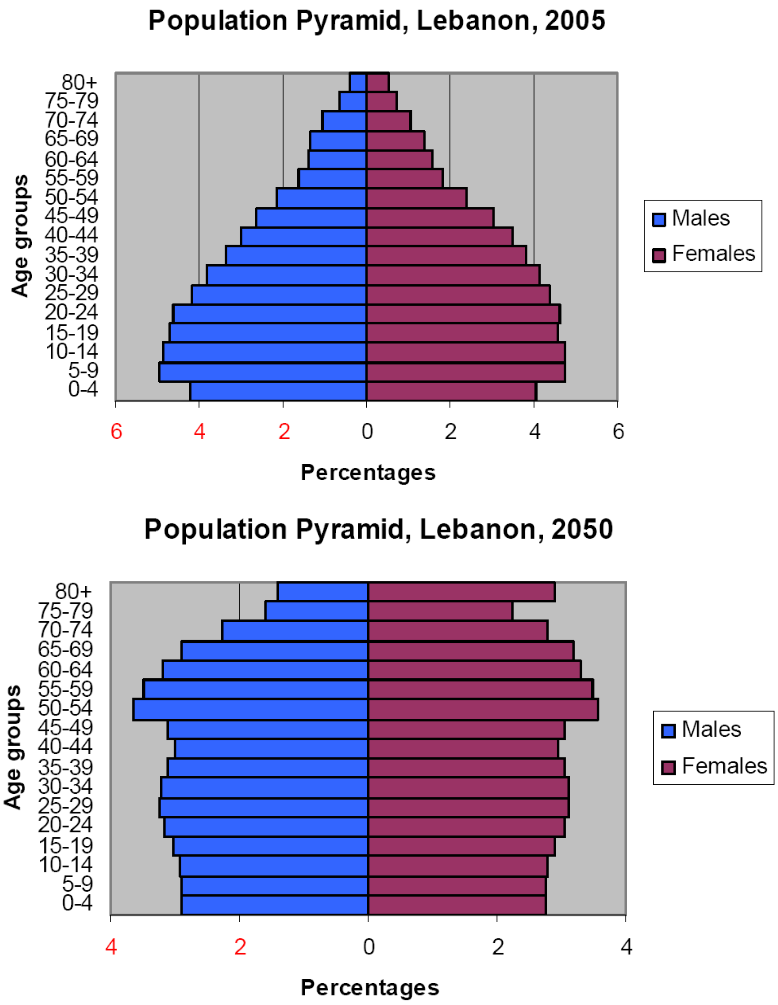


Figure 6.1: Population Pyramids in Lebanon over Years 2005 and 2050

Over the last two decades the Saida-Jezzine area witnessed substantial increase in population, its share of the total households nationally increasing from 4.8% to 6.5%, primarily resulting from the return of displaced families, both during the post-war decade (1990-2000) and following the events in 2000[32].

With the lack of official recent census for the populations nationwide and more particularly in the project area, the 2012 populations for the concerned villages were estimated based on a 0.8% population growth applied on year 2001 confirmed figures[33]. A summer/winter population ratio varying between 1.5 to 2.0 was assumed to estimate the seasonal populations for various villages. In fact, the 1.5-2 summer/winter ratio was established further to ESIA team discussions with villages Mayors and Mukhtars, on both sides of the river that confirmed the summer population have been, since always, greater than the winter populations in various villages. The reasons for this are primarily:

32 UNDP (2005) Development of Mapping of Living Conditions in Lebanon, 1995-2004
33 www.baldati.com

- Natives working in the coastal cities take their families to benefit from access to education, health and other social and community services;
- Natives living away from their villages will migrate back to avoid Beirut's summer heat and humidity during the long summer school vacation;
- Many natives of Beirut have summer houses, owned or rented, that they occupy during the summer months.

Notwithstanding this, only a small percentage of this population will in any way be impacted by the dam. Even those with only a distant view of the reservoir will be few. Most landowners within the proposed area of inundation are 'absentee landlords'.

As such the estimated summer and winter populations for 2012 of the villages, in the immediate surroundings of Bisri Reservoir, are presented in Table 6.2 where a total over 35,000 in the summer and more than 21,000 in the winter are reported.

Table 6.2: Approximate Population Surrounding Bisri Reservoir

Caza	Village	Estimated 2012 Population	
		Winter	Summer
Chouf	Aamatour	2,435	3,652
	Ain Qani	1,100	1,649
	Baiqoun	395	791
	Bater	1,717	2,575
	Bsaba	1,380	2,069
	Haret jandal	337	506
	Kahlouniyeh	824	1,236
	Khirbit Bisri	27	54
	Mazraat eDahr	960	1,919
	Mazraat El Chouf	4,208	6,313
	Moukhtara	1,259	1,889
Sub-Total - Chouf		*14,642*	*22,654*
Jezzine	Aariye	585	1,171
	Benouati	530	1,061
	Bhannine	223	446
	Bisri	301	603
	Bkassine	2,472	4,945
	Ghbatiyeh	256	511
	Harf	312	623
	Machmouche	268	536
	Midane	826	1,653
	Taiid	82	163
	Wadi jezzine	638	1,276
Sub-Total - Jezzine		*6,494*	*12,989*
GRAND TOTAL		**21,136**	**35,643**

6.4 Employment

The pursuing of UN's Millennium Development Goals[34] in Lebanon reported an increase in the employment-to-population ratio from 31.1% 1997 to 35.7% in 2004, still weak when compared to an average of 47.8% for the Middle East and 45%-60.9% for developed countries, implying a particularly high rate of economic dependency, not only within families in Lebanon but also on relatives in the Lebanese Diaspora.

According to the International Labor Organization (ILO) strict definition of unemployment[35], the unemployment rate in Lebanon is 6.4%, although the real rate is, in common with other countries of similar social development, believed to be substantially higher than official figures suggest. A 2011 World Bank analysis suggests 20% of the population live below the poverty line and, not surprisingly, unemployment is highest among unskilled workers.

The current minimum monthly wage in Lebanon is LBP 675,000 (about US$450).

Of the total workforce some 46% work in the service sector, 22% in trade, 15% in process industries, 9% in construction and 8% in agriculture, as illustrated in Figure 6.2. Eighty six percent of workers are employed by private sector companies and institutions, 13% by the public sector and 1% by international organizations, civil or partisan organizations.

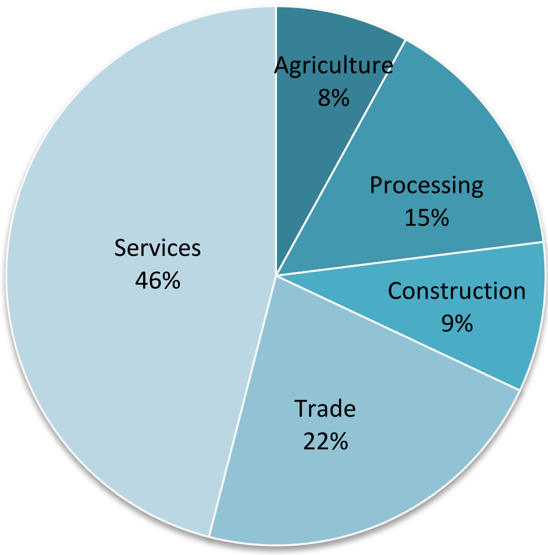


Figure 6.2: Distribution of Labour Force by Economic Sector

Agricultural activities are prevalent throughout the area of Bisri Reservoir, the valley upstream and downstream, the adjacent hillsides, and include fruit and vegetables grown in poly-tunnels and open fields, fodder crops, citrus and olives. Very few if any residents within the area directly impacted by the project work anywhere else other than

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34 UNDP. The Millennium Development Goals. Lebanon. http://www.undp.org.lb/WhatWeDo/MDGs.cfm.

35 The unemployment rate is the per cent unemployed (aged 15-64) of the economically active population.

where they reside, while few if any residents of adjacent villages work within the directly impacted area.

6.5 Household Structure and Tenure

As expected, most of the buildings in the villages surrounding the reservoir are residential, often with retail and service outlets on the ground floor and limited in height to generally no more than four stories. Within the valley in general and the reservoir area in particular, there are a number of spaced residential buildings, some of substantial structure and originally well appointed, but those that are not now derelict have fallen into disrepair and are used only to house seasonal farm labourers. There are also a small number, three or less, significant farmsteads fronting a modern farming operation supporting two or more related kinship groups.

The 2005 National Survey of Household Living Conditions showed that the population aged 15 and above in the Mohafazats of Mount Lebanon and South Lebanon were less economically active than those in Beirut, as shown in Table 6.3.

Table 6.3: Economic Activity by Mohafazat

Mohafazat	Females	Males	All
Beirut	36.2%	69.9%	51.1%
Mount Lebanon	23.7%	70.8%	47.2%
South Lebanon	16.6%	65.3%	39.7%
North Lebanon	11.2%	70.7%	40.0%
Bekaa	10.9%	64.2%	37.7%
Nabatieh	19.4%	63.6%	40.8%
Lebanon	**20.4%**	**68.9%**	**44.05**

According to the UNDP[36], South Lebanon has a high percentage of deprived households (37%), followed by Mount Lebanon (16%) in comparison to Beirut (9%). There was no significant reduction in the level of deprivation between 1995 and 2004 in the Chouf and Saida-Jezzine regions adjacent to the Awali Valley.

Initial indications, prior to the full socio-economic survey show that the majority of land holdings are large but within a family-holding may be sub-divided among individuals. Land owners are commonly absentee landlords, and 71% of the total residing households that were surveyed, in winter 2014, were non-Lebanese tenants. While only one tenant, of these 35 foreign households, has a legal tenancy right, the remaining 34 do not have any formal tenancy right to the property they are occupying and, hence, have declared themselves present on the property based on an In-Tolerance agreement with the landowner.

[36] The term deprivation and its derivatives are used to denote the situation of households or individuals whose overall Living Conditions Index, are below the threshold. UNDP (2005) Development of Mapping of Living Conditions in Lebanon, 1995-2004.

No squatters found among residents according to the socio-economic survey. While much labor is seasonal, with many workers migrating from Syria and Egypt, a high proportion may stay on the land after harvest, waiting for the next planting season.

6.6 Education and Health

The World Bank reports [37] a relatively high education enrolment rate in Lebanon especially during the early years, as shown in Table 6.4.

Table 6.4: Education Enrolment in Lebanon

Level	Enrolment
Elementary	95.4%
Intermediate[38]	86.9%
Secondary	74.9%
Tertiary[39]	51.6%

These rates are similar for females and males, with a slight increase for females after secondary level, an indication of women empowerment and development. Those who have attained only an elementary education make up the highest proportion of workers, 28.1%. As would be expected, the proportion of students continuing in education after the age of 15 is significantly higher in Beirut and Mount Lebanon than elsewhere, as shown in Table 6.5. According to a 2011 UNDP study, the expected years of schooling in Lebanon are 13.8, but the average achieved is only 7.9 years.

Table 6.5: Enrolment in Education by Mohafazat

Age	Beirut	Mount Lebanon	North Lebanon	Bekaa	South Lebanon	Nabatieh	Lebanon
5-9	98.9%	98.1%	99.1%	99.0%	98.3%	99.6%	98.6%
10-14	96.1%	96.5%	92.5%	96.6%	94.0%	95.7%	95.2%
15-19	79.4%	76.9%	61.4%	70.6%	67.2%	66.8%	71.1%
20-24	39.8%	39.0%	27.6%	29.3%	29.3%	32.3%	34.2%
25-29	9.8%	6.7%	4.8%	6.5%	8.1%	6.2%	6.8%

The percentage of illiteracy, measured by non-enrollment rates in schools, in Beirut and Mount Lebanon is only 5.6% and 6.6% respectively, whereas in the Bekaa it reaches 13.4%. Lebanon is well known for its numerous private educational institutions, which are attended by 53% of all students, while only 45% attend government education facilities.

According to UN statistics[40], the average life expectancy in Lebanon is 73. The country has witnessed significant improvement in pre/post-natal care and the under-five

37 The World Bank EdStats Database 2011". http://go.worldbank.org/ITABCOGIV1.
38 National Survey of Household Living 2004-2005. Chapter III. Labor Force and Economic Activity Rates (Employment and Unemployment) Ministry of Social Affairs, UNDP and CAS, 2006
39 The Status and Progress of Women in the Middle East and North Africa, The World Bank, 2009

mortality rate is only 20/1000 births. The infant mortality rate dropped from 28/1000 live births to 24/1000 between 1996 and 2011, and maternal mortality fell from 140/100,000 to 107/100,000 live births over the same period.

The reporting of HIV/AIDS cases is limited, with 52% of total cases being among those aged 31-50 years. Tuberculosis declined from 983 cases in 1995 to 375 in 2006 as a direct result of Directly Observed Treatment Short Course Chemotherapy (DOTS Strategy) according to the same 2008 UN report.

More than half, 51%, of workers do not receive any health insurance, while 49% are covered by at least one type of insurance as shown in Table 6.6. Since there is no unemployment welfare, the labor force is dependent on employment for health benefit. If those benefiting only from the NSSF[41] become unemployed, their coverage lapses after 3 months.

Table 6.6: Distribution of Health Insurance Coverage and Type

Type of Health Insurance	Proportion of Workers
National Social Security Fund (NSSF)	27%
Private (at own or employer's expense)	10%
Army and the Internal Security Forces	6%
Public Servants Cooperation	4%
Other type of cover	2%
Total Covered	**49%**
No Covered	**51%**

Other cover includes policies held outside Lebanon, municipality and mutual fund schemes, and UNRWA

6.7 Public Utilities and Community Services

There is a poor public utility provision throughout the project area. In most villages potable water is primarily obtained from wells after basic chlorination, from natural springs or obtained as bottled water.

While many residential buildings in the surrounding village centers are connected to a local sewerage network, this usually delivers to a plant only providing primary treatment, the effluent then inevitably discharged to surface watercourses. Premises lying on the outskirts of villages and remote from population centers, including all the buildings within the Bisri Reservoir area, discharge sewage to holding tanks, which in turn infiltrate to the ground. Although often termed 'septic tanks' they do not impart the level of treatment that their name implies elsewhere.

Power to existing buildings within the reservoir area is generally obtained from private generating units. Power cables are generally absent from the reservoir area. The farm at

40 UNDP, The Millennium development Goals. Lebanon 2008.
http://www.undp.org.lb/WhatWeDo/MDGs.cfm
41 NSSF (National Social Security Fund) is a health insurance and end-of service pension

the top end of Bisri Reservoir has at least one small photovoltaic panel but primarily relies upon a diesel generator. Some surrounding villages receive power from the Awali HEP.

Within the reservoir and the adjacent valley slopes there are no community facilities, although other than the historic Mar Moussa Church adjacent to the dam site within Mazraat El Dahr. Those in the surrounding villages are summarized in Table 6.7. The project proponent must invite the NGOs identified to future public consultation exercises. There are also few communal services within the vicinity of the reservoir, such as schools, playgrounds, non-governmental organizations, and health centers.

Table 6.7: Community Services in the Vicinity of Bisri Reservoir

Area	Playgrounds	Schools	Churches and Mosques	Cemeteries	Health Centres	NGOs and CBOs
Mazraat El Dahr	-	-	2 Churches	1	-	-
Bsaba	1	-	2 Mosques	1	1	• Youth Association of Bsaba
Mazraat El Chouf	1	1	1 Church 5 Majlis	5	1	• Progressive Women's Assoc. • Assoc. of Social Solidarity
Aamatour	1	1	1 Church 1 Majlis	1	1	• Aamatour Women's Asso • Ammatour Club • Cultural Gathering Asso
Bater	1 playground 1 public garden	1	1 Church 4 Majlis	1	1	• Tasleef • Cultural and Social Club
Bhannine	-	-	1 Church	1	-	-
Benwati	1	-	1 Church	1	-	-
Ghibatiye	-	-	1 Church	1	-	• Ghibatiye Charitable Society
Aariye	-	1	1 Church	1	-	-
Midane	1	-	1 Church	1	-	-
Harf	1	-	-	1	-	-
Bisri	-	-	1 Church	1	-	-

6.8 Vulnerable Groups

The project area has no indigenous tribes or ethnic minorities. The distinction between areas, municipalities and villages is essentially along confessional lines, with Muslim, Christian and Druse communities all present within the vicinity of Bisri Reservoir. Primarily comprising Lebanese citizens, each person is treated equally under the law without institutionalised discrimination of injustice. In respect of vulnerable groups, those identified in the project area are as follows:

- Women;
- The elderly and infirm
- Young people;
- Lebanese farm labourers;
- Foreign farm labourers including Syrian refugees.

Women

Lebanon has made significant progress towards achieving gender equality, with female illiteracy falling from 27% in 1990 to 7% in 2011. Educational attainment is greater for females than males and females occupy high positions in many fields of specialization. For instance, 42% of Lebanon's judiciary are now women.

There remain, however, differences in gender achievement across the spectrum of professions, with a greater proportion of females in office, service and unskilled work, and a higher proportion of males in management and skilled occupations. As elsewhere in the region, women, including those predominantly employed as homemakers, are primarily responsible for awareness and education, and frequently control 70% or more of household expenditure.

In many ways, educated Lebanese women who remain single have opportunities for advancement not universally available throughout the region. For political rather than spiritual reasons, marriage, divorce, child custody, inheritance and associated issues are controlled by the various religious sects. Lebanese law requires offspring to take the nationality of the father; a Lebanese mother is unable to pass on her nationality to children of non-Lebanese father. Perhaps most significantly, divorce initiated by women, even in the face of severe domestic violence, is difficult to obtain and often only granted after several years of suffering.

Within the villages surrounding the Bisri project, most women take on the traditional roles of homemaking and child-rearing, or work in local services. Within the agricultural families working in the reservoir area, many women play equal part in farming activities in addition to their other gender-related duties.

The Elderly and Infirm

In accordance with Lebanese tradition, the elderly and infirm are usually cared for within the family. In the Bisri valley, where most land owners are absentee landlords, elderly and infirm family members will live elsewhere. Seasonal workers and other residing temporarily on the land they are working will generally not bring elderly and infirm relations with them.

Given the relative remoteness of the Bisri valley, with no metalled roads, lack of public transport, and access to medical services, it is unlikely for elderly or infirm person to live there alone or with their family.

Young People

Young people under 25 years of age comprise 47% of the population. While few will now remember the years of civil unrest and invasion, their formative years have coincided with a period of political instability and stagnation. Many are therefore poorly motivated, unemployed or underemployed, and those who are employed either made use of the first opportunity available to them or are dependent upon opportunities provided through kin and family contacts. Around 20% of those aged 15-24 are unemployed.

UNICEF recognizes child labor to be one of the most significant social problems in Lebanon, especially in underserved urban neighborhoods in the major cities and in rural areas. In the area impacted by Bisri reservoir, most if not all of children present are those of migrant farm laborers and tenants. While few of these children are enrolled in education they generally work alongside their siblings and adult family members working the fields rather than being employed outside the family in industry, commerce, or in informal services. Despite the poverty, Bisri children are cared for as best as their family circumstances allow and do not normally suffer the same conditions as their urban cousins.

Lebanese Farm Labourers

Within the reservoir area there are a proportion of the farm workers who are Lebanese nationals and commute daily from Saida and surrounding villages to work for either the land owners or more commonly for those with formal tenancy agreements with the owners. These workers have no entitlement to land and under Lebanese expropriation law will receive only limited compensation for their loss of livelihood when the land they work is flooded.

During the period of construction and subsequent operation, these workers should be offered priority employment in dam and reservoir maintenance.

Foreign Farm Labourers

During the frequent site visits, a number of non-Lebanese farm labourers, including Syrians, Syrian Kurds, Palestinians and Egyptians were met. Those with a permanent residence elsewhere come and go seasonally, for planting and/or harvest. Others come with their families and either take over one of the vacant houses or set up camp within the area in which they are working. These often have no permanent residence elsewhere and may remain on the site between periods of employment for the simple expediency that they have nowhere else to go. Some of those met at Bisri have been on site for more than five years. Typically, a male worker will come and find work and after a few weeks or months send for his immediate family. In time, as the work appears more secure, more distant members of his extended family will join him, thus extending the family unit present on the site.

Invariably, these workers and their family have no security of tenure or right of occupancy. On completion of Bisri Dam, under Lebanese law, these workers will lose both their livelihood and home, yet have no entitlement to compensation or other redress other than what may be offered through the generosity of their employer and/or land owner.

6.9 Land Utilization

The Consultant has carried out several walkovers throughout the reservoir area and adjacent buffer zones to identify the types of land uses and properties that may need to be expropriated or the communities that might be impacted by the project. Within the inundated area, there are no significant communities beyond migrant labor family groups.

There are no non-agricultural commercial activities and no industrial activities throughout the reservoir area.

Land to be expropriated and inundated on the completion of Bisri Dam is presently utilized as shown in Table 6.8 and Figure 6.3. Photographs of typical examples of current usage are shown in Figure 6.4.

Table 6.8: Current Land Use within Expropriated Area

Landuse	Approximate Area – ha	% of Total expropriation
Open Field/Fallow	148	26%
Natural Vegetation	131	23%
River Bed and Bankside Vegetation	105	18%
Open Land	99	17%
Pine Woodland	82	14%
Polytunnels	4	0.7%
Built-up Area	1	0.2%
Total	**570**	**100%**

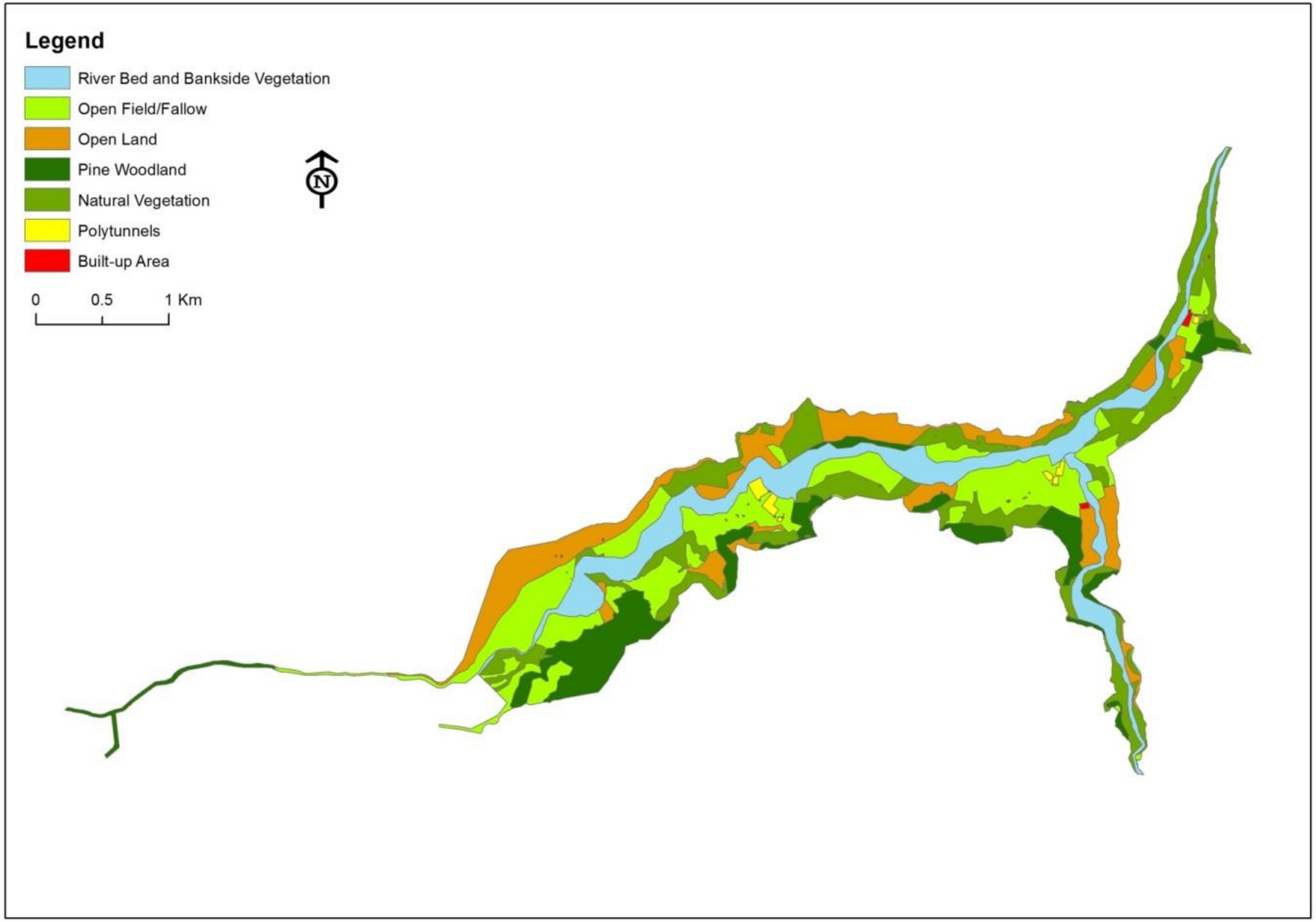


Figure 6.3: Current Land Use within Bisri Reservoir from GE Imagery

Built up areas in the reservoir area include:

- Two or three significant farmsteads, one housing a private menagerie that includes several endangered species, another predominantly a cattle farm;
- Otherwise abandoned 2-3 storey-houses now used by agricultural workers;
- Temporary poor quality shelters used by agricultural workers;
- Two designated archaeological sites, one the remains of a Roman temple, the other of unknown significance; and,
- The historic and culturally valued Mar Moussa Church and adjacent structures.

Agricultural lands include open fields variously tilled, cropped, laid fallow or under poly-tunnels. Open land is generally unused land with only sparse natural vegetation or scrub. River bed area includes the current braided flow channels, gravel and sand banks, and the natural vegetation resulting from seasonal inundation; such land generally unsuitable for agriculture.

Pine woodland comprises stands of mature pine trees with relatively little undergrowth, which if properly addressed on clearance prior to inundation will yield significant tradable timber resources. Finally, Natural vegetation includes areas that are well vegetated but for a variety of reasons have not been developed for agriculture.

Large farmstead

A substantial residence now used by seasonal workers

Housing for seasonal farm workers

Housing for seasonal farm workers

Historic arches from St. Sophia Monastery

Roman columns at Marj Bisri Archaeological Site

Mar Moussa Church

Newly irrigated land with tree crops

Figure 6.4: Current Land Utilisation within Bisri Reservoir

Poly-tunnels growing strawberries

Private menagerie with endangered species

Quarry in the Chouf Sandstone

Pine woods reminiscent of much greater forest cover

River bed and bankside vegetation

Open land, sparce vegetation and scrub

Mainly ropped fields, with some fallow land and pine forest

Figure 6.4 (cont'd): Current Land Utilisation within Bisri Reservoir

In addition to the dam site, area of inundation and adjacent areas within the confines of the valley, the ESIA has also looked at two broad buffer zones, the first up to 500 m from the expected reservoir shoreline, the second 500-1000 m away, as shown on Figure 6.5.

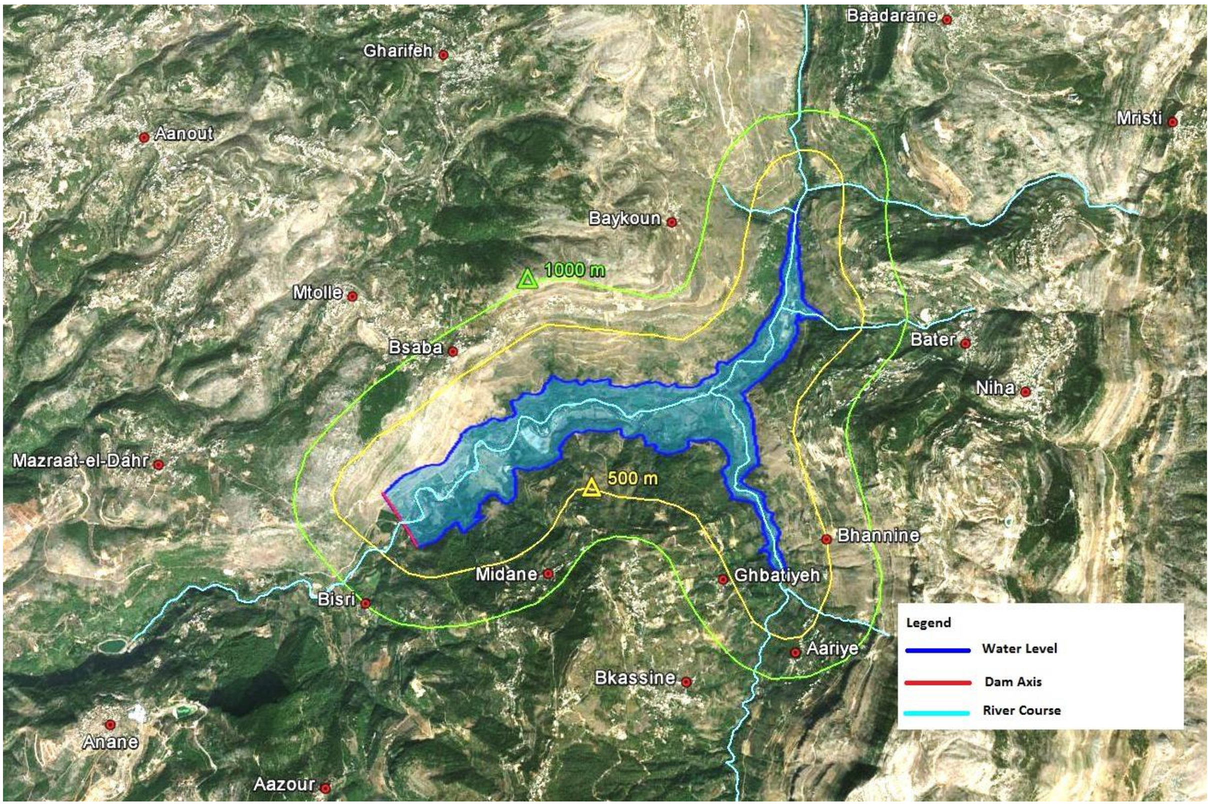


Figure 6.5: Buffer Zones around Bisri Reservoir

The 500 m zone is dominated by the even more sparsely inhabited and valley slopes that are often devoid of significant vegetation. Where terraces have been formed, tree crops such as citrus and olives predominate. Within this zone are a few outlying houses of Bater, Bhannine and Aariye, together with a few isolated houses and agricultural holdings away from village centers. Elevations at the edge of the zone reach an elevation of some 800 m.

The 1,000 m zone spans the tops of the surrounding hills and takes in the main areas of development at Bsaba, Aariye, Ghbatiye, Midane and together with outlying properties. At the far eastern edge of this zone is the nearest metalled road linking Aariye with Bhannine and onto Delghani, traversing the hilltops but not going down to the valley. Between the scattered settlements, terraced slopes, hilltop fields, and areas of natural vegetation and woodland prevail.

6.10 Cadastral Divisions and Information

The cadastral regions upon which Bisri Dam and reservoir will impose are shown in Figure 6.6 and the expected land take in each is listed in Table 6.9. Evidently, more than two thirds of land-take for the reservoir area are from Chouf Caza, with Aamatour and Mazraat El Chouf having equally the biggest shares of 31% and 23% respectively.

A detailed topographic survey of the whole area has been conducted by the Design Consultant and expropriation files of cadastral plots have been collected. However, ccadastral mapping showing individual plots is available for 98% of the project area, the remaining 2% are unmapped because some plot boundaries are not available for small parts of the project area and ownerships of the plots are yet to be defined by the cadastral judge. These regions are Bsaba and Bater.

The expected land take extends to some 570 ha, of which 434 ha is the inundated area including reservoir and dam footprint and 136 ha corresponds to the 15 m buffer zone. Some 53 ha of *Domaine Publique*, almost all within the reservoir area contain the river course and roads. The split of land take between cadastral regions is shown in the Table here below.

Table 6.9: Cadastral Regions Imposed upon by Bisri Reservoir

Casa	Cadastral Region	No. of Plots	No. of plots totally expropriated	No. of plots partially expropriated	Expropriated Area (ha)	% Area Expropriated
CHOUF	Bsaba	9	5	4	6.8	1.3%
	Mazraat El Chouf	277	225	52	120	23%
	Mazraat El Dahr	55	36	19	42	8%
	Aamatour	310	279	31	160	31%
	Bater	14	6	8	8.8	2%
	Sub-Total	665	551	114	338	65%
JEZZINE	Bisri	74	62	12	44	9%
	Bkassine	2	0	2	0.3	0.1%
	Benouati	27	19	8	4	0.8%
	Ghbatiyeh	4	1	3	6	1.2%
	Harf	69	64	5	46	9%
	Aariye	1	0	1	0.95	0.2%
	Bhannine	28	15	13	10	2%
	Midane	80	70	10	48	9%
	Deir-el-Mkhaless	3	0	3	2	0.4%
	Khirbit Bisri	13	4	9	18	3%
	Sub-Total	301	235	66	179	35%
Expropriation Grand Total		966	786	180	517	100%
Public Domain (river + roads)					53	
Total Land take					**570**	

**plus those in areas not mapped. Percentages are rounded.*

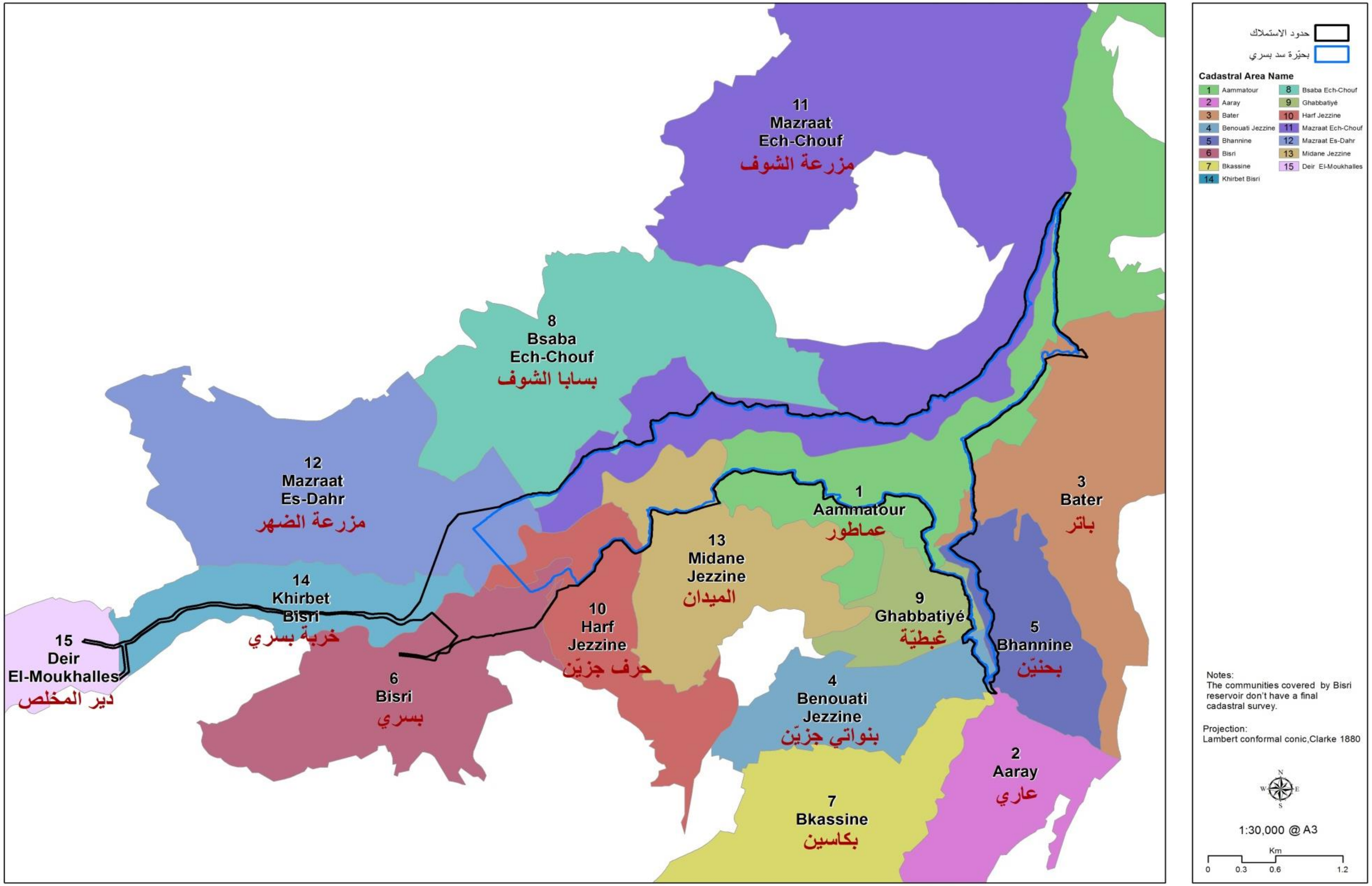


Figure 6.6: Cadastral Regions of Bisri Project

6.11 Cultural Heritage

By comparison to today's impression of quiet rural life, history relates the broad, flat and fertile valley of Nahr Barouk and Nahr Bisri to have been a hive of human and community activity. Repeated site walkovers, discussions with municipalities, Mukhtars and residents as well as investigations of available maps from DGUP and survey data from DGA have revealed the wealth of historical and cultural heritage that will be affected by Bisri dam.

6.11.1 Archaeology

In 2004 and 2005, a Polish-Lebanese team from the Institute for Archaeology and the Polish Centre for Archaeology at the University of Warsaw and the Directorate General of Antiquities (DGA) at the Ministry of Culture undertook a survey of sites throughout the valley and surrounding hills[42].

From the available records of the 2004 and 2005 field seasons, a total of 78 sites were identified, of which 27 fall within the area of expropriation for the Bisri project and a further 10 sites are within 100 m of the expropriation boundary. Of the others, a further 30 sites are less than 1km from the proposed reservoir, while another 10 are further than 1 km. The locations of the sites are shown in Figure 6.7 and listed, together with the prime remains discovered and distance from the expropriation line, in Table 6.10. A short report prepared following the 2008 field season suggests no further work on the sites or the material collected has thus far been undertaken. This report together with copies of the 2004 and 2005 field season data sheets as provided by DGA are given herein as Appendix H.

The sites identified at Bisri represent almost the full span of human history, from Paleolithic times prior to 8,300 years BCE through to the present day, as shown in Table 6.11. The oldest sites, of Paleolithic and Neolithic, are generally outside the immediate valley to be inundated and have yielded a series of stone and flint tools.

[42] Institute of Archaeology and Polish Centre for Archaeology. *The Polish-Lebanese Expedition to the Eshmoun Valley (Wadi Bisri): The Preliminary Report after the Third Season Activity in the Field and Study Season Survey 2008*. University of Warsaw.

Table 6.10: Sites Recorded by DGA in the Vicinity of the Bisri Valley

Site No.	Longitude	Latitude	Nature of Find	Distance from Expropriation Limit
Sites identified during the 2004 field season				
1	35,32,38.8284	33,35,26.0664	Pottery, wall, olive crusher, Persian-Roman	Within
2	35,32,50.5	35,35,30.5	Pottery, wall, olive crusher, Persian-Roman	Within
3	35,32,53	33,35,27.8	Pottery pieces, Recent	Within
4	35,33,1.3	33,35,34.5	(Unrecorded)	Within
5	35,33,5.1	33,35,36.4	(Unrecorded)	Within
6	35,33,30.4	33,35,53.9	Pottery pieces, Roman	80 m
7	35,33,31.1	33,36,0.4	Regular stone blocks, Undated	120 m
8	35,33,51.2	33,35,52.7	Pottery, Undated	Within
9	35,35,2.2	33,35,59.7	House, C20	15 m
10	35,34,15.5	33,36,6.4	Village, C19-20	100 m
11	35,34,43.8	33,35,38.3	Pottery, glazed, C19-20	Within
12	35,35,1.9	33,36,6.4	Pottery, C19-20, one fragment C2BC	190 m
13	35,35,3.2	33,36,12.8	House, Undated	340 m
14	35,35,18,6	33,36,18.7	House with large stones , Undated	270 m
15	35,35,24	33,36,13.7	Houses, Pottery, C19-20	60 m
16	35,35,6.1	33,36,9.3	House, Undated	170 m
17	35,35,15.1	33,35,52.8	Marj Bisri Temple, Roman	Within
18	35,36,4.1	33,36,39.6	Rock shelter, stone tool, Paleolithic	260 m
19	35,35,52.7	33,36,43.8	House, C19-20	Within
20	35,35,29.2	33,36,0.1	House, C20	Within
21	35,35,50.7	33,37,7.8	Stone arch, Undated	90 m
22	35,35,50.1	33,37,8.6	Cave, Use Recent	110 m
23	35,35,30.1	33,35,19.9	Ceramics and pottery pieces, Undated	130 m
23	35,35,30.4	33,35,19.8	(Unrecorded)	130 m
24	35,35,37.9	33,35,7.6	Pottery, C18-19; flint flake, Paleolithic-Neolithic	130 m
25	35,35,44.1	33,35,4.1	(Unrecorded)	270m
26	35,35,33.6	33,34,42.3	House, C19-20	Within
27	35,34,17.1	33,35,36.5	Settlement, pottery, Recent, some older	180 m
28	35,34,11.9	33,35,24.1	Pottery, Undated	570 m
29	35,35,6.7	33,33,35.1	House, Undated	2 km
30	35,35,6.1	33,35,27.5	House, pottery, C19-20	170 m
31	35,35,0.4	33,35,26.5	Settlement, pottery, C2BC to C3-4	230 m
32	35,35,1.1	33,35,15.8	Rock blocks, glazed pottery, C19-20	290 m
33	35,35,1.3	33,35,11.3	Possible stone borer, possibly Paleolithic	300 m
34	35,35,16.7	33,35,8.1	House, pottery, Undated	130 m
35	35,35,24.8	33,35,26.7	House, C20	Within
36	35,35,23.2	33,35,55.9	Rock-cut tomb (looted), pottery, C3-4	Within
37	35,34,32.1	33,35,46	Settlement, pottery, 2C BC	Within
38	35,33,44.2	33,35,26.1	Settlement, pottery, 2C BC	100 m
39	35,33,44.5	33,35,11.1	House, C19-20	340 m
40	35,33,24.3	33,35,11.5	Village, glazed pottery, C19-20	160 m

Table 6.10: Sites Recorded by DGA in the Vicinity of the Bisri Valley (Cont'd)

Site No.	Longitude	Latitude	Nature of Find	Distance from Expropriation Limit
41	35,33,24.4	33,35,19.4	Small stone fortress, pottery, Undated	50 m
42	35,35,58.2	33,37,4.7	Stone steps, pottery, Undated	70 m
Sites identified during the 2005 field season				
43	unrecorded	unrecorded	Pottery, Roman-Present	Not known
44	E 35,33,23.9	N 33,35,26.9	Stone mill, Undated	Within
45	E 35,33,9.08	N 33,35,14.0	House or checkpoint, Undated	Within
46	E 35,32,49.2	N 33,35,3.9	Rock-cut tombs, Roman to C2-3	Within
47	E 35,32,49.7	N 33,35,8.9	Village, pottery, Roman-Ottoman	Within
48	E 35,32,36.6	N 33,34,55.8	House or checkpoint, Undated	Within
49	E 35,32,35.2	N 33,34,51.0	House, Undated	Within
50	E 35,33,4.7	N 33,34,33.3	Settlement, pottery, ?Roman	700 m
51	E 35,32,33.3	N 35,32,33.3	Necropolis, pottery, Late Roman	3 km
52	E 35,33,21.9	N 33,35,23.8	(Unrecorded)	Within
53	E 35,32,29.3	N 33,34,25.1	Settlement, pottery, Roman	600 m
54	E 35,33,16.5	N 35,33,16.5	Settlement, pottery, Ottoman-Recent	4 km
55	E 35,33,59	N 33,35,51.7	Necropolis, pottery, Undated	Within
56	E 35,32,29.6	N 33,34,44.9	Possible rock-cut tomb, Undated	90 m
57	E 35,32,27.7	N 33,34,12.2	Pottery, Undated	1 km
58	E 35,32,46.9	N 33,34,1.6	(Unrecorded)	1.5 km
59	E 35,32,17.9	N 33,35,59.4	Settlement, pottery, Chalcolithic-Bronze Age	120 m
60	E 35,33,31.4	N 33,35,19.6	House, Undated	Within
61	E 35,30,42.8	N 33,34,12.9	Pottery, Undated	780 m
62	E 35,31,37.3	N 33,34,45.5	House, C19-20	360 m
63	E 35,34,50.3	N 33,35,45.9	(Unrecorded)	Within
64	E 35,31,3.6	N 33,34,46.7	Settlement, Roman-Recent	390 m
65	E 35,30,2.3	N 33,35,3.6	Settlement, Roman	640 m
66	E 35,30,32.3	N 33,34,58.9	House, pottery, ?Roman	330 m
67	E 35,32,9.2	N 33,35,14.4	(unrecorded)	300 m
68	E 35,31,36.6	N 33,35,1.9	Settlement, flints, ?Neolithic	120 m
69	E 35,31,41.1	N 33,34,55.1	Settlement, pottery, Recent	50 m
70	E 35,29,48.9	N 33,33,47.7	Necropolis, pottery, glass, Roman	1.9 km
71	E 35,29,19.6	N 33,34,17.7	Settlement, pottery, Undated	1.8 km
72	E 35,29,47.1	N 33,33,57.5	Rock-cut tombs, ceramic fragments, Roman	1.7 km
73	E 35,31,25.7	N 33,35,55.3	Mill, C19-20	1.8 km
74	E 35,31,26.5	N 33,34,58.7	Pottery, glass, Roman	Within
75	E 35,32,24.8	N 33,35,16.2	Settlement pottery, glass, coin, Roman	Within
76	E 35,32,32	N 33,35,16.5	(Unrecorded)	Within
77	E 35,28,40.9	N 33,34,14.9	Settlement, flints, pottery, Neolithic	2.8 km

Data taken from DGA record sheets. There are two sites designated 23.No location is given for Site 43. Those sites shaded red are within the area of expropriation, while those shaded green are outside.

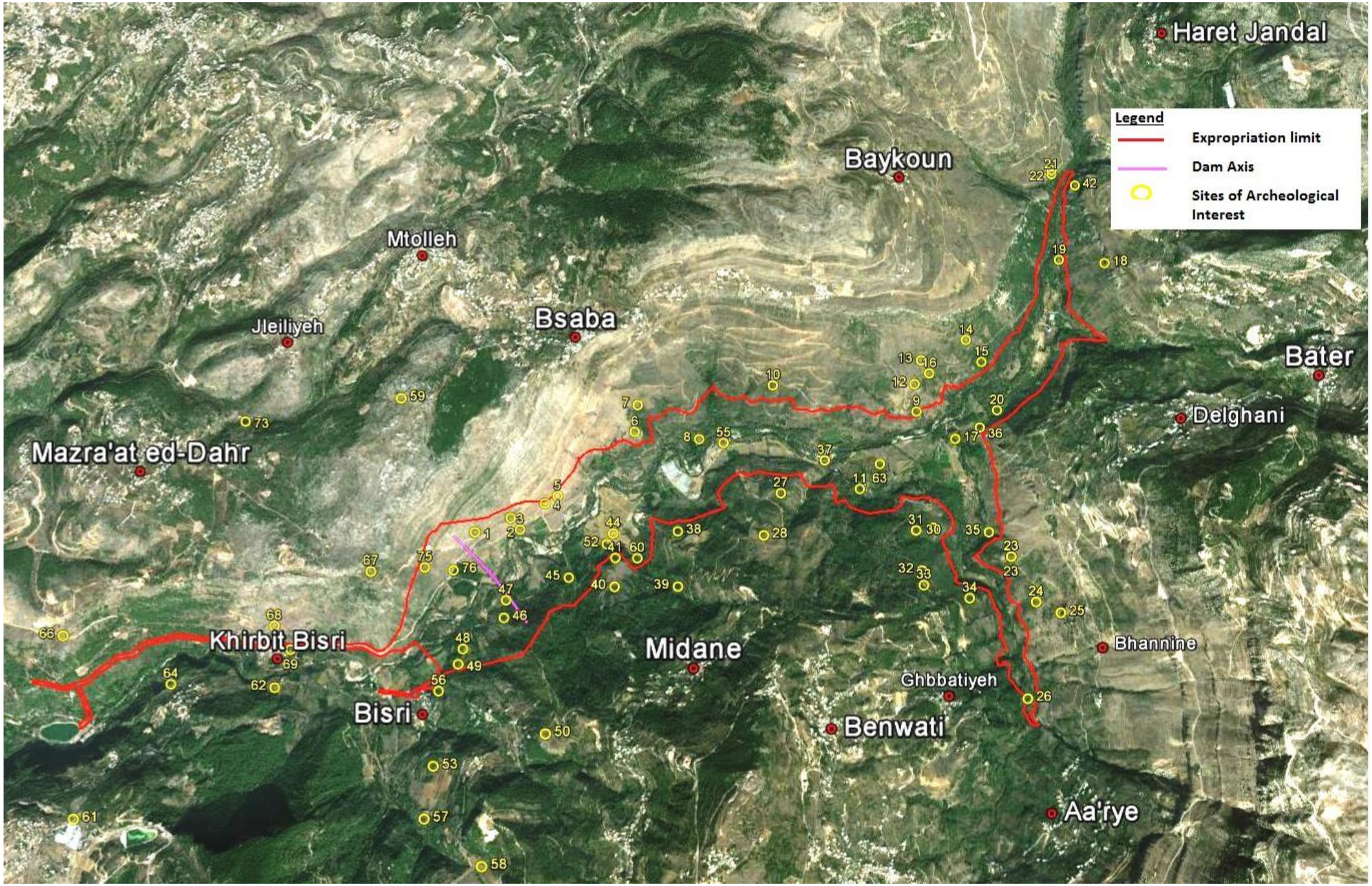


Figure 6.7: Sites of Archaeological Interest Recorded by DGA during the 2004 and 2005 Field Seasons.

