Environmental Assessment
North Gaza Emergency Sewage Treatment Plant Project

Final Report

The Palestinian Water Authority
(The Client)

Engineering and Management Consulting Center
EMCC
(The Consultant)
Supported by Dorsch Consult

February 2006
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<th>Full Form</th>
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<tbody>
<tr>
<td>BLWWTP</td>
<td>Bait Lahia Wastewater Treatment Plant</td>
</tr>
<tr>
<td>BOD</td>
<td>Biological Oxygen Demand</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>CAMP</td>
<td>Coastal Aquifer Management Program</td>
</tr>
<tr>
<td>CAMP</td>
<td>Coastal Aquifer Management Project</td>
</tr>
<tr>
<td>CMWU</td>
<td>Coastal Municipal Water Utility</td>
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<td>CSC</td>
<td>Common Services Council</td>
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<tr>
<td>DS</td>
<td>Dissolved Solids</td>
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<td>EMCC</td>
<td>Engineering and Management Consulting Center</td>
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<tr>
<td>EA</td>
<td>Environmental Assessment</td>
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<td>EMP</td>
<td>Environmental Management Plan</td>
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<tr>
<td>EQA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>EQA</td>
<td>Environmental Quality Agency</td>
</tr>
<tr>
<td>FC</td>
<td>Faecal Coliform</td>
</tr>
<tr>
<td>MOA</td>
<td>Ministry of Agriculture</td>
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<td>MOH</td>
<td>Ministry of Health</td>
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<td>Ministry of Industry</td>
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<tr>
<td>MOP</td>
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<td>MOTA</td>
<td>Ministry of Tourism and Antiquates</td>
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<td>MWRA</td>
<td>Ministry of Waqf and Religious Affairs</td>
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<td>NGEST</td>
<td>North Gaza Emergency Sewage Treatment Project</td>
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<td>NGWWTP</td>
<td>North Gaza Wastewater Treatment Plant</td>
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<tr>
<td>O&amp;M</td>
<td>Operation and Maintenance</td>
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<tr>
<td>PA</td>
<td>Palestinian Authority</td>
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<tr>
<td>PCBS</td>
<td>Palestinian Central Bureau of Statistics</td>
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<td>PLC</td>
<td>Palestinian Legislative Council</td>
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<tr>
<td>PLO</td>
<td>Palestinian Liberation Organization</td>
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<td>PNA</td>
<td>Palestinian National Authority</td>
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<td>PSI</td>
<td>Palestinian Standards Institute</td>
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<td>Palestinian Water Authority</td>
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<td>PMU</td>
<td>Project Management Unit</td>
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<td>SAR</td>
<td>Soil Aquifer Treatment</td>
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<td>SIDA</td>
<td>Swedish International Development Agency</td>
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List of Abbreviations

SS  Suspended Solids
TSS  Total Suspended Solids
UNRWA  United Nations Relief and Works Agency
USAID  United States Association for International Development
USEPA  United States Environmental Protection Agency
VDS  Volatile Dissolved Solids
WWTP  Waste Water Treatment Plant
WHO  World Health Organization
ملخص تنفيذي

1. مقدمة

تستعرض مطلاعية معالجة المياه العادمة الحالية في بيت لاهيا في تصريف مبادء الصرف الصحي المعالجة إلى البحرية العشوائية الكبيرة والتي تهدف المستقلة بهذا الوضع المرجع وسبل ANGWWT) . وفقًا لجوانب الفصلية حول تنفيذ مشروع طارئ يرتبط في أن مدخلية بغزة معالجة مياه الصرف الصحي في بيت لاهيا وعند تنفيذ مشروع مبادرات التحديث على حياء المتاعم والصحة من البكورة المستمرة في زيادة ذلك ضعيا الصرف الصحي المعالجة جزئياً إلى حياء الترشيح في موقع الجديد. وتعتبر هذه النسخة إلى تقييم الأمن البيئي للمشروع المقدم وتنتهي المشروع الطارئ وآثر التواصل على الموقع الحالي والموقع الجديد، والهدف الأكبر يتجاوز النصائح والتعليم والتحديث لدراسة التقييم البيئي النقطة

2. وصف النشاط

سوف يوفر بأن تقييم الأعمال الطارئة. والهدف الرئيسي لهذه الأعمال الطارئة هو منع حدوث كارثة إنسانية وكارثة حيوية في منطقة بيت لاهيا، وكحولياً من المشروع المتكرار الذي يضمن معالجة آمنة ومستمرة للمياه المعالجة في منطقة شمال غرب، والذي يهدف إلى:
- جيزة المياه المعالجة في النقطة الدقيقة بالمحيطة بمعالجة المياه المعالجة في بيت لاهيا، عن طريق تنفيذ:
- الشرق جنباً إلى جنوب، أن تقييم المنحة المفترضة للمياه في شمال عمان هو خطوة أولي نحو توفير حل طويل المدى يتكون ناجماً في معملية المياه المعالجة في محافظة الشمال.