Table 6.11: Spread of Bisri Archaeological Sites

Origin of Finds	Age	Number of Sites
Paleolithic	Before 8300 BCE	3
Neolithic	8300-4500 BCE	3
Chalcolithic	4500-3300 BCE	1
Bronze Age	3300-1200 BCE	1
Iron Age	1200-586 BCE	-
Babylonian/Persian	586-332 BCE	2
Hellenistic	332-37 BCE	4
Roman	37 BCE-324	21
Byzantine to Arab	324-1516	1
Ottoman and Modern	After 1516	24

Sites where finds from two periods are recorded are counted twice. Sites left undated are not counted. BCE: Before Common Era (Year 1)

On the basis of recorded sites, the valley seems to have prospered during Roman times, when their ability to travel would have resulted in the valley becoming a major route between the important cities of Tyr and Sidon on what is now the Lebanese coast, and Damascus. Twenty-one of the Bisri sites show evidence of Roman presence or occupation. Thereafter, the remains are primarily dressed stones from traditional Ottoman and Lebanese houses. Table 6.12 summarises the most significant finds.

Table 6.12: Common Finds from Bisri Sites

Prime Finds	Number of Sites
Dressed stones	48
Pottery sherds	49
Stone tools and flints	5
Glass	3
Rock-cut tombs/necropolises	7

Notwithstanding the large number of sites throughout the Bisri valley, which is expected to be the most significant is Marj Bisri Roman Temple, Site 17 of the DGA sites discussed above.

Close to the confluence between Nahr Barouk and 'Aariye', now more commonly known as Wadi Bhannine, lies the temple of Marj Bisri believed to be connected with the Temple of Ashmoun, also known as Bustan El Sheikh, in the Lower Awali Valley, dating back to the 7th Century BC. Originally Phoenician, Ashmoun was constructed over several centuries and shows Roman and Persian influences, with colonnades, mosaics, and the foundations of a Byzantine church. Both Ashmoun and Marj Bisri are believed to lie on the ancient road from Saida to Damascus, used by, among others, Alexander the Great, with Marj Bisri at the crossing point of Nahr Barouk doubtless affording refuse and respite prior to ascending Jebel Niha. The site of Marj Bisri and its immediate vicinity are shown in Figure 6.8. While the bridge across the river is thought to have existed since medieval times, the present single-arch structure, Figure 6.9, is thought to date from the Mamluke-Ottoman period.

Today, the visible remains of Marj Bisri are limited to four black granite columns shown in Figure 6.9, perhaps the entrance to the main temple, and several large dressed stone blocks exposed in the nearby river bank, believed to be the wall of the Temenos, the sacred area surrounding the temple (Figure 6.9). Pottery sherds of both Roman and Persian origin have been found in the vicinity and it is assumed the buried remains of other buildings and at least a small village will also be present. No comprehensive archaeological surveys of Marj Bisri, neither of another suspected temple site downstream, have been completed, although very preliminary investigations without excavation have been undertaken by the Polish Centre for Mediterranean Archaeology at the University of Warsaw working in conjunction with the University of Balamand.

The physiology of the Bisri Valley above the proposed dam location is very different from other westward-draining valleys from the Lebanese Mountains. Rather than being narrow, V-shaped and generally inhospitable to development, it is a broad and flat bottomed with thick, fertile and productive soils. Historically, a short distance downstream of Bisri and Al Jouba villages, seismicity along the Roum Fault caused a landslide that naturally dammed the valley to form a lake. As shown by site investigation boreholes, this was subsequently infilled by a thick sequence predominantly comprising black lacustrine clays. As the lake became filled, the river overtopped the landslip material and surface water once again flowed to the sea, meandering across the old lake bed and re-entering the previous and more typical steep-V-shaped valley downstream. The age of the landslip is unknown but archaeological evidence suggests the lake became filled and dried out during the late Hellenistic–Early Roman period. Furthermore, climate change in the form of increased rainfall during Late Roman times is thought to have increased river flow, rejuvenated erosion, and resulted in some damage to the remaining buildings.

At the site proposed for Bisri Dam, the lacustrine deposits are up to 90 m in thickness. While there has been no site investigation in the vicinity of Marj Bisri, some 4 km upstream from the dam site, these deposits will be expected to both thin and coarsen upstream.

While the current condition of Marj Bisri remains are unknown, it is reasonable to postulate the factors that may have played a role in their current state of preservation. From the ages cited above, it is likely the lake had dried up and the present fluvial regime reinstated prior to temple construction and that burial is the result of river flood deposition. The river course is complicated by both converging streams being braided. The present river channel immediately adjacent to Marj Bisri may have therefore migrated across the floodplain several times, accompanied by both erosional and depositional activity. Like many Lebanese archaeological remains, they may have collapsed prior to burial due to seismicity, although the presence of the four columns suggests any collapse may be only partial. The small, single-arch stone bridge over the river c.30 m from the columns contains blocks of likely Roman origin, so some of the temple may have been salvaged for other uses, a particularly common practice during the Crusader and early Arab period. With the reservoir full, current design proposals suggest the Marj Bisri Temple site will be covered by some 30 m of water.

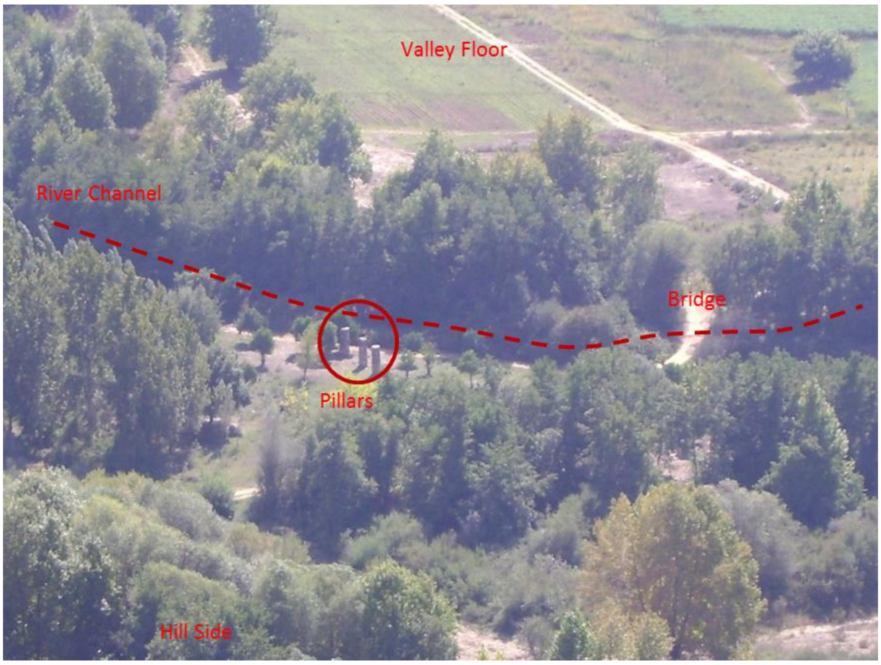


Figure 6.8: View across the Marj Bisri Site, Looking South-westwards

Mar Bisri columns

Large stones in river bed

Mar Bisri bridge

Dressed stones in river bank

Figure 6.9: Photographs of Marj Bisri

6.11.2 Cultural Heritage

That life in the valley continued since Roman times are evidenced by the remains of old stone houses, commonly called traditional Lebanese houses, constructed during the period of Ottoman rule and after. Many of these houses have now fallen into disrepair and the population of the valley today may be one of the lowest throughout its history.

Of particular significance as witnesses to the relatively recent cultural heritage of the area are the sites of Mar Moussa El Habchi Church and the remains of St. Sophia's Monastery, located very close to each other a short distance upstream of the proposed dam axis, as shown in Figure 6.10.

On the lower slopes of the valley, Mar Moussa Church is small and unimposing. Its importance in local culture and tradition was evident from the concern shown at public consultation. The future of the church is an emotive issue for many Mazraat El Dahr residents.

The site is believed to have been used for worship since the 13th century, but the church may have been rebuilt a few decades or more ago as evidenced by the anomaly of a particular cross-engraved stone, broken prior to rebuilding. While the major part of the block has been reused, the missing part was probably lost. Because access is limited to an unmetalled track that is rough and untended, services are no longer held other than on Mar Moussa Day, 28th August, each year. Photographs of the church are shown in Figure 6.10.

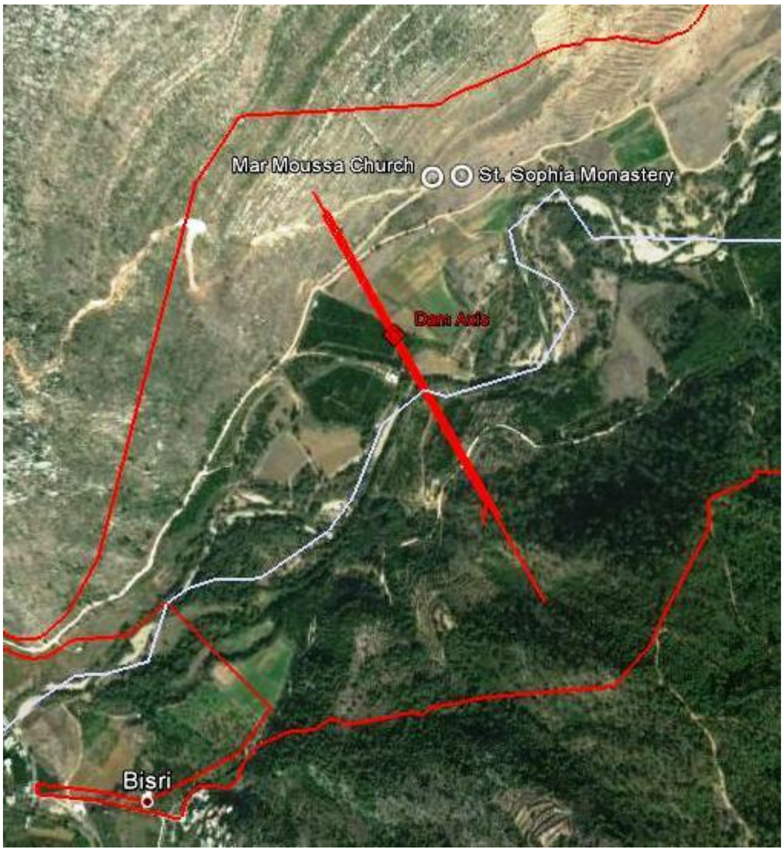
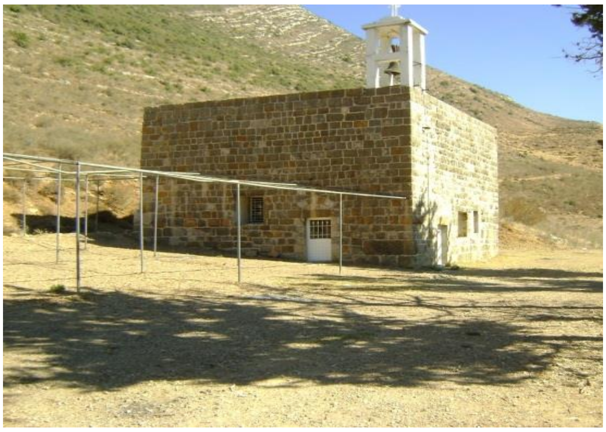


Figure 6.10: Location of Mar Moussa Church and St. Sophia Monastery

With the Mar Moussa site close to construction activity it will be irreparably impacted both directly and indirectly, the latter in the form of vandalism and/or theft of artifacts and old building materials. Unlike at Marj Bisri, the period available for rescue archaeology is likely to be insufficient for extensive and carefully documented excavations. The local community has already indicated they wish to see the church moved to a new location. Given the nature and relative simplicity of the structure, it will be entirely feasible to dismantle the church and the monastery arches block-by-block, number them and reassemble them in the same order. Saving old buildings this way is well practiced outside Lebanon, and relocating the church may be an acceptable solution.



Mar Moussa Church

Engraved lintel over one of the windows

Part of the interior

Broken engraved stone indicating the church has been rebuilt

Figure 6.11: Images of Mar Moussa el Habchi Church

Saint Sophia Monastery is just some 30 m from Mar Moussa but is thought to predate it. Investigations for the ESIA have yielded little information, but the type of construction seen in walls and arches of the stables, the only remaining part of the monastery, suggests it is considerably older than the church, even allowing that latter has been rebuilt. Adjacent to the stables are the remains of a thick stone wall, reported to be Byzantine in age that was once the boundary wall of the monastery. This suggests the monastery was also Byzantine. Photographs of the stable and the wall are shown in Figure 6.12.

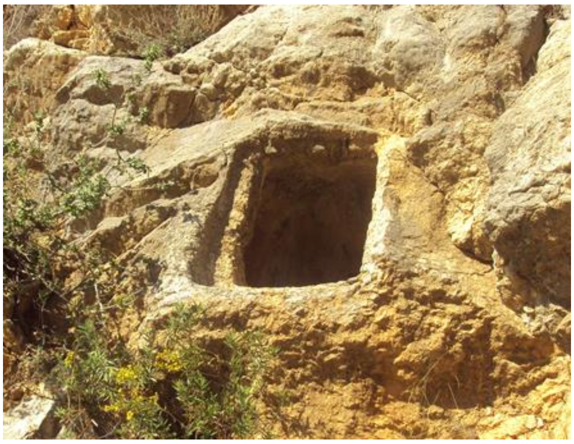
The other sites within the area to be inundated by Bisri reservoir appear to be of much less significance but nevertheless contribute to the overall heritage value of the site and aid our understanding of life in the valley in times past. These sites, illustrated in Figure 6.12, are all in the vicinity of Mar Moussa/St. Sophia, and hence in close proximity to the presently proposed dam site.

Remains of the monastery stables

The Byzantine wall to the monastery

Figure 6.12: Remains of St. Sophia Monastery

Old well c.20 m above Mar Moussa church



Rock-hewn burial chamber

Arches, c.350 m upstream from the church

Lack of planning empathy with heritage

Figure 6.13: Other Sites of Historic and Cultural Interest

6.11.3 Physical Cultural Resources Management Plan

To address the need for rescue archaeology in the Bisri valley as a result of the project, the DGA, CDR and other stakeholders held extensive discussion around the procedures to be followed for relevant rescue archaeology of the cultural heritage in the project area, including the Marj Bisri site. These are summarized below and detailed Physical Cultural Resources Plan (see Appendix D).

7. ANALYSIS OF ALTERNATIVES

7.1 Introduction

This section of the ESIA summarises the discussion, results and conclusions of the comprehensive comparative analysis of potential solutions to the augmentation of Greater Beirut's long-term water supply, the full details of which were presented in the Analysis of Alternatives of the Preliminary Draft ESIA.

In accordance with standard environmental assessment procedure, **Section 7.2** summarizes the 'Do Nothing' or the 'Without Project' Alternative.

To secure a holistic view of the potential solutions for the long-term supply to water to Greater Beirut residents, the GBWSAP ESIA has investigated a range of alternatives, some of which do not necessitate surface water impoundment by the construction of a dam. Given its location on the Dead Sea Transform Fault System, the boundary between the Arabian Plate and the African Plate, Lebanon is renowned for the dense coverage of structural discontinuities that impart spectacular topographic variation. That much of the geological succession comprises highly karstic carbonate strata clearly renders much of the country less than ideal for the construction of large dams and reservoirs. It is therefore prudent to consider non-dam alternative sources of water supply, and **Section 7.3** discusses the advantages and disadvantages of the following:

- Desalination;
- Ground Water;
- Rainwater Harvesting;
- Wastewater Reuse; and,
- Reduction in 'Unaccounted for Water'.

The Analysis of Alternatives also compared four dam sites of which Bisri dam on Nahr Bisri was selected by the project proponent to be the priority scheme to go forward to the full ESIA. In considering potential dam alternatives, sites at Damour on Nahr Damour (two sites) and at Jane on Nahr Ibrahim have been studied; the advantages and disadvantages of each alternative are summarized in **Section 7.4**.

7.2 The 'Without Project' Alternative

With the Greater Beirut area predicted to be home to some 3.5 million people by 2035, the present shortages of water, particularly severe during the hot and dry summer months will only be exacerbated by continued population growth, increased living standards, and changing climatic conditions due to global warming. With existing installed facilities and those proposed under GBWSP for the short-term relief of water stress, Greater Beirut may be expected to suffer severe stress and chronic shortages by 2020.

Longer term demographic changes are more difficult to predict, dictated more by changes into and out of the Lebanese Diaspora, the consequences of political stagnation, economic decline, and regional events more than internal organic growth. Following a period of relative stability on the cessation of civil war hostilities in 1990, population growth steadily declined from 1.4% in 2000 to 1.1% in 2009, after which the rate of decline accelerated, down to 0.24% in 2011[43]. The World Bank estimate for the same year was significantly higher, 0.73%. The highest among all was the rate of 0.8% estimated by the Central Administration for Statistics in 2010. Whichever is correct, Lebanese population growth is lower than near neighbors Egypt (1.9%), Jordan and Syria (1%).

The consequences of not commissioning new sources for public supply may therefore be expected to include:

- Further reduction in water availability to less than 3 hours/day;
- Increased pumping from illegal, unlicensed wells;
- Further depletion of resources already developed beyond their level of sustainability;
- Increase in both salinity concentrations and the area suffering saline intrusion;
- Increased use of tankered supplies, often from non-potable sources;
- Increased household expenditure on water[44];
- Increased wastewater seepage, hence in the prevalence of water-borne diseases;
- Social discord within families[45]; and,
- Conflict between those with access to potable quality water and those without.

7.3 Non-Dam Alternatives

7.3.1 Desalination

Desalination, the removal of salts from seawater or saline/brackish groundwater, is widely used in countries such as the UAE, Saudi Arabia, and Qatar for the production of water for public supply. Two primary technologies are in common use; the Membrane Filtration, also called Sea Water Reverse Osmosis (SWRO), and Thermal Technology of which the most common processes are the Multi-Stage Flash Desalination (MSF) and the Multi-Effect Distillation (MED). The major drawback of both processes is that they are energy intensive, MSF requiring 12-15 kWh/m^3, RO 3.5-5 kWh/m^3, respectively [46] accounting for up to 60% and 45% of total production costs[47]. Perhaps not surprisingly given the insufficiency of the energy sector in Lebanon, the GOL generally regards desalination as the *source of last resort*, when no other potential source of water is available.

MSF technology is more mature and robust, and well suited to the high salinity and often turbid water of the Arabian Gulf. Although, unlike Lebanon, these countries have access to cheap hydrocarbons, the overall cost remains very expensive and some plants operate

43 From Index Mundy.
44 Estimated to be US$28/month over the summer (World Bank 2010 GBWSP Project Appraisal Document)
45 It is well documented that in communities with adequate potable water where food can be prepared healthily and premises and persons cleaned hygienically, children have improved educational attainment, adults are motivated to optimise their employment potential, and there is less social unrest and family breakdown.
46 L. Awerbuch 2009. Desalination: The Vision of Today and the Future. Recent Advancements in Desalination.
47 FWR 2011: Desalination for Water Supply. The Foundation of Water Research.

on co-generated power with solar or waste-to-energy. In contrast, RO technology is more suited to source waters of relatively lower salinity and in respect of energy consumption is significantly cheaper. RO does however require the water to be pre-treated for the removal of suspended particles and micro-organisms that quickly cause the membranes to deteriorate.

Lebanese source waters that could be considered for desalination are likely to be limited to (i) seawater drawn from the Mediterranean and (ii) highly brackish near-coastal ground waters already impacted by saline intrusion. Processes applicable to low salinity source waters, such as ion-exchange and electro-dialysis are unlikely to be applicable. The use of co-generating thermal power with solar energy might look feasible but the overall contribution of solar would be significantly lower than elsewhere in the region and the high investment costs of solar power plants remain of serious concern. While the generation of desalinating power using refuse-derived fuels could benefit both power demand and solid waste management, large scale incineration of waste has long been a subject of political discord. Wind energy is potentially viable for small-medium RO units but impractical for large high-energy demand thermal desalination[48].

Given that Lebanon has a sustainable source of water from the Mediterranean Sea and plentiful coastal saline groundwater with which to blend the distillate to render it palatable, desalination would, at least theoretically, afford a technically-feasible solution to water supply for Greater Beirut. While such a facility might not be designed, developed and efficiently operated locally, a long-term DBO or DBOO contract with an energy supplier with a proven track record may be used to cover the cost of construction, the high levels of energy input, and the high quality O&M.

Environmental impacts include the need to locate an industrial complex on or near the coast, land expropriation, carbon and other atmospheric emissions from both the power plant and the process, and particularly the production of large quantities of wastewater, much of it in the form of super-saline brine that will adversely impact coastal and near shore communities and habitats. Of the water the desalination plant would take in from the sea, 40% will be processed as drinking water while 60% will be expelled with a salinity approximately twice that of sea water. Disposal of this in the Eastern Mediterranean where the circulation is already problematic and water quality generally poor, will only exacerbate environmental problems. Depending on the technology used and a number of other factors, a desalination plant producing 100,000 m^3/d could require a land take of 20-30 ha. The economics of desalination has improved in recent years but is still largely related to the cost of energy. Small-scale plants using RO and similar processes may afford little economy with scale.

The cost/m^3 varies significantly from one plant to another depending on location to source water and demand center, energy source, and technical complexities. Based on data reported by Karagiannis and Petros in 2006 for the Agricultural University of Athens, 1 m^3 of conventionally desalinated seawater ranges from $0.5 to 3.75. For a

48 Spang, E. The Potential for Wind Powered Desalination in Water-Scarce Countries. Fletcher School at Tufts University, February 2006

system relying on renewable energy sources and thereby requiring large scale RE installations, this can reach as high as $18.75.

MSF is the most widely used process for seawater desalination of seawater worldwide, particularly in the Gulf countries (ESCWA 2001) with access to cheap energy. Given the likely opposition to constructing a desalination complex on the Mediterranean coast, the absence of a cheap energy source – indeed, the frequent absence of any energy source – yet the increasingly widespread availability of saline ground water, RO may be much more amenable for Lebanon. This however would require a large number of separate plants feeding into the distribution network at different locations. The number required to produce adequate quantities to supply Greater Beirut would be excessive, but in the longer term, when natural sources have been developed to the maximum sustainable, additional contributions from one or two medium to large MSF or several RO plants my prove a viable option.

For an MSF plant developed through a DBO or DBOO to be feasible, the present law under which EDL, have the monopoly on power generation in Lebanon will need to be rescinded.

Desalination would also afford the opportunity to reduce the illegal abstraction from adjacent coastal aquifers, thereby enabling the exploration of saline ground water in the most technically efficient and cost-effective manner.

Given the expected increase in water salinity over time, shifting from low salinity treatment to medium or high salinity desalination could increase the cost between 1.7 and 5.3 times, respectively. Seawater desalination can cost as much as 3-4 times brackish water desalination (Dore 2005). For instance, RO desalination costs reported by Arroyo and Shirazi (2009) vary between 0.33 and 0.69 $\$/m^3$ for brackish water compared to 0.95-1.52 $\$/m^3$ (2009 equivalent) for seawater. Similarly, the RO system modelled by Dore (2005) gives costs of 0.22-0.28 $\$/m^3$ for brackish water desalination versus 0.5-0.7 $\$/m^3$ (2004 equivalent) for seawater desalination. Hence, a significant economic burden can be expected with aggravated saltwater intrusion and increased groundwater salinity. Replacing small RO systems with a larger (city-scale) facility can reduce desalination cost per capita by as much as 55% (Dore 2005).

Table 7.1 compares energy and electricity requirements among the commonly used technologies with estimates of their Capital Expenditures (CAPEX), while Figure 7.1 compares the Operational Expenditures (OPEX) of the three discussed technologies[49].

49 MENA Regional Water Outlook Part II – Desalination Using Renewable Energy Final Report, March 2011.

Table 7.1: Energy Requirements and CAPEX of MSF, MED, and SWRO

Description	Unit	MSF	MED	SWRO
Maximum Concentrate Temperature	°C	< 115…120	< 70	< 45
Typical Steam Pressure	*bar*	~ 2.5…3.0	~ 2.5 …3.0(a) ~ 0.3 …0.5(b)	0
Typical Present Day Heat Demand	*MJ/m³*	~ 233…258(c)	~ 233…258(c)	0
Typical Present Day Electricity Demand	*kWh/m³*	~ 3.0…5,0	1.5 – 2.5	~ 3.0…5,0
CAPEX	*$ / m³ per day*	1700 – 2900	1700 – 2700	1300 - 2500

Source: MENA Water Outlook 2011
(a) MED-TVC (b) "plain" MED (c) Corresponding to a performance ratio of 9 to 10 kg/2326 kJ

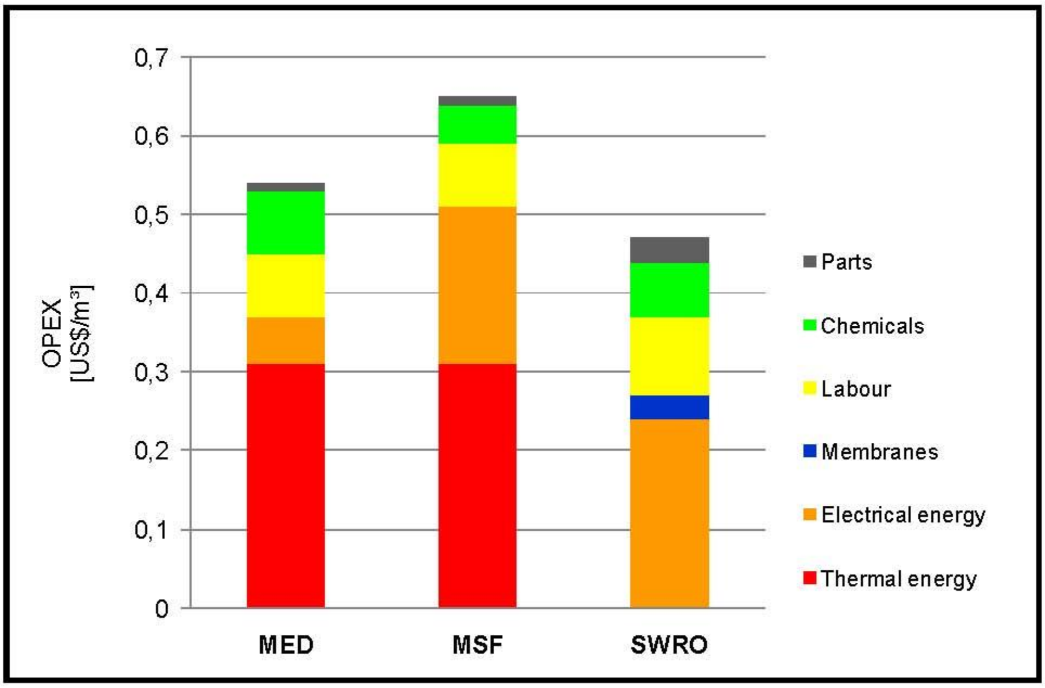


Figure 7.1: Operational Expenditures for three Desalination Technologies (MENA Water Outlook 2011)

The above Figure shows that all three technologies are either energy and/or electricity intensive processes. While SWRO does not require any energy for steaming, MSF requires about double the electricity that MED consumes. Given that energy and electricity supplies are not sustainable and not available at low costs in Lebanon, this raises serious doubts about the feasibility of the desalination option to augment water supply to GBA. The Lebanese electricity sector has indeed been struggling for more than two decades to meet population increasing demands, especially with the aging thermal plants and networks, insufficient supply and poor maintenance. The Energy sector remains highly dependent on GoL capabilities to cover the high costs of importing oil and other fossil fuels to meet the demand especially thermal Power plants consumptions. The sharp increase in international oil price during most of 2008 has in fact highlighted Lebanon's fiscal vulnerability[50].

The CAPEX and OPEX data shown above are only estimates and do not reflect the real cost expected scenarios for various sites. These costs may vary substantially depending on project specifics.

7.3.2 Ground Water

In the absence of adequate water supply for all citizens, ground water is already a proven and valuable source of water supply throughout Greater Beirut. With shallow near-coastal aquifers over-exploited, the potential for additional resource development from deep bedrock aquifers inland is believed to be extensive; yet, the associated political, technical and administrative issues often appear too onerous to afford optimum development of what would otherwise be a major renewable resource.

The present development of ground water for Greater Beirut may be summarized as follows:

- The shortcomings of the existing public supply networks and shortages have resulted in many individual buildings having their own borehole supply;
- The coastal aquifers are consequently over-exploited and increasingly saline;
- In the absence of comprehensive sewerage, shallow aquifers are often polluted;
- There is no effective control of well drilling and/or abstraction licensing. MoE estimates there may be 42,000 wells in Lebanon[51], of which only 620 are legally licensed;
- Given the inability and lack of political will to control resource development, GoL has placed a moratorium on new water wells, which like the existing laws, lacks adequate enforcement.

The last national groundwater assessment study dates back to 1970. Since then, more than 43,000 wells[52] have been drilled on top of which a total of 650 public wells to be added. While the annual natural recharge rate of ground water is 500 MCM, the groundwater extraction nationwide, from these wells, totals 705 MCM as shown in Table below, resulting hence, in 205 MCM yearly deficits (NWSS 2010).

Table 7.2: Groundwater Extractions by Water Establishment (NWSS 2010).

Water Establishment	Public Wells (MCM/yr)	Private Wells (MCM/yr)	TOTAL (MCM/yr)
BMLWE	89	119	208
NLWE	54	109	163
SLWE	71	70	141
BWE	53	140	193
TOTAL	**267**	**438**	**705**

50 Social Impact Analysis – Electricity and Water Sectors World Bank, March 2009.
51 Others will put the figure much higher.
52 Number and volumes of private wells are feared to be much higher than the 2010 NWSS reported figures due to the limited access to those private wells premises and the reluctant owners of sharing their true wells data.

In an attempt to assess the groundwater resources in Lebanon, an UNDP project at the MEW has established the Lebanese Center for Water Management and Conservation (LCWMC) whose one of the key tasks is to set a national database for the use of groundwater. According to the preliminary findings of the LCWMC survey[53], there are totals of 20,537 and 56,276 of licensed and unlicensed wells respectively with a distribution all over the WEs territories as shown in the Table below.

Table 7.3: Groundwater Wells Distribution by Water Establishment (LCWMC 2013).

Water Establishment	No. of Private Licensed Wells	Estimated No. of Private Unlicensed Wells	TOTAL No.
BMLWE	12,306	15,001	27,307
NLWE	3,138	14,876	18,014
SLWE	2,361	8,171	10,532
BWE	2,732	18,228	20,960
TOTAL	**20,537**	**56,276**	**76,813**

The reported total private wells number by the LCWMC (76,813 wells) exceeds by 70% the estimated number of wells, as found under the NWSS (43,000 wells), suggesting that the above estimated groundwater extractions could be much higher than 705 MCM per year and increasing as such the estimated annual recharge deficit.

Amid uncertainties about the actual number of wells and extraction volumes, there is a general consensus that groundwater resources in GBA and its environs is an over-exploited resource. BMLWE has the highest volumes of water wells extraction among other WEs (Table 7.2) and the same establishment counts for the highest number of drilled wells (Table 7.3), imposing as such quantitative and qualitative constraints over groundwater resources.

The concept that water is only assured if they see it in a reservoir rather than when it is stored underground is prevalent among many political activists. While a number of papers, research projects and consultancy assignments have addressed the availability and development of ground water resources, Lebanon still lacks a comprehensive understanding of aquifer potential and resource availability. Those previous studies that have been undertaken have often assumed the boundaries and extent of ground water catchments reflect those of surface water catchments, and reserves are calculated accordingly. This represents a fundamental flaw in the understanding of all Lebanese aquifers, not only in the major karstic limestone aquifers of the Sannine and Kesrouane Formations, but it is also untrue of the minor aquifers, in which water storage and flow is predominantly controlled by fracture permeability rather than primary intergranular permeability. In order to realize the potential of ground water, for present and future projects, for Greater Beirut and elsewhere, intense effort is needed to delimit and understand the physiologies and workings of the various aquifer systems.

53 Groundwater Assessment and Database Project in Lebanon, Lebanese Center for Water Management and Conservation LCWMC, 2013.

The identification of specific areas for ground water abstraction to enhance water availability in Greater Beirut is beyond the scope of the present project. In respect of the dam areas under consideration, Damour would seem to afford the best opportunity for ground water exploitation. Information from existing wells in the area, such as Dmit Municipal Well, suggest that 1,000 m^3/day or more for each well in a wellfield tapping the Kesrouane Limestone (J4) confined under the Bhannes Formation (J5)may not be unreasonable, subject of course to confirmation exploratory drilling, well testing and aquifer modelling prior to scheme design.

The subcrop of the Jurassic limestones at Bisri is complicated by faulting and the cover of recent lacustrine deposits, but if a dam is constructed here, long-term demands, might be supported by the conjunctive use of ground water pumped from the adjacent aquifer. Alternatively, the GBWSP might take additional water from a Bisri Wellfield rather than from a Bisri Dam, replacing and enhancing the flow no longer taken from Qaraoun Lake.

Again, a program of exploratory drilling, testing and modelling will be required prior to scheme design. Such a scheme would be most efficient if the level ground water abstracted were designed to reduce piezometric pressure such that the flow from otherwise unutilized springs rising within the area of inundation were curtailed, thereby controlling ground water outflow, maintaining higher water quality and marginally increasing surface flow storage capacity[54].

Any substantial development of ground water resources for public supply should be accompanied by a program of institutional strengthening and capacity building, together with legislative and judicial review to see how existing laws and regulations can be implemented and enforced. A priority should be to phase out illegal and unlicensed wells to limit further saline intrusion, and to preserve all large scale development of ground water resources for the public good.

The economics of ground water are primarily a function of pump efficiency, the depth from which the water is taken, and the cost of energy, the latter increasing with depth and decreasing with improved pump efficiency. Typically, these costs vary widely, from US\$0.05/m^3 to US\$0.30/m^3.

For ground water to become a substantial contributor to Greater Beirut's future water supply, existing abstractions will need to be retrospectively licensed for a set rate determined against the intended use, and actual abstraction charged against a restructured tariff structure that combines a fixed annual license renewal fee with an incrementally increasingly volumetric fee. The licensing authority, MEW, will need to use aquifer modelling to determine the safe yield of individual aquifer units and to ensure the total licensed abstraction from wells in that unit do not exceed what can be sustained through annual recharge, be it natural or artificial.

The opportunity costs associated with extracting and using the water immediately rather than leaving it in the ground for future use, when water table lowering with increase

54 Clearly, any new abstraction would need to preserve existing legal uses of spring outflow and ground water.

future costs can be substantially avoided if (i) well and aquifer yields are set at their long-term sustainable yields shown by ground water modelling, and (ii) wellfields are designed with minimum interference between adjacent wells.

Expansion of ground water abstraction also requires GoL to prioritize the installation of efficient sewage collection, treatment and disposal systems for developments that currently discharge raw sewage and storm drainage from urban areas in a manner that caused ground water pollution.

7.3.3 Rainwater Harvesting

In many areas of water scarcity, where ground water is polluted, too deep to extract economically, and surface water resources are seasonal, the collection of rainfall from the surfaces onto which it falls, *rainwater harvesting*, may be a viable option. Whilst common in developing countries where rain is plentiful, water demands low, and water quality has to meet only minimum standards, this means of securing water supplies is very common. In developed urban areas it is not common due to the large number of discrete catchment areas, often individual roofs, which require intense and often tortuous collection networks to channel the water to centralized storage tanks in volumes that render treatment to potable standards technically feasible and cost-effective.

Rainwater harvesting works best in areas of low population density where a single family has access to a roof. In urban areas such Beirut, where multiple families live under a single roof, the ability to capture sufficient rain for meaningful distribution is in any case limited.

For rainwater harvesting to sustain domestic consumption, precipitation should be frequent and of low intensity, thus permitting runoff to be easily controlled and the water in retention regularly renewed. In Lebanon, the dry season may extend to 6 or 7 months, and during the wet season storms are frequently intense. Even if all the rainfall could be captured and treated, water quality would deteriorate if storage was extended throughout the dry season. It is therefore impractical to consider rainwater harvesting as making any significant contribution to the public water supply requirements of the Greater Beirut Area.

With the exception of small hill ponds for local agriculture outside the urban area, government investment in rainwater harvesting is unlikely to be cost-effective. As water bills rise with the introduction of a consumption-based tariff structure, individual householders throughout Greater Beirut can be expected to install small catchment schemes to reduce their consumption of municipal water for non-potable uses such as yard washing and garden watering. In some of the modern residential compounds in upland areas with higher rainfall than the coastal plain, rainwater use might be extended to WC flushing, chiller make-up, firefighting reserve and the irrigation of public open space.

Within many areas of greater Beirut, there is likely to be social resistance to both the installation of rainwater harvesting facilities and its use.

For the purpose of investigating the potential use of harvested rain water in GBA, the present report has estimated the amounts of rain water that could potentially be collected all over Greater Beirut Area that extends over an area of about 253 km^2. With an average annual rainfall of 800 mm and a run-off coefficient of 0.8 corresponding to the estimated built-up area of 40%, water harvesting volume, by 2035, can reach to a total of about 120 MCM/year including all storage and distribution losses. An annual water collection increase rate of 4% is assumed. The projected rain water harvesting volumes with their gradual increase until 2035, based on the above assumptions are presented in Table 7.8 hereafter.

7.3.4 Wastewater Reuse

MEW predicts[55] water consumption growing from 225 Mm^3 in 2011 to 341 Mm^3 in 2035 without network improvements, and to 273 Mm^3 with leakage reduction. With the addition of public awareness and metering, the 2035 figure is reduced to 229 Mm^3. However, it is unlikely that leakage will be reduced below 25% and that public awareness and metering, on their own or together, will have little effect without the introduction of a consumption-led tariff structure and improved billing and revenue collection.

Using the intermediate figure of 273 Mm^3, and assuming 80% of this (218 Mm^3) is returned to public sewers as wastewater and 10% of this (22 Mm^3) is lost through infiltration from sewers, the expected volume of wastewater ending up in GBA treatment plants is 198 Mm^3. During the treatment process, a small proportion of the fluid content of incoming sewage will be incorporated with the sludge, lost to leakage from process tanks and pipework, evaporated from storage tanks, and utilized for filter backwashing and landscape irrigation. These losses are small and the treated TSE outflow may reasonably be expected to comprise 95-98% depending on the treatment of sludge, of the raw sewage inflow, i.e. a minimum of 188 Mm^3. Subsequent loss due to leakage from the redistribution pipework may account for 20% of outflow, making the total TSE resource delivered to the end user some 150 Mm^3. In practice, it may be somewhat less than this since treatment will need to be provided at several sites around the service area.

While high-quality TSE that has undergone primary, secondary and tertiary treatment may be suitable for non-potable uses such as the irrigation of roadside planting for fodder and tree crops, there is significant social resistance against its use. The application of TSE is not formally permitted for irrigating crops that may be eaten raw, or for public parks where children might play.

In several areas suffering extreme water stress - Singapore, Australia, Namibia, and a number of US States, have ‘Toilet to Tap’ schemes in which wastewater is treated to potable standards, using a process that includes microfiltration, RO, and disinfection, after which the treated effluent is added to a surface reservoir or injected into an aquifer where it undergoes natural treatment for a period of some months. The process is

[55] Ministry of Energy and Water. *Potable Water Balance in the Greater Beirut Area 2011-2035*.(MS PowerPoint presentation)

considerably more expensive than desalination and the consumption of such water will, in Beirut, meet with significant social objection.

The cost of a wastewater reuse system will include capital, O&M and life-cycle costs. Construction costs include land expropriation, construction, and equipment cost and pipes fee and sewage facilities. O&M costs include electricity, chemical treatment, personnel costs, reparation, and network maintenance.

A study by Asano (1998) estimated the total wastewater reuse system life-cycle cost by combining amortized capital cost with annual operation and maintenance costs and converting to \$/ m^3 (by dividing the estimated life cycle cost, \$/yr, by the reclamation facility capacity, m^3/year). The life cycle analysis is based on a 20-year facility life and return rate of 10%. Wastewater reuse system costs are presented as a function of facility capacity, end-use option and treatment process configuration. Costs have been identified by Asano (1998) estimating facility construction costs, equipment purchases and operation and maintenance fees. Initially, wastewater reuse systems are analyzed in terms of individual components based on design criteria. Cost data are derived for each element of a wastewater reuse system at various capacity levels and unit sizes. Site development and electrical cost are assumed as 10 and 15 percent of the total facility cost, respectively. A summary of the results found by Asano (1998) is presented in Table 7.4.

Table 7.4: Estimated Wastewater Reuse Treatment Life Cycle Costs (Asano, 1998)

Reuse Alternative	Recommended Treatment	Annual costs (\$/m^3)[a, b]
Agricultural irrigation	Activated sludge	0.20-0.55
Livestock and wildlife watering	Trickling filter	0.21-0.57
Power plant and industrial cooling	Rotating biological contactors	0.31-0.58
Urban irrigation – landscape	Activated sludge, filtration of secondary effluent	0.24-0.73
Groundwater recharge – spreading basins	Infiltration – percolation	0.09-0.21
Groundwater recharge – injection wells	Activated sludge, filtration of secondary effluent, carbon adsorption, reverse osmosis of advanced wastewater treatment effluent	0.94-2.64

(a): Costs are estimated for 4,000 to 40,000 m^3/d. Lower cost figure represents a 40,000 m^3/d plant while the upper cost represents a 4,000 m^3/d facility.
(b): Annual costs include amortized capital costs based on a facility life of 20 years and a return rate of 7 %.

At the present time, Greater Beirut disposes of its sewage to the Mediterranean Sea after, at best screening to remove the most significant solids, although the installation of secondary treatment is planned at three large wastewater plants within the GBA region to allow GoL to meet its responsibilities under the Barcelona Convention. The existing Ghadir Wastewater Treatment Plant serves 1 million population equivalent since 1997 in the Ghadir catchment, covering the area from Municipal Beirut to Damour River on the coast and up to Alley, Bhamdoun and Abey at 900 masl. CDR is to commission Design Consultants to complement the existing network and upgrade the existing plant to afford for secondary treatment. The proposed Wastewater Treatment Plant for Northern Greater Beirut will cater for 2 million population equivalent for the year 2025 in the Dora Catchment covering the area extending from Karantina to Nahr El Kalb on the coast, to a number of towns in Mount Lebanon at an elevation of 800 masl between Damascus International Road and Nahr El Kalb. The Project is composed of main and secondary collectors, a secondary treatment plant with a capacity of 3.75 m^3/sec, and the rehabilitation of the existing sea outfall facing Dora area.

While both existing and proposed wastewater treatment schemes in Beirut afford for primary and secondary treatments, the necessary facilities and resources required for wastewater reuse are not currently available and will not become available in the short-medium term unless provided through a BOO, BOT or similar funding agreement. Treatment plants need to be designed and constructed for tertiary treatment; operators will need to be trained, separate non-potable color-coded distribution networks constructed and the TSE use and application areas approved in accordance with MOE requirements[56].

7.3.5 Reduction of Unaccounted-for-Water

Unaccounted-for-Water (UfW)[57] is all the water that is lost to the system, cannot be charged for, and hence does not contribute to the commercial viability of the supplying authority, the BMLWE. The IWA[58] identifies the different categories of UfW, those relevant to the present project listed in Table 7.5. MEW/BMLWE estimates are that the current level of UfW is 40% of water supplied from the treatment plant, although many put the real figure significantly higher.

Table 7.5: Categories of 'Unaccounted for Water'

Type of Loss	Category
Non-Technical	Unbilled metered consumption; Unbilled unmetered consumption; and, Unauthorized consumption.
Technical	Consumer metering inaccuracies; Data handing inaccuracies; Leakage from network; Leakage and overflow from storage tanks; and, Leakage on service pipe before consumer meter.

Water Authority in GBA

As mentioned previously, the Beirut Mount Lebanon Water Establishment BMLWE is the direct project beneficiary. The Establishment has the key role in Water Supply and treatment operations, distribution to consumers, billing and cost recovery for the Beirut and Mount Lebanon service area.

According to the law no. 221 and its amendments, the BMLWE, as any other regional Water Establishment should:

[56] *MoE Policy for the Above Ground Use of Reclaimed Domestic Wastewater*. Draft 2, July 2004
57 Also sometimes referred to as 'Non-Revenue Water'
58 International Water Association.

- Design, implement, operate and maintain potable and irrigation distribution schemes based on the National Water Master Plan and resources as allocated by the MEW;
- Collect, treat and dispose of wastewater based on treatment and outfalls approved by the MEW;
- Propose water supply, irrigation and wastewater tariffs;
- Monitor the quality of domestic and irrigation water that is distributed to consumers.

BMLWE groups together the formerly six water authorities that were in charge of the water supply and distribution systems of the six Mount Lebanon districts (Cazas) in addition to the capital Beirut. The Establishment came into operation only in 2005 and covers now a total area of c. 2025 km^2 that is a home to about 2 million inhabitants with total registered connections of c. 475,000 and an estimated annual water production of 176 MCM from a number of springs, well fields, surface storage facilities, etc. The area that will benefit from the GBWSAP is part of the BMLWE regional coverage with an estimated area of 253 km^2 extending between Damour and el-Kalb Rivers in south-north direction and bounded by the Mediterranean Sea and the contour-line hills up to 300-400m from the West and East respectively.

While the irrigation demand volumes in the area under BMLWE coverage are the smallest compared to other Regional Establishments, the highly developed urban centers in Greater Beirut pose a great challenge to the water authority to meet an estimated annual domestic and industrial demands of 300 MCM (2009) that is almost the half of the national consumption for domestic and industrial water needs.

The key water facility that is under the management and operation of BMLWE is the Water Treatment Plant WTP at Dbayeh where Jeita/Qashqoush springs and ground waters are treated before being conveyed to GBA (60-85% of GBA supplies). The conveyance system, between Jeita springs and Dbayeh, has a capacity of c. 3 m^3/s while Dbayeh WTP, at full operation efficiency, could deliver 320,000 m^3 daily.

"Un-accounted-for-Water" in GBA

It is estimated that the water losses of the conveyor between Jeita spring and Dbayeh WTP could reach 30% due to an old and fissured canal, whereas the 60,000 m^3 of water, that are diverted from the tunnel for irrigation between the months of May and October are not demand-driven but in continuous delivery, increasing hence the inefficient water supply.

On the water head-works and distribution sides and in the aftermath of the civil war in early nineties, the GoL had planned, undertaken and completed number of rehabilitation and upgrading works for the water networks in many places in the country and more particularly in the GBA, under the umbrella of the National Emergency Recovery Program NERP that fostered the reconstruction and development works in the country after years of war hostilities. Given the large scale of war damages more particularly afflicted to all infrastructures, including domestic water, the NERP has been divided into more than one phase. It is mainly under the NERP 2 and 3 where the bulk of the defective distribution networks were rehabilitated in the GBA. Whilst the rehabilitation works under the NERP helped in reducing the losses of water throughout the various networks decreasing to some extent the "UfW", many of the expected rehabilitation works did not either take place or yet to be completed, which created large disparities in the "UfW" estimates among various regional offices of the BMLWE as shown in Table 7.6.

Table 7.6: The Estimated Technical and Non-Technical Losses by Regional Office in BMLWE (EUWI 2009).

BMLWE	Technical Losses %	Non-technical Losses %
Beirut North & South	15 – 28%	10%
Baabda Office	>55%	>35%
High Metn Office	30%	<15%
Kesrwan Office	30%	15%
Alley Office	30 – 40%	>15%
Jbeil office	>50%	15%

Major rehabilitation and installation of water networks had taken place where the new ductile Iron water mains came to replace the defective old and leaking head-works and water mains, and/or the community service lines that used to be galvanized steel were replaced by PE or DI new piping. These rehabilitation works are reflected in the lowest "UfW" estimates (<20%) for a number of areas, namely in the city of Beirut, coastal and southern Metn, like for instance the Bourj-Hammoud network that was fully rehabilitated under the NERP 2 and 3.

On the other hand, there are still major rehabilitation works to be carried-on for many other areas in GB where the losses due to "UfWs" are still significantly high, namely in areas under Baabda, Alley and Jbeil offices jurisdiction. The two latters unfold for old and overused networks with frequently missing as-built plans making it hard to connect efficiently the newly installed headworks/piping network to the existing ones.

Baabda district includes, among others, the southern suburb of Beirut that witnessed over the last three decades an impressive demographic growth[59] that the old and undersized networks were unable to accommodate. Despite many undertakings to upgrade the existing networks in this area (c. 170km of water-mains and 11 km to connect to Khalde area), the "UfW" estimates may still report values as high as 80% for piping installed in the seventies that could drop down to 25% for the newly installed sections of the network.

Amid of varying estimations among different regional offices, the BMLWE puts the average of the "UfW" in GBA at 40% that is 8% lower than the national average.

59 The population of the southern suburbs went from 140,000 inhabitants at the end of sixties to about 526,000 in early nineties accounting for at least one sixth of the Lebanese population. These exclude the population of the Palestinian refugees camps.

Non-Technical Losses

At the present time there is no volumetric metering of domestic consumers within the BMLWE service area. Each householder connected to the system pays a flat fee and water is received as frequently or as rarely as operational availability allows. Some consumers receive water for as little as 3 hours each day or even less in dry months, while many others have no mains water connection, preferring to utilize local wells or tankered supplies. The majority of GBA residents, whether connected to the system or not, buy bottled water for drinking.

Metering of commercial and industrial consumption is practiced but many small business premises, particularly those occupying the basement and ground floors of otherwise residential buildings, are often not metered. In total, only 16% of GBA consumer connections are metered and only 62% of water bills settled, this latter figure is already a great improvement on the collection rate for previous years. It is to be expected the 38% of bills not collected include many individuals and organizations that are among the highest consumers.

Under GBSWP, it is proposed to install 200,000 consumer meters to monitor consumption and reduce illegal connections. This in itself will not reduce UfW unless concurrently there is the introduction of a consumption-based tariff structure and the administrative mechanism, political will, and judicial support to ensure the fair and equitable application of this tariff, efficient billing and revenue collection. This includes the requirement for all government personnel and establishments to settle their water bills. The capacity building required to execute metering will afford significant employment opportunities.

In the longer term, as the adequacy and quantity public water supplies improve, private wells that are illegal and/or yield non-potable water should be phased out in favor of legislated mains connection, thereby improving operational efficiency and revenue collection.

Economically, a volumetric or rising bloc tariff has direct and indirect advantages. First it will ensure financial sustainability for the BMLWE improving furthermore its operation and maintenance capabilities towards detecting and better reducing the technical types of losses throughout the networks. In fact a "Demand and Tariff"[60] study in 2002 has shown that BMLWE has the potential of increasing tariffs either through the volumetric or rising bloc tariffs. The study showed BMLWE consumers have the highest financial capabilities nationwide in purchasing water at the price set back that time and roughly equaling 525,000 LBP/year. Their average (1,140,000 LBP/yr.) and minimal (633,000 LBP/yr) purchasing powers for water remain higher than the national average and minimal respectively. Secondly, the new tariffs structure will provide an incentive to conserve water as higher levels of consumption impose higher costs.

Tariff cost structures differentiate from one country to another. Saudi Arabia implements a progressive tariff structure, whereas in the UAE, Kuwait and Qatar a flat rate tariff is

60 Demand and Tariff Report, Jacobs Gibb, 2002.

implemented. In Saudi Arabia a 5 category tariff is imposed with the first two categories having an extremely low rate of $0.03/m^3 and $0.04/m^3 for the 0-50 m^3/month and 50-100 m^3/month categories respectively. Categories rates then increase quickly and reach $1.6/m^3 for all consumption exceeding 300 m^3/month. That tariff is equally implemented on different types of use (residential, governmental, agricultural and industrial).

By way of contrast, the UAE implement a unified flat rate on the different type of water usage. But the tariff rate differentiate from one Emirate to another with the lowest in Abu Dhabi and the highest in Dubai, $0.6/m^3 and $2.1/m^3 respectively. Having a similar structure, Kuwait implements a flat rate tariff structure with a variable rate depending on the type of water usage. The Lebanese water tariff is a flat rate which can promote more wasteful water consumption. Currently the tariff in Beirut and Mount Lebanon is 0.43$/m^3.

The economic and social gains to household-level metering will be captured only if meter installation follows after the improvement and extension of the water supply network and is closely aligned with the Government's contemplated switch to volumetric tariffs. Meters are expensive to install and read and they tend to have short service lives under intermittent supply. Households utilize meter information most when they face volumetric tariffs and are unlikely to change their behavior when under a flat rate system.[61]

In addition to measures to enforce reduction in demand, major public awareness campaigns are required to prevent some of the more excessive wastages by consumers, such as over-irrigation of gardens, and the watering of roadways in front of shops in the mistaken belief it has a significant impact of dust suppression.

GBSWP proposes to install 200,000 consumer meters to monitor consumption and reduce illegal connections. This in itself will not reduce UfW unless concurrently there is the introduction of a consumption-based tariff structure and the administrative mechanism, political will, and judicial support to ensure the fair and equitable application of this tariff, efficient billing and revenue collection.

Finally it is worth noting some of the BMLWE undertakings towards better managing the Non-Technical-Losses causes all over its territory as it follows[62]:

- Asset Valuation of the Water Supply Infrastructure;
- Business Plan for BMLWE (jointly with the USAID-funded Lebanon Water and Wastewater Sector Support);
- Customer water metering and water balance in Keserwan;
- Development of O+M contract for the wastewater treatment plant in El-Ghadir;

Standard procedures and vocational training for installation and repair of water supply networks.

61 Study of Project Cost Estimates, Financial and Economic Analysis, World Bank, p. 20
62 http://german-lebanese-ta-water.org.

Technical Losses

Losses due to the inaccuracies in consumer metering will be minimized by the efficient training of meter-readers or the use of smart-meters. Those due to data handing will be minimized by audit control.

The majority of leakage and overflow from storage tanks, most frequently from fittings such as valves, meters and other pipeline fittings, are usually observed by operators and can be substantially controlled providing the equipment, materials and expertise are available. The imposition of consumption metering will largely curtail domestic tank overflow and provide the impetus for consumers to maintain their pipework.

The service pipe from the network to the consumer's meter is often shallow or exposed, and leakage is often observed within a short period of time. Losses from deeply buried transmission and distribution pipework may be less easily observed if the issuing water infiltrates to ground water. Some leakage reduction is therefore relatively easy to attain and even on the networks the provision of GBWSP bulk meters should substantially reduce losses.

Across the Greater Beirut area, it is to be expected that leakage will primarily be from the networks. The reasons for this are various and will include but not be limited to the aging, inefficient and sporadically extended networks, poor construction practices, the lack of investment in modern infrastructure such as telemetry and smart meters, insufficient operational experience, and the lack of resources. While 15% leakage is attainable in small rural service areas where water is charged at a rate that particularly penalizes heavy users, most urban water supply authorities are pleased to achieve 20-25%. Given the erratic development of GBA networks, with pipes often laid at shallow depths and poor bedding material, residual war damage, and the lack of lorry weight-limit enforcement leading to excessive traffic loading, BMLWE will do well to realize a reduction in leakage to 25%.

Applying a gradual reduction of the current 40% "UfW" rate until the projected 25% by 2035, would lead to the estimated water savings shown in Table 7.7.

Table 7.7: Projected Water Saving by Reducing "UfW" until 2035.

Water Demand for GBA (MCM/yr.)		**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Demand	Domestic & Industrial Water Demands	225	240	260	290	320	340
	Gradual "UfW" reduction	40%	37%	34%	31%	28%	25%
	Domestic & Industrial Reduced Demands – Adjusted	225	233	252	281	310	330
Water Saving Achieved (MCM/yr.)		**0**	**7**	**8**	**9**	**10**	**10**
WATER BALANCE (with no losses reductions & no supplies augmentation)		**-205**	**-230**	**-260**	**-295**	**-325**	**-345**

Reducing "UfW" rates to 25% would spare a cumulative amount of water of 44 MCM 25 years time that is equivalent to six times the Chabrouh dam storage. Nevertheless this extra water amount will remain a meagre contribution in filling the gap of the next 25 years water deficit that is expected to reach 1660 MCM if no major dam or non-dam water supply schemes are put in place by that time.

In consequence, the NWSS estimates of the volume of water gained from all sources of leakage reduction may need to be revised downwards, from 85,000 m^3/day (31 Mm^3/y) to 64,000 m^3/day (23 Mm^3/y) and the consequential shortfall of 21,000 m^3/d (8 Mm^3/y) made up within additional resource development under GBWSAP.

The Public Expenditure Review (2010) assessed documented international experience in developing countries, and estimated average costs in the range of US$215-500 to reduce losses by 1 m^3/day. Assuming this is achieved for the entire year, it can be calculated that leakage/loss reduction through the measures implemented under GBWSP cost within the range US$0.58-1.37/$m^3$ saved. This compares relatively favorably with the other non-dam options for potable water supply.

The reduction in UfW is good management practice and all its sources, technical and non-technical, need to be the subject on on-going investigation and remediation, be it a leaking pipeline or errors in billing. While the saving in water supplied can be significant, it will at best contribute to delaying the need for investment in new sources.

7.3.6 Summary of Non-Dam-Alternatives

It is obvious that the Non-Dam-Alternatives, with all their inherent limitations within Greater Beirut context, as discussed above, will remain immature solutions towards augmenting the supply resources to GBA, under the short and medium terms if taken all together. Number of technical, social, economic, policy etc, constraints has to be overcome first for these alternatives to become reality. While seeing as a more realistic path way some of these Non-Dam-Alternatives applicable within the context of the studied area, the combination of all the proposed water supply solutions remain just conceptual with the mere objective of investigating the full potential of these sources and their impact on the water deficit of the Capital as shown in the Table 7.8.

Table 7.8: Water Balance relying on "Non-Dam-Alternatives" until 2035.

Water Demand & Supply for GBA (MCM/yr.)		**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Demand	Domestic & Industrial Water Demands	225	240	260	290	320	340
	Agricultural Water Demands	80	90	100	105	105	105
TOTAL DEMANDS (without losses reduction)		**305**	**330**	**360**	**395**	**425**	**445**
Supply	(1) Currently available water resources	100	100	100	100	100	100
	(2) Desalination Sources	-	-	No limit	No limit	No limit	No limit
	(3) Rain Water Harvesting Sources	53	63	75	87	102	120
	(4) Waste Water Reuse	122	114	98	103	114	125
	(5) The Unaccounted-for-Waters Contributions	0	7	8	9	10	10
TOTAL SUPPLY		**275**	**284**	**281**	**299**	**326**	**355**
WATER BALANCE without supply augmentation		**-205**	**-230**	**-260**	**-295**	**-325**	**-345**
WATER BALANCE with augmented Non-Dam-Supply		**-30**	**-46**	**-79**	**-96**	**-99**	**-90**
Expected Reduction in Water Deficit		**85%**	**80%**	**70%**	**67%**	**70%**	**74%**

(1) Ground water supplies cannot be considered as an infinite source. The forecasted scenarios of the NWSS tend to put a 500 MCM cap on the ground water extractions nationwide to reduce the current recharge deficit of 200MCM. As such any potential increase of other currently available sources would be balanced out by the ground water national decreasing forecasted supply, hence maintaining the same amounts of available resources in two decades from now.

(2) While the desalination of water alternative puts no constraints over the amounts of water that potentially could be supplied from the Mediterranean Sea, the desalination solutions to Lebanon, as discussed above, prove to be the most non-cost-effective due to the absence of inexpensive energy sources in Lebanon and to the long-time struggling electricity sector in the country. As such, no contributing volumes from desalination will be accounted for into the water balance table above, leaving Desalination solution as the "Source of Last Resort" with absence of any alternative solution.

(3) The potential of collecting all the rainfall water harvesting is assumed to take some time until the needed infrastructures and facilities will be all in place. As such an annual water collection increase rate of 4% is assumed until all the gradually installed infrastructures will be able to collect all what could be collected than used, i.e 120 MCM/year by 2035.

(4) Assuming that the social and religious barriers over the use of TSE water in GBA would be overcome, the potential of TSE water volumes that could be generated over the next decades will be included in the water balance of the Non-dam-supply-alternatives. However, the current state of the sewage networks with the lack of adequate connections between the treatment plants and the collection networks, when these are found, make the advanced TSE water figures only conceptual for the purpose of quantifying the potential of that water that could be used.

(5) As discussed earlier, the national target of reducing a total of 20%, by 2035, of the UfW in GBA looks impractical considering all the constraints imposed by the technical and non-technical shortcomings over the GBA networks. Correcting the reduction factor to more realistic and gradually reduced figure of 15% by year 2035 would spare modest water amounts.

With all inherent limitations and constraints unrealistically overcome, the non-dam-alternatives, would conditionally contribute in reducing GBA imbalance over the next 30 years. While the unconventional water sources will go mainly for non-potable water use, the augmented supplies will not eliminate the persisting water deficit that will keep on showing an annual water deficit varying between 30 and 100 MCM over the next 20 years.

The Table 7.9 summarizes the major advantages and/or setbacks that may facilitate or deter these solutions from being realistically achieved for the long-term supply of potable water to Greater Beirut.

Table 7.9: Summary of Potential Non-Dam Alternative Sources

Source	Advantages	Disadvantages	Conclusion
Desalination	• Plentiful and sustainable resources; • Could supply whole GBA demand; • Technically reliable; • Independent of Climate.	• Utilises an Industrial process; • Only 40% of intake to supply; • High construction cost; • Substantial coastal land take; • High energy and O&M costs; • Marine env. damaged by brine; • Politically unflavoured.	Highly feasible, but very expensive. For current consideration, the 'Source of Last Resort'
Ground Water	• Most discharge to supply; • Suitable for conjunctive-use; • Better quality than surface water; • Diverse source locations; • Modest carbon footprint.	• Limited future use due to over-exploitation • Resources currently ill-defined; • Probably insufficient to supply GBA alone; • Recharge climate-dependent; • Substantial energy costs.	Resources remain to be quantified but at minimum will significantly contribute to conjunctive use with a dam alternative alternative but with limited volumes to be used in the future
Rainwater Harvesting	• Basic technology; • Local sources; • Low carbon footprint.	• Short wet season; • Ill-suited to high-rise urban areas; • Climate dependent; • Poor public perception.	At best, it will contribute to household or compound non-potable water use.
Wastewater Reuse	• Source origin within GBA; • Source generally sustainable; • Majority of technology already required for best management practice.	• High treatment costs; • Lack of technical expertise; • Insufficient resources to meet GBA demand; • Very poor public perception and confessional objection.	Strong cultural objections. At best can supply substantial quantities of non-potable water for landscape irrigation, etc.
Reduction in UfW	• Optimises existing system efficiency and cost-recovery; • Promotes Best Management Practice.	• Requires political will, legal reform and judicial support; • Requires public cooperation; • Leakage unlikely to be <25%.	Should be pursued as is economically viable. Will not reduce the need for new source development.

In conclusion, desalination, albeit it technically, economically and politically the 'Source of Last Resort', is the only non-dam alternative capable of sustaining long term water supplies to Greater Beirut, but of course at the highest cost. The Ground Water cannot be considered as an infinite source. The forecasted scenarios under the National Water Sector Strategy put already a 500 MCM cap on the ground water extractions nationwide to reduce the current aquifers recharge deficit of 200MCM.

Other sources may reduce demand for potable quality water for non-potable uses. Reductions on UfW are simply good water industry housekeeping and should in any case be pursued as far as is economically feasible. In addition of facing strong cultural and societal objections, the Waste water supplies lack drastically the needed production and conveyance infrastructures, despite the GoL attempts to develop this resource since the end of war years. The major constraints towards developing massively exploited Rain Water Harvesting resources are the highly urbanized nature in most of GBA sectors, the high pumping and conveying costs if these are developed outside GBA in addition to the highly seasonal falling rain all over the Lebanese territory.

While some non-dam source alternatives may delay the need to invest in future dam project, after Bisri, they are unable to cater for the bulk of Greater Beirut demands.

7.4 Dam Alternatives

7.4.1 Introduction

As discussed above, desalination, currently the 'Source of Last Resort' technically, economically and politically, may be the only non-dam alternative capable of sustaining long term water supplies to Greater Beirut and this only in the case where the Lebanese energy sector is substantially improved to sustain large scale desalination. While additional ground water abstraction from bedrock aquifers away from the coastal plain may contribute significantly, the current understanding of the hydrogeological regime requires many years of study, testing and modelling before large-scale sustainable supplies can be assured.

To meet the medium and long term requirements to augment Greater Beirut's water supply it will therefore be necessary to impound some of the estimated 400,000 million m^3 of rainfall and snow melt that annually runs to the Mediterranean Sea.

As discussed previously, the potential for impounding surface water flows has long been recognized, and broader investigations to identify the most feasible river basins were completed as long ago as the 1950s. Subsequent work identified potential dam sites and more recently, as part of the National Water Sector Strategy and National Surface Water Storage Strategy, GoL has commissioned feasibility studies incorporating among others a range of technical considerations for the three sites listed below and located as shown in Figure 7.2:

On the Awali River upstream of Bisri village;

- On the Damour River above its confluence with Nahr Hammam; and,
- On Nahr Ibrahim upstream of Janneh.

Also as discussed previously, the present project is also looking at a second site in the Damour valley, a short distance further upstream and hereafter referred to as Damour East Dam, while the site cited above is Damour West Dam. Damour East has never been subject to any feasibility study but has long been argued by a group of concerned Beirut residents to be superior to either Damour West or Bisri dams.

While these impoundment schemes are not the only sources that may be viable for the long-term augmentation of Greater Beirut water supply, the detail to which three of the four have been previously studied renders it relatively straight forward, subject to additional detailed studies, to progress to final design and construction within an acceptable time frame to the project proponents.

Figure 7.2: Dam Locations

7.4.2 Damour Dams

The layouts of both Damour reservoirs are shown in Figure 7.3 and the outline of both for comparison in Figure 7.4.

Figure 7.3: Damour East and Damour West Reservoirs

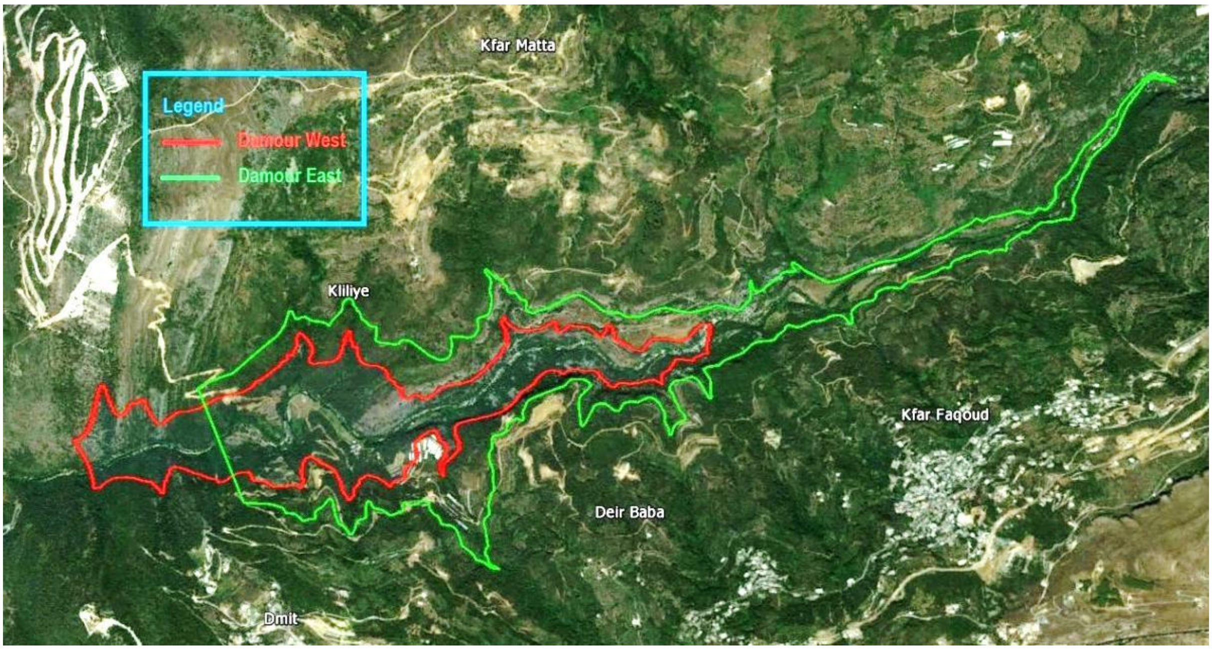


Figure 7.4: Comparison of Damour West and Damour East Reservoirs

The proposed Damour West dam, 98 m in height, is some 2 km upstream of the confluence of Nahr Hammam with Nahr Damour and about 4.5 km inland from the Mediterranean coast, at an elevation of c.50 masl. The reservoir has a catchment area of some 210 km^2, a capacity of 42 Mm^3, and extends for about 3 km upstream, largely contained within a narrow gorge. The proposal was subject to a Feasibility study by LibanConsult in 2009.

In 2010, some fifty Beirut residents campaigned against GBWSP, which they incorrectly perceived to include Bisri dam, to propose the Damour East dam, 150 m in height, located 300-400 m upstream of Damour West. In the absence of any maps or plans, the area of inundation has been determined by tracing the maximum water level contour on the most recent topographic map. Total storage is estimated (Chatila, 1998) to be 113 Mm^3. Due to the higher reservoir water level together with the relatively low valley bottom gradient, the area of inundation stretches 2.5 km further upstream than that of Damour West.

The prime difference between these two dam sites is that Damour West is on the lower marly limestones of the Sannine Formation (C4), while Damour East lies on the Abeih Formation (C2a), a sequence of thin limestones, marls and sandstones. While these formations may have markedly difference intrinsic permeability, the whole area is near the crest of the regional Mount Lebanon Western Flexure and hence secondary permeability resulting from expansional fracturing and fissuring predominates. As mentioned no feasibility study is available for Damour East.

The symmetric V-shape cross-section of the valley, similar at both sites, is considered suitable for dam construction as it will minimize foundation excavation. However, several longitudinal and transverse faults are reported to cross-cut the sites. A major concern for both dam sites is the potential increase in leakage through the fissured and karstic limestones of the westward dipping Bikfaya Formation (J6) in which many joints and fissures are infilled with clayey and sandy detritus. As the reservoir fills the water movement and pressure will flush out this material, increasing infiltration and consequentially enhancing fissure widening and rejuvenating karsification. With more extensive inundation at Damour East, both upstream and laterally, the potential for the water to flush out fissure infill and aggravate the already obvious instability of the valley sides is substantial. While neither of the Damour dams was recommended for the priority scheme, the area was recognized to have the potential of sustaining a small dam constructed on the Damour East site with a reduced maximum water level to limit lateral leakage.

7.4.3 Janneh Dam

Janneh dam on Nahr Ibrahim, 37 km from Beirut, is located in a steep gorge 17 km from the Mediterranean coast between the villages of Qartaba and Hdaine to the northeast, Lassa and Saraaita to the south east, as shown on Figure 7.5. The reservoir, with a catchment area of some 242 km^2, extends for 3.2 km upstream from the dam and is expected to contain 37 Mm^3 of water. A Feasibility study was carried out in 2006.

Figure 7.5: Janneh Dam and Reservoir on Ibrahim River

The principle formation underlying both the dam and reservoir site is the highly fractured and karstic Kesrouane Formation (J4). Several longitudinal and transverse faults cut the dam site, some infilled with basaltic material, thus reducing their permeability. None are believed to be active. The stated height of the dam is 165 m, of which 105 m will be above current river bed level, the lowermost 60 m within alluvial deposits that will be excavated to rock head.

Possible leakage recently suggested by various studies would render the dam infeasible. While the thesis has merit and is perhaps worthy of further study, the discussions of geological, hydrogeological and structural settings are based upon assumptions for which no justification is offered. In particular, there is nothing to support the suggestion the Jurassic aquifer of Upper Nahr Ibrahim is connected to Jeita Spring, north of Beirut. Such justification would need to involve exploratory drilling, dye-tracing, geophysics, test pumping and ground water modelling. If such a connection was proven and Janneh water did flow naturally to Jeita, the cost saving in transmission and the opportunity to upgrade existing Jeita abstraction would be attractive. In 2013, the Ministry of Energy & Water has actually launched the first construction phase of the Janna dam along the Nahr Ibrahim River. The dam will serve the Northern areas of Greater Beirut Mount Lebanon.

7.4.4 Summary of Dam Alternatives

In assessing each of the options for augmenting Greater Beirut water supply, the Analysis of Alternatives has conducted an options-prioritization-exercise, looking at both the fundamental considerations and the detailed impacts. In summarizing the conclusions to recommend the priority scheme option on which to progress more comprehensive assessment and environmental management proposals, two approaches were adopted. The first was a simple subjective comparison of the primary advantages and disadvantages, while the second more detailed comparison developed a Trade-Off Matrix, which despite often disparate and often inconsistent data, affected a multi-criteria analysis of the GBWSAP results at the time.

In developing the trade-off matrix, 13 technical, economic, environmental and social issues subdivided among 35 separate scored parameters were utilised. Since all the issues were not of equal significance, they were weighted as shown in Table 7.10.

Table 7.10: Trade-Off Matrix Major Issues Weightings

Issue	Parameter	Weighting
Natural and Human Heritage	Area of natural beauty; Ecological value; Archaeology/history inundated.	**1**
Lower Catchment Impacts	Flood protection; Loss of irrigation.	
Ground Water	Aquifer at outcrop; Downstream recharge zone; Hydraulic gradient reversal.	**2**
Upper Catchment Impacts	Erodibility of strata; Population contributing wastewater.	
Land Take	Loss of natural landscape; Loss of productive land; Loss of public infrastructure; Loss of Agricultural infrastructure; Household and business relocation.	

Table 7.10: Trade-Off Matrix Major Issues Weightings (Cont'd)

<table>
<tr><th>Issue</th><th>Parameter</th><th>Weighting</th></tr>
<tr><td>Hydroelectric Power</td><td>Supplied from dam.</td><td></td></tr>
<tr><td>Dam Construction</td><td>Dam design;
Construction materials.</td><td></td></tr>
<tr><td>Seismicity</td><td>Proximity to regional structures;
Historic seismic activity;
Reservoir loading;
Liquefaction</td><td rowspan="2">3</td></tr>
<tr><td>Surface Water</td><td>Mean annual flow;
Water quality.</td></tr>
<tr><td>Dam Site Geology</td><td>Formation Karsticity;
Formation fracturing;
Foundation issues.</td><td>4</td></tr>
<tr><td>Reservoir Geology</td><td>Floor water tightness;
Sidewall water tightness;
Shoreline erodibility;
Past landslips.</td><td rowspan="3">5</td></tr>
<tr><td>Water Supply</td><td>Meets GBA 2020 shortfall.</td></tr>
<tr><td>Cost Effectiveness</td><td>Overall cost of supply scheme;
Use of common facilities;
Cost per unit volume of water</td></tr>
</table>

Experimenting with a number of scoring regimes[63], including separately weighting positive and negative impacts, the results from the trade-off matrix divided the four dam options into two distinct groups, with Damour East and Janneh being consistently less favored that Bisri and Damour West. The advantages and disadvantages of each are summarized in Table 7.11.

63 Full details of trade-off matrix development, and the scoring regimes are given in the Analysis of Alternatives of the PD ESIA (August 2013)

Table 7.11: Summary of Potential Dam Alternatives

Scheme	Advantages	Disadvantages	Conclusion
Bisri	• High storage volume that meets GBA demands to 2030 or longer; • Utilises GBWSP transmission, treatment and storage facilities at limited additional cost; • Reservoir floor underlain by low permeability deposits; • Little or no pumping costs; • Lowest cost per unit volume delivered to GBA;	• Most land take is productive land; • Historic and cultural remains at risk; • High sedimentation risks; • High seismic risk.	Bisri dam is the only site that will supply GBA demand over an appreciable period of time with cost effective investment. Nevertheless; additional studies into reservoir geology, water tightness, seismic and sedimentation risks are needed prior to detailed design. Preference for the present dam axis location should be confirmed.
Damour West	• Land take mostly non-productive; • Favorable dam-site morphology in V shape; • Might utilize some GBWSP facilities.	• Small storage capacity; • Unlikely to sustain significant hydropower; • New treatment plant required otherwise additional conveyances costs; • Significant pumping costs.	Water storage is substantially less than at Bisri or Damour East, and dam site geology is less favored. Any dam here should have a reduced water level to limit lateral leakage and/or be part of a conjunctive use scheme with ground water.
Damour East	• Dam site geology better than at Damour West; • Favorable dam-site morphology in V shape; • High storage volume that meets GBA demands to 2030 or longer.	• High lateral leakage; • New treatment plant required, otherwise additional conveyance costs; • Significant costs to treat the J6 permeable strata; • Significant pumping costs; • Subject to block collapse from reservoir cliffs.	Notwithstanding; the high storage volume and the relatively better site-dam geology than Damour West, this scheme raises serious concerns about the potential excessive lateral leakage.
Janneh	• High flow rates, reservoir readily replenished each spring. • Favorable dam-site morphology in V shape; • High Potential of hydropower generation.	• Most land take is natural landscape; • Located on highly permeable strata, hence leakage likely to be substantial; • New treatment plant and transmission line required; • Highest cost per unit volume delivered to GBA.	As a stand-alone dam Janneh will only meet GBA short term needs at the highest expected costs. Futher investigations need to be carried out to address the concerns about dam and reservoir geology and water tightness.

By assessing the likelihood and severity of each of the dam construction facilitating and/or hindering conditions, the Alternatives Analysis was able to show that the three dams could well stand together in the following priority order and under the assumptions as discussed previously and as proposed in the MEW's National Water Sector Strategy and associated Surface Water Storage Strategy:

- Given its size, cost effectiveness, and all combined favorable geological settings, Bisri Dam is considered the priority option. The large size of the dam resulting in lengthy period of time of the project to be completed, Bisri dam construction could be started while other dam options would afford further investigations as was raised in the Alternatives Analysis Report.
- Janneh Dam could be constructed in phases with a reduced capacity, catering on short term for Jbeil and Kesrwane needs, until the reservoir geology and water tightness will prove to accommodate for higher storage capacity for longer term contribution to GBA.
- The first years of construction of Bisri and Janneh Dams will allow for a more in depth study about the feasibility of Damour West Dam, the outcome of which should indicate the way forward either to proceed with Damour West Dam or to advance with the Damour East from a feasibility study into a detailed design. In all cases Damour proposed Dams with their reduced volumes could be compensated by possible conjunctive use with ground water from underlying aquifers.

8. ENVIRONMENTAL AND SOCIAL IMPACTS

8.1 Introduction

This section of the ESIA report addresses the potential environmental and social impacts that might accrue from the GBWSAP.

As is the case with any ESIA, the spatial area for which the study or assessment would be conducted should be determined. This is known as the **area of influence** of the project, also called the impact area of the project, and could extend for considerable distances and well into the future. It includes, as defined by the WB, all project ancillary aspects, such as power transmission corridors, HEP, pipelines, canals, relocation and access roads, borrow pits/quarries and disposal sites, and construction camps, as well as unplanned induced developments that can occur later or at a different location. The area of influence may include the watershed within which the project is located, any affected estuary and coastal zone, off-site areas required for resettlement, migratory routes of wildlife, and areas used for recreational activities or religious or ceremonial purposes of a customary nature. The International Finance Corporation (IFC) adds on the definition of the area of influence to encompass "cumulative impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned, or reasonably defined developments at the time the risks and impacts identification process is conducted."

GBWSAP area of influence is defined at two levels: the immediate surroundings of the project's infrastructure works for direct, indirect and induced impacts on the one hand and a substantial area, that extends beyond the direct vicinity of the Project itself. The critical area of influence is the reservoir area and the lower catchment whereby it is impacted by the construction activities as well as the changes that will occur resulting from dam operation be it positive or negative, direct or indirect impacts upon which affected communities' livelihoods are dependent. The upper catchment will impact the environment mainly by what it discharges into the reservoir basin. The critical GBWSAP area of influence extends from the sources of Barouk and Aariye Rivers, incorporating the villages above and surrounding the reservoir, till the outlet of the Awali River on the coast, covering the agricultural plains downstream of the dam and the villages residing in this area. The Lower catchment measures to about 90 Km^2 and the upper catchment is about 200 Km2, as shown in Figure 8.1

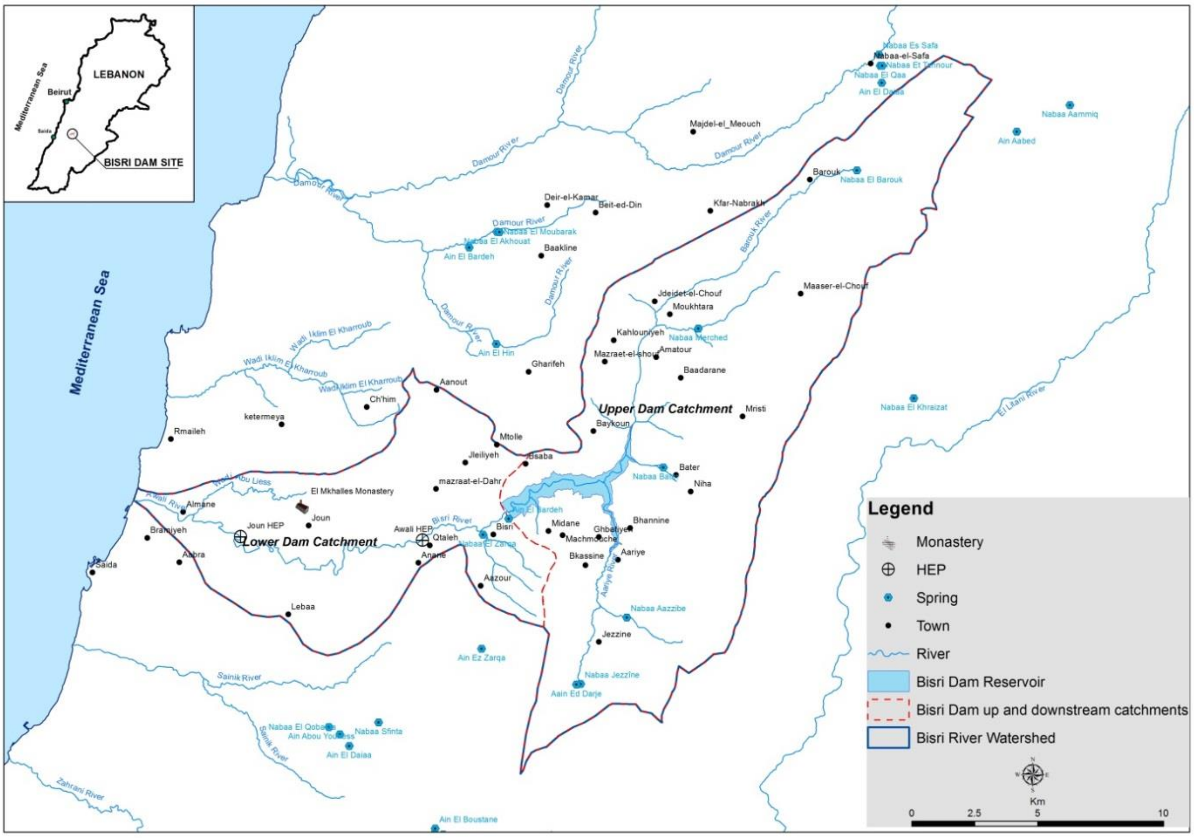


Figure 8.1: Upper and Lower Dam Catchments

An estimated 80% of the dam construction material (estimated at 6 million m^3 of fill) will be sourced from within the reservoir area, significantly reducing reliance on external quarries and subsequently minimizing the negative environmental impacts associated with the construction of new quarries or use of existing commercial quarries.Appendix M includes an assessment of quarriws in Lebanon and the associated Environmental Management Plan.

Clay is expected to be taken from the areas within two large meanders in the current flow channel, respectively 150-250 m and 550-700 m upstream of the dam axis. Between these two areas on the northern bank are significant outcrops of limestone that will be worked for crushed stone. Areas from which sand and gravel may be obtained extend between the dam site and the confluence of Nahr Barouk with Wadi Bhannine. The final suitability of all borrow areas will be determined by the appointed contractor through site investigation and the testing of materials prior to commencement of construction.

Rip rap material is expected to be sourced from outside the immediate project area, most likely from an existing commercial quarry located near the Saida area, approximately 15 Km from the dam site. Access to any quarry in Lebanon requires a permit from the Ministry of Environment which also imposes strict environmental controls and mitigation measures (including limitations on noise, air pollution mitigation measures, restricted access times to roads for traffic reduction etc).

Materials such as cement and reinforcing steel will also be obtained from existing licensed manufacturers. The dry cement will probably be procured from Sibline, which is the closest to the project site thus contributing less to the transportation-related greenhouse gases. Wastes will be disposed of at licensed sites yet to be determined by the Contractor, following approval of the concerned authorities.

The location of construction camps for workers is yet to be identified as it is a sole decision of the Contractor. However it is more likely to be within the valley subject to areas to be protected such as Marj Bisri. Mixed waste from the construction offices, workers' camps and messing areas, will need to be disposed of outside the dam catchment at the Naameh landfill, currently the prime repository for Beirut municipal refuse.

GBWSAP area of influence also encompasses Mar Moussa Church relocation for religious and ceremonial purposes, migration routes for wildlife in case a capture and rescue plan is needed, induced development including new access road, touristic attractions, recreational activities, to finally reaching water supply for GBA users.

The potential environmental impacts accruing from the project are discussed in **Section 8.2**, while the social impacts are discussed in **Section 8.3**. Cumulative impacts that might accrue from the combined effects of GBWSAP and other existing and proposed projects in the zone of influence are discussed in **Section 8.4**. **Section 8.5** is a summary table of potential impacts, each with their likelihood and likely severity. **Section 8.6** explains the details of the Environmental and Social Management Plan in cluding mitigation measures, monitoring, and institutional strengthening and capacity building.

In each section, impacts are divided into permanent, temporary and operational impacts. Impacts considered potentially permanent are generally inherent in project design. Potential temporary impacts are primarily limited in duration to the period of construction and are the result of the activities of the contractor and his workforce. The majority are therefore most readily mitigated through the adoption of good construction practices and strict adherence to a Construction Environmental Management Plan (CEMP). Operational impacts accrue from the use, management and maintenance of the completed project.

8.2 Environmental Impacts

8.2.1 Potentially Permanent Impacts

8.2.1.1 Impoundment and Inundation

Dam projects are often the cornerstone of water resources development policy. By storing runoff when it is abundant and preventing its loss to the sea they provide populations with a reliable source of water, help control flooding, and provide not only for domestic consumption, but also for irrigation, industry and for hydropower, the latter a non-fossil fuel source of energy that also reduces GHG emissions. Dam impoundment reservoirs frequently become the focus for tourist developments and water-based recreational activities. Land values along reservoir shorelines and on hillsides overlooking the water often escalate in value and adjacent villages benefit from the influx of new residents and visitors. The potential for induced development is discussed further in Section 8.3.4.

The presence of a new body of standing water will result in a variety of potentially adverse changes, the most serious of which will be the loss of land, be it natural landscape or productive farmland, developed or uninhabited. While the Bisri reservoir area is sparsely inhabited, the loss of productive land and natural vegetation is, as discussed above, extensive. The Bisri site contains no metalled roads and no easily useable river crossing points. There will therefore be no severance of communications. Indeed, the physical divide imposed by the valley also reflects political and confessional divides between surrounding settlements.

Large impoundments may emit substantial GHG emissions due to the release of the carbon sequestrated in the soil, plants and trees as these decompose. Soil and plant debris washed into the rivers and mixed with wastewater from catchment villages and fertiliser residues from farmland contributes to the accumulation of biomass. GHG emissions from large impoundments are discussed further under section 8.2.3.

As reservoir filling increases the load on underlying bedrock faults and fractures so will the risk of seismicity. This is a concern at Bisri where the reservoir is large and a major fault zone crosses under the valley beneath or very close to the dam site. As this risk increases so will the risk of rock falls and landslides. This issue has been studied in detail through the recently completed neotectonic seismicity study, supervised by the Dam Safety Panel of Experts Seismology expert.

Inundation will also cause the loss, alteration and creation of ecological niches and habitats. The permanent presence of the reservoir will transform riparian riverine habitats into lacustrine habitats with both adverse and beneficial effects. The likely impact on ecology and biodiversity are discussed further in Section 8.2.1.

A further permanent impact due to the presence of inundation will be erosion along the newly created reservoir shoreline, primarily generated by the inflow of tributary water courses and wind. This will erode the surrounding Chouf Sandstone (C1) and also transport shoreline and shallow water material further out into the reservoir and towards the dam.

8.2.1.2 Erosion and Sedimentation

A major significance of erosion and sedimentation is that it imparts a progressive decrease in reservoir storage, albeit this reduction is primarily in dead storage rather than operational storage. The accumulation of sediment behind the dam can increase pressure on the structure and hence the risk of failure, and also lead to turbine malfunction. Where erosion results in the catastrophic collapse of a rock face or landslip into the reservoir, the pressure wave created rather than the physical movement of water may be sufficient to cause the dam to collapse.

The crest line of much of the upper valley slopes is marked by the outcrop of fractures cliff-forming Mdairej Limestones (C2b) from where blocks frequently collapse, mass movement influenced of gravity and rain eventually depositing this material on the valley floor. The potential for such block erosion is illustrated in Figure 8.2.

Fractured limestones lining the crest of the Nahr Awali River

Large blocks on the upper valley slopes

Blocks on a lower slope above the valley floor

Figure 8.2: Block Erosion of the Cliff Limestone at Bisri

At the extremities of the inundation where the existing streams enter the impoundment, flow will suddenly slow and the sediment load will be deposited in the same way as a river flowing into the sea forms a delta. The first annual flood flows will remobilize some of this material and carry it further into the reservoir. Over the years, deposition either side of the main channel will predominate, and advantageously, new wetland environments and habitats will be created. At Bisri, the northern extremities of the reservoir on Nahr Barouk and the shallow, narrow lobe of reservoir in Wadi Bhannine, will be particularly susceptible to sedimentation.

The positioning of a dam to catch upstream sediment will also prevent sediment passing downstream. Silt and clay will therefore no longer be deposited over the downstream flood plain to annually enrich soil fertility. A common consequence of this is greater reliance on the use of chemical fertilisers. However, the extent to which flood deposition was important in the Nahr Awali valley might make this relatively insignificant.

While the floor of Bisri reservoir may be largely impermeable due to the presence of lacustrine clays, the walls will primarily comprise friable Chouf Sandstone that will easily be eroded by both shoreline wind-generated wave action and water circulation at depth. Sedimentation rate is estimated at 1,000 $t/m^2/yr$, a relatively high rate for Lebanon, reflecting the occurrence of sandstone outcrop across the upper catchment. To overcome the main effects of this, the detailed design of the dam has incorporated a dead storage volume of 9 Mm^3 at Bisri. This design criterion has been confirmed by the Dam Safety Panel of Experts.

Clay horizons in the sandstone formation tend to soften on contact with water and cause more competent overlying strata to collapse, thus generating landslip. Significant landslip deposits (eboulis) are evident in certain parts of the reservoir, such as at the location shown in Figure 8.3.

Figure 8.3: Eboulis Material above Bisri Reservoir

8.2.1.3 Upper Watershed Management

The major negative impacts upstream of the dam are those associated with the formation of the reservoir, such as the loss of land. Road construction for dam and power plant access, and if required, around the periphery of the lake, will open up areas previously only poorly accessible to the general public and encourage exploration further upstream. Tourism also has its downside, such as the abuse of existing communities, ecology and landscape with littering, fly-tipping, fire-lighting, trespass, tree-felling, rare flower-picking, egg-collecting, capture of live species, illegal fishing and general eco-vandalism. The construction of a private access road will better control those impacts and will indeed not allow the public to gain access to the dam site without permission of concerned parties.

A common consequential impact of reservoir development is the clearance of land for agriculture to replace the productive land inundated. Given the general steepness of surrounding and adjacent slopes, there is little opportunity to turn areas of natural vegetation into productive land. Even if this were feasible, the resulting land would not be of such high quality as that lost in the valley bottom. It must therefore be generally accepted that the Bisri scheme will result in the loss of some 150 ha of prime productive land to Lebanon's fertility bank. This land will be compensated as per the detailed provided in the RAP.

A significant impact will be the discharge of wastewater from upper catchment villages, directly or via leaking holding tanks, to the rivers feeding the reservoir[64], substantially increasing the nutrient load and resulting in eutrophic conditions. The discharge of wastewater into surface watercourses with only primary screening remains in places throughout Lebanon, although the areas served by rural sewerage schemes are slowly increasing[65]. With population growth in the mountains, and the dramatic increases experienced during the summer months when Beirutis and others escape the heat and humidity of the coastal plain, wastewater generation will continue to grow. Upper catchment villages must therefore be prioritised for the installation of a sewage collector system and treatment plants with at least primary and secondary process streams. Wherever cost-effective, particularly when neighbouring settlements deliver to a single treatment plant, the inclusion of tertiary treatment to provide water of a quality suitable for irrigation of public landscaping and tree crops should also be considered.

Over the years, there have been a number of sewerage studies undertaken under the auspices of CDR, and the Ministry of Environment by a variety of local and international consultants. Schemes have been proposed, plants prioritised and costed and have been compiled into the "***Plan D'Amenagement du Territoire Libanais***" which incorporates specific Catchment Management Plans, including for those areas included in the upper and lower catchment area of the Bisri dam. Detailed implementation plans for the project area will thus be developed in parallel to dam construction, to align with the Plan D'Amenagement du Territoire Libanais, and ensure sustainable operation of the dam and reduction of water quality risks post construction.

Similarly, storm drainage systems, primarily open channels along roads, also discharge into surface water courses, and hence ultimately to the impoundment area, without the benefit of sand traps, settling basins or hydrocarbon interceptors. With development and the imposition of hard surfaces, the rate of runoff will steadily rise.

While all municipalities have now initiated solid waste collection, in some remote villages this is less efficient than elsewhere and some may also find its way to watercourses. Fly-tipping by outsiders to the area remains a significant problem throughout the Lebanese mountains, with much of the material dumped ultimately finding its way into natural watercourses.

While rainwater harvesting is impractical for a city the size of Beirut, where several families share the single roof area of a high-rise multi-occupancy building, it does play an important role in many more upper catchment villages where low-rise single family occupancy buildings are more common. For example, the municipality of Mazraat El Chouf is planning to store 50,000 m^3 in a hill lake. Some residents construct concrete

64 During an ESIA site visit in October 2012 the water at the head of Narh Bisri, the confluence between Nahr Barouk and Wadi Bhannine emitted a distinct odour, suggesting that at least at times of low flow, the loading of nutrients is greater than the river can accommodate.
65 In 2002, less than 25% of households in the Cazas of Jezzine and Chouf were connected to public sewage networks, and this proportion is believed to have increased little in subsequent years.

reservoirs besides or underneath their buildings to store rainfall for reuse during the dry season. Such individual schemes are generally small and are unlikely to seriously impede runoff to Bisri Reservoir.

A negative impact of all impoundment schemes is the loss of water to evaporation. This will vary seasonally, being high in the summer and low in the winter, and be dependent upon a number of climatic and physiographic criteria. As previously discussed in Section 4 evaporation at Bisri, using the Class A pan method is expected to vary between 46 mm in January to 202 mm in July, with an average annual total of 1486 mm, which from a 450 ha impoundment equates to a loss of some 6.5 Mm^3, some 5% of the reservoir volume, and equivalent to that expected to leak into the surrounding rocks. Although a minor amount when considered against seasonal changes in reservoir storage, this may rapidly increase throughout at extended drought to become significant. Evaporative losses also work to decrease the dilution of incoming pollutants, including fertilizer and agricultural chemical residues, to the detriment of both water quality and aquatic habitats, and increased aquatic animal deterioration in the water reservoir.

8.2.1.4 Lower Watershed Management

Water below the proposed Bisri dam site currently originates from the following sources:

- Natural flows from the upper catchment;
- Inflow from lower tributary catchments;
- Spring discharge direct to the river;
- Discharge from Qaraoun and intermediate spring inflow from Awali and Joun power plants;
- Wastewater discharges including sewage from downstream communities; and,
- Drainage from ground water sourced irrigation schemes.

The most significant positive impact of almost any dam to downstream land owners will be the ability to control flow and reduce or curtail seasonal flooding. In Lebanon, the physiology of the generally steep sided valleys and major variations in seasonal flows have served to limit settlement to the higher valley flanks and hilltops, although the coastal plain through which Nahr Awali passes to the sea is prone to flooding as torrential river flows spread as they leave the confines of their valley. This situation may become more serious as global warming and consequential climate change increase. Sea level has been progressively rising since the 1950s, with the warming oceans being subject to thermal expansion. Coupled with the increasing intensity of rain storms and future urban expansion into presently unsettled flood-prone areas, capturing peak flows and releasing them in a controlled manner that does not cause flooding is therefore a major positive impact for downstream communities.

However, the most significant risk can be that as demand for water across Greater Beirut increases, the dam operators will reduce environmental releases, thereby endangering riverine ecology and downstream irrigation supplies, increasing soil salinization, potentially leading to conflict between downstream users. The project incorporates technical assistance to the Ministry of Energy and Water and BMLWE in integrated water resources management of all water sources used for distribution. This review of options to balance demands of urban and rural consumers, with those of the environment will greatly help establish procedures and program for determining the volumes of environmental flows to mitigate the derogation of downstream resources.

The reduction in downstream flow will also result in reduced dilution of chemical residues and dissolved oxygen (DO), increasing organic pollution. Reduced DO will also result from water passing through the hydropower turbines. Insufficient surface water will encourage farmers to abstract greater quantities of ground water, and increase saline intrusion to the aquifer. In the longer term, coastal plain ground water may cease to be suitable for irrigation unless treated, thereby increasing costs and decreasing farmers' competitiveness.

Reduced flow will consequently reduce the dilution of wastewater discharges, bringing those discharging immediately below the dam, such as Bisri village residents, into conflict with those abstracting further downstream.

Depending on the development and control of stratification within the reservoir, provision may be needed to ensure any releases of anoxic water are adequately aerated and diluted to render it fit for downstream use.

Immediately downstream of the dam and for a short stretch of the river thereafter, the high head and turbulence of spillway overflow and hydropower plant discharges may adversely scour the river bed and banks.