ستتم تنفيذ المشروع على مرحلتين:

المرحلة الأولى(A):

سوف يتم في هذه المرحلة ضمان الإزالة العاجلة لخطر الفيضان المعتمد في المنطقة المحيطة ببحث لاهيا في معالجة مياه العدامة. و edição أكثر تتعلقاً سوف يكون المشروع الطارئ من إشارة:
- منطقة ضخ في الموقع الحالي لمعالجة مياه العدامة في بيت لاهيا سوف تتكون هذه المرحلة على 5 مصبات (4 مضخة للعمل وواحدة للطوارئ) و_bridge لعال ضخ 3,240 م³/ساعة وضغط يصل إلى 6.2 برر.
- خط أضلاع معين ببطور 800 مل، وطول 8 كم لنقل المياه المعالجة جزئياً من البحرية إلى أحوال الترشيح.

تسعى أحوال الترشيح لمساحة تصل إلى 8 كم حيث يتم إنشاءها تجميع الموؤدون، المعالجة منطقة شمال غرب، بطلب ذات إنتاجية رباعية، مما ينافع إلى ذلك سوف يتم أيضاً تعديل التكامل المعتمدة بشكل وإنعكاس الحالات إحقاق الترشيح والواقعية للمياه المعالجة والمياه الجوية في الوقت الذي يتم فيه بداء محاكاة الصرف الصحي في شمال عمان كما يتم ذلك تكامل مناقع عام للمياه الجوية والأحواز، والمواد المستعملة.

المرحلة الثانية(B):

وهذه المنصصة لاسماء وجود حل طويل المدى لمعالجة المياه العادمة في منطقة شمال غرب، في خلال استكمال تحصيل الأمواج اللازمة للمهنة التالية من المشروع وواقع التوقع أن يتم في الوقت القريب سوف يتم الدخول في تنفيذ المرحلة.

3. الوضع البالغ لمطلاعية معالجة مياه الصرف الصحي في بيت لاهيا

أ gönderil مطلاعية معالجة مياه الصرف الصحي في بيت لاهيا عام 1976، استمر حتى سقوط مدينة بيت لاهيا في الجزر العشائي من طاقة عزنت اليوم بنظام معالجة طبيعية، واتزام للمواد، مما يجعل من لوحة ياشمloads. وكانت الفكرة خلال مرحلة التصميم الأولى هو إعادة استخدام المياه المعالجة من منطقة لمريان الزراعية المحاورة.

هذا الفكرة لم تحقق إلا أنها لم تراجع أي خيارات أخرى بشكل جدي وعند تنفيذ هذه العمل، وأن جيزة مياه المعالجة كانت جيدة، والشرطة الرئيسية كانت قادرة على استيعاب كميات المياه المعالجة من خلال الترشيح الطارئ، ومع نظام السكان واتباع الموازات للمعالجة ونزاقاً تعقيد الصرف الصحي، ازدادت كميات المياه المعالجة في مطلاعية بإدارة أعمال.(BLWWTP) 

هذا النص الخلاص من الكاباني الرملية.
إلى (BLWWTP) تناقص جودة المياه المتعالجة وكان الحجم الهابل للمياه ردية المتعالجة بسبب في التناقص المستمر في فترة التشريحة في منطقة الكتان الرملية المعروفة مما أدى إلى النهاية إلى تشكيك الحيرة.

تم إشارة سود ترابية من أجل حصر الحيرة وحماية المسكن والرياض الزراعية المجاورة من التعرض للفيضان.

تشادعت ظروف الوضع خلال السنوات القليلة الماضية بسبب تزويج دوهد اعتمادات جديدة يشيكل تشكيل صرف صحي. بلغ عدد السكان المخيم حاليا 180,000 نسمة. وهذا يجعل يشكيك جنوبيا، في حال اصابه، يكون مخيفا جنوبيا للايجان. بناءاً على ذلك فإن حجم المياه الداخلة إلى المنطقة حاليًا يفوق بكثير من 12,000 م³ في اليوم ما زاهد كثيرة عن الفيضا الاستعابية للمحمية.