8.2.1.5 Ground Water Resources

In unconfined aquifers it is generally the case that water table elevation is a subdued reflection of topography. Thus, ground water flow is often towards valleys and the occurrence of springs is most common on hillside slopes. In confined aquifers, ground water under pressure will find the route of least resistance to the surface, usually where the fractures penetrate the confining horizon and the overlying unsaturated material is thinnest, such as in the bottom of valleys.

Impoundment can therefore have a variety of impacts on both the local and regional ground water regime, and on the sustainability of existing water sources. The impact is two-fold; the additional quantities of water physically infiltrating the underlying strata and the pressure exerted by the column of impounded water above. As a result, water will flow laterally into any permeable or fractured zones within the reservoir walls. Water tables will be raised and hydraulic gradients changed, even reversed. Springs may cease to issue from their traditional sites and subsequently appear elsewhere, disrupting established water supply systems, and having potentially devastating effects where the new issues rise beneath or even within structures.

The pressure imposed by the reservoir on the valley floor will not only serve to exacerbate the situation by forcing water into the underlying strata, but will extend the impact where the reservoir is deeper than the confining pressure under which ground water is retained in the aquifer. Such impact is often of greater significance in karst systems, where underground flow may be enhanced and/or diverted to the extent reservoir storage and the predicted water supply is never realised.

The impact on ground water seepage from Bisri is expected to be relatively minor, estimated by the updated detailed design reports, some 6 Mm^3. Most significantly, the floor of the reservoir is primarily composed of low permeability lacustrine clays which, while known to reach a depth of some 90 m in the vicinity of the proposed dam axis, are only assumed to continue upstream over much of the area to be inundated. The lower valley walls that will contain the water are predominantly composed of Chouf Sandstone, a minor aquifer unit but containing clay horizons and intercalations that will do much to reduce infiltration. Although fractured, many of these are not open.

Overlying Lower and Middle Cretaceous strata crop out on the right bank of the river at the dam site, near the confluence of Nahr Barouk and Wadi Bhannine, and again at the northern extremity of the reservoir, where the dominant formation is the variable and hence relatively low permeability Abeih Formation (C2a). Leakage from the reservoir is therefore not expected to be excessive and may not exceed acceptable limits.

8.2.1.6 Biodiversity and Habitats

The construction of Bisri dam and its associated structures, in addition to the creation of the reservoir, will cause both loss and alteration of natural habitats, with resulting impacts on ecology and biodiversity. Direct loss of habitat will occur as a result of dam construction, inundation, installation of pipelines, and the upgrading of access roads. The presence of the reservoir will transform riparian riverine habitats into lacustrine habitats with both adverse and beneficial effects. The reservoir will reduce habitats for wildlife species that require flowing water but attract those adapted to still or slower-moving waters such as waterfowl.

Beneficial effects will arise from the habitats presented by the reservoir and new biological communities will establish themselves over time.

Flora

Dam construction will always result in the direct loss of riparian habitats and natural vegetation within areas that are recognized by UNEP to be fragile and vulnerable ecological zones. This however, must be balanced against the new shoreline habitats that favour the colonization of tree species on the banks of the reservoir.

Table 8.1 summarises the assessment of the expected impacts on the flora in Bisri dam and reservoir areas.

Table 8.1: Potential Environmental Impact on Flora at Bisri Dam Site

Indicators	Degree of Impact
Surface area of water reservoir	5
Biodiversity indices	2
Conservation status & values of species	2
Forest age structures/Vegetation formation type	2
Ecosystem resilience in the defined location	5
Change in micro-climate conditions	5

Availability of same ecological niches in the area	3
Landscape value	4
Post Dam vegetation adaptation	3

1 is the minimum impact, 5 the greatest impact

Detailed botanical surveys including targeted searches for protected species and/or those identified as species of significant nature conservation value in either a Species Action Plan or Local Biodiversity Action Plan are required if impacts on valuable habitats or species are significant. Where a habitat of potential nature conservation value is identified, more detailed quadrate-based surveys may be required.

Fish and Macro Invertebrates

The construction of artificial barriers across rivers is one of the major factors threatening the native fish fauna of the Mediterranean region, blocking or delaying upstream fish migration. As a matter of fact, dams causing the fragmentation of rivers are contributing to a decline in the number of a native fish species *Salaria fluviatilis*, known as freshwater blenny. Moreover, a major concern nowadays is that the Mediterranean area is progressively losing its biodiversity. In fact, studies have shown that around 70% of freshwater species within the region are catalogued as already extinct or threatened by extinction.

Impacts on fish are considered to be moderate to minor at Bisri dam site, but some mitigation measures should be taken to maintain fish populations downstream of the dam and to allow the passage for migratory fish so to protect spawning grounds. The construction of Bisri dam will significantly reduce water flow downstream, which will definitely affect the freshwater blenny population surviving in the lower course of the river.

For the conservation of freshwater blenny population, it may be necessary to protect specific components of the flow regime to keep stream ecosystems healthy. Base flow or environmental flow which is the minimal volume of water that the stream needs to support the fish, plants, insects, and protect water quality, and maintain healthy aquatic ecosystems in terms of biota, should be maintained. Special purpose flows should also be considered. These are flows designed for a particular ecological need, for example the flow needed to encourage breeding of the freshwater blennies.

Setting ecological objectives for rivers and streams allows specific ecological values to be protected by components of the environmental flow regime. In addition, ecological objectives can be used to assess the effectiveness of environmental flows.

Continuously running unpolluted water would help preventing the disappearance of the species. Freshwater should be kept running between the dam and the sea in order not to hamper the blennies from migrating back and forth.

The construction of the dam will not, however, pose a direct threat to the European eels. The Middle Eastern green carp may be expected to benefit from the new habitat created by the reservoir. A large population is expected to quickly become established and being commercially valuable, will also provide economic opportunity.

Both the minnow (*P. kervillei)* and the loach (*O. leontinae)* may thrive in large numbers and may have a significant role in the newly formed ecosystem, with the former offering some potential for commercial importance.

Herpetofauna (Amphibians and Reptiles)

The Bisri project will have direct impacts on reptile and amphibian habitats, both upstream and downstream of the dam, which will include disruption to habitats and/or breeding sites, reducing sources of food, and increasing vulnerability to predators.

Species with poor swimming ability may become stranded and prevented from interacting with mainland populations, particularly for breeding, and make them more vulnerable to illegal hunting. Other species may be positively affected by newly created habitats.

Amphibians usually require shallow aquatic habitats with slow-moving water for breeding, such as will only be found along the peripheral shoreline of the reservoir. These areas will suffer from seasonal and yearly fluctuating levels. Considering the breeding period involves several stages; mate attraction (advertising), mating, egg stage and larval stages (e.g. tadpoles), the breeding process might last for several weeks. If fluctuations occur during the breeding season (March-June), it would affect one or more of these stages. Since this period may correspond to that of increased snow melt in the mountains, it is highly likely such fluctuations will occur.

All amphibians are insectivorous (feeding on invertebrates) and food sources are primarily found in riparian and shallow water (littoral) habitats. The existing riverine habitats will be inundated on completion of dam construction, and new reservoir shoreline habitats offering the same abundance of food only established over time. The time to complete the filling of the dam is likely to take two years.

In the lower watershed the regulated river flow will positively impact those natural habitats subject to flooding while harming others where water flow is normally limited. New breeding habitats downstream of the dam will be created while other suitable aquatic habitats will disappear as a result of the dam construction. Thus, all amphibians in the dam area will be affected. Whether invertebrates, the source of food for amphibians near the river itself or in the riparian zone, will be affected, remains subject to speculation.

The upper level of the reservoir approaches the lower reaches of the Moukhtara River where there are populations of rare *Bufo cf bufo*, whose habitat appears to consist mostly of rocky terrain and riparian trees, some of which will be inundated.

Birds

The construction of the dam will certainly cause the disappearance of the majority of the bird species, although may be expected to return after completion of construction work. Other species, waterfowl such as ducks and geese, will be attracted by the new water-body. Shallower water downstream of the dam may be beneficial to wader species and individuals of the heron family.

The presence of a large body of standing water may disrupt the flyways of migratory soaring raptor species, as they will be deprived of thermal air currents necessary for soaring and saving energy during migration.

Noise generated by dam operation, the HEP and associated activities may also result in the disappearance of some bird species, while others may adapt to the new conditions and stay. The level of impact will be more apparent if a survey is conducted on a regular basis to understand population variations for the different species.

Some birds will be driven away permanently from nesting areas like the Short-Toed Eagle and the Long-Legged Buzzard, whereas others, like the Graceful Warbler, will adapt.

Mammals

Construction activity around the dam and elsewhere will result in habitat fragmentation, to which mammals are particularly vulnerable. However, once the dam is completed, mammals will adapt and adjust their behavior, despite any permanent obstructions to their previous dispersal routes. The reservoir may attract species such as bats and otters. Smaller mammals such as shrews and squirrels will tend to have smaller home ranges, and will therefore be susceptible to both habitat loss and fragmentation. Larger or more mobile species are less likely to experience significant habitat loss, albeit habitat fragmentation.

The diverse life-cycles, behavior, and habitat requirements of the different mammal species found in Lebanon, require effective mitigation, compensation and enhancement measures to be designed on a species-specific and also site- and project-specific bases. It is important to take measures to avoid impacts on habitats likely to be of particular value to mammal species of nature conservation importance wherever possible.

Creation of Wetlands

As discussed previously, the likelihood that the upper reaches of Bisri Reservoir, much of the areas upstream of the Nahr Bisri-Wadi Bhannine confluence, are likely to only contain narrow and shallow bodies of water that over time will silt up. Initially these areas may attract waders and other shallow water species, but with time, be transformed through marsh, peat bogs to eventually become dry land. Such areas are exceedingly rich in biodiversity may become a major ecological attraction. Even as dry land, these areas will continue to discharge surface watercourses to the reservoir and should hence remain undeveloped or uncleared for agriculture.

8.2.2 Potentially Temporary Impacts during Construction

8.2.2.1 Landscape and Productive Land

Construction sites are inherently unsightly and may impart substantial visual impact upon the landscape. Particularly bothersome may be spoil heaps and stock piles, labour camps, workshops, batching plants and parking areas. Large expanses of cleared ground prior to reservoir filling may also be unsightly, but it is better that crops are cleared as they come to harvest and trees cut to allow optimum recovery of timber rather than to inundate planted land and suffer excessive greenhouse gas emissions during the early years of dam operation. Contractors should plan land clearance to minimise the destruction of un-harvested crops.

As on most construction projects, land beyond the limited area of construction will be required for site offices, camp sites, materials storage, fabrication yards, and borrow sites for the winning of granular construction materials. At Bisri, it is currently expected that all these facilities, including sand pits and rock quarries will be within the reservoir area and hence inundated on completion. Where the excavation of materials extends above maximum water level, the contractor will be expected to provide benching and/or to grade slopes in a manner that meets the requirements of the Master Plan for Shoreline Development.

8.2.2.2 Biodiversity and Habitats

Construction activity, increased lorry movements, equipment noise and dust will result in the destruction and disturbance of wildlife and habitats. The erosion of unprotected excavations and from land cleared for both construction facilities and in preparation for inundation will increase sedimentation and turbidity downstream of the dam site, damaging and destroying riverine and bankside habitats, injure the gills of fish, and smother river flora and river bottom invertebrates.

Always a major concern with construction in an area such as the Bisri Valley is the propensity of construction labourers will partake of hunting, egg-collecting, plant-removal and trade-in-live-species, the cutting of trees outside the reservoir area, and the starting of fires.

The need to temporarily divert surface water flows around the construction site may introduce flow velocities, turbulence and submerged structures that some aquatic species are unable to tolerate.

8.2.2.3 Disruption to Existing Traffic Routes

There are no metalled public rights-of-way in the immediate vicinity of the Bisri dam site or within the area to be inundated. Traffic on existing unsurfaced tracks and footpaths in the vicinity of the dam site and throughout the reservoir area will be subject to disruption during construction but access to all properties will be maintained.

Access to the dam site from the coastal highway via Joun is narrow and only poorly capable of handling a significant increase in heavy transport. While it is expected this road will eventually be upgraded to serve induced developments, consideration should be given to the need for additional passing places or other improvements to reduce congestion, particularly during the transportation to site of heavy equipment and plant.

8.2.2.4 Disruption to Existing Public Utilities

With little settlement throughout the dam site and reservoir area, power is supplied from skid-mounted diesel generating units and telecommunications by one of Lebanon’s two mobile operators with relay stations on the surrounding hills. Water supply and sewerage facilities are provided locally and the only pipework is private, within individual premises.

There will therefore be no temporary disruption of public utility services.

8.2.2.5 Soil and Water Pollution

The main risk to soil and water pollution at Bisri will be during land clearance, when sewage holding tanks, underground fuel storage tanks will need to be emptied and removed prior to reservoir filling. Vacated property should be searched for containers, part-full or empty, originally containing oils, lubricating fluids and agricultural chemicals.

At the construction site itself, greatest concern is the potential for spillages of chemicals, fuel and hydrocarbon products, and for sewage discharges from the labour camp and on-site domestic facilities.

8.2.2.6 Drainage, Erosion, Turbidity and Sediment Load

The Updated 2011 Feasibility Study anticipates the diversion of river flow through the dam site using a combination of cofferdam and conduit sized to cater for a 25-year return flood. With this in place, all existing drainage should be maintained.

Dam site excavation, land clearance over the reservoir area, the stock-piling of granular materials, and heavy vehicle movements on cleared soil surfaces will all promote sediment discharge to the river, heighten turbidity and increase sediment loading, particularly during the rainy season. As discussed above, high turbidity and sediment load will seriously impact riverine and bankside ecology, as well as interfere with downstream abstractors and irrigation systems.

8.2.2.7 Air Quality and Dust

All construction sites are inherently dusty, especially during the hot summer months, primarily arising from soil and rock excavation, concrete batching, and heavy trucks and equipment operating on land cleared of vegetation. Bisri will be no exception and different mitigation measures will be required to safeguard the public and construction workers. The large numbers of heavy vehicles and machinery working at the dam site will concentrate the discharge of exhaust emissions, while the site offices, and camp and other facilities will operate diesel turbines for power generation.

Construction traffic egressing the site will take mud and dust onto public roads, and the increase in traffic will enhance also exhaust emissions along the main access roads.

8.2.2.8 Noise and Vibration

Noise and vibration are also unavoidable at construction sites and their impact may, depending on prevailing wind directions, be noticeable at Bisri where there are few other significant noise and vibration generators within the valley but potential sensitive receptors on the hillsides. Excessive noise, particularly when experienced continuously, outside normal working hours and on rest days, can be a nuisance, and in extreme cases, a health hazard. Those most at risk from excessive noise and vibration will be construction workers due to their proximity to construction plant and equipment, typical noise emissions from which are shown in Table 8.2.

Table 8.2: Typical Noise Emission Levels for Types of Construction Plant

Type of Plant	Distance between Plant and Observer		
	5m	20m	50m
Loader	90	78	70
Grader	90	78	70
Vibration Roller	86	74	66
Bulldozer	86	74	66
Sprayer	87	75	67
Generator	98	86	78
Impact Drill	87	75	67
Impact Piling	112	100	92
Concrete Mixer	91	79	71
Concrete Pump	85	70	62
Pneumatic Hammer	84	86	78

Figures in dB(A)

Perhaps the most significant impacts from construction noise and vibration are those arising during piling and blasting. Piling at Bisri is expected to be required in at least the approaches either side of the main dam and in the construction of the cut-off-trench and the monotonous series of pile-driver blows will echo through and around the valley. Given the nature of the reservoir floor, any need to blast out foundation excavations is expected to be minor. More significant will be the need to secure limestone rip-rap from a quarry expected to be within the upper catchment area. Blasting at the dam site may be required if the present site with one abutment in limestone strata is confirmed.

8.2.2.9 Accidental Damage to Property

The risk of damage to adjacent properties during construction at Bisri is minimal, primarily limited to over-zealous land clearance downstream of the agreed working area beyond the toe of the dam, and upslope from the agreed shoreline clearance level.

8.2.2.10 Intentional Damage to Property

The risk to natural habitats and wildlife through construction workers partaking of hunting, egg-collecting, plant-removal and other deleterious activities was previously highlighted. Construction workers are also known to partake in theft, vandalism and otherwise intentional damage to property. Theft of materials and equipment within the site is an issue for the contractor alone and may be expected to be contained by his own disciplinary procedures. Beyond the camp in adjacent villages it will be a matter for the local police and judicial authorities. Within the reservoir there are a number of locations where wanton damage may occur. These will include theft from crops yet to be harvested from land not yet taken over for the project, vandalism of abandoned buildings, and perhaps most significantly, desecration of Mar Moussa Church and of the Marj Bisri archaeological site, and damage or destruction of other heritage sites.

8.2.2.11 Excess Spoil

Current expectations are that relatively minor quantities of surplus soil and rock will be generated during the construction of Bisri dam. While accurate quantities of 'cut' and 'fill' are yet to be determined, the relative quantities are summarized in Table 8.3, provide the most accurate estimation to date. The main requirements for concrete and concrete products are included as they mostly comprise rock materials and are expected to be sourced from within the immediate vicinity of the dam. The largest requirements for 'fill' are of course for the main dam shell (3.5 Mm^3) and core (0.7 Mm^3).

Table 8.3: Preliminary Estimates of Cut and Fill for Bisri Dam

Structure	'Cut' to be Excavated	'Fill' to be Emplaced
Cofferdam	86,860 (Earth)	230,400 (Shell) 147,200 (Core) 27,460 (Riprap) 2,870 (Backfill)
Subtotals	***86,860***	***407,930***
Main Dam	746,900 (Earth) 8,921 (Rock)	3,536,420 (Shell) 686,250 (Core) 247,390 (Transition) 208,540 (Drain) 256,140 (Filter) 110,900 (Riprap) 408,332 (RCC)
Subtotals	***755,821***	***5,453,972***
Diversion Conduit	265,800 (Earth) 29,000 (Rock)	17,200 (Lean concrete) 10,800 (Structural concrete) 280,000 (Backfill)
Subtotals	***294,800***	***308,000***
Spillway		49700 (Structural concrete) 13590 (Paving)
Subtotals	***0***	***63,290***
TOTAL	***1,137,481***	***6,233,192***

All figures in m^3.

The exception where 'fill' is most unlikely to be sourced from 'cut,' and may even have to be sourced from outside the immediate area of the works, is for the provision of riprap.

The 1.1 Mm^3 'cut' materials, primarily earth rather than rock, is taken to include the lacustrine clays and overlying alluvial sands and gravels, which are assumed to be reusable, and surface soils and sub-soils that are not. Material that is not reusable is expected to be graded and compacted into the reservoir landscape prior to filling.

The quantities given above do not include the clearance of vegetation and fertile soils from throughout the reservoir area prior to filling. On the basis 0.5 m of soil and topsoil are to be stripped over an area of at least 430 ha, some 2.25 Mm^3 of material will be removed, almost all of which is unlikely to be reusable for construction purposes. Given its organic content, this material cannot be left within the area to be inundated. Since much of the topsoil will have been conditioned with a high fertility, it is recommended this be used to improve poorer soils elsewhere in the vicinity, or used within the Master Plan for Shoreline Development to promote landscape planting around the periphery of the reservoir.

Similarly, if the rock materials required cannot be obtained from the inundated area, any quarry excavation that will remain above water levels should be designed and graded to minimise landscape scaring and promote rehabilitation and/or future development.

8.2.2.12 Off-site Impacts

Access and Construction Traffic

The contractor will need to build a new access road to the Bisri Dam site from the public metalled road serving Bisri village, a distance of some 1.5 km. The potential need to increase the number of available passing places on existing local roads has been highlighted in Section 8.2.2.3 above. All points of contact between construction and public traffic will potentially give rise to accident black spots due the relatively low speed of contractors' trucks, damage to the road surface from increased flow of heavy traffic, and from the deposition of mud, chippings, oil and other foreign matter.

Road conditions and congestion may be expected to significantly increase if construction materials such as riprap cannot be taken from the reservoir area or adjacent areas.

Pollution

The most significant risk of off-site pollution will be those sources of soil and water contamination discussed in section 8.2.2.5 above carried downstream. With all construction facilities, including the camp site, being powered from diesel generating sets, regular, almost daily fuel deliveries are likely to be required. The risk of pollution from accidents resulting in spillage on the narrow public roads from the coastal highway will therefore be increased.

Similarly, if concrete batching is undertaken on site, there will be regular deliveries of bulk cement. Any spillage during offloading will increase particulate matter circulating in the air.

Waste Disposal Sites

During construction, some quantities of waste will be generated, primarily inert and/or non-hazardous, but also some hazardous materials. Inert waste will include surplus spoil and excess or spoilt earth materials, non-hazardous will include mixed municipal waste from site offices, accommodation blocks and site clearance, while hazardous waste will include the effluent from workers' facilities, waste construction chemicals, waste oil and spilt fuel.

Mixed waste from the construction offices, workers' camps and messing areas, will need to be disposed of outside the dam catchment. Preferably, this should be a licensed dump site or any other site that meets the national regulations for waste disposal of this nature and approved by MoE.

Large quantities of soil and rock will be generated during the excavation of dam foundations and diversion channels, but much of this is expected to be reusable on site.

The area of inundation should be cleared of organic matter prior to filling in order to avoid deteriorating water quality from subsequent biodegradation. The soils of Bisri are deep and fertile and while of little use for construction will be well suited to shoreline landscaping, or for transporting to parks and gardens where good conditioned soils are at a premium. On the basis of stripping a minimum of 0.5 m of fertile soil over an area of 430 ha, more than 2 million m^3 will be available for reuse. While timber such as pine trees will be felled by the owners and sold, undergrowth, natural and abandoned vegetation should be shredded, composted and made available to adjacent horticulturalists. No open burning of vegetation should be permitted. The take of unharvested crops will be minimized within the land clearance schedule.

Site clearance will also give rise to considerable quantities of demolition waste, primarily concrete, but also timber (fence posts), ceramics (sanitary ware); pipes, cables and plastics. Most irrigation pipes are surface laid and will be removed by owners. Concrete may be crushed, stripped of steel reinforcement and crushed for use as general fill for access roads and similar low specification uses. Surplus concrete may be disposed of in borrow pits, as may surplus spoil.

Potential disposal options to be investigated by the contractor in developing his Construction Waste Management Plan will include but not necessarily be limited to:

- Use on other concurrent construction projects;
- Use as landfill daily and/or final cover;
- The regarding of borrow areas;
- The reinstatement of existing quarries; and,
- Use on on-going reclamation projects.

All redundant and spend construction machinery and equipment shall remain the responsibility of the contractor until disposed of off-site.

The movement of waste materials out of the project area will increase haulage costs, fuel consumption, traffic congestion and atmospheric emissions. Wherever possible, waste should be reused or disposed of on-site. Where the export of waste from the project area is unavoidable, the contractor shall endeavor to utilize the return trip of vehicles consigning inbound construction materials. All vehicles leaving the site should undergo wheel washing, and deliveries in and out should be scheduled late at night or early morning. On no account will construction labor be permitted to sell waste and/or surplus materials to local residents.

8.2.2.13 Consumption of Materials

The consumption of materials for construction will be significant but all granular materials and rock products such aggregate are expected to be sourced from within the reservoir site, either from the alluvial detritus lining the river bed, the underlying lacustrine clays, or from borrow areas on the valley sides. The exception may be riprap, which because of block size and rock quality specifications may need to be sources from outside.

All water consumed on site is likely to be taken from the river and given appropriate treatment prior to use. Only drinking water used for camp messing facilities may be brought in from outside.

Based on Table 8.3 above, the preliminary consumption of materials, with no allowance for wastage, is expected to be as given in Table 8.4.

Table 8.4: Preliminary Estimates of Consumption of Materials at Bisri

Material	Total Volume	Composition and Volume of Materials					
		Cement	Aggregate	Sand	Clay	Water	Block Rock
Shell	3,766,820	-	60% 2,260,092	40% 1,506,728	-	-	-
Core	833,450	-	-	-	100% 833,450	-	-
RCC	408,332	20% 81,666	30% 122,500	40% 163,333	-	10% 40,833	-
Transition	247,390	-	45% 111,325	55% 136,065	-	-	-
Filter	256,140	-	60% 153,684	40% 102,456	-	-	-
Drain	208,540	-	65% 135,551	35% 72,989	-	-	-
Paving	13,590	10% 1,360	45% 6,115	45% 6,115	-	-	-
Structural Concrete	60,500	20% 12,100	45% 27,225	25% 15,125	-	10% 6,050	-
Lean Concrete	17,200	15% 2,580	40% 6,880	30% 5,160	-	15% 2,580	-
Riprap	138,360	-	-	-	-	-	100% 138,360
Backfill	282,870	Assume taken from excess 'cut'.					
TOTALS	-	97,706	2,823,372	2,007,971	833,450	49,463	138,360

All figures in m^3.
Since excavated 'cut' exceeds the required 'fill', it is assumed no additional consumption is required for backfill

As discussed in the table above, nearly 6 million m^3 of earth materials are expected to be consumed in the construction of Bisri Dam. The majority of these materials – building aggregate, sand and clay, are expected to be taken from temporary borrow areas within and adjacent to the area of inundation, as near as is practically possible to the construction site.

Clay will be taken from the thick sequence of lacustrine deposits known to be present below the valley floor. Sand will be excavated from the Chouf Sandstone formation that crops out on the side of the reservoir area in which there is an existing quarry, and will be graded for use. If necessary, sand and gravel will be taken from the recent alluvial deposits adjacent to the main river flow channels. The limestone beds in the valley sides will be worked, crushed and graded to produce building aggregate.

The dam designer has investigated the potential source of material from within the reservoir area. Clay is expected to be taken from the areas within two large meanders in the current flow channel, respectively 150-250 m and 550-700 m upstream of the dam axis. Between these two areas on the northern bank are significant outcrops of limestone that will be worked for crushed stone. Areas from which sand and gravel may be obtained extend between the dam site and the confluence of Nahr Barouk with Wadi Bhannine. The final suitability of all borrow areas will be determined by the appointed contractor through site investigation and the testing of materials prior to commencement of construction.

All these activities will be subject to the permitting requirements of the Higher Committee for Quarries. These will include the formulation and presentation of both an Excavation Plan and a Reinstatement Plan. For those borrow area that will be completely submerged, the excavated volume will contribute to reservoir storage and may also be considered, subject to appropriate safeguards, for the disposal of surplus spoil unsuitable for construction and other inert construction waste.

In designing the borrow areas, sheer faces should not be left where they will give rise to excessively deep water adjacent to the periphery of the reservoir, thus providing a risk to both maintenance workers and the public. Consideration should be given to locating the quarry floor just above maximum water level so it can subsequently be utilized for shoreline development, and the systematic benching of the upper slopes used for access and hillside development.

The Contractor can expect his proposals for borrow areas, wherever they are located, to be subject to Environmental and Social Impact in accordance with MOE regulations and for this to be approved by the Ministry prior to Higher Committee consideration of his proposals. The contractor will be responsible for all negotiations with land owners and the payment of compensation compatible with the provisions of World Bank OP.4.12 and other relevant safeguard policies. Residents within a distance of 500 m of the outer limits of the borrow area and within any greater area identified from seismic modelling to be impacted by blasting, shall be meaningfully consulted.

The only material for which there remains significant uncertainty is the rip-rap, which required thickly-bedded poorly fractured beds of limestone from which large blocks of rocks can be obtained. While there are several quarries in southern and central Lebanon producing this material, the geology can vary and sites can pass into thinly bedded fractured beds that will be unsuitable. The sourcing of rip rap will therefore be determined shortly before, rendering the site unsuitable. Rip rap is expected to be sourced from outside the immediate project area, most likely from an existing operation with all relevant permits and licenses already in place.

Materials such as cement and reinforcing steel will also be obtained from existing licensed manufacturers. The cement is expected to be obtained from Sibline, the closest cement works to Bisri, thus saving significant transport costs, fuel consumption and consequential exhaust emission and global warming.

In summary the total volumes of materials are nearly 100,000 m^3 of cement, over 4.8 million m^3 of crushed and/or graded earth materials such as sand and aggregate, more than 800,000 m^3 of clay, 50,000 m^3 of water, and 140,000 m^3 of block rock. The aggregate, sand and clay is expected to come from working resources within the reservoir area, and the water will be taken from the river. The block rock is likely to be worked from a borrow area on the overlooking hillside, but remain exposed after the reservoir is full.

The 100,000 m^3 of dry cement, which will come from elsewhere in Lebanon, probably Sibline, will weigh some 150,000 tonnes, and its manufacture may be expected to emit some 135,000 tons of CO_2-equivalent greenhouse gases.

8.2.3 Potential Post-Construction Operational Impacts

Water and Power Supplies

At the time of the current report update, and based on the ESIA consultant discussions with the designer, the proposed Bisri dam water releases will be allocated securing 5.1 m^3/s or 5.8 m^3/s for the domestic needs to Greater Beirut and 0.3 m^3/s and 0.45 m^3/s for the environmental flow to be maintained downstream the dam, in summer and winter respectively. The production of hydroelectric power is considered a "by-product" of the dam releases and as such is not considered as consumptive usage like the previous ones.

Domestic and Industrial Supplies

Based on the river guaranteed flow over 30-year-monthly records, the dam design is proposing two storage/supply scenarios:

-6-month delivery period between June and November at constant releases of 5.1 m^3/s. No release in other months.

-6-month delivery period between June and November at constant releases of 5.8 m^3/s. No release in other months.

The rainy season in Lebanon extends from November to April each year leaving the other months almost dry. It is generally acknowledged that the purpose of any dam is to regulate the high winter/spring inflows to be in part stored and released during the dry summer. The dam supply volume would meet some of the GBA domestic water needs during the dry months of the year, generally from April to October.

Power Supply

One main advantage of Bisri dam is its geographic overlapping with the Litani Hydro-power plants network that is composed of three plants: Marakabeh plant located in South Bekaa; Awali Plant located in the valley of Bisri river and finally Joun plant that is located about 10km downstream of Awali facility and all three connected by mean of tunnels network. Only Awali and Joun plants are located downstream of the proposed Dam. The three plants produce in total 190 MW of hydro-electric power that is sold out to the "Electricite du Liban" and contributing about 10% of total produced electricity by the national company.

It is expected that future dam release of 5.1 m^3/s or 5.8 m^3/s will be conveyed by a mean of tunnel to Awali plant that is about 4km downstream its location. By proposing such conveyor routing, the released dam flow could be potentially used to generate additional power in Awali plant, estimated to be 8-10 MW, as per the designer preliminary estimates, while it will be diverted to Ouardaniye WTP before it reaches Joun Plant. As such, in constructing Bisri dam and related infrastructures the way they are conceived now, one of the Litani three hydropower plants could be extended leaving the two others solely dependent on releases from Qaraoun Lake. The two hydropower plants included in the Bisri project will also offset losses in hydropower at the downstream Joun plant.

Irrigation Needs

Farmers of the upper Bisri watershed rely on the upstream watershed diversions to meet their irrigation water needs in the agricultural lands extending between Barouk and Moukhtara villages.

There is an estimate of 300 ha of irrigable lands, downstream the dam that is currently relying on the Litani-Bisri water scheme. Assuming an average irrigation consumption rate of 7000-9000 m^3/ha, the irrigable lands downstream the dam would require some 2.0-2.7 Mm^3 (0.12-0.15 m^3/s) during the seven months irrigation season that are well covered by the 0.6m^3/s as accounted for in the dam design[66].

The detailed design of Bisri Dam must ensure that downstream irrigation needs, as estimated above, are met given the high importance of these water releases to communities that rely heavily on agriculture for their income source.

Environmental Flow

Environmental flows are critical for the area below any dam, where the natural hydrological regime is substantially changed and may result in a better downstream flood control while altering water quality. Commonly, as will be the case at Bisri, environmental flows will not be expected to reproduce natural stream flow, but should be sufficient to maintain the key ecological values of the stream.

During the dry season, environmental flow tends to be dominated by the base flow, primarily originating from the seepage of groundwater into the watercourse. This base flow is the minimal needed to support the fish, plants and insects, and to protect water quality. Low flows need to be maintained as close as possible to the natural stream flow, although given the dam's fundamental objective is to arrest runoff and the consequential loss of water to the sea, this is often impractical.

Using the Q95 percentile of the river flow duration curve, accounting for four ecological elements that are the river physical characteristics, fisheries, macrophytes and macro-invertebrates, the Flow-Duration-Analysis for Bisri River estimated the base flow to be 0.3 and 0.45 m^3/s for summer and winter, respectively. The estimated environmental flows should only be used to sustain freshwater and estuarine ecosystems and the human livelihoods that depend on these ecosystems.

Other components of environmental flows are also to be considered, such as; the small and larger flood flows and the special purpose flow. While the flood flows purpose is to flush away fine sediments that accumulate into the river course, inhibiting the development of fish and water plants habitats, the special purpose flow is needed for

66 The lower and higher irrigation consumption rates correspond on one hand to the reduced irrigation demands thanks to efficient agricultural extension and on the other hand to the currently applied amount of water with no water conserving measures.

particular ecologic needs such as to support breeding of a species of fish or to protect of a frog species. The flood and special purposes flows could be obtained by a sufficient volume of water flowing over the dam spillway, a release through the dam valves or the combination of the two sources. While no national and regional guidelines or similar dam experiences in Lebanon would suggest the flood and special flows, it is believed that site specific and detailed ecological survey would help in setting the threshold values of these flows.

8.2.3.1 Downstream Flood Control

The most significant positive impact to downstream land owners will be the ability to control flow and reduce or even curtail seasonal flooding. However, the physiology of the generally steep-sided valleys downstream the dam and the major variations experienced in seasonal flow in Bisri River have served to limit settlement to the higher valley flanks and hilltops. Other than the floods of April 1971 that affected the Awali hydropower Plant, no major flooding of populated areas has been recorded in the valley. The coastal plain areas adjacent to the river are prone to flooding as torrential river flows spread on leaving the confines of the valley, which occasionally has a serious impact on agriculture.

Probable Maximum Flood is estimated at 3,000 m^3/s for the design of the spillway. This flow is equivalent to more than ten-times the peak annual flow recorded in the river. Despite being a rare occurrence, such a flow will erode and scour the existing river bed, and cause considerable flooding. This will result in physical damage to the river banks, the hydropower plants and their appurtenant structures, coastal plain agriculture, buildings and public infrastructure.

Flooding is the third largest cause of death due to natural hazards worldwide[67] and a Flood Management Plan with appropriate Emergency Response Procedures (ERPs) must be developed within the Bisri Dam management procedures. It should include a demarcation of the PMF inundation limits as well as a register of structures including buildings, agriculture areas, and public infrastructure, together with a prioritization of the damages caused by flood flows and frequency to develop appropriate mitigation. This Plan would be in addition to that developed following Dam Break Analysis, which will cover the ultimate disaster.

8.2.3.2 Dam Safety

Dam safety is a vital consideration and one that must be taken extremely seriously. As mentioned in Section 3.4, international funding agencies generally require the provisions of World Bank Operational Policy *OP.4.37 Safety of Dams* to be implemented in full where equivalent provisions is not incorporated within national legislation.

A major contribution to dam safety is the formulation of Dam Safety Plans based on Dam Breach modelling and inundation analysis undertaken by the dam designer[68]. Often referred to as Dam Break Analysis or DBA, this primarily hydrological modelling exercise is standard procedure in dam design and provides for (i) the evaluation of design

[67] Tobin, Graham A. and Burrell E. Montz. 1997. *Natural Hazards Explanation and Integration.* Guilford Press.
[68] CDR. *Detailed Design of Bisri Dam Project: Dam Breach Model*. Dar Al-Handasah (Nazih Taleb)), August 2013.

performance, including the sizing of emergency spillways, and (ii) the development of regional and community Emergency Preparedness Plans.

The development and implementation of an Emergency Preparedness Plan (EPP) is a positive step dam owner can take to accomplish dam-safety objectives, to protect their investment, and to reduce the potential liability associated with a dam failure. The purpose of this Emergency Action Plan is to identify emergency situations that could threaten the Bisri Dam, and to plan for an expedited, effective response to prevent failure of the dam.

The High Relief Commission has the authority to direct the Dam Operator to take immediate and appropriate action to remedy situations posing serious threat to human life or health, or risk of property damage.

When conditions at the dam have caused the declaration of an emergency, actions are to begin immediately with the notification of the Emergency planning Manager. An Emergency Operations Centre will be set up in the Dam Administration Building to monitor the progression of the situation and to coordinate remediation activities.

The Prime Minister (High Relief Commission), the South-Lebanon Governorate, Saida municipality, Er Rmaile municipality, Karkha municipality, Joun municipality and the Dam Operator will be notified.

The South-Lebanon Governorate officials will in turn notify the internal security forces, army personnel and the Fire Department for appropriate action.

The Emergency planning Manager or his or her designated representative will be responsible for on-site monitoring of the situation and for keeping local authorities informed of developing conditions at the dam from the time that an emergency starts until it ends. The internal security and army shall maintain security at the dam. The Emergency planning Manager shall be responsible for declaring the situation terminated and for a follow-up evaluation of the emergency.

Local officials and downstream residents will be notified by landline telephone or internet if available; otherwise via cell phones or emergency personnel (in person or using their radios). Notification procedures have been formulated for four different levels of alert: “abnormal” condition, “watch” condition, Possible Dam Failure, and Imminent Dam Failure.

Bisri Dam has been designed as a clay-core rock-filled dam 790 m long and 73 m high impounding a reservoir of 125 million m^3. The model therefore adopted the US Army core of Engineers HEC_RAS software and calculated the breach formation time using a US Bureau of Reclamation recommended procedure. Model runs were undertaken for both a seismic loading failure and a flood overtopping failure, the prime modes of breach for Bisri Dam.

The results from the model show a peak flow of 43,000 m^3/sec at the dam and 41,000 m^3/sec at the coast. The flood wave initially generated as 28 m in height, but due to the configuration of the valley does not significantly reduce until it reaches the coastal plain, becoming 10 m at the coast. The lag time between peak flow at the dam and peak flow at the coast was 30 minutes, the speed therefore more than 43 km/hr. Comparing the one-dimensional US Corp of Engineers model with a three-dimensional CDF flow model the results were not significantly different. Using Google Earth images in the absence of a detailed asset survey to estimate damage, the cost is estimated to be 110 to 130 million US Dollars.

Because of the steep V-shaped configuration of the valley in its middle sections between the dam and the coast, the most affected villages in the path of a dam breach flood by either seismic loading or flood failures are Bisri and Khirbet Bisri a short distance downstream of the dam, and Aalmane and Quastani a short distance inland from the coast.

Dam safety plans and Quality Assurance are in an advanced phase of preparation and should be finalised by Project Appraisal.

8.2.3.3 Ouardaniye Water Treatment Plant

After passing through the new Joun HEP, water from Bisri Dam will be directed to the Awali Conveyor and thereafter to Beirut via the new Ouardaniya Water Treatment Works[69]. The initial construction of the works will comprise two parallel treatment process streams, each with a capacity of 1.5 m^3/sec, but layout and design will provide for total capacity to be doubled, to 6 m^3/sec, when the Bisri scheme is commissioned. Each process stream is expected to comprise the following:

- Flow splitting (controlled);
- Flash mixing (for full treatment);
- Flocculation;
- Lamellar clarification;
- Aeration;
- Flash mixing (for direct filtration);
- Rapid gravity filtration;
- Disinfection through Contact Tanks;
- pH adjustment;
- Granulated Carbon Filtration; and,
- Sludge and filter backwash treatment.

The performance of treatment streams is required to comply with *EU Council Directive 98/83/EC Standard for Water Intended for Human Consumption*, as listed below.

69 The conveyor and the WTW are being constructed under GBWSP, not GBWSAP (the present project) and are expected to be operational prior to the completion of Bisri Dam.

Table 8.5: Ouardaniye WTW Final Treated Water Quality Requirements

Parameter	Unit	Parametric Value
Microbiological Parameters		
Escherichia coli	colonies/100 ml	0
Enterococci	colonies/100 ml	0
Chemical Parameters		
Acrylamide	µg/l	0.10
Antimony	µg/l	5.0
Arsenic	µg/l	10
Benzene	µg/l	1.0
Benzo(a)pyrene	µg/l	0.010
Boron	mg/l	1.0
Bromate	µg/l	10
Cadmium	µg/l	5.0
Chromium	µg/l	50
Copper	mg/l	2.0
cyanide	µg/l	50
1,2-dichloroethane	µg/l	3.0
Epichlorohydrin	µg/l	0.10
Fluoride	mg/l	1.5
Lead	µg/l	10
Mercury	µg/l	1.0
Nickel	µg/l	20
Nitrate	mg/l	50
Nitrite	mg/l	0.50
Pesticides	µg/l	0.10
Pesticides - Total	µg/l	0.50

Parameter	Unit	Parametric Value
PAHs	µg/l	0.10
Selenium	µg/l	10
Tetra- & Tri-chloroethane	µg/l	10
Trihalomethanes – Total	µg/l	100
Vinyl chloride	µg/l	0.50
Indicator Parameters		
Aluminium	µg/l	200
Ammonium	mg/l	0.50
Chloride	mg/l	250
Clostridium perfringens	number/100 ml	0
Colour	Acceptable to consumer. No abnormal change	
Conductivity	$\mu S.cm^{-1}$	2,500
pH	units	6.5 - 9.5
Iron	µg/l	200
Manganese	µg/l	50
Odour	Acceptable to consumer. No abnormal change	
Oxidisability	mg/l O_2	5.0
Sulphate	mg/l	250
Sodium	mg/l	200
Taste	Acceptable to consumer. No abnormal change	
Colony count 22C	No abnormal change	
Coliform bacteria	Colonies/100 ml	0
Total Organic Carbon	No abnormal change	
Turbidity	Acceptable to consumer. No abnormal change	

Depending on operational conditions, the designer shall consider granulated activated carbon filters in place of rapid sand filters and the provision of ozonation after clarification. Should further raw water quality tests indicate the presence of pesticide residues such as dieldren and lindane, the designer will need to reconsider the appropriate treatment stream, with activated carbon filters being an option.

8.2.3.4 Greenhouse Gas Emissions

With increasing concern about the global impact of Greenhouse Gas (GHG) emissions[70] from all aspects of human activity, climate scientists have recently been looking at the potential for emissions from reservoir-based hydropower schemes, in which GHGs are emitted from both the reservoir and the power plant. Bisri will emit GHGs with or without a power plant.

Bisri reservoir may be expected to reach a maximum depth of 65-70 m, with the average throughout the inundated area around 35-40 m. Thermal and water quality stratification may therefore be expected due to changes in seasonal mixing within the water column and the introduction of nutrients through soil erosion and wastewater

70 Primarily, according to the IPCC, carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O)

discharge[71]. The various sources of the main GHGs, carbon dioxide (CO_2) and methane (CH_4), associated with reservoirs, are illustrated in Figure 8.4.

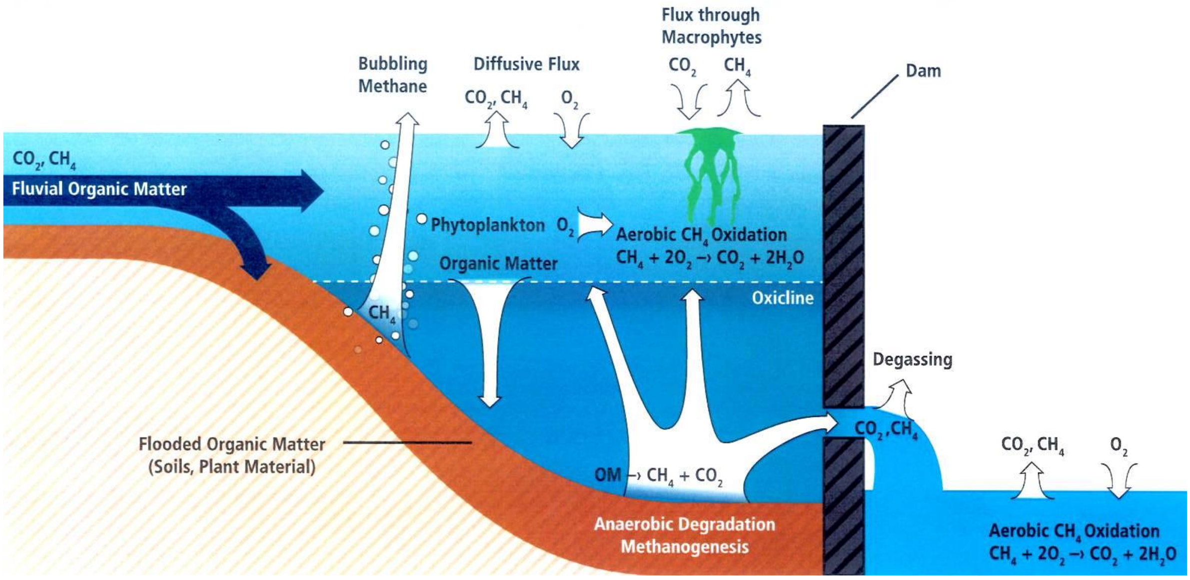


Figure 8.4: CO2 and CH4 Pathways in a Freshwater Reservoir (After Guerin, 2006)

When a reservoir is initially filled, the carbon sequestrated in the soil, plants and trees is released as this material anaerobically decomposes. After this initial period of enhanced emissions, inflowing rivers wash in soil and plant debris that contribute to the accumulation of biomass on the reservoir bottom. In Bisri, given the lack of sewerage systems throughout many of the mountain villages draining into the valley, this will also include raw or only partially treated wastewater discharges, and soil eroded from the steep valley slopes during heavy rain and turbulent snow melt. The main gas given off by this decomposing biomass is methane, a major constituent of GHG, twenty-one times more ozone-depleting than carbon dioxide.

Seasonal variations in climate and river flow maintain a constant annual supply of biomass. The reservoir shoreline becomes vegetated as the high spring water levels fall throughout the dry season, and are inundated again with the onset of winter rains and early spring snow melt. While this vegetation will have sequestered only limited amounts of CO_2 during its short life, this will also be converted to CH_4 as it aerobically decomposes. Also within the aerobic zone, phytoplankton will photosynthesise oxygen, promoting methane oxidation to CO_2 and water, while macrophytes will take in CO_2 and give off CH_4.

These and other gases dissolved in the water, in addition to being released from bottom sediment and at the water surface, the water is further degassed during its passage over the spillway or through power turbines.

Scientific research is not sufficiently advanced to enable the various GHG contributions to be quantified, but the likely relevance each to Bisri reservoir is outlined in Table 8.6.

71 The impact of stratification on water quality is discussed elsewhere.

While hydropower is generally considered to be a 'green' source of power that contributes little to global warming, recent studies have shown GHG emissions from hydropower schemes may, under particular circumstances, meet or even exceed those of fossil-fuel alternatives for the same generation capacity. However, literature research for the present ESIA suggests emissions from the plant alone are likely to be minor, 5-15 g CO_2eq/kWh [72, 73], with substantially higher values quoted for hydropower including contributions from the impoundment, such as the biodegradation of vegetation, and changes in land use arising from the scheme. In respect of the Bisri scheme, the potential for GHG emission due to hydropower will be limited by the limited generating capacity and that it is operate for only six months of the year. As indicated above, greater emissions will arise from the reservoir, for which hydropower is not the prime objective.

Table 8.6: Susceptibility for GHG Emissions from Bisri Reservoir

GHG Source	Susceptibility of Bisri
Rainfall and Wind	Heavy intense rainfall and strong wind increases shallow water turbulence and hence the release of dissolved gasses.
Drawdown zone vegetation	In areas of less-steep slopes and fertile soil cover, seasonal vegetation growth and hence carbon inputs may be extensive.
Upper catchment inputs	Treated and untreated sewerage outflows, storm runoff and soil erosion will each contribute significant carbon inputs.
Decay of inundated soils and biomass	Given the fertility of much of the inundated land, total clearance of soil and vegetation prior to filling may be difficult, and hence methane emissions from anaerobic degradation high.
Growth and decay of aquatic plants	Reservoir margins will frequently abut fertile soils. Shallow water growth will be extensive, particularly in the shallower areas such as the northern end of Bisri reservoir and in Wadi Bhannine, where with sedimentation, wetland environments may develop.
CH_4 bubbles	Being largely surrounded by friable sandstones, the sediment load at Bisri will be high, and the potential for bubbling methane significant. Bisri sediments are Bedrock most susceptible to erosion, so high sediment load. Lower hydrostatic pressure will release more bubbles
Plankton growth and decay	High nutrient inputs such as wastewater and storm drainage discharges will increase plankton growth.
Degassing at turbine outlet	Flow through turbines will rapidly change water pressure and temperature. Gas solubility will decrease with decreasing pressure, and CO_2 and CH_4 released.
Lower catchment emissions	Increased turbulence downstream of the dam will induce oxidation, the growth of methanotrophic bacteria, leading to methane oxygenation.

[72] Consensus suggests hydro-plants emit 35-70 times less GHGs than conventional fossil-fuel plants.
[73] Kumar, A., et al. 2011. *Hydropower*, In IPCC Special Report on Renewable Energy Sources and Climate Change.

8.2.3.5 Local Climate Changes

Large dams and their corresponding impounded reservoirs are types of infrastructure that most often trigger a large-scale change in Land Use and Land Cover (LULC), where more arable land may be irrigated and downstream areas more urbanized due to reduced risk of floods and increased availability of products and electricity. Such systematic changes in land cover can induce changes to local climate through increased availability of moisture and impact on local and mesoscale circulation patterns. More specifically, large water bodies exhibit different sensible and latent heat fluxes from terrestrial lands, which may result in a spatial gradient in humidity and wind patterns. However, the latter remains uncertain and area-specific as it depends on the general/regional climate, size of the reservoir and its surrounding. For instance, humid regions are forested and exhibit comparable moisture fluxes due to transpiration as from evaporation from open water bodies. Thus the clearing of a forest to create an artificial lake is unlikely to create a distinctly different local climate. For semi-arid and Mediterranean regions, the open water body of a reservoir, however, adds sufficiently more moisture than the sparsely vegetated surroundings, resulting in spatial gradients of water vapor. A typical example of such possible changes was studied around the Ataturk dam lake and its surrounding, which is part of the Southeastern Anatolia Project (Turkish initials "GAP") in Turkey[74]. The dam reservoir has a surface area of 817 km2 with a capacity of 48,700 Mm3. The recent study around the dam reservoir concluded an increase in local temperature and thereby Relative Humidity in two stations close to the dam lake. The study used records from two nearby stations for 30 consecutive years (1972 to 2002) for statistical analysis of trends in six climate variables. While total annual precipitation appeared to be unaffected by the construction of the dam and reservoir filling, mean annual temperature increased from 170C to 190C which resulted in increase in relative humidity from 48% to 55%. Nevertheless, such increases highly depend on the size of the reservoir, which is manifested by another study conducted on Pornariou dam in Greece. The study revealed that the dam reservoir, with a capacity of 865 Mm3 had little to negligible influence at two nearby meteorological stations, one few meters away from the reservoir shoreline and another 4.5 km away[75].

8.2.3.6 Reservoir Stratification

Lakes and reservoirs greater than 3-5 m in depth will tend to develop seasonal thermal stratification due to the differences in density between warm and cold waters. Although most common in areas of climatic extremes, such as where surface icing forms, the anticipated conditions at Bisri; cold high-volume inflows from spring snow melt and warm low-volume inflows throughout the summer and autumn, are likely to result in the stratification of the reservoir. Failure to identify and control it frequently poses major problems for water service companies and may compromises the effectiveness of water treatment streams, the meeting of regulatory water quality standards and consumer

[74] Hüsamettin BULUT, Bulent YESILATA*,M. Irfan YESILNACAR. Trend Analysis for Examining the Interaction between the Atatürk Dam Lake and Its Local Climate. *International Journal of Natural and Engineering Sciences 1 (3): 115-123, 2008*.

[75] *http://itia.ntua.gr/getfile/595/1/documents/2003Lagadinou.pdf.*

expectation, and the adequacy of environmental flow releases. The different strata that typically develop and the characteristics of each are illustrated in Table 8.7.

Table 8.7: Potential Stratification of Water Supply Reservoirs

Zone	Characteristics
Epilimnium	Aerobic conditions, with relative warmth A high dissolved oxygen maintained by penetrating sunlight, and kept mixed by surface winds
Thermocline	Thin layer with rapid change of T°C and DO
Hypolimnium	Anaerobic conditions, relatively cold and low dissolved oxygen

Typically, and to be expected at Bisri, stratification becomes more severe during the summer months when the intensity and duration of sunlight increases and mixing due to reservoir inflow decreases; thus coinciding with the main period of Bisri operations. The differences in temperature and DO become more marked and the thermocline rises within the water column. Hence a greater proportion of the reservoir turns anaerobic and in consequence minerals such as manganese, iron, sulphides and arsenic are released from bottom sediments, phosphorous and ammonia may be released, causing algal blooms proliferate, and dissolved mercury is converted to methylated mercury, a form that bio-accumulates in fish and fish eaters, including humans.

The rate at which the hypolimnium becomes anaerobic significantly increases where inflows are nutrient-rich, i.e. contain a high proportion of sewage discharge; the added bacteria more quickly consuming what little oxygen may be available.

8.3 Social Impacts

8.3.1 Potentially Permanent Impacts

8.3.1.1 Land Acquisition and Property Take

The development of dams always involves the permanent occupation of land, not only for dam construction and reservoir impoundment, but also for new access roads to previously remote sites, and for the resettlement of displaced PAPs (Project Affected Persons), relocation of their businesses and rehabilitation of their livelihoods. As well as opening up areas for construction, new roads may also improve access to previously remote settlements, affording them better access to regional centers, government facilities and public services. They may also open areas to less desirable influences such as trespass, fly-tipping, and a range of illegal social and commercial activities. Land acquisition for the resettlement of PAPs may be in less advantageous areas, away from family and friends, with longer home-to-work and home-to-school journeys, and inconvenient for previous social gatherings, places-of-worship, etc. The act of resettling can also cause conflict with existing residents, especially in Lebanon where small adjacent areas are often socially removed by being under the control of different social, political and religious factions.

Therefore, the loss of agricultural land, tilled and improved over generations, is not simply the loss of fertile soils and yet-to-be harvested crops. Similarly, cultural heritage is not limited to archaeological and historic sites but includes recent sites such as traditional bathing places, wedding venues and burial sites. Both the Lebanese Diaspora and those that have remained have a great sense of place and many retain relations with *their village*.

Many site visits to Bisri dam site have been undertaken since January 2012 to identify land property, cultural and other sites that may need to be expropriated or otherwise be impacted by dam construction. A detailed socio-economic survey of households and businesses within and adjacent to the impoundment area has been carried out after all cadastral and land ownership information had been gathered, and an updated survey is currently underway. The survey consists of structured interviews at all available households, businesses and agricultural holdings, the results and systematic analysis of which are detailed in the Project Resettlement Action Plan.

The existing utilization of land within the Bisri reservoir area, examples of the different types of land use and properties, and the substantial historic and cultural interests, have been previously discussed in Sections 6.9 to 6.11 above. Bisri reservoir area and the 15 m buffer extend over some 570 ha located across 15 cadastral regions. Construction will result in the loss of productive land estimated to extend to some 150 ha, some 25% of the area to be taken. The braided river bed and natural bankside vegetation occupies 105 ha, with built-up areas; farm buildings, housing and heritage, less than 1%. A compensatory planting of natural tree cover around the reservoir is suggested which involves the 1:1 replacement of the main forests in the expropriated area including oak, pine and poplar trees. The remaining area is primarily uncultivated natural vegetation on the bottomlands away from the river and generally open land and scrub on the lower valley slopes. The number of built-up structures to be inundated is estimated at 135 over a total number of 88 plots with a total area of around 1.0 ha, the majority already abandoned (some derelict) or only providing seasonal accommodation for agricultural labourers.

Land take will also occur for other project activities and associated infrastructure like the distribution lines and access roads leading to the conveyor.

The total number of individual plots of land, identified from available cadastral mapping, is currently identified to be about 966, split between the various cadastral regions as shown on Table 8.8.

Table 8.8: Extent of Land Take within the Reservoir Area

Casa	Cadastral Region	No. of Plots	No. of plots totally expropriated	No. of plots partially expropriated	Expropriated Area (ha)	% Area Expropriated
CHOUF	Bsaba	9	5	4	6.8	1.3%
	Mazraat El Chouf	277	225	52	120	23%
	Mazraat El Dahr	55	36	19	42	8%
	Aamatour	310	279	31	160	31%
	Bater	14	6	8	8.8	2%
	Sub-Total	665	551	114	338	65%
JEZZINE	Bisri	74	62	12	44	9%
	Bkassine	2	0	2	0.3	0.1%
	Benouati	27	19	8	4	0.8%
	Ghbatiyeh	4	1	3	6	1.2%
	Harf	69	64	5	46	9%
	Aariye	1	0	1	0.95	0.2%
	Bhannine	28	15	13	10	2%
	Midane	80	70	10	48	9%
	Deir-el-Mkhaless	3	0	3	2	0.4%
	Khirbit Bisri	13	4	9	18	3%
	Sub-Total	301	235	66	179	35%
Expropriation Grand Total		966	786	180	517	100%
Domaine Publique (river + roads)					53	
Total Land take					**570**	

8.3.1.2 Involuntary Resettlement

One of the most significant impacts of development projects such as dams is the involuntary displacement of the resident population. It is estimated that worldwide, large dams have displaced nearly 60 million people.

Involuntary resettlement is a critical process that can result in negative impacts with wide ranging cultural, economic and health consequences, especially on ethnic minorities and vulnerable groups such as women and children, the elderly and infirm. Enforced relocation can cause alienation in a socio-cultural milieu, leaving them severely disadvantaged. A fundamental principle of resettlement policy is that it should provide PAPs with standards of living at least equivalent to, and preferably better, than their pre-relocation conditions, compensated not only for physical loss but also for discomfort and social loss. Bisri dam when constructed should allow PAPs priority advantage to new economic opportunities such as tourism, or increased irrigation, to restore and improve their standard of living.

A Resettlement Action Plan (RAP) for the Bisri scheme presents the results of the detailed topographic survey and socio-economic survey comprising structured questionnaires for households, agricultural establishments and commercial enterprises.

As previously discussed with social baseline conditions, GBWSAP has the advantage that no significant settlements lie within the area to be inundated or within at least 500 m of the expected reservoir shoreline. While land take will be extensive within the proposed area of inundation, some 570 ha, residential properties are few and there are no commercial or industrial premises and no significant public infrastructure or community facilities within the impoundment area. In total, 966 separate cadastral plots will be expropriated, which include around 135 building structures that could be residential, water tanks, storage rooms, generator rooms, religious places, or animal refugees. The residential accommodations that are occupied are house seasonal farm workers that will need to be relocated. Payments will also be made to tenants, employees and others who may suffer loss, each considered on case-by-case. This type of compensation will be based on the following:

a) ***Loss of Tenancy Rights*: ** Any tenant with a legally valid tenancy will be entitled to compensation in accordance with Lebanese Laws and the terms of the tenancy.
b) ***In- tolerance or Work Accommodation*** : PAPs living in tolerance or work-related accommodation, estimated to be 42 households, are entitled to compensation even where they have no formal tenancy agreement or land use rights, as is in most cases of Bisri residents.
c) ***Illegal Occupants:*** none of the surveyed 49 households declared itself as squatter. Therefore, such occupant category does not apply to the project.
d) ***Loss of Access to Common Property*:** All PAPs losing access to common land, such as traditional grazing rights, will be entitled to a portion of the compensation available in proportion to their share. Such rights are absent within the project area.

PAPs are expected to be compensated for their loss of livelihood, land take and resettlement. Most landowners are absentee landlords.

Workers are mostly non-Lebanese, mainly Syrian, Syrian Kurd, Palestinian and Egyptian, the majority of which may stay on the land till the next planting season.

Those who lose employment will be entitled to compensation for their loss of earnings and potential loss of livelihood. The more legally settled and longer the employment history of any worker is, the higher will be the compensation the worker will get. There could be number of employment categories as it follows:

a) ***Full-time Employee***: Based on the latest Households survey, none of the 70 full-time employees, works based on a formal employment contract. In all cases, the Project will compensate full-time contractual workers at a rate of 20USD daily for total of 245 days, whereas full-time workers under no contract, if any, will be entitled for compensation at a rate of 10USD daily for a total of 156 days.
b) ***Part-time / Occasional and Seasonal Workers***: The Survey revealed a total number of 33 part time seasonal workers in the area of the project. These workers will be compensated at their current wage for a period of 3 months.

Transitional costs will be included as part of the compensation to help all the above PAPs in moving their movable goods and assets.

Consideration of Foreign Nationals

A high proportion of Bisri PAPs are foreign nationals working as farm labourers, predominantly Syrian, with some Kurds and a few Egyptians, together with Palestinians from the refugee camps in Saida[76]. Some Syrian seasonal workers have chosen not only to remain on site and not to return to the present turmoil of the on-going Syrian uprising but also to bring some of their relatives into the Valley fleeing the continuing civil unrests back home.

Among other objectives, the 2014 Jan-Feb Households Survey aims at updating the statistics and socio-economic situation with respect to the foreign population in the Bisri Valley to accord with the latest refugees movement particularly related to the Syrian war refugees.

Table 8.1 below summarizes the findings of the 2014 Social Survey with regard to the foreign population and Refugees distribution.

Table 8.9: Bisri Valley Foreign Population and Refugees Distribution

Valley Foreign Population	individuals	households
Other Arabs Non-Refugees	72	14
Other-Arab Refugees Registered with UNCHR	79	17
Other-Arab Refugees not Registered	23	4
GRAND TOTAL	**174**	**35**

The 2014 Social Survey revealed that there were at the time of the survey, 174 declared non-Lebanese residents. While 72 individuals have considered themselves non-refugees, the remaining 102 individuals have declared themselves war refugees; but not all these are registered with the UN High Commission for Refugees. The total of 102 individuals will not be entitled to any compensation according to the World Bank OP 4.12 because of their Refugees status[77].

The remaining 72 residing non-refugees in the Valley will either be compensated, as their Lebanese counterparts under the Lebanese Law or to the World Bank O.P 4.12 Policy on the Involuntary Resettlement. This depends on their residency, employment, tenancy, status etc as explained above.

In accordance with CDR policy, the assessment complies with the structure and guidelines of World Bank Policies, as well as with the requirements of the Government of Lebanon (GOL). Despite the availability of such clear guidelines there are often problems with the implementation of these programs. A common reason for this is that World Bank guidelines are more stringent and socially-responsible than national practices.

[76] While the 2010 Labour Law permits Palestinian refugees in Lebanon to work outside their camps, the provisions for issuing work permits have never been implemented.
[77] While the 79 registered UN refugees will be assisted by the Project covering their transportation costs to UNHCR designated refugees camps if they are willing to, the Project will facilitate to the other 23 non-registered refugees to get registered with the UNHCR and eventually to cover their transportation costs to refugees camps.

Eagerness of governments to accord with Bank guidelines comes from political commitment. A specific problem with Lebanese expropriation law is that it affords no provision for those who derive a livelihood from land to which they have no title, a category into which the majority of those displaced by the project fall. Under the Lebanese law, compensation for land and asset expropriation and resettlement is made via a single cash payment, with no provision for land-swaps or other assistance in re-establishing a home or livelihood. Funding agencies, on the other hand, such as the World Bank are usually more considerate and will usually expect PAPs to be compensated for loss of livelihood, even where that livelihood is obtained by working land to which they have no title.

This gap will be handled using World Bank requirements OP 4.12 which, in this case, would prevail above the Lebanese law.

8.3.1.3 Public Health and Wellbeing

Despite the obvious adverse impacts such as inundation, dam projects are generally perceived to assist socio-economic development and poverty reduction by providing improved access to water supplies, hence improved public health, increased educational and career attainment, power for industry, and new commercial opportunities such as tourism and fish farming.

A consequence of upgraded roads for construction and operational traffic will be better access to and from adjacent settlements, which in turn leads to improved accessibility to health care and social services, education and employment, thus enhancing the overall quality of life. At Bisri, the most immediate beneficiaries of improved access will be the residents of Bisri village and its environs, but as development induced by the scheme expands so will improved access to surrounding villages.

Optimising reservoir management will require the imposition of improved wastewater management in villages currently discharging to the dam catchment area. In addition to benefitting the water utility company, who may be more motivated by the desire to improve water supply to distant consumers rather than the local population, it will also help local residents acquire improved sanitary conditions in their homes and throughout the community. If wastewater inflows to Bisri reservoir are to be minimised, sewerage schemes for up to 45 existing towns and villages will eventually be required. Given the importance of sewering the upper catchment villages to the success of the project, it is recommended that CDR revisit existing plans and expedite a Bisri Catchment Sewerage Master Plan before Project construction.

Albeit the positive impacts that dam projects bring to marginalised villagers especially in terms of better access to health facilities, the impacts of dams on environmental and social determinants often worsen the health status of vulnerable communities; they transfer hidden costs to the health sector and they undermine the project's sustainability. Negative health impacts often incur costs that are not accounted for in the project. Preventive actions significantly help in reducing suffering of affected communities and economic burden on the health sector. WHO has always expressed concerns about the impacts of dam projects on human health, particularly regarding contagious and vector-borne diseases. WHO perceives human health as not only the absence of disease and infirmity but also *a state of complete physical, mental and social well-being*. Public awareness campaign should be carried out to inform affected communities about the possible impacts of dam projects on their health.

Often with dam projects there is no equitable distribution of the benefits. Beneficiaries are usually in an urban area far from the actual dam site, leaving local and downstream communities suffering from adverse health impacts including increased transmission of vector-borne disease, exposure to higher concentrations of pesticides, and decreased water quality and quantity.

8.3.1.4 Upper Watershed Management

The *Atlas du Liban* prepared by CDR in 2004 identifies the Bisri Catchment to be among the *exceptional* natural *valleys of national interest*. Dam projects typically benefit communities other than those within their immediate vicinity and the public consultation session held to date quickly revealed an undercurrent of opposition to sending water and power to Beirut when there was unfulfilled demand locally. While conflict does arise, it needs not be inevitable if the issues are addressed from the outset of the project.

Upper watershed and surrounding communities are often the main beneficiaries of opportunities presented by the physical presence of the reservoir; be it investment opportunities in tourism and recreational businesses, nature reserves, and enterprises. Each of these opportunities will also create considerable employment, as will dam operational management and maintenance. It should be MEW/BMLWE responsibility to prioritise the employment of local residents, particularly those resettled by inundation of their land or otherwise severely impacted by the project. However, no such policy has been initiated to date in that respect.

8.3.1.5 Lower Watershed Management

Beneficiaries of dam projects are often in an urban area far from the actual dam site, leaving local and downstream communities suffering from adverse health impacts including increased transmission of vector-borne diseases and decreased water quality and quantity.

Water flow will be significantly reduced downstream of the proposed dam, increasing the concentration of not only wastewater discharges, but also fertilizers and pesticides, increasing the risk of poor quality of water irrigating crops downstream. Irrigation water may contain *E. coli* strain and may have chemical residues above allowable limits. This may bring residents in the upper watershed into conflict with those abstracting further downstream. Also, reduced flow will make soil salinity increase, potentially leading to conflict between downstream users. MEW should undertake a detailed study of existing water use and establish a public register of Water Rights prior to Dam operation, whereby water abstractions for downstream users are quantified and earmarked.

8.3.2 Potentially Temporary Impacts during Construction

8.3.2.1 Public Health and Safety

Construction sites are inherently unsafe and given the scale of construction and land clearance to be undertaken, the risk to public safety in terms of both physical extent and the types of risk posed will be substantial. While the Bisri construction site is generally remote from immediately adjacent settlements, it is to be expected that people wishing to see the dam throughout the period of construction will increase traffic and visitor numbers.

Notwithstanding this, if public access is adequately managed, the prime risks during the period of construction are expected to be from unauthorized access and trespass.

8.3.2.2 Worker's Health and Safety

The construction industry has an inevitable record of annul deaths and injuries. While risk to public safety will be limited by only casual acquaintance with site activities, the risks to those employed on the project are more varied and omnipresent. They are however generally well understood, documented and relatively easily managed through adherence to good construction practices, standard H&S provision, and common sense. Occupational health and safety programs will be supported by staff training for the project and the appointment of the Assistant Project Manager. Details of the required training are discussed in the Capacity Building and Training Section.

Instructions on emergency measures necessary to safeguard employees and the wider environment will be prepared as part of the Operations Manual for the project.

The risk to workers on the Bisri site is enhanced due to its relative remoteness and the distance, in both kilometres and travel time, to the nearest hospital. While doctors and health centres are available in surrounding villages, the closest medical facilities are the public hospitals in Saida (125 beds) and Jezzine (40 beds), together with a selection of public and private facilities of all types in Beirut.

A comprehensive Health and Safety Plan shall be developed by the project proponent and the contractor, in accordance the World Bank's Environmental and Health Safety Guidelines. Special attention presented should be paid to Health and Safety measures, due to extensive civil works associated with Dam construction and associated facilities. Below listed items indicate Actions and Indicators of health and safety item:

1. General conditions

- Establish general guidelines on potential safety and accident risks;
- Establish safety and security notices for hazardous materials;
- Prepare specific emergency operating instructions;
- Provide sufficient potable water for drinking, cooking and personal hygiene purposes;
- Adhere to all applicable speed limits and implement speed limits for trucks entering and exiting the site;
- Provide a comprehensive first aid kit and train staff members onsite to use it;

- Comply with the World Bank and local Health and Safety Requirements, specially the Decree

  No. 7964/2012 that is the amendment of Decree No. 14293/2005 related to the general conditions of public safety in structures, and fire prevention & earthquakes;
- Ensure that contact details of the local medical services are available to the relevant construction personnel prior to commencing work by displaying them in very visible places on the site;
- Ensure that all employees receive and utilize appropriate personal protective equipment (e.g. hard hats, steel toe boots, respirators) and are trained on these as required;
- Restrict access to the construction site by proper fencing and provide guards on entrances and exits to the site;
- Establish buffering safety zone surrounding the sites;
- Install warning signs at the entrance of the site to prohibit public access and stress on utilizing the appropriate personal protective equipment;
- Provide training to a dedicated staff about the fundamentals of occupational health and safety procedures;
- Provide personal ID cards for all employees;
- Provide adequate loading and off-loading space and respect minimum clearance requirements;
- Provide appropriate lighting during night-time works;
- Provide environmental friendly fire-fighting equipment such as dry powder extinguishers within the premises of the plant;
- Conduct a fire-fighting and leak checks training drills for the operating staff;
- Prohibit smoking as well as litter or weed build-up in the area as these may pose fire risks.
- Provide roads inside the project with speed limits signs of 25 km/hr to decrease risks of collisions and accidents;
- Provide all contained locations such as mechanical and technical areas with proper ventilation system. Such action will help to avoid excess humidity that contributes to damp musty air, odors, mold and mildew. Moreover, ventilation of the closed car parks prevents the build-up of toxic fumes and flammable gases from motor exhaust and also clears smoke in the event of a fire;
- Develop an emergency response plan;
- Properly rate electrical installations and equipment and where applicable, protecting them against use in a flammable environment;
- Proper labelling and storing chemicals, oils, and fuel to be used on-site.
- Provide internal road and project entrance with necessary guidance to enhance avoid accidental collation.

2. Specific conditions

- All workers involved shall prior to commencing the works receive a health and safety instruction where the special risks are described and rules are established in case of incidents.

- All workers shall be submitted to an initial medical check, focused on the specific risks of this operation. This medical check shall be repeated upon termination of the works.
- A sufficient stock of the personal protection equipment will have to be kept at every working site. The minimum personal protection equipment shall consist of:

1. Industrial protection helmet;
2. Appropriate working clothes;
3. Eye goggles, respiration equipment and ear plugs;
4. Safety boots and gloves for protection against mechanical and chemical risks.
5. Mobile phones shall be switched off during working time

3. Fire prevention

A fire protection and emergency procedures plan shall be developed in collaboration with the local fire department. The plan shall, among others, provide information on:

- Ensure that all employees are aware of the location of safety and rescue equipment available at the site. A clear emergency response plan panel should be fixed at several locations that indicate the safety and firefighting equipment;
- Provide all areas with sufficient fire detectors (heat and smoke) and adequate firefighting equipment (sprinklers, hoses, distinguishers, etc);
- Provide an automatic fire suppression where necessary;
- Ensure that the emergency response plan panel includes the floor map and the evacuation directions, exists and stairs with respect to the reader location (this should be written in languages understood by all workers at stuff);
- Ensure that contact details of the local firefighting services are available to the relevant stuff and worker personnel;
- Provide all escape routes with appropriate artificial lighting to illuminates when main electricity supply fails. Such supply should be derived from the project main electricity supply;
- Every escape route should be distinctively and conspicuously marked by emergency exit sing of adequate size and languages;
- Provide environmental friendly fire-fighting equipment such as dry powder extinguishers within the premises of the project;
- All fire safety equipment and fixtures shall be regularly serviced and maintained. The owner or their agent shall certify annually that each of the fire safety measures specified in this statement has been assessed by a properly qualified person;
- Conduct annual fire-fighting and leak checks training drills for the operating staff; and, prohibit smoking to avoid health problems and possible fires occurrence.

4. Traffic

Land transport

- Use non-peak traffic times or provide alternate routes when needed and when feasible;
- Use of properly trained flagmen and road side signs, and when needed coordinate will local authorities for a proper traffic flow;
- Proper planning and development of a traffic control plan that takes into account the reservations and inputs of residents;
- Adequate warning, signing, delineation and channelling at least 500 m down and up-gradient from the project sites;
- Restrict movement and transportation of construction machinery outside construction sites to off-peak traffic hours and during night-time;
- Independent access roads to construction sites accommodating for heavy duty vehicles of up to 40 tons brut weight.
- Provide proper traffic flow management plan within the project and at the access points;
- Control traffic management plan by installation of proper distributed road signage and monitoring devices; speed limitation signs in the project and at the access points;
- Ensure the presence of adequate parking areas;
- Apply continuous roads and pavements maintenance;
- Provide crossovers be with signals to facilitate safe crossing;
- All trucks entering or leaving the site shall have their trays suitably covered to prevent spillage of any material from the truck onto the road;
- All vehicles being loaded or unloaded shall stand entirely within the property;
- Vehicles leaving the premises shall be sufficiently free from dirt, aggregate or other materials such that materials are not transported onto public roads;
- All trafficable areas and vehicle manoeuvring areas on the site shall be maintained in a condition that will minimize the generation or emission of windblown or traffic generated dust from the site at all times.
- Contractor shall provide all necessary Lebanese licenses and documentation required for transport of the hazardous waste to the Lebanese border
- Road transport in Lebanon shall be limited to daylight outside the rush hours, due to safety reasons and transport in bad weather shall be avoided;
- Vehicles transporting wastes shall be under surveillance at any time. Under the supervision of the MoE the trucks transporting the wastes shall be escorted by a firefighter vehicle in accordance with the civil defence and lead by internal security forces to provide free road access and uninterrupted routing in order to reduce time spent on the road.

Contingency plans and emergency procedures shall be developed to cover events due to operational failures, natural causes and acts of third parties. The plans and procedures will cover, as a minimum, fire, explosion, bomb alerts, leaks and spills of hazardous materials, structure or equipment failures; injuries and illnesses; risk from natural disasters (wind, sandstorm, earthquake); and third-party risks (potential impacts of an accident occurring at another Industrial facility which may impact upon the transmission line or the substations).

All accidents, injuries and incidents should be recorded and investigated and information and feedback from employees should be evaluated.

8.3.3 Potential Post-Construction Operational Impacts

8.3.3.1 Public Health and Safety

The permanent impacts on public health, such as enhanced water and power supplies, improved access to villages and community services, to better wastewater disposal, have previously been identified in Section 8.3.1.3 above. Operational impacts will primarily focus on health and safety issues of the impounded water and its use.

The flow control afforded by Bisri Dam will, under most return storms, prevent overbank events downstream and hence the risk to life from flooding. It will also prevent the worst effects of drought, when addition flow can be released from storage to sustain downstream licenced abstractions and irrigators. Conversely, the World Health Organisation has long been concerned about the impact of dams and other types of water projects on human health, especially the transmission of communicable diseases. More water use generally translates to more wastewater generation, and local communities given improved access to water supply should also be provided with improved sanitation to decrease the risk of waterborne disease.

Reservoirs promote the breeding of vectors and vermin as well as the spread of disease, particularly where there is poor circulation that gives rise to stagnant backwaters, favoured breeding site for mosquitoes. At Bisri, the northern extremity of the reservoir and to a greater extent the southerly arm along Wadi Bhannine may only be inundated to a relatively shallow depth. Such areas will be highly susceptible to silting, which after only a few years operation may create a marshy and humid wetland habitat in which vectors and vermin will readily breed. However, the most serious diseases that may arise under these circumstances, such as malaria, filariasis, schistosomiasis, dysentery and typhoid, are not endemic to Lebanon.

Reduced water availability and quality at the lower end of the catchment towards the sea may result in reduced dilution of fertiliser residues and other agricultural chemicals. If releases from the dam substantially reduce mean monthly flows, dam construction and social development should be accompanied by agricultural extension services to help farmers minimise chemical applications, reduce residue runoff, and hence the risk to public health.

In semi-arid regions like Lebanon, new dams can quickly be subject to eutrophication due to over-enriching by organic nutrients from wastewater discharge and fertilizer runoff. Increase deforestation to increase water yields also contribute to increased sediments and nutrients in the reservoir. The most common result is excessive aquatic weed growth or 'blooms' of cyanobacteria that may, in excessive doses, become toxic and hence lethal to humans and animals. Indeed, the artificial impoundment of water in the hot climate creates the perfect environment for the growth of cyonabacteria. Low level exposure to some of these toxins in drinking water, food, or during swimming can promote live cancer and various gastrointestinal and allergenic illnesses in humans, but the majority of cyanobacteria species are relatively easily treated by the normal elements of water treatment such as that proposed for Ouardaniye.

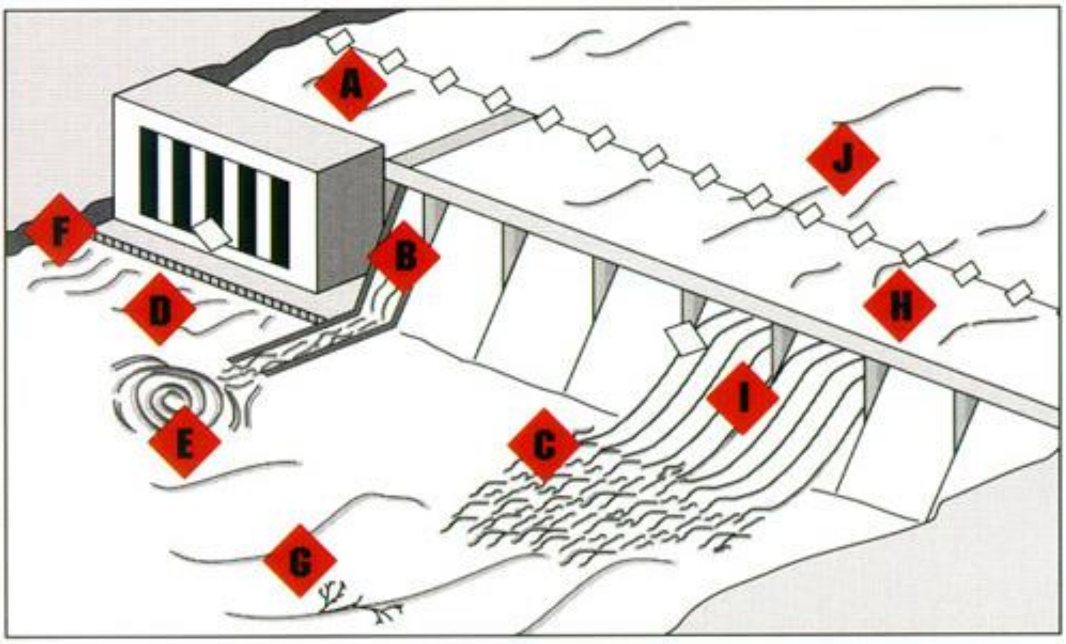
Large reservoirs like the one of Bisri elevate sub-soil affecting the level of calcium and trace elements. This might lead to fluorosis which can affect teeth and the skeleton, the latter leading to a crippling syndrome of knock-knees among villagers. The maximum allowable limits of Fluor in Lebanon are 1.5 and 0.7 mg/L at 8-12 ^{o}C and 25-30 ^{o}C, respectively.

For present purposes, the ESIA assumes Bisri Dam and reservoir will be opened to public access, with recreational use of the water and shoreline permitted, albeit perhaps to only limited vehicular access and/or at a cost to the user. Given the site's proximity to urban centres such as Beirut and Saida, and to summer resorts in the Chouf Mountains, the prevention of public access may be almost impossible. Opening the site will enable appropriate measures for public safety and environmental protection to be put in place and regulated, as well as stimulate commercial activity.

Permitted activities might include walking, running, fishing, swimming, canoeing, yachting, picnicking, and camping, each perhaps limited to specifically designated areas. Banned activities should include motocross and rallying, use of ATVs, cutting of timber, motor boats, water skiing, and others that will disturb the general peace and tranquillity the presence of a large body of water inherently imparts.

There are, of course, multiple risks to public health and safety simply from the presence of a large body of water and its associated facilities. Dams and reservoirs constitute a major risk of drowning and other accidents, especially for the elderly and small children, trespassers and those involved in horse-play. The risk of drowning also extends to livestock drinking at the shoreline. While particularly dangerous areas may be fenced off, it will be both impractical and undesirable to fencing the entire 6-7 km periphery of Bisri Reservoir. Significant reduction of the inherent risks can be achieved with a *Master Plan for Shoreline Development*, restricting activities such as bathing and children's activities to shallow areas, and separating bathing areas from those used for yachting and canoeing. While much of the Bisri shoreline must be expected to be developed privately, public access must be maintained if people are not going to run unnecessary risks in areas of deep, turbulent and otherwise unsafe waters. Typical risks to public safety at dams[78] are shown in Figure 8.5.

[78] From: Federal Energy Regulatory Commission, *Safety Signage at Hydropower Projects* October 2001



A	Hazardous approach marked by boom
B	Sudden change in spillway discharge
C	Strong unpredictable currents above & below dam
D	Sudden turbulent discharges from power plant
E	Deceiving reverse currents below spillways
F	Slippery surfaces on dam crest and shoreline
G	Submerged hazards above and below the dam
H	Open spillways not be visible from the dam
I	Debris passing over or through the dam
J	Turbulent water in dam approach

Figure 8.5: Typical Risks to Public Safety in the Vicinity of a Dam

The primary means of protecting the public is to erect walls and fences where access needs to be prevented, information and warning signs where there is danger and/or activities need to be restricted. A Code of Conduct will need to be developed. Examples of the type of signage used on reservoirs are given in Figure 8.6.

On completion of Bisri dam, the following are likely be needed:

- Booms across the reservoir upstream of the dam, a safe distance (50 m or more) above first occurrence of turbulent water, to prevent the entry of boats and to warn swimmers;
- Security fencing around all elements of the dam and hydropower plant;
- Fencing either side of the reservoir upstream as far as the boom, and downstream to a point below the reach of spillway eddies, whirlpools and other turbulence;
- Fencing both sides of the crest if public crossing is to be permitted;
- Warning notices to publicise the dangers around the dam;
- Information notices to show areas safe for the range of water based activities (boating, swimming, fishing, etc.), parking areas, boat launching ramps, public access tracks, picnic areas, etc.;

- Siren to warn when discharge structures are to open or close;
- A Public Awareness Campaign via national media, local schools and community organisations, as well as on site.
- Utilisation of the dam and reservoir as an educational resource, teaching about the surrounding countryside, its history, its geology, the river and its catchment area, reservoir ecology, dam and reservoir operation, hydropower generation, water safety, water sports, training, etc.;
- Regulation backed up with meaningful enforcement for non-compliance.

Figure 8.6: Examples of Dam Public Safety Information and Warning Notices

As the surrounding areas are developed, particularly if facilities such as restaurants, resort hotels, boatyards are developed along the shoreline, public safety will need to become a responsibility shared between the dam and reservoir operator (assumed to be BMLWE), property developers, owners and facilities managers. Safety issues should also be addressed in the proposed Shoreline Master Plan, Development Guidelines, Building Controls, etc.

8.3.3.2 Upstream and Downstream Impacts on Agriculture

The continued increase in population worldwide is increasing the risks to global food security, leading to increased demand for crop production and irrigated agriculture. Therefore there is more need to store water and the construction of dams is one of the main schemes to achieve this goal. Dams are supposed to help farmers manage water supply and boost their crop yields. According to the International Commission on Large Dams (ICOLD), the main purpose of the construction of dams worldwide is the provision of irrigation water as shown in Figure 8.7. A major portion of water stored behind dams in the world is indeed withdrawn for irrigation.

A report from the International Water Management Institute (IWMI) indicates that even with the best irrigation efficiency, the world needs an extension of irrigated areas by building more dams and storages.

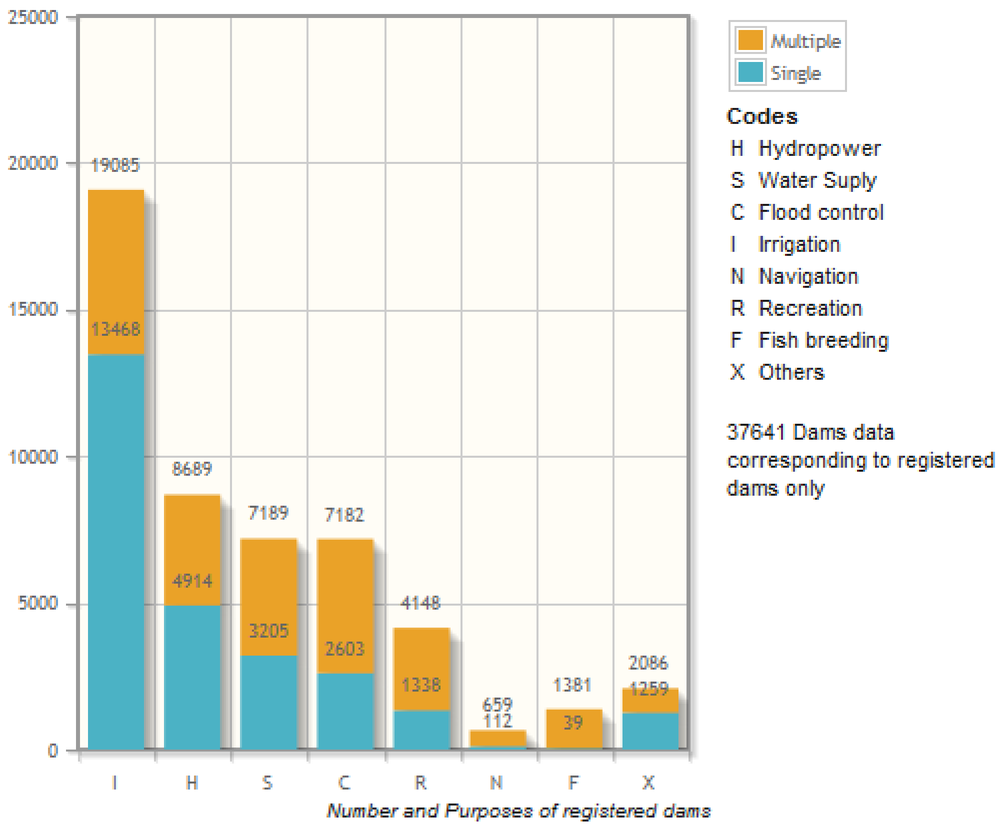


Figure 8.7: Number and Purposes of Registered Dams Worldwide according to International Commission on Large Dams

For Bisri dam however, water supply for the inhabitants of Greater Beirut Area is the main purpose and irrigation is only a secondary benefit from its construction.

The following will discuss the upstream and downstream impacts of Bisri dam on Agriculture in the affected area.

Upstream Impacts

Bisri reservoir development will inundate 150 ha of productive land, resulting in external costs to Lebanon's soil fertility bank. This loss of land for agriculture cannot be compensated for on the steep adjacent slopes that are relatively of low quality as regards soil fertility.

Dam designers have accounted for irrigation withdrawals from Bisri reservoir for irrigated agriculture extending between Barouk and Moukhtara villages in the upper Bisri watershed. Productive land includes apple orchards and summer vegetables grown in open field.

According to the World Commission on Dams and in order to fill the dam reservoir, water use upstream is often restricted, especially in rain-scarce years. This however is not currently part of the reservoir operation policy. Restricted water use upstream would increase the vulnerability of upstream agricultural production to rainfall shocks.

A significant impact will be the discharge of pesticides and fertilizers from upper catchment agriculture, directly or via leaking holding tanks, to the rivers feeding the reservoir, substantially increasing the nutrient load and resulting in eutrophic conditions.

Therefore, it is primordial to ensure continued good water quality through improvement and extension of agriculture, calling for capacity building and institutional strengthening in MoA's department of Agricultural Extension.

Downstream Impacts
The most significant positive impact of almost any dam to downstream land owners is the ability to control flow and reduce or curtail seasonal flooding. Downstream from dams, farmers can benefit from a steady year-round controlled water flow. This helps increase output of agricultural commodities, which require inputs from other sectors such as energy, seeds and fertilizers.

It is estimated that about 300 ha of irrigable lands, downstream the dam, are currently relying on the Litani-Bisri water scheme. Assuming an average irrigation consumption rate of 7000-9000 m^3/ha, the irrigable lands downstream the dam would require some 2.0-2.7 Mm^3 (0.12-0.15 m^3/s) during the irrigation season, which is well accounted for by the Dam Design.

In dry years, insufficient surface water will encourage farmers to abstract greater quantities of ground water, and increase saline intrusion to the aquifer. Ground water may cease to be suitable for irrigation unless treated, thereby increasing costs and decreasing farmers' competitiveness.

Reduced flow downstream of Bisri dam will consequently reduce the dilution of wastewater discharges, bringing those discharging immediately below the dam, such as Bisri village residents, into conflict with those abstracting further downstream. This results in poor quality of irrigation water for downstream farmers, with possible detection of *E. coli*, thus affecting quality of irrigated crops.

8.3.4 Induced Development

Induced development is the expansion of economic activities within and into an area that has suddenly become attractive through a new but prior development. Prime examples are the opening up of previously inaccessible land induced by the construction of a new road, or, as in the present case, the access road to a dam, the reservoir providing the focus for visitor interest. Most commonly, and likely to be the case at Bisri, the attracting development is public sector; the induced development private sector.

Given the relative uniqueness of the Bisri scheme and its proximity to urban centres such as Beirut and Saida, visitor attraction may be expected that will commence soon after the start of construction. The precursor to induced development may therefore be coffee vans and refreshment trucks, with existing cafés, petrol stations and other services in Bisri and villages en-route from the highway catering for the influx. To avoid conflict with construction operations and risk to public safety, the project proponent might invest in a Visitor's Centre with touristic services not located in the direct vicinity of construction site, but on the hillside a short distance downstream from where views over the works can be enjoyed in safety. Once the dam is commissioned, the Visitor's Centre might be expanded to provide information and educational facilities with restaurants and the usual public facilities, together with a view over the completed dam and power plant.

The greater attraction will be the simple presence of the body of water that will become Bisri Reservoir. There will be considerable demand for land, on the surrounding hillsides for the construction of villas, apartment blocks, hotels, hill resorts, restaurants, access roads and public infrastructure. While these may also occupy shoreline plots, waterside land is more likely to induce smaller water sport focused accommodation, camping and picnic sites, bathing areas, shoreline walkways and cycle tracks, boat rental and repair yards, yacht and canoe clubs. In addition to visitor and recreational activities, the reservoir will also afford the opportunity to expand local irrigated agriculture and develop water-based commercial enterprises such as fish farming. No development plans have so far been officially put in place and a *Master Plan for Shoreline Management* shall be endorsed by CDR with the collaboration of DGUP.

Whether or not induced development is a positive or negative impact will wholly depend upon the degree to which it is controlled by the planning authorities. If development complies with a well formulated and agreed Master Plan the results may be entirely positive. If development is not planned and piecemeal, or certain political and/or commercial interests are allowed to violate the Plan, the results may be entirely negative. The spread of new development of any type will increase the flow of surface runoff and wastewater, including raw sewage, to the reservoir unless the installation of public utility infrastructure of appropriate capacity keeps place with development and discharge of wasterwater and agrochemicals is regulated. The lack of public infrastructure will not only cause water pollution, rendering the tourist facilities and water-based activities a risk to public health, but will also propagate algal blooms that will impact power generation equipment and water treatment plant operation, and derogate the quality of water available for downstream irrigation.

Given current conditions throughout the reservoir area, atmospheric emissions and noise and dust from power generators, vehicles and boats, etc. will also be a significant impact of induced development.

New access roads and pipelines for the dam and the power plant will open up areas previously poorly accessible to the general public which will lead to exploitation of the natural resources such as illegal fishing, haphazard settlement construction, and landscape deterioration, unless a proper Shoreline Development Master Plan was implemented and access was restricted to previously remote areas.

8.4 Cumulative Environmental and Social Impacts

Environmental Assessment is essential in identifying and mitigating environmental and social impacts that might accrue from engineering projects to better manage those impacts on areas, resources and people directly or indirectly affected by a given development. However, individual projects should not be assessed as stand-alone developments isolated from their spatial and temporal contexts, and understanding the cumulative environmental and social impacts from multiple projects or even the same project over an extended period of time is indeed crucial to identify and manage incremental impacts on the project area of influence. Hegmann et al. (1999) defines cumulative impacts as "changes to the environment that are caused by an action in combination with other past, present and future actions". They are the combined effects of a development or project coupled with those of other existing or planned ones. Projects may be of the same type like several hydroelectric projects on the same river or within the same watershed, or cumulative impacts might occur because of the project itself and other induced developments including access roads, touristic attractions, recreational and economic activities, in addition to other adjacent land uses. Examples of cumulative impacts include the following:

- Multiple water abstractions leading to reduced water flow in a watershed;
- Bioaccumulation of pollutant concentrations in a water body or in the soil;
- Increased sediment loads on a watershed;
- Increased erosion in a watershed;
- Interference with wildlife migratory routes;
- Wildlife population reduction caused by increased hunting, road kills, and forestry operations; and,
- Secondary social impacts, such as more traffic congestion and accidents in the project's area of influence owing to increased transport activity.

Methodology
Environmental and social impacts of a given project, combined with the incremental impacts resulting from other existing and/or future developments, may result in significant cumulative impacts that would not be expected in the case of a stand-alone development.

Cumulative impacts occur as interactions between different projects, between the projects and the environment, and between components of the environment. The magnitude of the combined effects can be equal to the sum of the individual effects or can be an increased effect on the valued environmental and social components, or VECs. VECs are sensitive or valued receptors directly or indirectly affected by a specific development, and can also be affected by the cumulative effects of several developments. They are the ultimate recipient of impacts because they tend to be at the ends of ecological pathways, as shown in Figure 8.8.

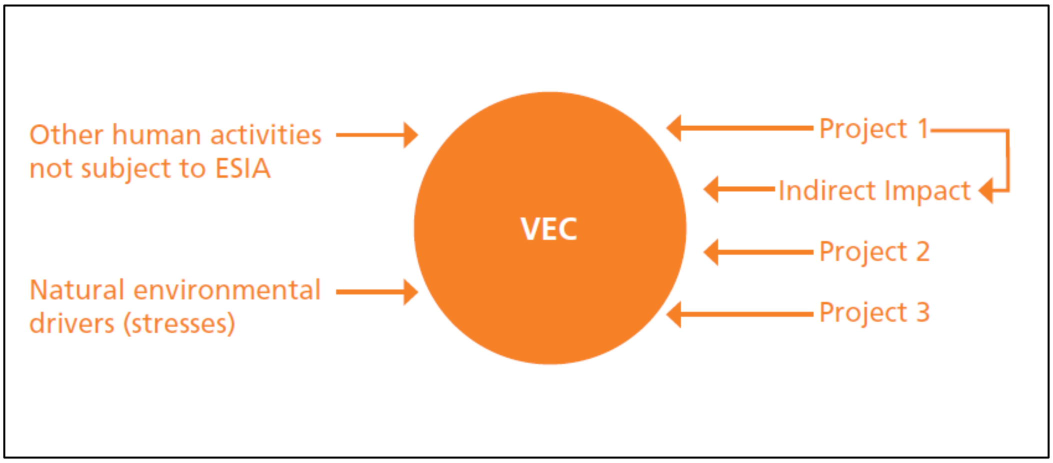


Figure 8.8: VEC-Centered Perspective

GBSWAP Cumulative Impacts

The cumulative impacts assessment reported in this section of the ESIA Report focuses on the interaction of the GBWSAP Project and developments that are realistically defined at the time the environmental assessment is undertaken, where such projects and developments could directly impact on the project area of influence. A set of VECs has been selected as shown in Table 8.9.

Table 8.9: Most Significant VECs for GBWSAP

Environmental and Social Component	Subcomponent	Parameter	Examples of VECs
Water	-Water Abstraction -Water Quality -Hydrological Flow -Domestic Water Supply	-MoE Water Quality Standards - Flow rate	-Water Resources -GBA water Consumption -Downstream Flow
Air	-Ambient Air Quality	-Greenhouse Gases	-Sensitive Receptors -Terrestrial Environment
Power	-	- Power Supply	-Power Supply
Land Use	-Natural Use -Human Use	-Land Cover -Reservoir Sedimentation	-Agriculture and Reforestation
Habitats and Wildlife	- Terrestrial Habitats - Riverine Habitats	- Species Diversity - Species Population - Wetland Development	-Flora species -Fish Species -Amphibians -Reptiles -Birds -Mammals
Public Health	-	-Health Costs Incurred (diarrhea, chronic illnesses)	-Sensitive Receptors -GBA water users

Table 8.10 is a matrix showing those incremental impacts, whereby the sign (+) means positive cumulative impact, (0) means no cumulative impact, and (–) means negative cumulative impact. Developments that could have cumulative impacts on the project area of influence have been identified; the existing ones namely GBWSP and Joun, Awali

and Anan HEPS, and the proposed ones mainly the Shoreline sewerage treatment schemes and a reforestation scheme in the upper catchment.