من غاذ 2001 وتحي Agile 2004 إزداد مستوى الماء في الحيرة بعد 2.5 م من حل تخصيص هذا المحمية أو على الأقل أبل في حالة مساحات مياه القبة، قامت سلطة المياه الفلسطينية بإخضاع بعض الإجراءات الطارئة:

وهي:

- استخدام أحماض تشريحة المياه الأمطار القائمة بمضخ المياه الزائدة من الحيرة وترشها.
- إنشاء أحواض تشريحة المياه الفائضة مساحة 13,000 م² من حبة معالجة المياه العادية.
- إنشاء منصة جيدة من الحالة الحياتية للحيرة للحزمة المياه المعالجة إلى أحواض التشريحة.

الأحداث العامة يشكيك جودة المياه 8,000 م³ في اليوم وهو ما يعادل لثين كميات المياه المعالجة داخل الحيرة 12,000م³. تشق المياه المعالجة داخل الحيرة 12,000م³ وتحوي إتلاف التعادل أو المشتركة بين مياه الأحياء هناك، وتحوي مياه الجوانب الأخرى "الماء" و "الحيرة" في اليوم تقريبا 20 سم. مما يكبدит مياه المياه في البحيرة مساحة مساحيا لتسيير في حوض رقم 7 و يسبب ذلك عدم تدفق المياه من حبة معالجة إلى الحيرة وتشكيك كمال نظام المعالجة.

بنت الحيرة اليوم ومعها أحماض الطريق الصغيري تتصدى سهولة 35 كطيار ويطلث كتيريا ومعق 9 متر تقريبا وبحجم 1.5 متر تقريبا. مستوى المياه في الحيرة أعلى بعدة أمتار من المساحات قرب من المياه (بيت لاهايا وام النصر). قرب من مساحات المياه في الحيرة والمناطق المجاورة يصل إلى "الماء" ينكمش مدفوع في الجزء الشمالي الغربي من الحيرة.

تشكل الحيرة الأخطار دائماً وتفاصيل على السلامة العامة. حدد المحمية ليست محلياً والأطفال يمكن أن يستكن بها ويغوروا. القيضان قد حدث حالياً عندما ازداد السد الترابي لحوض طريق صغير في الحالة الجوية العربية. هذا الفيضان بسبب في حرج حائزين ومانشاة حرة واعاج لجامعة من السكان ونسبة في نتائج ملحوظة للأنسونيات في بناء لاهايا. ونسبة سلطة المياه الفلسطينية فإنها يوجد في ينسر في فشل مباشر أو غير مباشر إذا حدث خلل في الحيرة أو السيد وظائف المياه إلى التجاعيد المجاورة.

4. تقييم المشروع

تشخيص الفترات البالية البايرونية الأهمة والوحدات الناجمة من المشروع:

4.1. مصادر ومواد المياه

مع نهاية المرحلة الطارئة (2008) سيكون منسوب المياه الجوفية أضلاع أنحاء التشريحة حوالي 3 م³/م² على منسوب المياه. من الموقت أن يتوقف الماء إلى مساحة 700م²، ينخفض البحر إلى 300 متر قبل المشتركة إلى 250 متر.

أتوقفت نتيجة الموجهات الصغرية لحزمة المياه أن حدة التآكل تعاملية الجزء الاستمراري بعد حوالي 8 سنوات (2014). كما أن منسوب المياه الجوفية تحت كلية التشريحة سوف ينخفض إلى حوالي 6.5 متر في ذلك الوقت. على المدى البعيد (عام 2025) سوف ينخفض ذلك على 120 متر وسوف تصل المياه إلى مساحة 2200 متر.

بنتج البحر، و 1100 متر بنتج البحر، و 1200 متر بنتج البحر، و 1300 متر بنتج البحر، و 1400 متر بنتج البحر. إن الحالة في بناء لاهايا مهقت 18٪ من المياه المضيفة إلى الخزان الجوفي، وذلك خلال المرحلة الطارئة ومرحلة الحراة جوية مدة على التوالي. والحركة الجوية للماء في الأجواء المكثفات سوف تنص إلى النصف في هذه المنطقة بسبب حرارة الماء المضيفة.