Table 8.10: Cumulative Impacts on Selected VECs

		Existing and Proposed Projects			
VECs	**Parameters**	**GBWSP**	**HEPs (Joun, Awali, and Anan)**	**Sewerage Treatment Schemes**	**Reforestation Scheme**
Water	*Water Abstraction*	0	0	0	0
	Water Quality	+	0	+	+
	Flow Rate	+	0	0	+
	Domestic Water Supply	+	0	0	0
Air	*Greenhouse Gases*	0	-	+	+
Power	*Power Supply*	0	+	0	0
Land Use	*Land Cover*	0	0	0	+
	Reservoir Sedimentation	0	0	0	+
Habitats and Wildlife	*Species Diversity*	0	0	0	+
	Species Population	0	0	0	+
Public Health	*Health Costs*	+	+	+	+

+ Positive Cumulative Impact
- Negative Cumulative Impact
0 No Cumulative Impact

The cumulative socio-economic impacts resulting from GBWSAP and other development projects such as GBWSP will, if well managed afford an overall increase in domestic water supply to GBA consumers, providing them with better water quality treated in the proposed Ouardaniye WTP. Hence, the combined effect will be positive. The main benefits will be decreased health costs as incurred by incidences of diarrhea and other health conditions, some of which are chronic as a result of the current impaired water quality. Also of benefit to GBA residents is curtailing the costs burden of securing water from private tankers. Improved water infrastructure, treatment, and metering will definitely lead to a better water management system, decreased water losses and a more sustainable water supply.

The results of the study carried out for this assessment indicate that the existing HEPs in the Project Area will have a positive impact on power supply as GBWSAP has the potential to generate additional power in the Awali plant estimated at 1.5 MW. This will definitely enhance livelihoods thus having a positive cumulative impact on public health through improved sanitation, hygiene, and hospitalization. GHG emissions will increase adding on the ones afforded by GBWSAP.

As to the proposed sewerage treatment schemes in the upstream villages, the assessment has determined that the major changes that can be expected will occur as a result of better discharge quality to the valley, thus resulting in better water quality to GBA users and reduced GHG emissions from the reservoir. However, emissions from the wastewater treatment plants should be taken into account. Villagers in the upper watershed will *de facto* benefit of enhanced sanitation, improved public health, and better livelihoods.

Another scheme, which may alter the suspended sediment flux in the reservoir, is upstream reforestation discussed in Section 8.6.3 of this report, a key element for watershed management and protection. The effect of reforestation programs on the sediment transport into the Bisri reservoir reduces the sediment flux from bank erosion and landslides, contributing to longer life span of the dam itself. Although large concrete dams have a theoretical design life of 80-100 years, the actual lifespan of a dam is determined by the rate at which its reservoir fills with sediment.

Other cumulative impacts of upstream reforestation programs are offsetting carbon dioxide emissions by increasing storage of carbon in terrestrial pools or carbon sequestration. In addition, these forests will contribute to reduced evaporation in the upper catchment leading to increased runoff down the valley into the reservoir. Forests also provide alternative habitats and migration routes for some bird and mammal species, otherwise impacted by Bisri dam.

Induced Development

Clearly with the construction of Bisri Dam there is potential for a large number of planned developments in the vicinity of the Project. Induced development, discussed in more details in section 8.3.4 of this report, will only have a positive cumulative impact if a well-planned and agreed Master Plan is adopted. If development is chaotic and piecemeal, or certain interests are allowed to violate the Plan, cumulative impacts may be entirely negative. Unless appropriate public utility infrastructure is put in place and discharge of wastewater and agrochemicals is regulated, flow of surface runoff and wastewater to the reservoir will rise. This will increase eutrophication in the reservoir with the propagation of algal blooms that will impact power generation equipment and water treatment plant operation, and derogate the quality of water available for downstream irrigation.

Examples of induced development for GBWSAP include the access road to a dam opening up areas previously poorly accessible to the general public which may lead to over-exploitation of the natural resources, in addition to the construction of villas, apartment blocks, hotels, hill resorts and restaurants on the overlooking hillsides with their associated access roads and public infrastructure. Waterside land is more likely to induce smaller water sport focused accommodation, camping and picnic sites, bathing areas, shoreline walkways and cycle tracks, boat rental and repair yards, yacht and canoe clubs. Atmospheric emissions and noise and dust from power generators, vehicles and boats, etc. will be a negative cumulative impact. In addition to visitor and recreational activities, the reservoir will also afford the opportunity to expand local irrigated agriculture.

8.5 Summary of GBWSAP Potential Impacts

Table 8.11 summarises the impacts that might accrue from Bisri dam design, construction and operation, along with the likelihood of occurrence and likely severity of each.

Table 8.11: Summary of Potential Impacts Arising from the Bisri Scheme

Issue	Potential Impact	Likelihood	Likely Severity
Land Take	Land taken for dam and reservoir, access roads	Unavoidable	Major
	Land take for resettlement and/or relocation of PAPs	Expected	Minor
	Loss of natural landscape	Unavoidable	Moderate
	Loss of existing communities	Not Expected	n/a
	Loss of individual homes	Unavoidable	Moderate
	Loss of non-agricultural business premises	Not Expected	None
	Loss of temporary employment	Unavoidable	Major
	Loss of permanent employment	Expected	Moderate
	Loss of productive land	Unavoidable	Major
	Loss of historic and cultural heritage	Unavoidable	Major
Impoundment	Additional loss and severance of access	Expected	Moderate
	Increased risk of seismicity	Expected	Major
	Loss of natural vegetation	Unavoidable	Moderate
	Impaired water quality from uncleared vegetation	Unavoidable	Major
	GHGs from uncleared vegetation	Expected	Major
	Soil erosion along new foreshores	Expected	Major
Sedimentation	Creation of backwaters on tributary streams	Expected	Moderate
	Loss of capacity and sediment build-up at dam	Expected	Moderate
Upper Watershed Management	Road construction opens area to non-residents	Expected	Minor
	Resettlement increases water use/waste generation	Expected	Minor
	Social unrest due to the restriction of human activity	Not Expected	n/a
	Loss of water quality due to evaporation	Unavoidable	Major
	Impaired water quality due to discharges above dam	Expected	Moderate

Table 8.11: Summary of Potential Impacts Arising from the Bisri Scheme (Cont'd)

Issue	Potential Impact	Likelihood	Likely Severity
Lower Watershed Management	Reduced non-agricultural surface water resources	Unavoidable	Moderate
	Reduced water resources for existing agriculture	Unavoidable	Moderate
	Water-use conflict	Expected	Moderate
	Loss of stock watering points	Not Expected	n/a
	Salinization of downstream floodplain	Expected	Moderate
	Reduced dilution of chemical residues, sewage	Expected	Moderate
	Reduced Dissolved Oxygen downstream	Expected	Moderate
	Scour by water released under increased head	Expected	Minor
Ground Water	Reverse ground water flow upstream of the dam	Expected	Moderate
	Reduced downstream aquifer recharge	Expected	Moderate
	Change in water table	Expected	Moderate
	Deterioration in ground water quality	Expected	Major
Biodiversity and Habitats	Loss of indigenous flora	Unavoidable	Moderate
	Loss of terrestrial habitats	Unavoidable	Moderate
	Reduced aquatic habitats	Expected	Major
	Reduced downstream biodiversity	Expected	Moderate
	Build-up of weed and algal mats around spillways	Expected	Moderate
	Disruption of flyways	Expected	Moderate
	Barrier to fish migration and loss of spawning areas	Expected	Moderate
	New habitats for migratory bird species	Positive	Moderate
	New farming fish species	Positive	Moderate

Table 8.12: Summary of Potential Impacts Arising from the Bisri Scheme (Cont'd)

Issue	Potential Impact	Likelihood	Likely Severity
Agriculture	Inundation of agricultural land	Unavoidable	Major
	Loss of fertile soils	Unavoidable	Major
	Loss of yet-to-be-harvested crops	Unavoidable	Major
	Derogation of downstream irrigation	Unavoidable	Major
	Fertilizer use upstream increases nutrient load	Expected	Moderate
	Increased soil salinity downstream	Expected	Major
Settlement and Resettlement	All residents in the inundated area will be displaced	Unavoidable	Moderate
	Disaggregation of communities	Not Expected	n/a
	Impact on indigenous groups/lifestyles	n/a	n/a
	Social conflict between existing residents and PAPs	Not Expected	n/a
	Competition for resources between residents & PAPs	Not Expected	n/a
	Particular impacts on vulnerable groups	Expected	Moderate
Public Health	Increase in water-related diseases	Expected	Moderate
	Increase in mosquito breeding sites	Expected	Moderate
	Climatic changes such as increased humidity & fogs	Expected	Moderate
	HV transmission lines in proximity to housing	Not Expected	n/a
	Public services overburdened	Not Expected	n/a
	Risk of landslides/rock collapse into reservoir	Expected	Moderate
Indirect Issues	Negative impacts from increased urban development	Expected	Moderate
	Upper catchment activities limit dam efficiency	Expected	Moderate

Table 8.12: Summary of Potential Impacts Arising from the Bisri Scheme (Cont'd)

Issue	Potential Impact	Likelihood	Likely Severity
Construction Issues	Construction site unsightliness	Expected	Moderate
	Increase traffic generation and exhaust emissions	Expected	Moderate
	Noise and dust from site clearance and excavation	Expected	Moderate
	Temporary works such as drainage diversion	Unavoidable	Moderate
	Camp working area sewage and solid waste disposal	Expected	Moderate
	Emissions from batching plants & power generators	Expected	Moderate
	Increased hunting, egg collecting, live capture	Expected	Moderate
	Social conflict between workers and residents	Expected	Minor
	Importation of contagious diseases	Expected	Minor
	Fuel spillage and waste oil disposal	Expected	Moderate

8.6 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

8.6.1 Introduction

This section of the ESIA report discusses the three elements of the Environmental and Social Management Plan (ESMP) as agreed with project stakeholders involved in its implementation. Proposals for impact mitigation are discussed in **Section 8.6.2**., while Environmental and Social Monitoring and Institutional Strengthening/Capacity Building are presented in **Sections 8.6.3 and 8.6.4** respectively.

It is important to note that under Lebanese law the Council of Ministers (CoM) is the starting point for each new investment project in all sectors and under all circumstances. Whether raised externally or by a specific minister, CoM assigns the proposal to the appropriate government agency. Major projects beyond the capacity of government funding, such as GBWSAP, are usually assigned to CDR, which in coordination with all concerned departments do whatever is necessary to progress the project towards implementation, including negotiating foreign funding institutions.

Upon completion of all preparatory work, including those procedures required by foreign financial institutions, CDR raises to the CoM a draft financing agreement and all documentation on project components; identification, cost, implementation program, legal/administrative/financial conditions, the appraisal document agreed with the foreign funding agency, as well as the road map for all stakeholders responsible for the project implementation and, later on, its service performance.

Having approved these components, CoM authorizes the concerned minister and CDR to sign the Loan Agreement, and then transmits this Agreement and its enclosures, via a Presidential Decree, to the Chamber of Deputies for passage into Law.

Only after the President of the Republic has signed the Law and it is published in the Official Gazette are the Government of Lebanon, its responsible ministries and their executive agencies committed to implement the project in accordance with the terms and conditions stated in the Loan Agreement, including adherence to the ESIA and RAP.

Thereafter, other ministries will assess their level of involvement and make representation to CDR for funds to undertake any further studies and works to fulfil their responsibilities under the Law. For example, at this stage the Ministry of Culture will seek funds for the DGA to plan, initiate and supervise archaeological rescue; the MOE will approve the project, subject to approval of an EIA study, and CDR will initiate the issuing of bid documents for construction. The detailed plans for each mitigation measure have been discussed in depth with each stakeholder and roles and responsibilities for funding and implementation agreed.

8.6.2 Environmental and Social Impact Mitigation

This section proposes mitigation measures to address the impacts identified in Section 7 under three separate groupings:

- Pre-Construction impacts
- Construction impacts

- Operational impacts

Details of land acquisition and resettlement are discussed in the Resettlement Action Plan, which has been prepared as a separate report.

8.6.2.1 Pre-Construction Impact Mitigation

The most effective pre-construction impact mitigation strategies are implemented throughout all phases of engineering design. In particular, the precise location of the dam was chosen to provide the best possible geological conditions with minimum risk of settlement and seismicity, minimum and least disruptive land take, and minimum loss of biodiversity, habitats and cultural heritage.

Geological conditions

With Roum Fault passing at least in close proximity to the Bisri Dam and to the project in general, its significance, the potential for movement, and the impact of reservoir loading, detailed analysis of the impact of potential seismic risk on the dam was studied in detail through a neotectonic assessment of seismic risk, reviewed by the Dam Safety Panel of Experts and currently in final stages of completion.

Land take

Loss of property, assets and means of livelihood will be mitigated by providing adequate resettlement and compensation in accordance with the RAP for the project that is compliant with World Bank Operational Procedure OP 4.12 and relevant provisions of the Lebanese Law. Details are provided in the RAP, including preliminary assessments of compensation rates.

Loss of biodiversity and habitats

Construction project should neither be initiated during breeding or hibernating season of animals nor during the active season of plants. In addition, night shifts or dawn and dusk must be avoided. The breeding season in Lebanon is in spring and hibernation is in winter. Hence the construction work will start during summer where the disturbance that might occur will deter birds from their nesting sites as well hibernating reptiles and mammals will keep away from these places, thereby reducing the negative effect of the construction. This applies to flora relocation as well.

A preliminary Biodiversity Management Plan has been developed, and builds on a detailed ecological assessment of sensitive biodiversity in the project area. The Biodiversity Management Plan is presented below. The implementation of the plan will be monitored by a biodiversity specialist. This will minimize the negative effect on the population size and decrease causalities, and any other disturbances towards the natural environment. The Biodiversity Management Plan will be finalized to accurately reflect the contractor’s CEMP and construction schedule.

Flora

Dams' downstream effects on riparian forests are strongly affected by the character and magnitude of adjustment of the fluvial-geomorphic system. The geology, hydrology, climate, and management have a direct influence on the ability of the fluvial system to adjust to dam-induced changes, as well as on the character and magnitude of that adjustment. The major concern regarding vegetation communities and plant diversity is the control of water flooding, niches destruction of important plant species and the disturbance imposed within the demographic structure of riparian forest (age structure and sex ratio).

The timing of the implementation of the mitigation strategy for managing impacts on vegetation communities should take into account the three phases of the project implementation: pre-construction, construction and post construction phases of the project. Consequently, the suggested mitigation measures are the following and are reflected in the Biodiversity Management Plan:

The fluvial adjustment must be anticipated along alluvial channels where dams alter downstream hydrology and/or sediment load. This is important to give room for the colonization of tree species expected to occur along the banks of the lake. The sex ratio of dioecious species such as *Populous* and *Salix* must be monitored to ensure the re-establishment of the tree populations (pollination and seedlings recruitment). The translocation of endemic and species with critical conservation status such as *Orchis* sp., *Fritillaria* sp., *Ornithogalum* sp., *Hyacinthus* sp., ferns and other species must be done before the construction of the dam and the inundation of downstream areas.

Management practices of the dam must foresee steps to reduce the disturbance intensity and allow the mimic of the natural conditions that existed before the dam construction in order to increase biodiversity in the newly established river banks and lake formation.

Individual trees and patches of vegetation to be retained close to busy construction zones shall be fenced. The location of fencing will be approved by a plant ecologist. Signs indicating the area is a "sensitive environmental area" will be clearly and securely affixed to the fencing. Mature citrus and stone fruit trees are hard to be transplanted. Consequently, the orchards in Marj Bisri will be lost. This loss has to be accounted for during planning and implementation of the project.

Fish

The dam is an artificial newly formed ecosystem that will have a certain impact (negative and positive) on aquatic organisms. The most important issue that should be taken into consideration is to allow a year-round river inflow and outflow and prevent contamination with sewage or polluted water of any sort. Continuously running unpolluted water would help preventing the complete disappearance of many species.

For eels which are catadormous species (spawning in the sea and returning to fresh water) blocking their migration will affect their reproduction hence their population. Freshwater keeps running between the dam and the sea in order not to hamper the eels from migrating back and forth. Hence, a side water flow should be taken into consideration when constructing the dam to allow the connection between the fresh water stream and the sea.

A small population of an endangered freshwater blenny (*Salaria fluviatilis*) has been detected in the lower part of Nahr Awali. This fish lives exclusively in the lower course of rivers. It is a critically endangered fish and has disappeared from all Lebanese rivers. The freshwater blenny population in the Awali is very small (about a hundred individuals) and confined to a limited space (about a kilometer). It is thus vulnerable and at high risk of extinction. The blenny does not exist in the same site of the dam but in the lower course of the river, that is in the last 1-2 kilometers of freshwater. The dam by itself does not affect this species if clean freshwater keeps running year round. The construction of the dam at the level of Bisri will modify the fluvial discharge preventing or significantly reducing water flow downstream where the fish survives. To prevent the disappearance of the fish, the lower part of Nahr Awali should never dry up as this species cannot move to another area or survive without water. If this happens once, its complete eradication will be inevitable and irreversible. Hence, canals or side water ditches allowing continuous flow of water even when the dam level drops to keep enough water running on the river bed all year round.

In addition to maintaining the environmental flow, the free passage of native fishes is an important issue for the conservation of freshwater blenny, should this be deemed necessary. Among these techniques is the fish passes technology. One or more fish-passes that connect the river to the dam shall be built, allowing the fish to enter and leave the dam. By definition, fish passage becomes a necessity when a dam is separating a species from its habitat; therefore, such facilities are required when fish like *Salaria fluviatilis* are unable to pass upstream a dam. Indeed, fish passes help attract migrant to a specific point in the river downstream and induce them actively or make them pass passively either by trapping them in a tank and transporting them upstream or by opening a waterway. The design of such facilities depends on the behavior of *Salaria fluviatilis* and their effectiveness relate to the presence of attraction flow, suitable location of the entrance, adequate maintenance and the adaptation of hydraulic conditions such as velocity, turbulence, flow patterns and aeration levels to the target *Salaria fluviatilis*. Indeed, the water velocity in the facility should comply with the behavior of freshwater blenny and its swimming capacity, keeping in mind as well that excessive aeration could act as a barrier for it. In addition, like any other type of fish, *Salaria fluviatilis* is very sensitive to environmental factors such as temperature, dissolved oxygen levels, light, odor and noise. Therefore it is crucial that the water quality feeding fish passage facilities be the same as the one flowing across the dam.

Seeing that little information is known in Lebanon concerning freshwater blenny, fish passes facilities should be designed in a way so that they can be changed when needed to improve and optimize their performance. Also, it is primordial to monitor their effectiveness from time to time to ensure that they are working properly and enabling *Salaria fluviatilis* to pass freely across the dam.

Amphibians and Reptiles

Amphibians and reptiles are very sensitive to the dam construction. Amphibians depend on the water habitat for their survival and reproduction. Fresh water reptiles like snakes and fresh water turtle depend on this water source for survival.

The construction process should be conducted outside the breeding and hibernating period. Similarly, the filling process should be conducted outside the breeding season and not during the hibernation period. The most appropriate period for filling the reservoir is between July and October. During that period, the filling process will be slower allowing the animals to escape and move with the rising water level. Some reptiles, however, will not have the eggs hatching before August, and this will incur a waste of reproductive effort for that year.

The upper level of the reservoir approaches the lower reaches of the Moukhtara River where there are populations of rare *Bufo cf bufo*, whose habitat appears to consist mostly of rocky terrain and riparian trees, some of which will be inundated.

The following mitigation measures have to be taken into consideration for the conservation of *Bufo cf bufo*:

1. Water flow downstream should always be maintained at levels that do not harm the riparian vegetation or destroy general and breeding habitats;
2. Breeding habitats on the lake peripheries should be evaluated regularly and alternative habitats should be created. One measure that would benefit not only the amphibian species but many other plants and animals, is to create artificial wetlands in the areas at the edge and/or surrounding the artificial lake whereby water levels are kept there at constant permanent or semi-permanent levels especially during the breeding season. This will allow the establishment of permanent shallow littoral zones that will become home to various plant and animal species;
3. Measures should be taken to avoid drying-out amphibian breeding sites through local disruptions to hydrology;
4. Pollution of amphibian breeding sites should also be prevented, by the sensitive design of construction site drainage and the implementation of pollution control measures;
5. The installation of reptile-proof fencing to prevent *Bufo cf bufo* from returning or accessing to the most hazardous parts of the construction site and,
6. The seasonal programming of site clearance works should also be reviewed, to avoid the hibernation period during which aggregations of torpid reptiles could be encountered that would not have the ability to escape the works.

Birds

Birds are sensitive group and can be easily disturbed. Disturbance by dam construction might have a negative impact on their status. The following mitigation measures should be considered:

- Blasting should be kept to a minimal and scheduled during the daytime. In this case night resting birds in the area will not be disturbed.
- Transport machinery should be kept to minimal and used in efficient and optimal way. Proper vehicle maintenance is important to avoid noise and air pollution. Drivers of vehicles as well as workers have to understand the fragility of the ecosystem and should deal with it carefully.
- Restrict access to hunters through appropriate signage and barriers
- The work should start outside the breeding season, and tree clearance should be avoided during the bird nesting season (in spring) to avoid disturbance and endangering bird species. Proper guidance from a wildlife expert should be taken on occasions when wildlife is noticed within or near the site.
- Noise creating sources should be properly lined and secured. Noise pollution should be eliminated this could be done by installing the compressor and generator in a properly constructed room, which should be enough to filter out most of the noise.
- No exotic bird species should be introduced to the wilderness of the site without guidance from a natural resourced approved specialist.
- Proper guidance should be taken from a wildlife expert on occasions when wildlife is noticed within or near the site.
- There is a need to maintain the Oak (*Quercus calliprinus*) in some stands to maintain the population of Jay that is known for its benefits to ecosystems.
- The Bruti Pine (*Pinus brutia*) is a flammable tree and easily infested by the Processionary caterpillar. Subsequently, it should be managed to avoid natural fire near houses and to reduce the allergic impact of the caterpillar. Its management should be accompanied with the introduction of Cuckoo that eats the poisonous caterpillar.
- Wherever possible, undertake vegetation clearance outside the bird nesting season, March to August inclusive.

Mammals

Mammals wander long distances in search for food, mate and water. The fragmentation of the dam area will affect the animal feeding sites, habitat, and potential mating; in addition to posing threats on animals’ life, in particular for young animals. To ensure animal safety, decrease causalities, decrease the effect of fragmentation, the following measures will be implemented:

1- Fence the most exposed edges;
2- Grow bushy hedges around the dam and on the road side; and,

3- Dig a ditch surrounding the most accessible edge of the dam or the road to obstruct animal crossing

Moreover, the above mentioned should be built taking into consideration funneling the animals towards a safe crossing points along the narrow edge of the dam. Such crossing points could be in the form of bridges or tunnels.

Visual deterrents could be installed but these will have a short term effect as the animals will get used to their presence and the effect of these deterrents will be questionable. Road signs will help drivers to be more cautious and avoid crossing animal over.

Habitat and/or species translocation for this project might not be necessary or could be a last resort if some very critical species might be affected.

Biodiversity Management Plan

A preliminary Biodiversity Management Plan has been proposed and is summarized in Table 8.12. The plan describes the mitigating measures, costs and responsibilities of the impacts described above. The biodiversity baseline, conservation management actions and mitigation have been generally identified and reflected in the Biodiversity Management Plan. The biodiversity specialist team described in the Biodiversity Management Plan section will develop a biodiversity monitoring plan to monitor biodiversity and habitat management, the results of which will inform the project on the level of degradation to the sensitive habitats and the presence of any direct or indirect activities/actions potentially degrading these habitats especially as it relates to the identified endangered species of fish (namely the blenny freshwater fish). To supplement the management/mitigation measures, the biodiversity monitoring plan will include surveys that will take place during pre-construction, construction and operational phases of the project. These surveys will measure indicators that include but are not limited to: water quality, environmental flow volume and quality, number of target species as well as numbers of indicator species, and cumulative impacts within the upstream watershed. Supplemental details to the biodiversity management plan will be included in a revised version of the ESIA

Table 8.12 Biodiversity Management Plan

	Project Biodiversity Risk	Recommended Mitigating Measure	Responsible Party	Estimated Cost (USD)
Flora	Ccontrol of water flooding may lead to destruction of important plant species and disturbance imposed within the demographic structure of riparian forest	Translocation of endemic and species with critical conservation status such as Orchis sp., Fritillaria sp., Ornithogalum sp., Hyacinthus sp., ferns and other species must be done before the construction of the dam and the inundation of downstream areas	Works contractor	N/A
		Implement environmental flows to reduce the disturbance intensity	Dam Operator (BMLWE)	N/A
		Install fencing around trees and patches of vegetation close to construction zones	Works Contractor	10,000
		Signs indicating the area is a "sensitive environmental area" will be clearly and securely affixed to the fencing	Works Contractor	N/A
Fish	Reduced volumes of year-round river inflow and outflow, and possibility of water contaminiation with sewage or polluted water will seriously deteriorate the environmental conditions of various fish species and/or block reproduction	Ensure connection of water between dam and downstream water resources.	Dam Operator (BMLWE)	N/A
	Significant reduction in water flow downtream of Bisri river may seriously impact the locally endangered freshwater blenny fish.	Maintain environmental flow as designed	Dam Operator (BMLWE)	N/A
Amphibians and Reptiles	Risk of sudden reduction in water availability to hamper viability of amphibians and reptiles	Schedule filling of the dam during the October - July season to minimize disruptions to breeding season. Schedule site clearance works during non-vulnerable periods.	Dam Operator (BMLWE)	N/A
	Reduction in water availability will impact the environmetnal conditions of the populations of the rare Bufo cf bufo, whose habitat appears to consist mostly of rocky terrain and riparian trees	Implement a construction site drainage system to reduce pollution to water resources	Works Contractor	Included in construction contract estimate
		Operate dam to maintain water levels as long as possible to optimize breeding and spawning seasons	Dam Operator (BMLWE)	N/A
		Install reptile-proof fencing to prevent *Bufo cf bufo* from returning or accessing the most hazardous parts of the construction site	Works Contractor as advised by Biodiversity Management Specialist	10,000
Birds	Disturbance to natural environment may lead to a reduction in bird colonies	Schedule any required blasting during the day	Works Contractor	N/A
		Tree clearance to avoid spring nesting seasons	CDR	N/A
Mammals	Fragmentation of natural environment as a result of dam construction may obstruct mammal routes and expose animals to drowning and other risks	Fence exposed edges and install bushy hedges along exposed roads	Works Contractor as advised by Biodiversity Management Specialist	N/A
		Construct crossing points for strategic animal crossings	Works Contractor as advised by Biodiversity Management Specialist	N/A

Monitoring of Biodiversity Management Plan

As seen above, the Biodiversity Management Plan will be implemented in close coordination with the construction schedule. The Plan will thus be updated to reflect the contractor's CEMP and to reflect construction implementation details, as agreed post tendering and contract award.

The Biodiversity Management Plan will be led and supervised by a biodiversity specialist with a team of specialist support staff, one for each of the following: flora (including trees), fish and aquatic invertebrates, amphibians and reptiles, mammals, and birds. The time each of these is expected to be engaged on the project will be as follows:

- Biodiversity Specialist/Team Leader: 35% of time over 2 years, followed by 20% for the remaining period of construction and reservoir filling, assumed to be 3 years (Total input; 16 man-months)
- Specialists (4 persons) in fish and aquatic vertebrates, amphibians and reptiles, mammals and birds: 4 man-months each prior to commencement of construction, and 3 man-months each during reservoir filling (Total inputs; 28 man-months)
- Specialist in flora including trees: 6 man-months prior to and during early construction, 3 man-months on-call during reservoir clearance, and 4 man-months during post-construction during reservoir filling (Total input: 13 man-months)

The budgetary allowance for implementation of the Biodiversity Management Plan is therefore estimated as given below. It is anticipated these costs will be borne by the Project Management Unit.

Staff Costs:
Biodiversity Specialist: $160,000
Species Specialists (5): $328,000
Transport and Expenses: $10,000

Other Costs:
Field Equipment: $9,000
Construction-related activities: $170,000
Capture and relocation: $10,000

TOTAL Biodiversity Management Plan BUDGET: $687,000

The expected time inputs, all part-time in the proportions discussed above, are currently expected to be as follows. In practice, these will be dictated by the start date of construction and the schedule of land occupation and clearance adopted by the contractor, which are as yet unknown.
The Biodiversity Management Plan Schedule is proposed in Table 8.13.

Table 8.13: Best Times for activities Affecting Biodiversity

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Start construction												
Site clearance												
Flora relocation												
Tree relocation												
Reservoir Filling												
Staff Deployment												
Biodiversity Specialist Years 1-2 Years 3-5												
Fauna Specialists (4) Year 1-2 Year 3-5												
Flora Specialist Years1-2 Years 3-5												
Further details of inputs are discussed in Section 9.2.2.												

Mosquito Breeding and Control Measures

In a public health context, mosquito breeding and growth of disease vectors in and around impounded reservoirs remains of concern and necessitates proper management. Stagnant water bodies in puddles along the shores of a dam reservoir and pools forming in the river channel immediately downstream may constitute, depending on many environmental conditions, ideal breeding habitats for mosquitos. While the latter poses a public health risk, management and mitigation of such risks starts with the elimination of those factors that are conducive to mosquito breeding. At a pre-impoundment stage, site clearance should be aimed at creating a clean shoreline including removal of underbrush, trees, vines, sheds, etc., especially within the normal fluctuation zone of the reservoir. Marginal drainage ditches may be required for this purpose and to provide access for small boats for inspection of potential mosquito breeding sites during breeding seasons. In addition, they provide access and escape for top-feeding fish which are important predators of mosquito larvae

Cultural Heritage Management Plan

The significance and extent of archaeological, historic and recent cultural heritage throughout the Bisri project area has been considered in depth as part of this study.

The nature of the various sites, location, age and content, have previously been identified in Section 6 above. While there is much overlap between the archaeological and cultural – it is convenient to separately discuss the measures to be undertaken to rescue and preserve them, as two separate exercises will be required, each under the control of different organizations; the DGA and the Maronite Diocese of Saida.

The primary elements of work to be undertaken are;

DGA Responsibility:

- Collection of pottery shards, glass and other artefacts from surface soils and shallow excavations at previously identified sites;
- Trial pitting and/or geophysical surveying at selected sites where buried structures may be present;
- Major excavation and the removal of material at Marg Bisri Roman temple; and,
- Excavations in the vicinity of Mar Moussa Church and the remains of St. Sophia's monastery.

Maronite Diocese Responsibility:

- Deconstruction, removal and reconstruction of Mar Moussa Church and of St. Sophia's Monastery; and,
- Scavenging old building materials from the ruins of 19-20th century houses to provide for new construction adjoining the relocated Mar Moussa Church.

The old houses that lend themselves to the salvage of traditional building blocks are of the type shown in Figure 8.9.

Figure 8.9: Potential Architectural Salvage

Archaeological Rescue

Given the long and honourable history of the Bisri Valley, one the primary route between the regionally important cities of Saida and Damascus, each and every one of these sites is worthy of further investigation and documentation prior to inundation, and where appropriate of rescue excavation. The potential loss of Mar Moussa and Marj Bisri raised emotive comment at public consultation and attendees expressed their requirement to see the church relocated and the temple excavated and moved.

Under Lebanese law, only the DGA is authorized for the planning and execution of archaeological investigations and rescue excavation, following their own policies and procedures and with little assistance from others than from the funding agencies, in this case GBWSAP, and archaeological specialists, such as the University of Warsaw, with whom they associate.

The re-siting of the rescued remains, particularly those of Marj Bisri temple, will both aid heritage preservation and provide a valuable educational resource on the historic associations of the Bisri Valley. While the dam designers have yet to determine sites for borrow areas, most are expected to be in the valley floor. The sites of archaeological interest within the area to which the dam construction contractor will expect to have unfettered access will need to be investigated prior to commencement of construction. Given the distance of Marj Bisri from the dam site, it is expected excavation here will continue throughout construction, but the site will require protection from malicious damage by the large temporary workforce that will be present in the vicinity.

At the present time, the most suitable site for re-erecting and displaying any rescued archaeological remains will be adjacent to any future Visitor's Centre for the dam and reservoir, perhaps with an adjacent Heritage Park if justified by the nature of the finds and available funding.

Rescue archaeology will commence as soon as the Expropriation Decree is published. Those sites within the area of construction or related activities such as labour camps and borrow pits, shall be dealt with prior to these sites prior to the contractor moving onto site. Thereafter, rescue work will continue until such time as reservoir filling curtails activity.

DGA will readily identify partners to partake in the rescue work, notably universities offering training for their students and staff, and also to provide funding, such a bilateral aid and cultural exchange. The funding for rescue archaeology expected to be provided by the project is estimated to be US$500,000.

Architectural Heritage Preservation

Heritage preservation, as distinct from archaeological rescue, is primarily concerned with the relocation of Mar Moussa Church, St. Sophia's Monastery and architectural salvage from some of the old ruined houses throughout the valley.

While formulating the Environmental Management Plan for the project and in preparing the Resettlement Action Plan, meetings have been held with Bishop Elias Nassar of the Maronite Archdiocese of Saida, the Church's architectural advisors, the head of Mazraat El Dahr municipality and the priest responsible for Mar Moussa.

In summary, the outcome of these meetings and discussions has been as follows:

- Mar Moussa Church must be re-erected so as to retain its present appearance;
- The Church authorities will consider the remains of St. Sophia's Monastery being re-erected on the same site depending on the outcome of research they will undertake in the historical archive at Bkirki;
- Any religious artefacts found during the removal of these structures of from archaeological investigation of these and adjacent sites should be returned to the Church authorities for preservation and safe keeping;
- The Church may also be interested in undertaking architectural salvage from the old houses in the valley to collect old building stones. stone lintels, etc, that could be used to construct other buildings on the new Mar Moussa site;
- The preferred new site is one at a higher elevation directly above the present site;

- If this is not possible, Mar Moussa must in any case remain within the municipality of Mazraat El Dahr;
- The plot on which the church is re-erected must be either *Domaine Publique* or owned by the Maronite Archdiocese;
- The ESIA/RAP consultant assessed possible relocation sites for the Bishop's consideration;
- The Bishop will handle all negotiations with CDR and the municipality/local community/religious endowments;
- The Bishop will appoint a specialist to be involved in the relocation.

Further to the initial meeting with the Bishop, DAH's GBWSAP environmental team undertook repeated walkovers of the area to identify possible Mar Moussa relocation sites. Four potential sites, Options 1-4 on Figure 8.10 and Figure 8.11, were identified, all within a relatively short distance of the existing site, all substantially above highest possible water level in Bisri Reservoir, and all within the cadastral region of Mazraat El Dahr. Option 1 has been selected as the most appropriate option, following concurrence by stakeholders. The distance of the present Mar Moussa site from the existing river bed is approximately 200 m.

Figure 8.10: Plan View of the Four Site Options for the Relocation of Mar Moussa Church

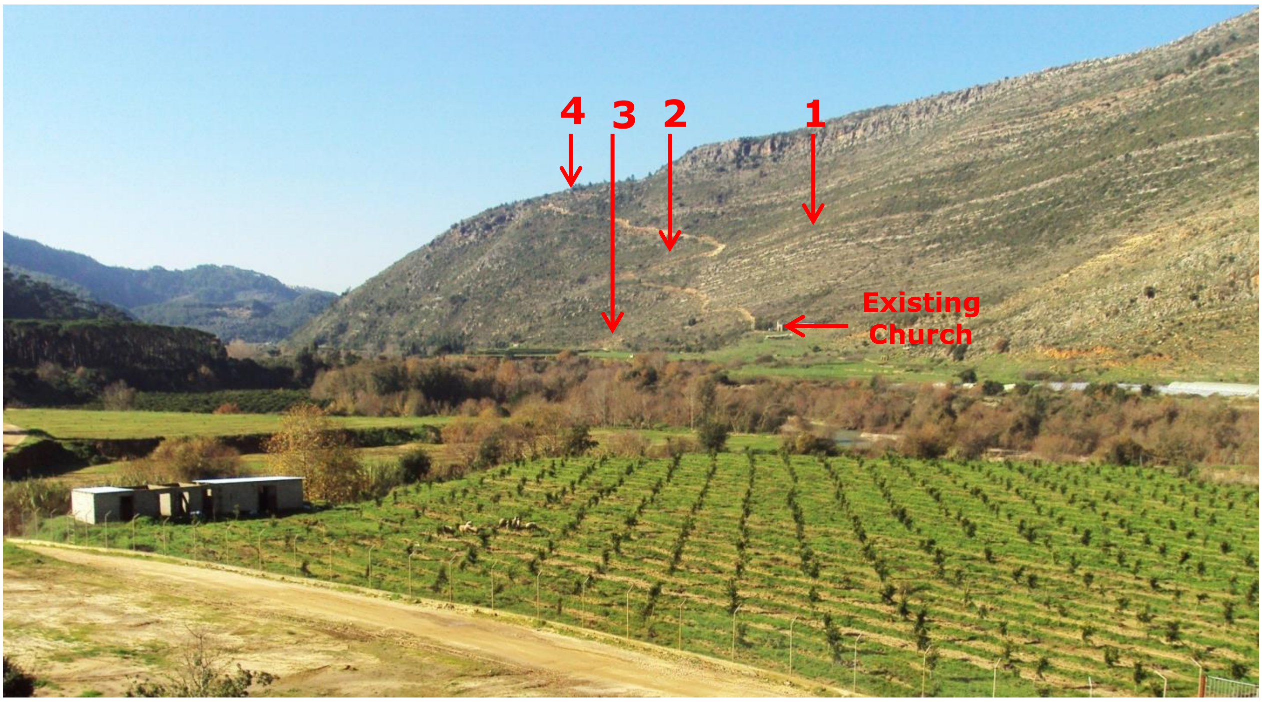


Figure 8.11: Ground View of the Four Site Options for the Relocation of Mar Moussa Church

Each site affords a number of advantages and disadvantages, as listed in Table 8.14. In terms of criteria for site selection, the most significant features are ranked from 1 (most advantageous) to 4 (least advantageous), in Table 8.15 according to the preliminary consideration of the Consultant.

Table 8.14: Advantages and Disadvantages of the Mar Moussa Relocation Sites

	Advantages and Opportunities	Disadvantages and Treats
Option 1 300 m NNW of present site, 500 m from river. Plots 391 and 395, or 392 and 394.	• As near vertically above the old site as is possible; • Good view upstream over the reservoir; • Lower expropriation costs due to steepness of slope.	• Plots are not within present expropriation Decree; • Steep slopes (>50%) make site preparation costly; • A new access route 400 m in length is needed; • The new access track will increase expropriation to 6 plots, 2 not otherwise be fully expropriated; • Site will look unattractive and mar the landscape; • Cost of reconstruction will increase due limited working space and difficult access; • No provision to expand current facilities.
Option 2 600 m WSW of present site, 500 m from river. Plots 870, 411 and 412.	• The topography is less steep and site clearance will be easier; • A larger area is available for the future development of church facilities.	• 300 m downstream of the dam and 30-40 m higher than the crest, the view from the site will primarily be the dam and its concrete apron with only limited views of the reservoir beyond; • Site is outside the present expropriation, although the plots needed are being partially taken; • Reinforced concrete walls will be needed along the site's long sides to provide stability.

	Advantages and Opportunities	Disadvantages and Treats
Option 3 750 m SW of present site, 200 m from river. Plots 410, 413, 414 and 416.	• The site is already to be expropriated; • Site is adjacent to the existing access road; • Site is at a similar elevation to present site; • Most convenient for reconstruction; • Available land provides for additional facilities in the future.	• The existing access track will be heavily used by construction traffic for a period of 5 years from commencement; • The site may be more susceptible to vandalism than the other sites; • The site is in the highest dam break risk area, i.e. the church will be totally destroyed should the dam suffer structural failure; • The vista from the site will be overwhelmed by the height of the dam and its downstream apron.
Option 4 900 m WSW of present site, 700 m from river. Plots 778, 786, 1832 and 2-3 others	• The highest of the site options, giving long vistas up and down stream without being overwhelmed by the dam structure; • The existing track from Mazraat El Dahr contains no very steep sections; • Land available for the future expansion; • Site may require limited retaining walls; • Being relatively close to the village, the church may attract larger congregations than is possible at the present site.	• Part of the site is outside the present expropriation area; • Site clearance may be difficult due to in-situ rock; • Less available area to accommodate for both church and monastery • Very expensive cost of land for land reclamation and terracing

Table 8.15: Rating of Mar Moussa Relocation Options

Option No.	1	2	3	4
Steepness of slope	4	3	2	1
Pleasant views	2	3	4	1
Ease of access	4	3	2	1
Ease of site clearance	4	3	1	3
Need for r/c retaining walls	4	2	3	1
Proximity to M el D	3	2	4	1
Need for additional land expropriation	1	1	1	4
Space for future facilities	4	2	3	1
Security	1	2	4	2
Ease/cost of Reconstruction	4	3	1	2
TOTALS	31	24	25	17

1 most advantageous, 4 least advantageous

On the basis of the preliminary assessment, Option 4, some 900 m from the present location, is recommended for the reconstruction of Mar Moussa Church. Church relocation has also been discussed at Public Consultation sessions with CDR and PAPs, and villagers showed no objections to Option 4 as being the recommended location. Option 4 has been reflected in the expropriation documents to be financed and implemented under the project RAP.

If Mar Moussa is relocated where there are good views over the valley and the future reservoir, it will increase its current function from once annually to more frequent religious celebrations. It may become the locally preferred site for the celebration of religious festivals such as Christmas and Easter, and for family events such as weddings and christenings. The potential to readily increase land availability is therefore included in the selection criteria above.

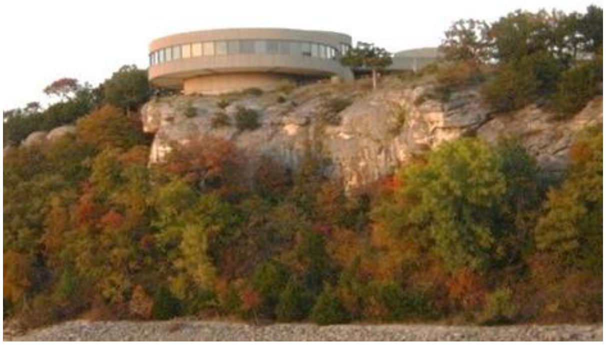
The relocation of Mar Moussa Church and of the remains of St. Sophia Monastery will need to be expedited prior to commencement of dam construction. The cost of deconstructing and reassembling the outer walls, and other demolishing and constructing anew the interior, is estimated at US$ 2,000,000 and is reflected in the EMP. The work will be included within the tender documents for dam construction and will be completed by the contractor prior to commencing the main contract.

Visitors Center

The nature of the Bisri project prevents any of the heritage sites being conserved, preserved, restored, adapted or maintained in-situ. The viable approach to conserve significant structures and artefacts excavate, deconstruct, relocate and reconstruct. In previous sections of the present report the benefits of a Bisri Visitors Centre have been expounded. The Centre should be conceived in the Ottoman or traditional Lebanese vernacular styles and built to contemporary standards. The complex should incorporate the Ottoman Arches and even perhaps the remains of St. Sophia Monastery if the Church authorities decide it is inappropriate to locate it with the Mar Moussa into the functionality of the facility. If the community so desired, Mar Moussa Church might be relocated on the same site.

Archaeological remains from Marj Bisri might form the centre of a Heritage Park, perhaps located adjacent to the Visitors Centre, exhibiting the history of the valley, a photographic record of the pre-inundation landscape, and other worthy features that would serve to both preserve the heritage and inform future generations. Ideally, the centre would be located where it afforded views over the dam and reservoir.

In common with large water bodies around the world, Bisri Dam will attract visitors. It will therefore be inherent upon BMLWE to manage visitor numbers, the types of activities undertaken, and the sites utilised. Failure to do so will ensure inappropriate activities in inappropriate places contribute to the impairment of water quality and public danger. Experience worldwide has shown that a Visitors Centre, such as those illustrated in Figure 8.12, are successful in providing a focal point to visitor attraction and access control, and promoting the facilities as a touristic and recreational destination in its own right.



Stunning views make Truman Dam Visitor Center as destination in its own right.

Access and signage to Truman Dam Visitor's Centre.

Educational exhibits at Dworshak Reservoir Visitor Center

Environmental Education Center at Kerr Reservoir Visitors Centre

Figure 8.12: Examples of Visitors Centres at Lakes and Reservoirs

While Bisri dam and reservoir will in time become an accepted part of the landscape and a destination for visitors, its attraction will start with construction. Not only will the raising of the dam be impressive, the steadily change in landscape during reservoir filling will also be of interest to many. In addition to providing for a Visitors Centre to cater for this interest, such a facility will enable the project proponent to promote the project, display progress, encourage good behaviour towards maintaining water quality, and public safety. At the outset of construction, the Visitors Centre may need be little more than a simple prefabricated structure with display boards, a picnic area and car parking without which visitors will attempt to gain unregulated access, clutter public roads and partake of otherwise unwarranted behaviour.

With time and growing visitor numbers, the site may be further developed with environmentally-sustainable and iconic buildings and may, like many others at similar attractions, provide some or all of the facilities and attractions listed below. Many Visitors Centers are established as charitable NGOs, the profits generated being dedicated to the provision of facilities, educational activities and promotion of sustainable lifestyles.

Potential facilities within the Bisri Dam Visitors Centre might include:

- Reception/information desk;

- Dam and Reservoir viewing platform;
- Fixed informative and educational displays of pre-reservoir landscape, dam construction, hydropower generation, water treatment and distribution, Bisri Valley history, Marj Bisri rescue archaeology and artefacts, Mar Moussa Church relocation, Bisri Reservoir ecology;
- Temporary display space available for hire for craft shows, art exhibitions, etc;
- Lecture theatre and work rooms for visiting school groups;
- Snack bar and café facilities; and,
- Public utility services.

The grounds of the Visitors center might afford:

- Security checkpoint;
- Adequate car parking;
- Heritage Park with the structures removed from the reservoir;
- Picnic area;
- Craft and traditional trades exhibits; and,
- Children's play area.

Equally importantly, the Visitors Centre will deter activities that will disrupt the peace and tranquility of the reservoir, such as Quad bike riding, the lighting of fires, loud music, littering and hunting. As induced development around the margins of the reservoir progresses, the center might take on an administrative role, such as selling tickets for particular activities, or become the base for water bailiffs and biodiversity wardens caring for new shoreline and wetland communities.

Notwithstanding the development potential, it should remain outside the scope of the present project. Current governmental responsibility should be limited to the construction and commissioning of the dam and its appurtenances, and resolving in as amicable manner as is possible and in accordance with Lebanese Law and World Bank requirements the issue of resettlement and asset loss. However, the project can support the development of the preliminary framework and plan that GoL can develop further outside the project. The development of a Visitors Centre and Heritage Park will, given Lebanese entrepreneurship, be left to the private sector when market conditions are deemed appropriate.

Benefit Sharing

The overwhelming beneficiaries of GBWSAP will be the water consumers of the Greater Beirut conurbation.

In order to more equitably spread the benefits, GOL will establish the means to help the communities on the surrounding hills and throughout the dam catchment, initially through the capital funds available for the project, later through continued revenue from primary beneficiaries. To this end, CDR will establish a Benefit Sharing Program to provide the means to improve community services and the local environment. The Benefit Sharing Program will be administered by CDR and will support local projects concerned with issues such as reforestation, community power supplies, eco-tourism, and assistance to NGOs as appropriate. Details of implementation of the Benefit Sharing Program will be established and operate are given in Appendix I.

8.6.2.2 Temporary Construction Impacts Mitigation

Most construction impacts are temporary and can be mitigated through good construction practices and effective site supervision. The World Bank has published principles on waste management that are applicable to many construction activities[79].

The Contractor will be expected to manage his staff and adopt the ESMP contained herein and develop it in relation to his own particular activities, methodologies and equipment, in a Bisri Dam Construction Environmental and Social Management Plan, to be approved by the client and the construction manager prior to commencement of work on site. The CESMP will contain a number of specialist sub-plans including but not limited to the following:

- Traffic Management;
- Demolition and Land Clearance;
- Drainage, Erosion and Sedimentation;
- Public Utilities Disruption;
- Solid Waste Management;
- Liquid Waste Management;
- Public Safety and Security; and,
- Worker's Health and Safety.

Thereafter, implementation of the CESMP shall be subject to ongoing monitoring and inspection by the construction manager. Each sub-plan shall include a considered risk assessment, and for those events with a high risk of occurrence Emergency Response Procedures (ERPs) shall be formulated. A public complaints procedure will also be put in place. The minimum scope for each of the proposed sub-plans is given in Table 8.16.

Table 8.16: Minimum Scope for CESMP Sub-Plans

CESMP Sub-Plan	Minimum Scope
Traffic Management	For vehicular and non-vehicular traffic, the location and schedule of road closures, diversions and temporary passages, traffic control and signage, lighting and watching at night, notification procedures. Breakdown recovery, accident reporting, and emergency access.
Demolition and Land Clearance	Proposals for demolition, checks for asbestos and other hazardous materials, hazmat disposal, architectural salvage and recycling, debris treatment and recycling, and ultimate disposal of non-reusable/recyclable items. Schedule of land clearance to minimize loss of un-harvested crops and the generation of dust.
Drainage, Erosion and Sedimentation	Maintenance of flow in the existing watercourse, prevention of erosion from excavations and cleared land, use of settling ponds, trenches and silt curtains.
Public Utilities Disruption	Schedule of any expected disruptions and details of alternative arrangements to be put in place.

79 Pollution Prevention and Abatement Handbook, World Bank, 1998.

CESMP Sub-Plan	Minimum Scope
Solid Waste Management	The minimization of waste, off-cuts, materials no-fit-for-purpose, spent materials and defunct equipment. Proposals for sorting and recycling, and for ultimate recycling of residual debris. Identification and disposal of hazmat. All residual waste (after reuse/recycling) shall be disposed of at a licensed disposal site. Only inert construction waste may be buried on site. Non-reusable cleared vegetation shall be shredded and composted. There shall be no open burning of waste.
Liquid Waste Management	Identification of waste liquids, and the arrangements for their reuse/recycling and ultimate disposal. Proposals for bunded fuel tanks, waste oil disposal, and site sewerage for workers.
Public Safety and Security	Site security to prevent public access, badge control, fencing and signage for working, storage and other areas.
Worker's H&S	General adherence to 'best practice' health and safety practices as prescribed in the World Bank's Environmental Health and Safety Guidelines. Provision of protective clothing, site safety regulations, confined area working, awareness training, signage and posters, first aid facilities, accident reporting and emergency procedures

8.6.2.3 Operational Impacts Mitigation

Operational impacts will primarily be the responsibility of BMLWE, the Bisri scheme operator. Mitigation measures for the major impacts will include those discussed below.

Soil erosion along new foreshores

Plant cover shall be increased around reservoir to help control erosion and landslip. Loose blocks from the upper cliffs shall be safely removed as they appear.

Reservoir stratification

Water stratification may cause a great proportion of the reservoir to turn anaerobic, leading to the release of minerals that promote the development of algal blooms and form methylated mercury, thus posing major problems for water service companies and potentially compromising the effectiveness of water treatment streams. Blowers, compressors, pumps and other equipment will be needed to maintain a level of mixing within the reservoir that prevents the development of water quality stratification.

Deterioration in groundwater quality

Groundwater quality may deteriorate from the seepage of reservoir water into the adjacent aquifers. The best way to sustain ground water quality is to promote groundwater resource management and maintain surface water quality.

Reduced aquatic habitats

Many of the aquatic species currently present in Nahr Bisri will adapt to the new lacustrine environment. Others will come to occupy vacated niches. To permit migration for spawning and feeding the means for fish to by-pass the barrier of the dam should be provided. This may necessitate the construction of fish leats, ladders and tubes. Any commercial fish farming enterprises can be based on native species rather than introduced species such as trout, bass, tilapias, and mosquito fish, which will come to overwhelm native species.

Derogation of downstream irrigation

The quantity of irrigation water is expected to decrease downstream while fertilizer use will increase upstream. As such, agricultural extension services will be required to optimize the use of low water-use crops and promote water-saving irrigation practices. A reasonable allowance shall be made for the release of environmental and other compensation flows that matches changes in future requirements.

Increased soil salinity downstream

Due to the reduced water quantities downstream, compensatory discharge will have to be provided to leach soil salts.

Maintenance

The potential significance of these impacts will be a direct function of the quality of the planning and preparation carried out beforehand, the effectiveness of advance warning signs, and the quality of site supervision.

Sedimentation

To minimize sedimentation and the loss of capacity and sediment build-up at the dam, it is important to promote reforestation and soil conservation in the upper catchment and around the periphery of the reservoir, and also to monitor reservoir depth to assess sedimentation. The development of wetland on the main contributing watercourses as well as a reforestation scheme in the upper catchment will reduce sediment load.

As discussed in the Updated Hydrological Report (DAH-NT, 2013) the reservoir has been designed to accommodate 9 million m^3 of sediment within 50 years operation. This will be provided for by 'dead storage' capacity, the volume that can fill with sediment without impacting the normal operation of the dam. Once this volume is filled, there is increased risk of incoming sediment working its way to the dam and entering the water supply transmission pipeline or the hydropower turbines.

Sediment management starts with dam and reservoir design; with the dam being designed with a low level sluice within the dead storage zone, through which the water discharged can carry some of the accumulated sediment. This will not only dispose of sediment but also flush out long-stored water that may have a tendency to turn anoxic. Also at the construction stage, areas of unstable soil and rock on the slopes of the reservoir should be excavated to reduce later collapse into the lake. Given the abrupt changes in topography between coastal plain and interior mountains, and the tendency for short duration–high intensity rainfall, the majority of Lebanese rivers yield high rates of sediment. As discussed previously, the extremities of Bisri reservoir, particularly the areas upstream of the Nahr Barouk–Wadi Bhannine confluence, where the reservoir is narrow and the water relatively shallow, may be expected to fill rapidly. Since these areas afford a minor portion of the whole storage volume, it is suggested these might be left to fill and develop wetland habitats, that as vegetation becomes established will increasingly filter out incoming sediment. Also during design, in considering upland catchment management, a series of low retention ponds, essentially walls constructed across the rivers upstream of the reservoir, that each wet season will temporarily arrest the first and often most-heavily silt-laden flood flows sufficiently to allow its coarser bed load to drop out.

Another way of reducing the impact of sediment and ultimately extending the operation life of the Bisri asset would be the construction of a series of weirs to reduce inflow velocities and promote sediment deposition before the incoming streams reach the wetlands. Much of settled material here will be coarse-grained and a potential source of building aggregate that will be (i) replenished annually, and (ii) environmentally-responsible. A portion of the turnover from the commercial exploitation of such a resource, through tariff or operating licenses or taxes on production, might be used for cultural heritage preservation and management.

Notwithstanding these measures, significant volumes of primarily silt and fine sand sediment will still reach the main body of the reservoir, and regular monitoring of sedimentation and clearance works will be needed.

The most common means of monitoring the build-up of sediment is acoustic echo-sounding on a GIS platform, allowing rapid and accurate reservoir-bottom surveys. Using proprietary software, the system can also calculate rates of accumulation and from the characteristics of the return signal, the nature of the sediment (rock, sand, silt, mud). Using different acoustic frequencies it is also possible to determine the presence of aquatic vegetation and fish shoals.

Initial geospatial data of the reservoir and its borders will be collected and digitized as a polygon shape file. From a simple stage board and fixed bench marks the water level in the reservoir will be recorded each time a survey is taken. Water temperature, which will affect the speed at which the acoustic signal will move through the water column, will be taken, and since the survey boat will be traversing back and forth over the reservoir it would be convenient to include continuously recording water quality sensors.

Correlation of survey results should be taken with spot sampling, using drop (gravity) or vibration coring to estimate sediment thickness. These samples will also provide for the analysis of sediment composition, including organic content, the origin of which will include bankside vegetation, fish excreta, upper catchment wastewater discharge, and human activities on the reservoir.

All work for an inland reservoir such as Bisri can be undertaken from a small launch fitted with an independent power supply and outboard motor and a basic navigation/tracking system working on shoreline signals.

An accurate pre-impoundment topographic map is vital if future rates of sediment accumulation are to be calculated. While a survey of the reservoir area has recently been completed, the pre-inundation topography, including borrow areas and other construction disturbance, must be undertaken immediately prior to reservoir filling. These considerations have been incorporated into the Operation and Maintenance Framework Dam Safety Plan. The project will also incorporate specific technical assistance to the BMLWE (the eventual operator of the dam) on all issues related to operation and maintenance of the dam and reservoir, including sedimentation management.

As highlighted above, the most effective means of reducing sedimentation are those measures addressed during design. When sediment build up within the main body of the reservoir does become a problem, currently expected to be only after several years of operation, the most effective means of reducing it will be by pump dredging or by bucket excavator fitted with an extended boom working off a barge. Such work should be undertaken in the autumn, when the depth of water is at its lowest, at the end of the summer supply period and before the onset of winter recharge.

Reforestation

Unregulated deforestation and expansion of cultivation practices in the upper catchment will result in progressive soil erosion leading to significant reservoir siltation, reduced ecosystem function, and more erratic downstream flows. Notwithstanding that reforestation is an expensive, labor-intensive, and time-consuming initiative, it is considered by watershed management schemes to be an effective option as to assist in stopping watershed devastation by reducing soil erosion and nutrient depletion, decreasing sediment loading in reservoirs and increase their lifespan. Forests provide with wildlife habitats, migration routes for some species, carbon sequestration, and water catchments, where they serve to maintain the hydrologic conditions required to generate hydroelectric power, irrigate crops, and supply water for industrial and household use. A judicious reforestation policy could reduce by 20% water lost into the sea and increase water availability in the country by 50-100%. Forests also supply the country with timber and may be a hub for recreational and tourism activities in the area. The reforestation plan should be of interest and benefit to the local community. It should be formulated accounting for the needs of the villagers who should be trained to recognize the importance of reforestation.

Bisri sedimentation rate is estimated at 1,000 t/m2/year, which is a relatively high rate for Lebanon. To overcome the main effects of this, designers have proposed a dead storage volume of 9 Mm3 over a 50-year period. To limit siltation and improve reservoir lifespan, some type of intervention should be undertaken, focusing on land use intervention through reforestation of the upper reaches of the catchment. Reforestation of denuded rangelands will provide improved land cover which would afford the largest sediment reductions. This provides improved catchment hydrology and water quality by reducing sediment into the lower portions of the Awali River basin. When sediment build up within the main body of the reservoir does become a problem, the most effective means of reducing it will be by pump dredging or by bucket excavator fitted with an extended boom working off a barge. Although seemingly clear that land use changes, reforestation, and corrective works affect sediment dynamics, the relative importance of each of these factors remains unclear, which is proposed for further research.

Forests are an important carbon sink for greenhouse gases. Trees naturally sequester carbon dioxide, contributing about 90% of the earth's surface carbon storage. A cubic foot of timber retains approximately 15 kg of carbon. The UN recognized carbon trading as mitigating greenhouse gas emissions. The approximate international market value of one tonne of carbon is $ 19.

Irrigation schemes, urban consumers, and hydroelectric power supply would all benefit from reforestation activities in the upper catchment areas. Reforestation would also improve water routing and channeling and hence helps control flooding events.

Because reforestation requires upper catchment producers to change their land use, economic incentives are required to redirect decision making towards more environmentally prudent production practices (Johnson et al., 2002). Whenever possible, it is wise to select lands that are *Domaine Publique* which saves the GoL the whole expropriation procedure and costs.

The success of reforestation will require a collaborative effort on the part of various stakeholders: Ministry of Agriculture, municipalities, local communities, forest managers, and ecologists. Together they would need to develop a meaningful plan to implement reforestation. This is expected to include an education outreach effort to inform the public about the issues facing the entire catchment. The implementation plan shall be based on a multi-criteria analysis taken into account benefits to local communities, location, tree types, accessibility, and ecology among others listed in the Table 8.17.

Table 8.17: Selection Criteria for a Reforestation Plan

Primary Selection Criteria	Interest of and benefits to the local community
	Public lands over which municipality has control
	Tree species that thrive in the Project area climatic and ecological conditions
	Depth of soil more than 40cm
	Soil type conductive to successful growth
	Topography conducive to planting and ensuring access to planting site
	Availability or accessibility to irrigation water
	Geographic distribution and social diversity
	Significant land area available to reforest, with a preference for more than 25 ha
Secondary Selection Criteria	Site history, favoring sites of biodiversity or watershed significance
	Grazing pressure, including the need for fencing

Large stem diameter seedlings are preferred as they resist damage caused by movement of soil, rocks, debris. They resist attacks by pests, and are more likely to survive and grow after deer browsing, are more resistant to heat stress or sunscald, and have a large amount of foliage and a corresponding large root system. Tall, well-branched seedlings grow above competing vegetation and may better overcome the ill effects of animal browse due to their many branches and buds. However, they may be more likely to topple if the site is windy or has shallow soils. Short seedlings may offer advantages on sites without vegetation competition that are droughty or very windy. However, animal browsing can be a problem, if stems have few branches or buds. Large root systems help anchor seedlings in windy sites and they offer better growth in moist or dry sites. Transplanting should be done in early spring and trees are nurtured through the summer with some assisted irrigation but very limited in the case of forest trees. For rocky sites, container seedlings are recommended.

Selection of Tree Species for GBWSAP

Given that the main forests in the Project Area are Oak and Pine woodlands, in addition to olive trees, it would be advisable to have a mix of *Quercus sp.* (like *Quercus calliprinos* or *Quercus infectoria)* in rocky sites and *Pinus pinea* and varieties of Olive trees in non-rocky ones for the reforestation plan, as they would thrive well in the established ecosystem and climatic conditions. Careful attention should be given as to the special handling and planting needs of each species taking into account different site requirements. Good quality, high vigor and healthy seedlings which can be obtained as bare root or in container should be procured from a certified nursery in Lebanon.

Characteristics of *Quercus sp.* are summarized as follows:

- Evergreen;
- Naturally found from sea level to 1800m;
- The tough evergreen leaves of the lower slopes keep water inside, with thick coverings, necessary to survive the blasting heat of summer;
- Under the canopy of trees there is an understorey of shrubs and a ground cover of plants;
- Kermes Oak (*Quercus calliprinos*) with its long thin acorns is a common part of the lowland forests as shown here at Bentael Nature Reserve in Figure 8.13
- The seeds of the oak trees - acorns are a special food for a number of animal species including the Jay, a common bird found in the Project area; and,
- The refuge for several mammals including the Badger (*Meles meles canescens*), which is a rare species that is expected to be present in the Project Area.

Figure 8.13: Kermes Oak and its Long Thin Acorns at Bentael Nature Reserve

Characteristics of *Pinus pinea* shown in Figure 8.14 are summarized as follows:

- Coniferous evergreen;
- Can exceed 25 m in height, but 12–20 m is more typical;

- In youth, it is a bushy globe, in mid-age an umbrella canopy on a thick trunk, and, in maturity, a broad and flat crown over 8 m in width;
- The bark is thick, red-brown and deeply fissured into broad vertical plates;
- Thrives well in soils derived of sandstone;
- "Flowers" in the late spring, and in the summer produces hard cones;
- In late summer, it is possible to hear the cones cracking open in the midday sun;
- New stands of *Pinus pinea* should be planted with 10% *Pinus brutia* for proper pollination; and,
- When properly cared for in its first few years, can grow surprisingly fast in the right habitat, and new trees will reach a decent size within the lifetime of today's middle-aged people.

Pine trees have high economic value because of its edible pine nuts. A single tree of stone pine can produce about 40 kg of cones. One ha of stone pine forests comprises 200 to 260 trees, from which 8,000 kg of cones are produced and 320 kg of edible pine nuts are extracted, sold at $70/kg. Pine nuts are a staple ingredient in the Lebanese cuisine used in many dishes like kebbeh, sfiha and many Lebanese sweets. The pruned wood is used for firewood, the cone shells and the nuts peel are used for heating as well, and the resin is used as a snake repellent and for medicinal purposes for goat.

Figure 8.14: Pine Trees in Bkessine-Jezzine Area

Characteristics of Olive trees, shown in Figure 8.15 are summarized as follows:

- Evergreen tree or shrub native to the Mediterranean area, Asia and Africa;
- It is short and squat, and rarely exceeds 8–15 m in height;
- The silvery green leaves are oblong, measuring 4–10 cm long and 1–3 cm wide;
- The trunk is typically gnarled and twisted;
- The fruit is a small drupe 1–2.5 cm long;
- Trees show a preference for calcareous soils, flourishing best on limestone slopes.

- Olives grow very slowly, and over many years the trunk can attain a considerable diameter.

Figure 8.15: Olive Picking in Jezzine Area

Like Pine trees, Olive trees have high economic value because of its oil and olives production. A single olive tree produces 5 kg of olives sold at 5$/kg and 10 L of olive oil sold at $6/L. One ha of olive trees comprises about 300 trees, from which 1,500 kg of olives are produced and 3000 L olive oil is extracted.

Dam Safety

A major contribution to dam safety is the formulation of Dam Safety Plans based on Dam Breach modelling and inundation analysis undertaken by the dam designer. The dam breach report includes an Emergency Action Plan with details of implementation. Dam Safety Plans either issued to date or under preparation include:

- Construction Supervision and Quality Assurance Plan;
- Instrumentation Plan;
- Operation and Maintenance Plan; and,
- Emergency Preparedness Plan.

Details of the above mentioned reports are included herin in Appendix J.

Discharge of Waste Water from Upper Catchment Villages

One of the prime adverse impacts on the operation of Bisri dam and reservoir will be the influx of wastewater discharged from villages across the upper catchment. Since the end of the civil war, many sewerage schemes have been implemented, and collection and treatment improved elsewhere. Nonetheless, in rural catchment such as that of Nahr Bisri and its tributaries domestic wastewater makes up a high proportion of summer base flow. With the retention of water in Bisri Reservoir it will be vital for those villages still discharging to contributing surface watercourses to have a comprehensive collection networks and at least primary and secondary treatment facilities. Not to do so will risk anoxic conditions to develop within the reservoir and for the waters to become eutrophic, with the propagation of algal blooms.

Over the years, there have been a number of sewerage studies undertaken under the auspices of CDR, and the Ministry of Environment by a variety of local and international consultants. Schemes have been proposed, plants prioritised and costed, and have been compiled into the National "***Plan D'Amenagement du Territoire Libanais***", currently under implementation by CDR, which incorporates specific Catchment Management Plans, including for those areas included in the upper and lower catchment area of the Bisri dam. Detailed implementation plans for the project area will thus be developed in parallel to dam construction, to align with the Plan D'Amenagement du Territoire Libanais, and ensure sustainable operation of the dam and reduction of water quality risks post construction. The Ouardaniye water treatment plant has also been designed to treat water taken from the upper Bisri catchments, as they stand today. This will significantly minimize risks to public health and the environment.

With the advent of Bisri dam, it is imperative that schemes for the upper catchment area, on both the northern (Chouf) side and the southern (Jezzine) side be prioritised and completed prior to the Bisri water coming on stream. As part of the present ESIA, the consultant has looked at various documents supplied by CDR that purport to confirm that wastewater master plans for either side of the river are in place and that project execution can expedited to meet the necessary time frame.

It is impractical and uneconomic to treat each village separately and adjacent villages are grouped together into sewerage service areas to deliver their collected sewage to a centralized treatment plant. CDR's latest proposal for Chouf sewerage[80], shows sewage collection schemes serving 97 villages transmitting sewage flows to 25 separate treatment plants. Within these villages, those listed in Table 8.18 are located within the Bisri catchment.

Table 8.18: Bisri Catchment Villages in Chouf Sewerage Proposals

Benouati	Bsaba
Barouk	Mazraat ed Dahr
Balloon	Mazraat ech Chouf
Khraibe	Ain Ouzain

Proposals for sewerage of villages in South Lebanon[81] include none in the Bisri catchment.

[80] CDR. *Region du Chouf: Etude du Plan Directeur et du programme des Stations d'Epuration du Chouf*. Contrat 6973 Rapport Final. Schema Directeur. Libanconsult/Cabinet Merlin, Juillet 2007.

[81] Le Bureau de Cites et Gouvernements Locaux Unis Liban, Syrie, Jordanie. Etude Portant definition de Schemas *Directeurs d'Assainissement dans 3 Federations du Sud Liban; Federation d'Iklim al Toufah*. Rapport de Prestations 5 et 6, Resume, Decembre 2012.

While there are clearly sewerage plans, there has been little documented evidence that a comprehensive approach to the sewering of Bisri catchment villages is in place, has an agreed timetable for implementation, and an approved budget.

Given the importance of sewering the upper catchment villages to the success of the project, CDR have committed to updating existing plans and expediting a Bisri Catchment Sewerage Master Plan before Project construction.

Investment in establishing new and/or enhanced sewerage collection, conveyance and treatment facilities is key to ensuring the sustainability of GBWSAP investment. The estimated total population, by year 2020, of the 41 villages of the Bisri upper reservoir catchment will be around 85,000 based on a population growth rate of 0.8% as set by the CAS in 2010. According to the 2003 National Wastewater Strategy, some 55,000 inhabitants of these villages will already be served, although perhaps not to the extent and security of service required to sustain Bisri water quality.

Working from the 2003 strategy and applying an increase of 90% over predicted 2005 costs, the required sewerage schemes may be expected to cost approximately 190 $ per capita served and 190$ per linear meter of pipe installed. Taking the unsewered communities separately, 30,000 people in 2020 be served and an estimated 90 km of pipeline, the total cost of sewering these villages is estimated to be US$23 million, rising to US$32 million when enhanced facilities in already served villages are included to bring all catchment sewerage up to the standard that will adequately protect GBWSAP reservoir.

Land Acquisition and Resettlement

CDR will provide entitlement to persons who lose their land or other assets. The principal form of compensation will be a cash payment based on the assessment of full replacement cost, as described in the RAP, which was informed by a detailed socio-economic survey of impacted households and business enterprises.

Grievance Redress Mechanism

Once PAPs have been notified of their compensation and a valuation prepared and received, further discussions and negotiations between individual PAPs and the PIC will be initiated. Details of the Grievance Redress Mechanism are discussed in the RAP.

Costing Environmental Degradation

Over recent years, significant interest has been paid by environmentalists to Valuing Natural Capital as well as Costing Environmental Degradation, which according to OECD (2001) [82] is defined as *"the deterioration in environmental quality from ambient concentrations of pollutants and other activities and processes such as improper land use and natural disasters."* It is therefore important that not only the impacts of projects are considered, but also the cost of these impacts relative to the value of benefits that will accrue for the project.

[82] Organization for Economic Co-operation and Development.

A case study carried out by the World Bank[83] has laid out some estimates of the cost of Environmental Degradation in Lebanon. In 2000, the cost of environmental degradation was estimated at 2.8-4.0 percent of GDP per year, with a mean estimate of close to USD$565 million per year, or 3.4 percent of GDP[84]. With a GDP of almost $43 billion in 2012 for a population of 4.425 as per World Bank figures, the mean estimate of environmental degradation is estimated at USD$1,462 million per year. This is considered relatively high, in the order of 1.5 times higher than high-income countries. The reasons for this are manifold: (i) health costs incurred by low water quality and poor sanitation facilities, (ii) poor air quality and its impact on health, (iii) soil degradation and loss of productivity, and (iv) significant coastal zone degradation. In addition, the cost to the global environment is estimated at about 0.5 percent of GDP that is $ 215 million using WB figure for GDP of 2012.

Economists model individual decision-making as measurement of costs and benefits. Pure private costs are the costs that the buyer of a good or service pays the seller. External costs also called externalities, in contrast, are the costs that people other than the buyer is forced to pay as a result of the transaction. The bearers of such costs can be either particular individuals or society at large. External costs are often difficult to quantify in terms of monetary values. Social costs are the sum of private costs and external costs. Figure 8.16 shows the different components of the total economic value of forests.

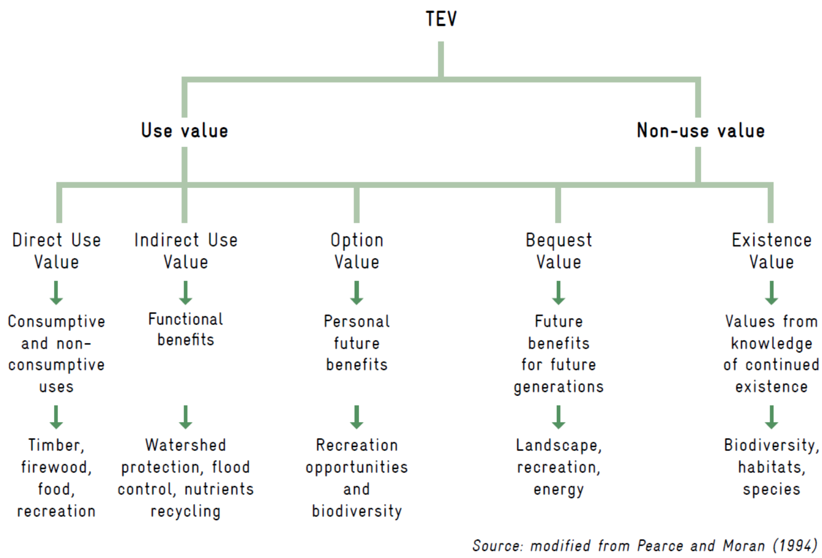


Figure 8.16: Total Economic Value of Forests85

When valuating the cost of environmental degradation, both private costs and externalities should be accounted for. In discussing the issue with the Ministry of

[83] World Bank Environment Department in June 2004 on the 'Cost of Environmental Degradation- the Case of Lebanon and Tunisia'
[84] Sarraf, M., Larsen, B., and Owaygen, M. Cost of Environmental Degradation- The Case of Lebanon and Tunisia. The World Bank Environment Department. Environmental Economic Series, Paper NO. 97, June 2004.
85 Pearce, D. and D. Moran. 1994. The Economic Value of Biodiversity. Earthscan, London.

Environment, current practice in Beirut seems to take the private cost as the real estate values as those capitalize benefits stream from different land uses be it agricultural, natural vegetation or woodland. The extent of land acquisition to include the dam site, the area inundated by the impounded reservoir, and a 15 m buffer zone around the remaining reservoir periphery to provide for shoreline access, is some 570 ha, the cost of expropriation of which may be expected to approach some $ 150 million.

Table 8.19 shows value estimates of Bisri Dam expropriation area according to land use.

Table 8.19: Value Estimates of Bisri Dam Expropriation Area

Category	Value (USD)
Expropriation Area	$120,751,312
Structures to be demolished	$1,054,590
Trees losses	$24,659,727
Other Lands attachment losses	$3,763,058
Total	**$150,228,686**

Social damage caused by environmental degradation is crucial to quantify especially in vulnerable Mediterranean ecosystems countries in general and Lebanon in particular. With a better understanding of public externalities generated by forests and natural ecosystems it becomes critical for governments to account more effectively and transparently for the cost of environmental degradation.

Despite the difficulty in estimating the current capacity for net oxygen production at Bisri, a strategic starting point would be to determine the amount produced from 1 ha mixed vegetation and multiply this by the vegetated area to be lost to the dam and reservoir. However, the determination of net oxygen production is very imprecise. Internet searches reveal a plethora of unsubstantiated figures, primarily for mature forest trees, which vary with species, condition and prevailing climate. Assuming this could be accurately determined, the monetary value of this oxygen then needs to be established. Similar imprecise strategy surrounds assigning a monetary value to vegetative carbon sequestration.

Environmental degradation within the Dam and reservoir in addition to land acquisition costs will include but not necessarily be limited to the following:

- Loss of some 150 ha of mostly prime or potentially prime Lebanese agricultural land;
- Loss of produce to local food supply chains, produce perhaps only replaced by imported produce;
- Loss of some 230 ha of natural terrestrial habitat throughout naturally-vegetated areas;
- Loss of more than 100 ha of riverine habitat, to be balanced against newly-imposed and more extensive lacustrine habitat;
- Loss of some 80 ha of productive pine woodlands and its annual crop of pine seeds;

- Loss of almost 500 ha of vegetation (area calculated as total area estimated at 570 ha minus non-vegetated area) with varying capacities to photosynthesise oxygen and sequestrate atmospheric carbon.

In the case of Bisri Dam, external costs may encompass grazing, recreation, watershed protection, carbon sequestration and biodiversity, the value estimates of which are summarized in Table 8.20

Table 8.20: Value of Natural Ecosystems Benefits in Lebanon (US$, 2010 prices)

	Total Economic Value ($/ha)
Wood Forest Products (WFPs) [a]	-10
Grazing and Non-Wood Food Products (NWPs) [b]	187
Recreation, hunting	125
Watershed Protection [c]	n.c.
Carbon Sequestration [d]	-15
Biodiversity	8
Total	**296**

Sources: Croitoru and Merlo (2005) [86] updated to 2010 prices by GIZ[87]

Notes: *[a] The aggregated value of WFP removals, net growth of standing timber and WFP losses to forest fires.*
[b] The aggregated value of NWFP use benefits and losses to forest fires. NWFPs such as grazing, cork, fruits, nuts and plants, are the most important forest benefit and can contribute 40% of household income.

[c] the aggregated value of watershed protection benefits and the value of erosion, floods and landslides due to poor forest management.
[d] The aggregated value of carbon sequestered in forest growth and carbon losses from deforestation and forest fires; the monetary estimates are based on carbon prices on international markets in the year of reference, updated to 2010.
The negative values in the table mean that the estimated social costs due to poor forest management are higher than the estimated forest benefits.
n.c. = Not calculated due to insufficient information.

The total area of lands with environmental social benefits which include forests, natural vegetation and open land is about 500 ha. Environmental costs for Bisri Dam are therefore estimated at $148,000.

The cost of environmental degradation will not simply be the cost of land and asset acquisition balanced against the cost of dam construction, or indeed the cost of those impacts expected to accrue throughout the upper and lower catchment areas. In the upper catchment, for example, the effective and efficient operation of Bisri Dam requires that each of the villages draining into Nahr Bisri have effective sewage collection and treatment to prevent the development of anoxic conditions in the reservoir. The cost of this is put at US$23 million. While the necessary construction projects will now be given

[86] Croitoru, L. and M. Merlo. 2005. Mediterranean forest values. In: Merlo, M. and L. Croitoru (Eds.) Valuing Mediterranean forests: towards total economic value. CABI Publishing. Wallingford.
[87] Contribution of Forests to a Green Economy in the Middle East and North Africa- Evidence, Drivers and Policy Orienta tions. GIZ. March 2013.

a higher priority that they may have had if the dam was not to be built, they had previously been identified for future sewerage schemes under the National Wastewater Action Plan.

Also to be factored into consideration of environmental degradation costs are those associated with not implementing the Bisri project; the cost of continuing with the present dire public water supply in the face of growing demand and growing population, the environmental and social cost of not supplying 2 million Greater Beirut residents, the cost of allowing the present 120 Mm^3 annual deficit in supply increase towards 200 Mm^3 by 2020. The lack of safe potable water has an additional cost in terms of expenditure on bottled water, estimated at 0.5% of GDP per year[88] equivalent to $ 215 million. The cost of diarrheal illness and mortality is estimated at 0.5-0.6% of GDP totaling to $ 215-258 million caused by a lack of access to safe potable water and sanitation, and inadequate domestic, personal and food hygiene. Most of those impacted are children.

The cost is not simply that of alternative sources, which the present study has shown not to be as effective as Bisri, but also the cost of potential political unrest during long, hot and waterless summers.

Artificial lakes and reservoirs almost anywhere in the world attract induced development – hotels and villas on the overlooking hillsides, shoreline properties, resorts and water sports centers, together with attendant public infrastructure and community services. Bisri may be different, but the severity, and ultimately the cost, of the additional degradation will depend on the degree of control, the formulation and strict imposition of environmentally-responsible development guidelines.

These additional costs will apply equally to areas upstream and downstream of Bisri reservoir where similar losses occur. More specifically, dam construction will cause ecological changes due to the alteration in the natural environmental flows below the dam with direct impacts on water user abstractions and the environmental flows needed to maintain bankside vegetation and aquatic ecology. Most noticeably perhaps, the dam will affect irrigation practices by reducing the access of crops to water. If the soil dries out in the summer months, the structure will weaken and subject it to wind erosion. Irrigated areas will progressively reduce and once productive land will be abandoned and the cost of subsequent rehabilitation will be high. The lower controlled flows below of the dam may also severely impact any recreational use of the river and reduce the aesthetic appeal of riverside restaurants.

Large reservoirs commonly trigger a change in the local microclimates by increasing air humidity and altering wind patterns, perhaps influencing changes to crops and living conditions on adjacent hillsides. Houses on the lower slopes of the reservoir may see an increase in air-conditioning costs. Mosquitoes and other vectors that favour damp humid breeding sites may increase in numbers and potentially impact human health.

88 Sarraf, M., Larsen, B., and Owaygen, M. Cost of Environmental Degradation- The Case of Lebanon and Tunisia. The World Bank Environment Department. Environmental Economic Series, Paper NO. 97, June 2004.

It is reasonable to assume that Bisri reservoir will eventually have a peripheral road skirting its shoreline, be it an unsurfaced track for BMLWE operatives to access the shoreline to clear seasonal vegetation, or a major highway serving waterside properties. Dam construction will therefore increase car and vehicle use in a once remote area, contributing ozone-depleting exhaust emissions as CO_2, CO, CH_4, NO_x, SO_2, and HFC. According to the USEPA, the annual emission of a passenger car travelling 19,000 km per year is 5.1 tonnes of CO_2 equivalents (USEPA, 2011). In Lebanon most cars do not travel more than 8-10,000 km/year, suggesting annual CO_2 emissions around 2.5 metric tons per Km. The cost of 1 tonne of CO_2 equivalent is estimated at $15-19[89]. Once road usage is determined and a *Master Plan for Shoreline Development* is in place, the contribution of vehicular traffic, currently almost zero in the reservoir area, can at least be estimated.

In summary, the costing of environmental degradation in Lebanon in general and for the Bisri project in particular is hampered by a dearth of reliable information and cost significance. Nevertheless it is clear that the cost of degradation resulting from the construction of Bisri dam and the inundation of a large area of land will be substantially less than the failure to supply the growing population of Greater Beirut with a reliable good quality public water supply.

8.6.2.4 Summary of GBWSAP Impact Mitigation

In summarizing the mitigation measures proposed for the Bisri scheme, Table 8.21 builds on the risk of individual impacts previously given in Table 8.11 above, and provides appropriate mitigation measures for each impact identified and the responsible party to carry out such measure. In ensuring the full range of potential impacts and mitigation measures are covered, the ESIA draws upon the documentation of the World Commission on Dams.

Table.8.22 summarizes the costs of the major proposed environmental and social impact mitigation measures.

Generally, the GBWSAP ESMP shall be applied to all phases of the project, from preliminary and detailed design through construction and on to operational and maintenance.

[89] Ecosystem Marketplace, 2011. Back to the Future. Bloomberg New Energy Finance based on 2010 Market. New York, US.

Table 8.21: Summary of Proposed Environmental and Social Impact Mitigation Measures

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
Land Take	Land taken for dam and reservoir, access roads	Unavoidable	Major	Locate reservoir to minimize land take and loss of natural landscape per unit volume impoundment.	Designer
	Loss of natural landscape	Expected	Moderate		
	Land take for `resettlement and/or relocation of PAPs	Unavoidable	Minor	Locate reservoir to minimize land take per unit volume impoundment. Provide adequate resettlement and compensation in accordance with RPF and RAP compliant with Lebanese Law.	Designer, RAP Developer and Project Proponent
	Loss of existing communities	Not Expected	n/a		
	Loss of individual homes	Unavoidable	Moderate		
	Loss of non-agricultural business premises	Not Expected	n/a		
	Loss of productive land	Unavoidable	Major		
	Loss of temporary employment	Unavoidable	Major		
	Loss of permanent employment	Expected	Moderate		
	Loss of historic and cultural heritage	Unavoidable	Major	Salvage cultural property and reconstruct within existing communities. Avoid inundation of immoveable sites such as burial grounds. Undertake rescue archaeology.	Project Proponent
Impoundment	Additional loss and severance of access	Expected	Moderate	Create alternative access roads around the reservoir;	Project Proponent
	Increased risk of seismicity	Expected	Major	Analyse hydraulic loading to assess seismic potential and avoid areas of high risk. Design to minimise seismic loading.	Designer
	Loss of natural vegetation	Unavoidable	Moderate	Increase planting around reservoir;	Designer
	Impaired water quality from uncleared vegetation	Unavoidable	Major	Vegetation and soil to be cleared prior to inundation. Treatment plant will provide suitable process stream to ensure water delivered to GBA of potable quality.	Contractor

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	GHGs from uncleared vegetation	Expected	Major	Vegetation and soil to be cleared prior to inundation.	Contractor
	Soil erosion along new foreshores	Expected	Major	Construct shoreline protection. Increase planting around reservoir.	Designer and Contractor
	Reservoir stratification	Expected	Major	Install provision for mechanical mixing where natural circulation insufficient.	Designer
Sedimentation	Creation of backwaters on tributary streams	Expected	Moderate	Promote development of wetlands. Promote reforestation of upper catchment slopes. Monitor reservoir depth to assess sedimentation. Operate reservoir to minimize sediment build-up. Allow for sediment loading in structural design.	Designer and Operator
	Loss of capacity and sediment build-up at dam	Expected	Moderate		
Upper Watershed Management	Road construction opens area to non-residents	Expected	Minor	Ban land clearance for new agriculture. Restrict access to previously remote areas.	Project Proponent
	Soil Erosion and Sedimentation	Expected	Moderate	Promote reforestation of upper catchment slopes and the expansion of existing forests.	Project Proponent
	Social unrest due to the restriction of human activity	Not Expected	n/a	Ensure new developments prioritize the local employment.	Project Proponent and Contractor
	Loss of water quality due to evaporation	Unavoidable	Major	Promote shoreline planting and reforestation.	Operator
	Impaired water quality due to discharges above dam	Expected	Moderate	Adopt an integrated planning framework and a strict ESMP, and provide effective enforcement. Developing sewerage and solid wastes systems for villages throughout the upper watershed in accordance to GoL master Plans.	Project Proponent
Lower Watershed Management	Reduced non-agricultural surface water resources	Unavoidable	Moderate	Provide agricultural extension and other services to promote low water-use crops and irrigation practices. Ensure resettled communities are adequately resourced without detriment to existing communities.	Project Proponent
	Reduced water resources for existing agriculture	Unavoidable	Moderate		
	Water-use conflict	Expected	Moderate		
	Loss of stock watering points	Not Expected	n/a	None required	

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	Salinization of downstream floodplain	Expected	Moderate	Provide adequate compensatory flows to leach salt build-up.	Project Proponent
	Reduced dilution of chemical residues, sewage	Expected	Moderate		
	Reduced Dissolved Oxygen downstream	Expected	Moderate	Provide for multi-level releases to avoid the discharge of anoxic water. Design for aeration downstream of dam site;	Designer
	Scour by water released under increased head	Expected	Minor	Provide for energy dissipation from dam outflow; Provide for sediment trap and its orderly release.	Designer
Ground Water	Reverse ground water flow upstream of the dam	Expected	Moderate	Undertake hydrogeological study and modelling to assess impact on ground water levels and flow;	Designer
	Change in water table	Expected	Moderate		
	Reduced downstream aquifer recharge	Expected	Moderate	Provide adequate releases to maintain recharge; Provide downstream structures to induce shallow recharge.	Designer and Operator
	Deterioration in ground water quality	Expected	Major	Promote ground water resources management.	Project Proponent
Biodiversity and Habitats	Loss of indigenous flora	Unavoidable	Moderate	Promote the colonization of shoreline trees. Provide for species rescue and relocation. Minimize disturbance of non-inundated vegetation.	Operator
	Loss of terrestrial habitats	Unavoidable	Moderate	Provide mammal-resistant fencing. Provide for species rescue and relocation. Provision safe crossing points to enable dispersal and links between fragmented populations.	Operator and Project Proponent
	Reduced downstream biodiversity	Expected	Moderate	Provide compensatory discharges to maintain downstream biodiversity.	Operator
	Build-up of weed and algal mats around spillways, etc.	Expected	Moderate	Control algal blooms by using appropriate additives (e.g. 22 kg/ha $CuSO_4$). Harvest weed and algal growth for compost, fodder or biogas.	Operator

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	Disruption of flyways	Expected	Minor	Planting trees to create habitat corridors; National hunting ban to be enforced as per Law 580/04.	Operator
	Reduced aquatic habitats	Expected	Major	Provide fish leats, ladders and other by-passes. Protect spawning grounds; Incorporate sensitive design, i.e. allow shallow areas for spawning, etc.	Designer
	Barrier to fish migration and loss of spawning areas	Expected	Moderate		Designer
	New habitats for migratory bird species	Expected	Positive	Promote reforestation and areas of dense shrub.	Operator
	New farming fish species	Expected	Positive	Ban the introduction of exotic species such as trout, bass, tilapias, and mosquito fish. Promote the user of native species.	Operator
Agriculture	Inundation of agricultural land	Unavoidable	Major	Consider stripping highly fertile soils from reservoir area and spreading on adjacent less fertile land.	Project Proponent and Contractor
	Loss of fertile soils	Unavoidable	Major		
	Loss of yet-to-be-harvested crops	Unavoidable	Major	Consider relocating the poly-tunnels and their content with no actual loss, or move when fallow.	Project Proponent
	Derogation of downstream irrigation	Unavoidable	Major	Use agricultural extension to promote low water-use crops species and irrigation practices.	Operator
	Fertilizer use upstream increases nutrient load	Expected	Moderate		
	Increased soil salinity downstream	Expected	Major	Provide compensatory discharge to leach soil salts.	Operator
Settlement and Resettlement	All residents in the inundated area will be displaced	Unavoidable	Moderate	Provide adequate compensation in accordance with RPF and RAP compliant with Lebanese law.	Project Proponent
	Disaggregation of communities	Not Expected	n/a	No significant communities to disaggregate. Resettlement unlikely to result in conflict as resident Lebanese PAPs will keep within their previous communities.	
	Impact on indigenous groups/lifestyles	n/a	n/a		
	Social conflict between existing residents and PAPs	Not Expected	n/a		
	Competition for resources between residents & PAPs	Not Expected	n/a	None required.	

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	Particular impacts on vulnerable groups	Expected	Moderate	Provide social support to vulnerable groups. Use resettlement to aid poverty alleviation.	Project Proponent
Public Health	Increase in water-related diseases	Major	Moderate	Implement health awareness campaigns and provide adequate health care facilities. Maintain water free of algae. Develop and implement an Emergency Response Procedures.	Operator
	Increase in mosquito breeding sites	Major	Moderate	Implement health awareness campaigns and provide adequate health care facilities. Spray mosquito breeding sites if necessary.	Operator
	Climatic changes such as increased humidity & fogs	Expected	Moderate	None.	
	HV transmission lines in proximity to housing	Not Expected	n/a	Power generated at dam to be used at dam. New turbines for network distribution to be located at existing plant will utilize existing cableways.	
Indirect Issues	Negative impacts from increased urban development	Expected	Moderate	Adherence to coordinated sustainable development via Shoreline Development Master Plan.	Project Proponent
	Upper catchment activities limit dam efficiency	Expected	Moderate	Restrict activities on the upper watershed to those that have minimal environmental and social impact.	Project Proponent
Construction Issues	Construction site unsightliness	Expected	Moderate	Construction contractors to offer priority employment to PAPs and other local residents; Contractor to develop and implement a comprehensive Construction Environmental and Social Management Plan.	Contractor
	Increase traffic generation and exhaust emissions	Expected	Moderate		
	Noise and dust from site clearance and excavation	Expected	Moderate		
	Temporary works such as drainage diversion	Unavoidable	Moderate		
	Camp working area sewage and solid waste disposal	Expected	Moderate		
	Emissions from batching plants & power generators	Expected	Moderate		
	Increased hunting, egg collecting, live capture	Expected	Moderate		
	Social conflict between workers and residents	Expected	Minor		Contractor

Issue	Potential Impact	Likelihood	Likely Severity	Mitigation Measures	Responsible Party
	Importation of contagious diseases	Expected	Minor		
	Fuel spillage and waste oil disposal	Expected	Moderate		

Likelihood

	Not Expected
	Expected
	Unavoidable
	Not Applicable

Likely Severity

	Minor
	Moderate
	Major
	Positive
	Not Applicable

Table.8.22: Summary of Proposed Environmental and Social Impact Mitigation Measures and Estimated Costs

Issue	Mitigation Measures	Responsible Party	Basis of Cost	Estimated Cost ($)
Land Take and Resettlement	Archaeological rescue and safe storage of artifacts	DGA and Project Proponent	Consultant's estimates with storage site acquisition, clearance, fencing and building- Included in Construction Costs	$500,000
	Relocation of Mar Moussa Church, St. Sophia's Monastery, and architectural salvage	Maronite Diocese of Saida and Project Proponent	Deconstruction and reassembly of main walls, demolition and replacement of church interior vaulting. Included in construction costs.	$2,000,000
Impoundment	Increase planting around reservoir.	Operator and MoA	Tree band 12 m wide, planted on a 3 m grid, over half the reservoir periphery	$3,000,000
	Design and install provision for mechanical mixing where natural circulation insufficient.	Designer and Contractor	Included in construction costs	n/a
Sedimentation	Promote development of wetlands.	Operator	Promotion budget only	$10,000
	Promote reforestation of upper catchment slopes	MoA and Municipalities	Promotion budget only	Included above
Upper Watershed Management	Promote reforestation of upper catchment slopes and the expansion of existing forests.	As above	Promotion budget only	Included above
	Adopt integrated planning, a strict ESMP, and effective enforcement.	GOL, DGUP, Project Proponent & Municipalities	Of wider benefit that GBWSAP and should come from GOL budget	n/a
	Develop sewerage and solid wastes systems for villages throughout the upper watershed.	Project Proponent, MEW, and Municipalities	various documents supplied by CDR	$23,000,000
Lower Watershed Management	Design and provide for multi-level releases to avoid the discharge of anoxic water, and for downstream aeration.	Designer and Contractor	Included in construction costs.	n/a
	Design and provide for energy dissipation from dam outflow and sediment trap	Designer and Contractor	Included in construction costs.	n/a
Biodiversity and Habitats	Biodiversity Management Plan	Mitigation Activities and specialist staff.	Biodiversity specialist and species specialist part-time for pre-construction, construction and reservoir filling.	$687,000

Issue	Mitigation Measures	Responsible Party	Basis of Cost	Estimated Cost ($)
Agriculture	Provide agricultural extension to promote low water-use crops species and irrigation practices.	MoA and MEW	Extension office for 2 years, with vehicle, admin support, etc.	$500,000
	Provide compensatory discharge to leach soil salts.	Operator	Included in construction costs	n/a
Public Health and Safety	Implement health awareness and water safety campaigns.	MoH and Operator	Awareness and safety campaigns	$200,000
	Spray mosquito breeding sites if necessary.	Operator	Operator, protective clothing, water-safe chemicals, labor, 3 applications/year	$2,000,000
	Provide for Public Safety at dam site	Designer, Contractor and Operator	Fencing and signage (Included in construction costs)	n/a
	Develop and implement an Emergency Response Procedures.	Designer, Operator, Civil Defense and Municipalities	Included in GOL costs	$1,000,000
Construction Issues	Contractor to develop and execute a comprehensive Construction Environmental and Social Management.	Project Proponent, Contractor and Construction Manager	Included in construction costs. 'Best Practice' construction only.	n/a
Total Costs of Mitigation beyond normal Design, Construction and Operation				$32,897,000

8.6.3 Environmental and Social Monitoring

8.6.3.1 Introduction

This section of the ESIA outlines the proposed Environmental Monitoring Plan for Bisri dam and reservoir. **Section 8.6.7** presents the Key Performance Indicators for the Project, while **Section 8.6.8** presents Environmental Monitoring and Reporting which includes:

- Baseline Condition Monitoring;
- Site Inspections;
- Environmental Quality Monitoring;
- Complaints Monitoring;
- Bi-Annual EMP Implementation Reports;
- Land Acquisition and Resettlement Reporting;
- Environmental Auditing;
- Post-Construction Operational Reporting; and,
- Monitoring Programme.

8.6.3.2 Key Performance Indicators and Standards

The Key Performance Indicators and Standards for the project are listed in Table 8.23.

Table 8.23: Key Performance Indicators and Standards

Parameter	Standard/Indicator
During Design	
Dam Site Confirmation	Optimum/minimal land take and E&S impacts
Dam Design	World Bank Operational Policy, *OP.4.37, Safety of Dams*.
During Construction	
Potable Water	Lebanese Drinking Water Standards
Air Quality Emissions	Lebanese Stack Emission Standards for Fixed Plant Lebanese Exhaust Emissions Standards for Mobile Plant and Vehicles
Noise	Lebanese Noise Emission Limits for Outdoor Areas
Worker's Health and Safety	No. of accidents and working days lost Compliance with World Bank Health and Safety Guidelines Compliance with Lebanese Labor Law Compliance with Lebanese Standards for the Discharge of Wastewater to Watercourses
Public Safety	No. of incidents involving the public
Vibration	No. complaints from the public
Cultural Heritage	The documentation of Chance Finds
During Operation	
Dam Safety	World Bank Operational Policy, *OP.4.37, Safety of Dams*, and, Reports of the Dam Safety Panel
Water Quality	Lebanese Standards and WHO Guidelines for Drinking Water

Design standards to be confirmed by design consultant

8.6.3.3 Environmental Monitoring and Reporting

The mitigation measures to be adopted to minimize potentially negative impacts during construction can only be determined via an appropriate monitoring program. Such program involves the objectives below:

- Monitor any significant changes to the project physical, chemical, biological and social environment;
- Determine if such changes result from project or non-project causes;
- Determine the impact of non-compliance with national and international standards;
- Assess the effectiveness of impact avoidance and mitigation; and,
- Highlight unforeseen areas of concern and any need for additional measures.

For environmental monitoring to be both effective and meaningful to the implementation of the ESMP, the results need to be available to all concerned parties, with milestone reports also made available for public consultation, perhaps most easily via CDR's GBWSAP web page.

Pre-construction environmental performance in respect of the design standard adopted will be reported by the design consultant in the Final Design Report.

The primary reporting of environmental issues during the period of construction will be as follows:

- The results of individual monitoring campaigns will be reported by the contractor to the Construction Manager as and when they become available;
- Individual Site Inspection Reports by the Construction Manager's inspectors, reported at Monthly Contract Progress Meetings;
- The results of environmental quality monitoring received during the month will be appended to Monthly Progress Reports; and,
- Bi-annual ESMP Implementation Reports prepared by the Construction Manager, to include the results of individual site inspections and environmental quality monitoring, together with a discussion of the implications and issues arising.

Post-construction environmental monitoring will primarily focus on the safety and development of the upper catchment of dams, the quantity of reservoir inflows and outflows, and water quality within the reservoir and delivered to supply, in addition to the installation of infrastructure especially wastewater and tree planting to reduce soil erosion.

Baseline Condition Monitoring

Baseline measurements of existing surface water flows, their quality, and sediment loading should be taken to provide values against which to measure the expected future impacts of the project and thus to which operational monitoring can be assessed.

The proposals for the baseline monitoring of water quality and flow have been highlighted in Section 4.9 *Water Quality*, above. The TOR for an appropriate Consultancy Contract to run up to the time the dam is commissioned is given in Appendix K.

Site Inspections

For site inspections and monitoring to be effective, it will be necessary for authorised personnel from MEW, MoE and the construction manager to have guaranteed access to all project sites, for which a suitable clause must be incorporated into contract documents. Visual inspections by water establishments should be provided monthly around the reservoir and weekly around the dam.

The day-to-day visual monitoring of construction activities will be the primary mechanism by which the contractor's performance will be shown to comply with good construction practice, applicable legislation, standards and guidelines, and the requirements of the ESMP. Whilst these inspections will be the responsibility of the construction manager, MEW and MoE may wish to undertake occasional independent inspections in respect of issues over which they have particular concern.

To facilitate inspections, a standard pro-forma checklist will be deployed. This will detail the locations and activities inspected, identify areas in which the Contractor is non-compliant with the ESMP, and propose remedial action. Copies of these reports shall be circulated to the CDR Project Manager, the Construction Manager and the Contractor. Where remedial action is proposed, discussions with the Contractor shall be held within a period not exceeding 24 hours to ensure the requirements have been understood and the works put in hand. Areas of high impact sites will be inspected monthly. Other major activities of less impact level should be inspected every 3 months, while a general site inspection will be undertaken twice per year.

Daily site reports will be tabled at monthly Progress Meetings, at which *Environmental Issues* will be a specific agenda item specifying details on the location, activities, facilities as well as proposing remedial actions. The Minutes of Meeting will summarize areas of non-compliance and/or areas where additional mitigation is required. Monthly Progress Reports will also include a specific section on *Environmental Issues* and will summarize issues arising, compliance and non-compliance during the reporting period, and issues outstanding. These reports will primarily be circulated internally within CDR, the Construction Manager and the Contractor. During the preparation of any or all reports, access will be granted to the more routine and more frequent site inspection records retained by the construction manager as part of his normal duties.

Financing of the environmental site inspections and their reporting is deemed to be included in the cost of broader construction activity inspections born by the Construction Manager.

Environmental Quality Monitoring

Environmental Quality monitoring undertaken by the Contractor will be reported on a regular basis and will be reported as part of the project quarterly progress reports. Where this involves direct measurement of a given parameter, the results should be reported to the Construction Manager within a period not exceeding 24 hours. Where numerical or laboratory analyses are required, the outcome should be reported within 24 hours of receipt of the analytical results. All laboratories and other third party reporting enterprises shall be subject to pre-approval by CDR.

Complaints Monitoring

Additional monitoring needed to investigate specific complaints made by riparian landowners or the public arising from construction activity will be given highest priority and reported in good time for remedial action to be identified and executed with the minimum of delay.

Reporting of all complaints monitoring results will include the following:

- Details of the complaint, including its nature, name and contact details of the complainant, and the reported severity of the incident;
- Sampling, methodologies, equipment calibration reports, and other background material, and the empirical results;
- Details of any extreme or abnormal events that may have influenced the empirical findings;
- Analysis of the findings highlighting any changes of significance and discussing the causes of change;
- Recommendations on actions to be taken; and
- Follow up on the recommendations of previous reports.
- If the PAP is not satisfied with his award and according to the standard appeal procedures, a representation to Appeals Committee may be made, but both the cost of representation and the time to receive a decision may be a significant deterrent, particularly to poorer PAPs.

To overcome additional costs and delays in solving compensation disputes, often experienced in adopting the standard appeal procedures, a Grievance Redress Mechanism (GRM) could be initiated once PAPs have been notified about his compensation value and before any Appeal recourse. This procedure helps in settling grievances amicably through Local Authorities. It generally precedes the appeal to the court and is readily accessible to all PAPs. Each complaint is assessed on a case by case basis. GRM could challenge the compensation value but neither the Expropriation Act nor the Land-Take over decision. PAP that is deemed significantly affected by the Project may claim additional forms of assistance.

Bi-Annual EMP Implementation Reports

Incorporation of individual site reports, relevant sections of Monthly Progress Reports, and all monitoring results from the period being reported, into Bi-Annual ESMP Implementation Reports will highlight persistent non-compliance or continued negligence by Contractors and present all supporting documentary evidence. The circulation of bi-annual reports will include concerned municipalities, the Ministry of Environment, and Ministry of Energy and Water. Bi-Annual reports should also be uploaded to the CDR GBWSAP web page. Copies shall also be made available for public consultation.

Land Acquisition and Resettlement Reporting

Progress on land acquisition and resettlement will be reported as laid down in the GBWSAP Resettlement Action Plan at the following intervals.

- From the approval of the Expropriation Decree by the Council of Ministers for a period of six months – monthly;
- Thereafter, bi-annually until all outstanding land acquisition and resettlement issues, including Appeals to Court, have been settled.

Two types of land acquisition monitoring exist, the internal and external monitoring.

Internal Monitoring:

The internal monitoring of the Resettlement Action Plan (RAP) will be undertaken by the Community Liaison Officer (CLO).

The CLO and his staff will:

- Facilitate the work of the external and independent monitors through effective record keeping and the preparation of periodic Project Progress Reports; and,
- Monitor the progress of the RAP implementation against predetermined performance targets.

External Monitoring:

Progress in the implementation and monitoring of the RAP and associated mitigation measures will be reviewed as a key element of project supervision missions undertaken by the World Bank and other agencies. These missions would include field review of implementation efforts and identification of problems, which may occur. Review of RAP implementation will also be included in the Mid-Term Review and the Implementation Completion Report, which are prepared for all World Bank supported projects.

In addition to the standard pro-forma format, these progress reports will include descriptive narrative on the following:

- Progress on land acquisition and resettlement;
- Progress on the disbursement of compensation;
- Community Liaison Activities;
- Grievances registered, actions taken, and the outcomes;
- Issues related to female heads of Households and Vulnerable Groups;
- Other issues on which the CLO wishes to report.

A separate social survey of resettled and relocated PAPs will be undertaken as part of the project evaluation six months after resettlement.

Environmental Auditing

No specific provision is made for Environmental Audits. The Ministry of Environment will *de facto* audit the bi-annual reports of the Supervision Consultants as approved the Project Proponent.

Although international funding agencies are unlikely to undertake formal auditing, future missions during the period of construction can be expected to include members tasked with particular responsible for environmental and social issues. Effective auditing will be established by the environmental and Social Advisory Panel.

Post-Construction Operational Reporting

Post-construction monitoring will take the form of routine site inspections to confirm Bisri Dam and all its appurtenances are operating properly. These should be undertaken at least monthly, even when the off-takes and hydropower plant are not operational, but with operational experience this time period may be extended during the dry season and/or reduced during the rainy season.

No provision is also made for operational reporting. The MEW will be the effective owner of the dam and decide policy, while BMLWE will be operator, incorporating existing and new GBWSP O&M practices, including reporting procedures.

Environmental and Social Advisory Panel

As previously discussed, an Environmental and Social advisory panel will be appointed to provide independent review of, and guidance on, the treatment of environmental and social issues associated with planning, design, construction and operation of Bisri dam and reservoir from the date of their appointment, which should be imminent, to a period expected to be not less than 3 years into dam operation. The Panel will meet twice each year and make its findings and recommendation to the project proponent and the World Bank, for whom they will also provide oversight of safeguard policy requirements.

Monitoring Program

The proposed program of environmental and social monitoring is summarized in Table 8.24 and includes the means by which the required information will be obtained, the frequency of collection and the responsible organization. The cost of construction environmental monitoring for ESMP implementation is assumed to be incorporated within construction costs, i.e. those of the contractor and the construction manager, while those of operational monitoring will be incorporated in BMLWE operating costs.

Table 8.24: Environmental Quality Monitoring Requirements

Category	Indicators	Location	Method	Duration	Frequency	Purpose	Expertise Required	Responsibility	Estimated Cost	Total Estimated Costs
Pre-Construction Environmental Quality Monitoring										
Surface Water Quality	Lebanese Potable Water Standards	4 locations; Nahr Barouk and Wadi Bhannine at extremities of reservoir, two other seasonal inflows	Water sampling and full laboratory analysis	Ongoing until completion of construction and throughout operations	Quarterly, varied to include high and low flows	To confirm background conditions for comparison in operational monitoring	Experienced surface water sampler	BMLWE	$1,500 per sample	$330,000 (including staff costs)
Rate of Sedimentation	Volume and size of sediment captured	Nahr Barouk and Wadi Bhannine at extremities of reservoir	Sediment capture behind a small weir or sediment capture pit	Ongoing	Quarterly, varied to include high and low flows	To confirm design assumption	Hydrologist	BMLWE	$15,000 per site	$600,000
Rescue Archeology and Heritage Relocation	Archaeological finds unearthed and documented	Marj Bisri	Excavation, observation and documentation	Ongoing until completion of construction	Seasonally	To make sure implementation strategy is implemented	Archaeologist	DGA	$120,000	$ 120,000
	Structures removed and reconstruction	Mar Moussa	Dismantling and reassembling	Prior to construction	Monthly	To address community concern for heritage	Building conservationist	DGA	US$ 250,000	$ 250,000
Land Expropriation and Resettlement	Progress of expropriation execution. PAP satisfaction	All lands to be acquired under the project	Expropriation and resettlement reporting	Throughout expropriation	Monthly for 6-months, then bi-annually.	To monitor progress and ensure transparency	Community Liaison Office	CDR	500,000	500,000
Construction Environmental Quality Monitoring										
Site Inspection	General construction activity	All sites associated with the Bisri construction	Visual and descriptive, against check list	Ongoing throughout period of construction	Daily	To ensure compliance with good construction practice and EMP	Environmentalist with construction site experience	Construction Manager	$2,000,000	$ 2,000,000
Complaint Investigation	Any parameter relevant to the nature of the complaint	At or in the vicinity of sites for which complaints are received	As appropriate for the parameter being monitored	As necessary	As necessary	To investigate complaints and provide a basis for redress	Environmentalist with experience of field monitoring and analysis	Contractor and Construction Manager	Depends on complaints received	n/a
Health and Safety	Absence of unauthorized public. Injuries and work days lost among workers.	All sites of construction and project related activity	Primarily visual and descriptive, against a check list. Time card records	Ongoing throughout period of construction	Monthly	To protect the public and workers in accordance with H&S BMPs	Experienced H&S site supervisor	Contractor and Construction Manager	Included in construction costs	n/a
Air Quality	Lebanese atmospheric emissions standards,	Contractors' work sites and selected sensitive receptors	Visual assessment and portable air quality equipment	Dependent on source	On suspicion of non-compliance	To prevent air pollution	Site inspector	Contractor	Included in construction costs	n/a

Category	Indicators	Location	Method	Duration	Frequency	Purpose	Expertise Required	Responsibility	Estimated Cost	Total Estimated Costs
	fixed and mobile									
Noise	Lebanese ambient noise standards	At selected sensitive receptors	Ambient noise monitoring equipment of approved manufacture	Over 1 hour during the working day	On suspicion of non-compliance	To prevent noise nuisance	Site inspector	Contractor	Included in construction costs	n/a
Cultural Heritage	Documented Chance Finds	Any unknown remains unearthed during construction	DGA standard procedures	As necessary	Every find DGA deem worthy of recording	To improve understanding of Lebanese and optimize relic recovery	DGA Inspector	Contractor and DGA	Depends on number of finds and delay caused	n/a
Post-Construction Environmental Quality Monitoring										
Air Quality	Stack emissions from stand-by generators	At stacks and sensitive receptors	Portable stack insertion monitors and other monitors	Over 12 hours	Every 3 months during the operating season	To prevent air pollution	Plant Engineer	BMLWE	US$ 500 per sample	US$ 5,000
Workers Health and Safety	No. of accidents and working days lost	On the dam and reservoir sites	H&S records	Ongoing	Ongoing	To monitor compliance with Operator's H&S Manual.	Operator's Health and Safety Inspector	BMLWE	Included in ongoing O&M	n/a
Public Health and Safety	No. of accidents and injuries.	Dam, reservoir and environs	Accident reports	Ongoing	Ongoing	Promote security and safety, and adequacy of signage.	Compliance with Operator's H&S Manual and EMP.	Compliance with Operator's H&S Manual and EMP.	Included in ongoing O&M	n/a
Dam Safety	Dam Safety Panel inspection reports	Dam site	Visual inspection and review of Dam Safety File	Ongoing	Throughout construction and every 3-5 years, post construction	To identify early warning signs of potential failure	Dam Safety Inspection Panel	BMLWE/CDR	$25,000 per inspection	$ 25,000
Reservoir water	To check development of stratification	2 fixed sampling points within reservoir	Multiple depth sampling and on-site analyses	Seasonal	Monthly from May to October	To confirm adequacy of mixing to limit stratification	Experienced water sampler and boatman	BMLWE	$1,000 per sample	$30,000
Groundwater	Groundwater flow and water quality	Selected springs and wells	- Flow gauging, water level monitoring and sampling	Ongoing	Bi-annual	To identify changes in groundwater regime	Hydrogeologist	BMLWE	$3,000 per sample	$30,000
Biodiversity	Diversity of species and habitats	Dam, reservoir and environs	Visual observation and survey	Seasonal	Annually for 3 years, then every 5 years	To assess fish migration and reduced biodiversity	Ecological team	BMLWE	$20,000	$80,000
Downstream abstraction	Adequacy of environmental flows	Downstream abstraction sites	Survey of abstractors	During Autumn	Annually	Optimize abstraction management	Agriculture extension officer	MoA/MEW	$10,000	$50,000
Reservoir Sedimentation	Sediment build up	Reservoir	Depth or Echo sounding	Ongoing	Annually, in May or June	To check loss of dead storage and protect intakes	Mechanical Engineer and Boatman	BMLWE	$10,000	$50,000
Induced Development	Adherence to Shoreline Master Plan	Surrounding lands	Enforcement of planning regulation	Ongoing	Ongoing	Safeguard investment in dam and protect water resources	Development inspector	Planning Authorities and Municipalities	No cost to project	n/a
Total Monitoring Costs										$4,070,000

Note: Total Estimated Costs are calculated for 5 years of operation

ESMP Planned Implementation

Figure 8.17 shows the proposed schedule for the implementation of the ESMP pre-construction, during construction, and during operation.

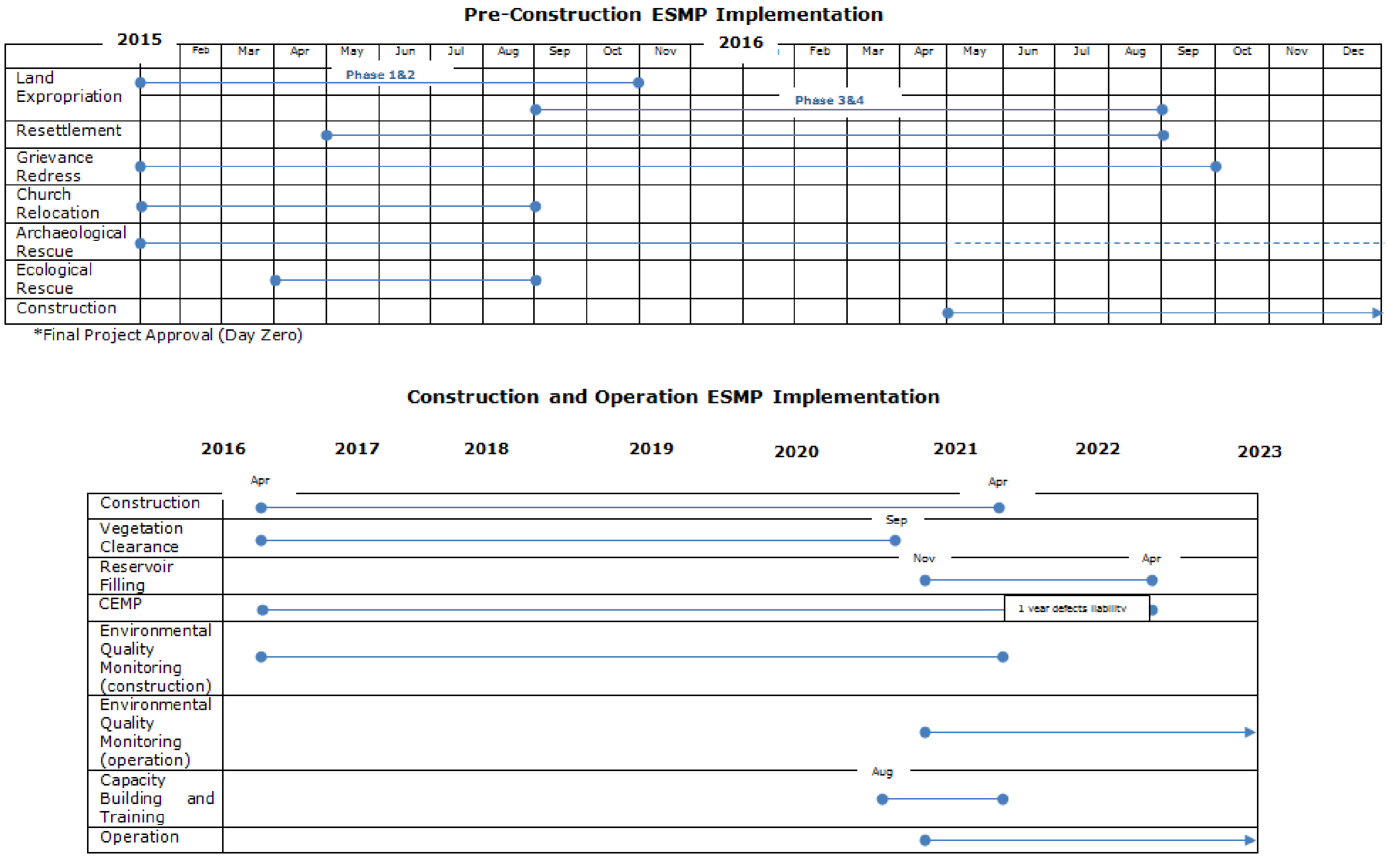


Figure 8.17: Proposed Schedule for the Implementation of the ESMP

8.6.4 Institutional Strengthening and Capacity Building

The requirements for the post-construction management, operation and maintenance of a large dam such as Bisri are not to be taken lightly. With the exception of Qaraoun Lake managed by the Litani River Authority and from which water is taken for hydropower generation and irrigation, neither MEW nor BMLWE have significant experience of managing and operating a dam to supply such a large urban service area. It is therefore expected that the BMLWE will also take responsibility for the operational management and maintenance of Bisri Dam and Reservoir.

8.6.4.1 Institutional Structure and Responsibilities

The prime institutional stakeholders in respect of expected management structure and responsibilities are shown in

Figure 8.18 and Table 8.25, respectively.

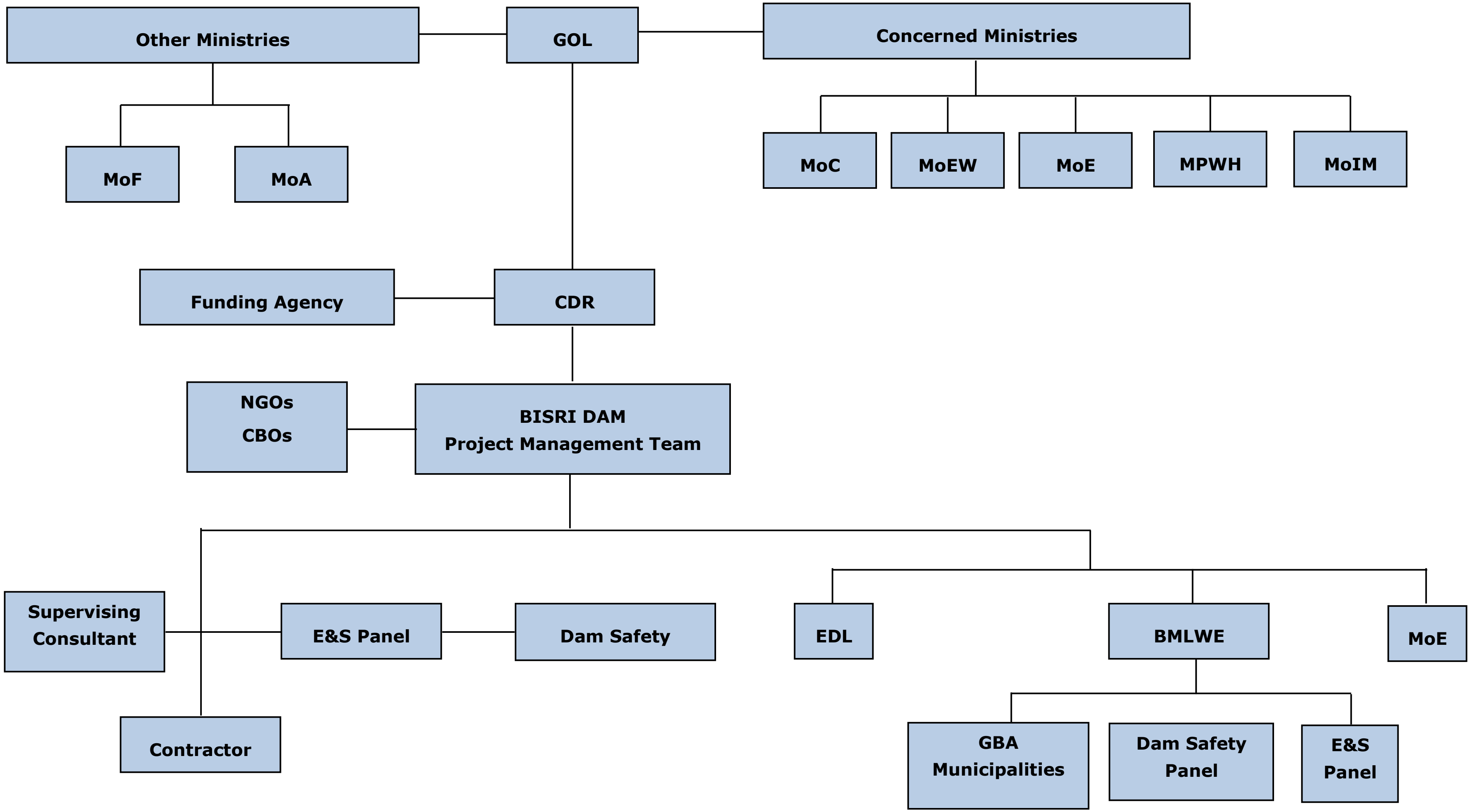


Figure 8.18: Institutional Structure for Bisri Dam Management

Table 8.25: Prime Institutional Stakeholders for ESMP implementation and Bisri Dam Management

Institution	Prime Responsibilities
CDR	In its planning role, commissions specialist studies and dam design, secures funding, pre-qualifies contractors and manages the tender process through to award, executes land acquisition, and on behalf of GoL acts as the contract administrator.
MEW	The effective dam owner; establishes operational policy including determining available yields and environmental releases. Ensures formal Dam Safety Panel inspections are undertaken according to pre-agreed schedules.
BMLWE	Day-to-day operational management of the dam and its appurtenances, implements MEW policy, ensures environmental yields are delivered to riparian owners. Maintains the dam, the reservoir shoreline and operational monitoring. Facilitates dam safety and E&S panel inspection visits. Responsible for public safety including the maintenance of warning signage. Manages structures and water resources downstream of the offtake upstream of the Joun power plant to the Awali Conveyor, the treatment plant, post-treatment distribution, leakage reduction, cost billing, etc.
MoE	Setting and monitoring the adequacy of environmental flow releases to cater for non-abstraction requirements. A *statutory consultee* for the Dam Safety Panel. As existing laws, shoreline development environmental permitting.
EDL	Purchase from BMLWE the hydropower output and sell it on customers at a rate that at least ensures cost recovery.
MPWH	Implements the Bisri Reservoir Shoreline Development Master Plan.
MoA	Puts in place agricultural extension services to maximise the efficiency of downstream irrigation practices for minimum water use. Advises MEW on the adequacy of releases to maintain legal abstractions. Advises the dam operators on the permitting of commercial fish farming within the reservoir.
DGA	Collection of pottery shards, glass and other artefacts from surface soils and shallow excavations at previously identified sites; Trial pitting and/or geophysical surveying at selected sites where buried structures may be present; Major excavation and the removal of material at Marg Bisri Roman temple; Excavations in the vicinity of Mar Moussa Church and the remains of St. Sophia's monastery. Archaeological finds unearthed and documented during construction
Diocese of Saida	Deconstruction, removal and reconstruction of Mar Moussa Church and of St. Sophia's Monastery; and, Scavenging old building materials from the ruins of 19-20th century houses to provide for new construction adjoining the relocated Mar Moussa Church.
Concerned Municipalities	Implementation of Land Expropriation Procedure
MoSA	Implementation of the RAP especially regarding refugees registered at the UNHCR
UNHCR	Assist the 79 registered UN refugees with resettlement to UNHCR designated refugees camps if they are willing to. Facilitate the other 23 non-registered refugees to get registered with the UNHCR and eventually assist them with their resettlement to refugees' camps.
LRA	Manages the two hydropower plants anticipated through the Bisri project to offset lost hydropower at the Charles Helou power plant.

Operational Management

While CDR will oversee the implementation of dam construction and associated activities, MEW will become the de facto 'owner' on behalf of GOL. Two entities, both working under the tutelage of the Ministry will be involved in operational management; the BMLWE will take responsibility for operating the dam, discharging water to the treatment works and power plant, maintaining environmental flows, maintenance of the reservoir and the management of water quality, operation of the transmission system and the treatment plant. BMLWE will also be responsible for all aspects of onward supply and distribution to greater Beirut consumers.

BMLWE has the key role in water supply and treatment operations, distribution, billing and cost recovery for a service area that extends to 2205 km^2 and more than 2 million customers. Under Law No. 221 of 2000 and subsequent amendments water establishments are responsible for:

- Planning, building,, operating and maintaining potable and irrigation water transmission and distribution networks;
- Planning, building,, operating and maintaining domestic sewage collection networks and treatment plants;
- Ensuring the quality of water supplied to consumers;
- Recommending to GOL tariffs for water, irrigation and wastewater on the basis of prevailing socio-economic conditions;
- Oversee works, studies, and operations by private service providers.

BMLWE came into operation in 2005 and has managed 475,000 registered connections and supplies an estimate 176 MCM of water annually from springs, wellfields and surface reservoirs. The area that will benefit from the Bisri scheme covers some 210 km^2 between Nahr Damour and Nahr el-Kalb Rivers, and between the Mediterranean coast and an elevation of 300-400m.

The key water facility currently under BMLWE management is the water treatment plant at Dbayeh where Jeita/Qashqoush spring and ground waters are treated before being conveyed to Greater Beirut. In addition, BMLWE is assigned responsibility for distributing potable water from Chabrouh WTP to Kesrwane and Metn.

MEW working with BMLWE and EDL will prepare procedures for the operation of the dam, the release and control of water, both supplies to GBA and environmental flows, and releases for the generation and distribution of hydropower. GBWSP initiatives in water saving such as household metering, a volumetric tariff structure and reduce leakage will greatly improve operational efficiency and increase cost-recovery. With the Ministry of Agriculture, improved agricultural extension services need to be established to help upstream farmers reduce agro-chemical use, and downstream farmers to improve irrigation efficiency and reduce the volumes of water taken from the river. Premiums might be introduced for the production of organic crops, and compensation in kind; perhaps priority planning permits for landowners relinquishing their Rights to Water, introduced.

Day-to-day dam managerial tasks required throughout the year, despite the expected 6-month-operational period, will include but not necessarily be limited to, the following:

- Adhere to dam safety procedures including the maintenance of warning signage;
- Monitor downstream abstractions;
- Monitor the quantity and quality of releases to the GBA treatment plant;
- Ensure adequate releases to maintain environmental flows, given the requirement will change seasonally and with time;
- Monitor the quality of reservoir inflow and hydropower plant outflow;
- Monitor the development of lake stratification, and operate mixing facilities to limit the spread of eutrophic conditions to pre-determined levels;
- Limit the growth of algae and maintain fish stocks;
- Maintain the shoreline to limit wind and wave erosion;
- Monitor potential bloc-collapse from the high valley cliffs and take remedial action;
- Maintain the dam, the reservoir and their surroundings in a clean and litter-free condition; watch for fly-tippers;
- Facilitate Dam Safety Panel and Environmental and Social Advisory Panel inspections and implement their recommendations.

The tender documents will state clearly that it is the Contractor's responsibility to get all necessary permits from the concerned authorities and the CDR will only help in releasing the necessary letters to the concerned authorities. Some of these permits are:

- Environmental permit from the Ministry of Environment
- Permit for road construction from Ministry of Public Works
- Permit for deforestation from Ministry of Agriculture
- Building Permit from Urban Development Department, a subdivision of the Directorate General of Urbanism
- Permit for Quarries exploitation from the High National Council of Quarries, which is part of the Ministry of Environment

Operational Employment

The operation of Bisri dam and reservoir will necessitate a wide range of different skill sets. The types of staff required are expected to include those listed in Table 8.26. The numbers of individuals required for each position is only tentative and will depend on management efficiency, maintenance requirements, and involvement with associated activities such as recreational use of the reservoir. It is strongly recommended that BMLWE senior engineers responsible for overall operational issues be seconded to the design team and construction management prior to the commencement of operational duties.

Table 8.26: Likely Requirement for Bisri Dam Operational Staff

Position	No.	Prime Responsibilities
Bisri Site Manager	1	Overall management and organization. Oversight of development proposals
Deputy Manager Water Supply	2	Oversight of all water supply activities and the release of environmental flows
Deputy Manager Dam Safety	1	All aspects of dam safety including coordinating Panel inspections
Deputy Manager Reservoir Operations	1	Level control, water quality monitoring, aeration and mixing
Deputy Manager Shoreline Operations	1	Inspection of shoreline, public safety and signage, landscape management, vegetation control
Senior Engineer Dam operations	2	Assignment and supervision of day-to-day operational and maintenance tasks
Hydraulic Engineer	3	Performance monitoring and maintenance of hydraulic equipment
Mechanical Engineer	3	Performance monitoring and maintenance of mechanical equipment
Electrical Engineer	3	Performance monitoring and maintenance of all electrical equipment including the small hydropower unit at the dam
Maintenance Technician Mechanical Plant	2	Maintenance inspections, cleaning and repair
Maintenance Technician Electrical plant	2	Maintenance inspections, cleaning and repair
Maintenance Technicien non plant structures	2	Maintenance inspections, cleaning and repair
Craftsman/Labourer	4	Assist technicians with maintenance and repair
Janitor	2	Cleaning of offices and facilities
Groundsman	2	Maintain grounds and dam structures
Landscape Gardener	4	Maintenance of planted areas and vegetation control
Bankside Labourers	6	Maintain reservoir shoreline
Reservoir Labourers	6	Clear floating refuse from reservoir
Boatman	3	Manage and maintain workboats
Security/Gatekeeper	5	Prevention of unauthorized access.

Some of these positions will be full-time, some part-time during the operating season only or filled by staff seconded from other BMLWE activities. Sufficient numbers of staff will be required to work a shift system giving 24/7 cover with call-out support during the operational season. Additional employment is also likely to be generated by the expansion of hydropower generation at the existing Awali plant.

This employment makes no allowance for associated activities such as the management and operations of the Visitors Centre, which may include guides, antiquities wardens and conservators, not for involvement with any recreational use of the reservoir.

BMLWE must be *statutory consultees* for all planning or permit applications for any development or activity within the dam catchment area, and will therefore need appropriate staff to review these applications as they arise.

8.6.4.2 Institutional Strengthening

MEW and BMLWE will each need to establish specialist departments to oversee the management and efficient execution of their various responsibilities in respect of Bisri Dam, and to provide for the operation and management of future dams projects elsewhere in Lebanon.

The required institutional strengthening and reform is expected to be incorporated with broader reorganisation required for the successful management and operation of GBWSP facilities and proposals for increasing operational efficiencies.

8.6.4.3 Capacity Building and Training

In addition to the requirements for institutional strengthening identified in the previous section, the lack of dam management and operational experience extends to individuals. The operation and maintenance of Bisri dam will require a substantial programme of capacity building, particularly in the following activities:

- The operation and maintenance requirements of installed equipment;
- Operational management and supervision of large dams;
- The legal aspects of 'Rights to Water' and their practical implementation;
- Master planning development and oversight; and,
- Agricultural extension.

These requirements will need to be satisfied through a range of mechanisms including:

- The new employment of suitably qualified managers and maintenance staff;
- Training schemes for selected existing staff; and,
- Subcontracting selected services or indeed the overall management of the dam and reservoir pending the building of in-house capacity.

As part of the construction contract, it will be important for relevant BMLWE staff to be seconded to the teams of both the contractor and construction manager to receive hands-on knowledge and experience of the equipment and apparatus installed. This secondment must in addition and separate from any contract oversight on behalf of GoL these organisations may impart. On completion of construction, the contractor will be expected to compile a comprehensive Equipment Manual giving details of every item of mechanical, electrical and electronic equipment installed. This will include details and specifications of each item together with information on its operation and maintenance. The Contractor should ensure pre-identified BMLWE staff be trained on O&M procedures for the installed equipment. For selected items, generally the heavier duty and/or more sensitive items, the construction contract should allow for relevant staff to travel overseas for on-the-job training or for representatives from the manufacturers to be brought to Lebanon to train staff locally, as is appropriate for the particular equipment.

Notwithstanding the potential for training O&M overseas, selected BMLWE operations staff proposed for supervisory positions should be given the opportunity to visit and receive detailed briefing, including hands-on training, at dams of similar size and purpose outside Lebanon. Such training may be best undertaken in countries such as Algeria, France, Morocco, and Turkey, each of which have a large number of operational dams and also afford little or no language barrier to Lebanese workers. Such training may be provided through unilateral aid.

With few large master planning exercises outside the Beirut Central District, undertaken and managed by Solidere, and various urban expansion plans for the main cities and towns, capacity building in managing and executing urban plans in the public sector in While for the development of comprehensive Master Plans for both the development of the Bisri Reservoir Shoreline and adjacent hillsides, if this is indeed to be permitted, and for the installation of sewerage throughout all upper catchment villages, may be expected to be let to suitably qualified and experienced consultants, it will be necessary for CDR, MEW, DGUP, MOE, MOSA and municipalities to have staff trained in the oversight of such projects with the capability of making a meaningful and appropriate contribution to plan development.

Internal capacity building is likely to be required within MEW’s legal team, to allow them fully understand the issues surrounding the ‘Right-to-Water’ in Lebanon, in particularly the rights of downstream riparian owners.

While MOE and the construction manager can be deemed to already have a good understanding of the environmental quality monitoring required under the CEMP, the CM environmentalist and the contractor’s environmental specialist will arrange a seminar for MOE oversight staff on site. Held during the mobilisation period, this training will provide familiarity with the site, confirm the parameters to be measured, the equipment to be used and other details of the monitoring programme. Prior to commissioning, BMLWE staff responsible for operational environmental monitoring will also need to be trained, by the CM environmentalist and/or as part of the operational training of installed equipment, as is seen to be appropriate at the time.

While MoA already provides extension services, the consensus among experienced agriculturalists is that this does not provide the level of expertise required to optimise farming efficiencies. Capacity building of staff in respect of modern low water-use crop species and irrigation equipment and practices should therefore be provided.

Of particular concern during both construction and operation will be Health and Safety. Aspects of Dam Safety and Public safety have been respectively discussed in Sections 8.4.3 and 8.4.4 above, the capacity for which is primarily provided for through the Dam safety Panel and the public signage and limitations on access incorporated into construction requirements. Of particular concern in respect of the need to build capacity will be occupational health and safety, for both temporary construction workers and for the permanent operational staff of Bisri Dam and reservoir.

As part of Dam design, Emergency Preparedness has been addressed in respect of dam failure and discussed in Section 8.2.3.2 above, but the response mechanism established will also serve other emergencies such as fire, explosion, bomb threats and spillage of hazardous materials into the reservoir. Plans for individual incidents will be determined by the dam operator.

Extensive capacity building will be required in respect of occupational health and safety during construction and the Contractor's CEMP for the project will contain detailed H&S requirements and procedures. The appointed contractor and the construction manager (supervision consultant) will have dedicated H&S officers attached to their teams on site. In unison, these officers will hold training courses for all contractors and construction management staff at all levels from project manager through site supervisor and foreman to labourer. Approved sub-consultants and sub-contractors will undergo the same training, as will regular visitors from CDR, MEW, DGA, MOE, BMLWE and other organisations. Occasional (day) visitor's will be briefed on H&S requirements before they are allowed to pass from the reception area to construction areas. The contractor's H&S provisions will also include his activities in respect of labour camps and borrow areas, and staff using these will also undergo the training courses.

Training will also be given to relevant staff for specifically hazardous duties, such as handling hazardous materials, working in confined spaces, and electrical safety.

8.6.4.4 Cost of Capacity Building

Although significant capacity building has been identified, much of the cost will be inherently included via the application of 'best practice' construction and operational procedures. Much will also be achieved with time and covered by increased revenue from BMLWE consumer subscriptions.

As part of the establishment costs, the dam operator will immediately need to build capacity in dam management and operation. As recommended above, it is expected that the Deputy Managers for Dam Safety and reservoir operation, listed in Table 8.27, will need a minimum of two-month on-the-job training with an experiences dam O&M organisation outside Lebanon. The Senior Engineer, specialist engineers and technicians, also listed in Table 8.27, 15 persons in total, should be seconded to work with the contractor's M&E team and specialist supplier's sub-contractors during equipment installation, testing and commissioning.

The cost of this training and capacity building is estimated as follows:

For the Deputy Managers:
2 persons each sent for 2-month dam management training overseas
at $18,000/person/month: US$72,000.

For the Engineers and Technicians:
15 persons each seconded to the contractor for 1-month
at $8,000/person/month: US$120,000.

Total capacity building costs specific to Bisri Dam immediate requirements: US$ 192,000.

8.6.4.5 Total Costs of the ESMP Implementation

Table 8.27 summarizes the total costs of the ESMP implementation assigned for mitigation measures, monitoring, monitoring reporting, and capacity building.

Table 8.27: Total Costs of ESMP Implementation

Mitigation Measures	$32,897,000
Monitoring	$ 4,070,000
Capacity Building	$ 192,000
Total Costs of ESMP Implementation	**$ 37,159,000**

9. CONSULTATIONS AND COMMUNICATIONS

9.1 Introduction

In accordance with CDR policy on public participation, which generally follows that of the World Bank and other international funding agencies, GBWSAP commenced with the drafting of a *Consultations and Communications Program*[90] (C&CP) detailing the steps that would be followed throughout the project, from site selection through to commissioning. Prepared prior to the PD ESIA, C&CP was necessarily somewhat generic since the form of water supply augmentation, dam or non-dam, had yet been determined.

In this section of the ESIA, **Section 9.2** summarises the scoping consultation sessions undertaken for the ESIA, while **Section 9.3** details the consultations undertaken during the whole period of the ESIA study. **Section 9.4** summarizes the public sessions held to disseminate the findings of the ESIA.

Section 9.5 details the consultation sessions planned shortly after submission of the present report, to relate the details of the study and to disseminate the results to stakeholders, and summarises the remaining C&CP program though design, construction and commissioning.

9.2 Scoping Consultations

At the outset of the EIA process, the preparation of the ESIA, a series of Scoping sessions was held during April and May 2012, commencing with an Institutional Stakeholders session at CDR offices in Central Beirut to which ministries, other governmental agencies and NGOs were invited. This was followed by separate meetings in the vicinity of the three potential dam sites, that for Bisri being held at Mazraat El Dahr Municipality on Tuesday 10 April 2012. Finally, two separate sessions were held for Beirut residents, the prime GBWSAP beneficiaries, at Hadath Municipality on Tuesday 24 April 2012 for southern suburb residents and in Downtown Beirut at Beirut Municipality on Saturday 5 May2012 for Beirut municipality residents. All presentations and the subsequent proceedings were conducted in Arabic, but the Consultant’s team was also prepared to present and respond in English and French, had the need arose.

With the exception of the institutional stakeholders meeting, which was by written invitation, all these meetings were advertised in the national press and via flyers to concerned municipalities. The ESIA Consultant established a dedicated mobile phone line manned 24/7 and a dedicated email address via which details of venues, dates and times, together with other information on the meetings and the project, could be obtained.

Full details of these meetings, lists of attendees, the issues raised and the Consultant’s written responses are given in Appendix L herein.

[90] GBWSAP Consultations and Communications Programme. Dar Al-Handasah (Shair and Partners) Doc. No. L12002-0100D-RPT-ENV-01 Rev1, February 2012.

In respect of the Bisri scoping session, attendees represented just over 50% of the potential area to be inundated, including several from municipalities within the Chouf Al-Aala municipal federation, in whose jurisdiction nearly 70% of the inundated area is located. As at all meetings, arriving attendees were given a handout relating the nature of the project and the intent of the meeting. Following the Consultant's presentation, the session was opened to the floor and attendees could raise comments or questions verbally or in writing. Those doing so verbally were also asked to record what they said in writing so that in addition to the immediate verbal response, a formal written response could be provided.

Attendees generally conducted themselves in an orderly fashion, many recognising the importance of water supply, the urgent need for additional power generation, and the potential economic opportunities from waterside developments, recreational activities and commercial enterprises such as fish farming.

9.3 ESIA Consultations

One of the difficulties in undertaking public meetings for Bisri is that GoL have been discussing the project for so long that residents have come to believe it will never be built. Even with the identification of Bisri as the priority scheme from Analysis of Alternatives, many recently contacted landowners continue to express this opinion.

To overcome this and the limited availability of formal land ownership details, GBWSAP Phase Two commenced with a wide range of informal discussions with heads of municipalities, Mukhtars local residents and farmers, and literally, give the low population of the area, anyone seen within the area to be inundated.

These informal contacts allowed the Consultant to establish a land ownership data base, which provided the basis for the more formal socio-economic survey comprising structured interviews with affected households, businesses and agricultural holdings.

The safeguards (ESIA and RAP) consultant presented the results and recommendations of the ESIA study in different venues for institutional stakeholders in 2013, for local PAPs in the villages in the vicinity of the proposed Bisri dam, and for Greater Beirut residents. The date and timing of all meetings were agreed with individual municipalities. The village sessions were scheduled at weekends and early evening's week-day for Beirut Water Consumers to allow the maximum number of concerned people to attend.

The series of ESIA consultation sessions carried out by the Consultant in 2013 is summarized in Table 9.1.

Table 9.1: List of ESIA Consultation Sessions in 2013

Time	Place	Audience
30/12/2013	CDR	Institutional Stakeholders
02/02/2013	Midane Municipality	PAPs
02/02/2013	Mazraat El Daher	PAPs
06/02/2013	Hadath Municipality	GBA consumers
09/02/2013	Ammatour Municipality	PAPs
09/02/2013	Mazraat El Chouf	PAPs

Key issues raised in the consultations included: (i) need to gain access to drinking water, (ii) ensuring access to jobs and other opportunities for tourism, (iii) need to preserve archaeological, historic and cultural heritage such as Mar Moussa church and other historical ruins, (iv) need to access productive land upstream and downstream of Dam; and need for people living in the vicinity of Dam to benefit from water supply as the Beirut residents, (v) means of compensation for land take and fairness of compensations for expropriated lands, (vi) the returns for such project on local residents in economic and employment terms, (vii) issues of sewage, sanitation and wastewater before and after Dam construction, and (viii) protection of environment from pollution. These issues have been addressed in project design through detailed planning in the compensation/resettlement process, and environmental management aimed at sustainable use of resources (water, land, etc.)

Following revisions to the ESIA and RAP consequential upon changes to Dam design, land expropriations requirements, completion of the household survey and the establishment of indicative costs, further sessions of public consultation were held as follows:

Date	Location	Time	Venue	Attendees
Friday 25 April 2014	Aamatour	10.00am	Dar Ammatour	PAPs
	Mazraat El Chouf	3.00 pm	Municipality Hall	PAPs
Saturday 26 April 2014	Bisri	10.00am	Church Hall	PAPs
	Mazraat El Dahr	3.00 pm	Municipality Hall	PAPs

In addition to the attendees noted above and given on the list of attendees, the following were also present to undertake the presentations and respond to comments from the floor:

Organization	Persons
ESIA/RAP Consultant	4
CDR	2
World Bank	1
Dam Design Consultant	2

Attendees were predominantly male. Those females that did attend were as follows:

Location	Number	Details
Aamatour	None	-
Mazraat El Chouf	2	1 municipality office employee 1 young daughter with her father
Bisri	4	1 wife accompanying her husband 2 sisters
Mazraat El Dahr	None	-

One month prior to these sessions, on Wednesday 26 February, copies of plans showing the extent of proposed expropriation together with a list of plot numbers was posted in each of the four meeting venues for public reference. The scale of these diagrams was such that plot numbers could easily be distinguished. During each of the sessions, the ESIA/RAP consultant erected special display panels showing the plots affected. At two locations, Mazraat Al Chouf and Bisri, the original diagrams were still in place but considerably faded. At the other two sites the municipality had removed the diagrams from the walls but kept them available for public reference. At all four sites on the day of the session's new copies of the plans were given to each municipality for future public reference.

Each of the four sessions followed the same general format:

- Distribution of hand-outs and attendance sheet;
- Short introduction by CDR;
- Introduction by ESIA/RAP Consultant, explaining the purpose of the session, introducing those present from CDR and the consultants, and explaining the current status of the project;
- PowerPoint slide presentation of ESIA study and its outcome;
- PowerPoint slide presentation of the RAP, with specific details of land expropriation procedures, grievance redress and indicative rates of compensation;
- The majority of each session was then open to receive comments and concerns from the floor.

The main comments received are given below. In addition, two of the municipalities (Mazraat El Chouf and Bisri) submitted pre-prepared comments, while one of the attendees at Bisri, a lawyer representing several landowners, drew up a petition at the end of the session to which several landowners appended their signature. The petition suggests the possibility of passing a law regarding the establishment of a company for Bisri Dam where landowners are shareholders. A small number of people, refused to sign the attendance sheet, while some other refused to acknowledge their comments in writing.

The overall attitude of all four audiences was strongly opposed to the construction of Bisri Dam. At Aamatour, barely has the introduction to the session been completed when for several minutes the meeting descended into uproar as attendees stood and shouted their opposition. At the other three sessions the presentations were received more politely, but at each, mild uproar again resulted when the indicative rates of compensation, everywhere considered far too low by attendees, were displayed. As was always anticipated, the majority of comments raised from the floor concerned land expropriation and asset compensation.

Main issues raised by PAPs in the four villages included: (i) need to allocate water and power generated by Bisri dam to neighboring villages and account for irrigation needs, (ii) benefit of project should go to villagers not GBA residents to encourage them to stay in their villages, (iii) loss of productive land and biodiversity, (iv) cash compensation is not enough especially that land has an inheritance value to landowners, (v) PAPs want to get involved in property valuation, (vi) municipalities should benefit from Bisri dam revenues and get yearly compensation to invest in development in neighboring villages, (vii) need for access roads to villages, (viii) need to relocate historical and archaeological remains, (ix) study desalination as an alternative, (x) need to study risk of seismicity, (xi) need for wastewater treatment schemes in villages in the upper catchment, (xii) surface water quality, (xiii) pesticide residues in water, (xix) vector-borne diseases and bad odors in the Project area, (xx) increased water salinity and impact on agriculture and residents, (xxi) possibility of creating several ponds instead of a large dam, (xxii) possibility of passing a law for the establishment of a company for Bisri dam similar to Solidere where landowners are shareholders, (xxiii) relocate the proposed dam axis.

Details of Public Consultation sessions are given in Appendix L.

9.4 ESIA Findings Dissemination Consultations

Following the submission of the present ESIA report, the Consultant, on behalf of the project proponents, organized a series of meetings to disseminate the findings of the study, to outline the proposed construction program in so far as it is known, and to outline for PAPs the procedures for land and asset expropriation.

The ESIA consultant presented the results and recommendations of the ESIA study in different venues for institutional stakeholders, for local PAPs in the villages in the vicinity of the proposed Bisri dam, and for Greater Beirut residents. Full Details of these meetings are given Appendix L of this report.

The date and timing of all meetings were agreed with individual municipalities. The village sessions were scheduled at weekends and early evenings on weekdays for Beirut Water Consumers to allow the maximum number of concerned people to attend.

Each session commenced with the introduction by the Project Proponent in which the scope, objectives and an update about GBWSAP advancement were shared with the audience. The Consultant (Dar Al-Handasah) then gave a power point presentation covering the project base line conditions, the potentially expected impacts and mitigation measures and the study recommendations. The floor was then opened to attendees to air their comments and concerns. In order to focus on the expected concerns of the different audiences, the presentations varied slightly between sessions. The proceedings of all sessions were in Arabic.

9.5 On-Going Consultation and Communications Program

Subsequent to completion of the Final ESIA, which will include the details and results from the post-Draft ESIA consultation sessions, and completion of the RAP for the project, more focused sessions for directly affected PAPs will be held to explain expropriation procedures, the information they need to prepare, and respond to their queries.

These consultations are currently outside the ESIA Consultants Scope of Works and are expected to be primarily conducted by either the design consultant or CDR's Expropriation Department.

Thereafter the project proponent will continue consultations throughout the period of land expropriation and beyond from a Project Information Centre (PIC) where PAPs and other concerned persons will be able to consult project documents, find contact details of real estate agents, lawyers and other service providers, and lodge comments, queries and complaints. The PIC will continue to operate throughout the period of construction and until the reservoir is at least 80% filled. The location of the PIC should be in a village adjacent to the project and in close proximity to the optimum number of PAPs.

The RPF and RAP, in which the policy and detail of land and asset expropriation are described and the procedure for resettlement detailed, will with the ESIA, be made publicly available at the PIC, via the Internet on the World Bank's *Infoshop* website or equivalent portal of other funding agency, and on CDR's website.