من الموقت أن ينخفض منحوض على الكمية الإجمالية لمخزون المياه الجوفية (20,000 م³/م² سنة) وذلك بسبب تشريحة أثناء المرحلة الطارئة ومرحلة الطارئة ومرحلة 650 م³/م² سنة، وذلك بسبب التشريحة أثناء المرحلة الطارئة ومرحلة الطارئة ومرحلة 650 م³/م² سنة، وذلك بسبب التشريحة أثناء المرحلة الطارئة ومرحلة الطارئة ومرحلة 650 م³/م² سنة، وذلك بسبب التشريحة أثناء المرحلة الطارئة ومرحلة الطارئة ومرحلة 650 م³/م² سنة، وذلك بسبب التشريحة أثناء المرحلة الطارئة ومرحلة الطارئة ومرحلة 650 م³/م² سنة.

فيما يتعلق بالكلوريد، وبالمقارنة مع عودة المياه الأصلية الموجودة حول أحواض الخزان الترشيح المتوقع (300-780 ملليوم/متر)، فإن المياه المصافرة (250 ملليوم/متر) سوف تحت جودة الخزان الجوفي بشكل ملحوظ. في نهاية المرحلة الطارئة، المياه المصافرة سوف تحل بشكل كامل أو جزئياً بحلول نهاية مدة تغطي 200 – 300 متر ابتداءً من حافة أحواض الترشيح، وعلى المدى الطويل فإن المياه المصافرة سوف تحل بشكل كامل محل المياه الجوفية الأصلية بعدد 500 متر غرباً و200 متر شرقاً و400 متر شمالي وجنوباً من جوانب أحواض الترشيح. في خارج حدود هذه المنطقة سيكوّن هناك مناطق انتقالية تأثيرة عن تأثيرات عملية الخلط والتكيف المتوقع.

فيما يتعلق بالبترول، مع نهاية المرحلة الطارئة، ستكون المياه المصافرة قد استبدلت بشكل كامل المياه الجوفية الأصلية على بعد 250 متر غرباً و150 متر شرقاً و200 متر شمالاً وجنوباً من حافة أحواض الترشيح.

وفي خارج حدود هذه المنطقة سيكون هناك مناطق انتقالية ناتجة عن تأثيرات عملية الخلط والتكيف. هناك 4 أبار زراعية على الأقل ستقوم بضخ المياه، وفيها N0-3-N يتركز يزيد على 6 ملليوم/متر. لن تتأثر أي بئر من الأبار الإسرائيلية في المنطقة، وسكون عودة المياه المنفعة لأستخدامها في الزراعة. وعلى المدى البعيد، فإن المياه ذات الجودة العليا سوف تستفيد المياه الملوثة نتيجة للثلاث عوامل 1. التخيف، 2. تكرار عملية الضخ والترشيح إلى المياه الجوفية، 3. تلاشي NO3 والترشيح إلى المياه الجوفية، 4. تأثيرات Nا، إذا ورث المياه من خلال طبقات البحيرة (الطبيعية) الغنية بالمواد العضوية. وفي هذه العملية فإن جزء من النتائج سوف يفقد بواسطة عملية التزويج والتكيف واستعداد النباتات.

المستودع الأ的原则 المتوقع يفترض أن مشروع المعالجة الكامل لن يتوقف في المستقبل القريب وأن عملية الترشيح للمياه العادية المعالجة جزئياً سوف يستمر على مدى الربع في هذه الحالة فإن دارة محطة المعالجة BL WWTP المقالية من المشروع أن يتراجع. بسبب هذا أمرًا لا يمكن التخلص منه في المنطقة المتأثرة ما لم يتم إشارة نظام خاص لضخ المياه المعالجة من أبار حول منطقة الترشيح. أما بالنسبة للبكتيريا فقد أشارت نتائج التحليل البيئي إلى أن المنطقة الواقعية في مسافة 150 متر من موقع الترشيح تستقبل مياه الترشيح خلال وقت مكوث أقصر من 6 ساعات وبعد هذه الفترة الزمنية فإن العوامل البكتيرية لست تكون ذات أهمية. وستنخفض عملية التزويج في المنطقة غير المسببة فوق الخزان الجوفي حوالي 16 يوم.

العوامل الاجتماعية والاقتصادية

4.2

المرحلة الطارئة، BLWWTP

سوف يوفر نقل المياه المعالجة من محطة معالجة بيئية وراء أراض إضافية نتيجة التخلص من بحيرة المياه المعالجة. هناك هذه الأراضي يمكن بعد فترة زمنية قصيرة أن نستخدم لأغراض التربة أو الزراعة، كما يمكن لها أن تكون مناسبة لبناء مناطق سكنية جديدة.
NGWWTP (A)

تتمثل مقتضيات الشهداء الفلسطينيين أيضاً لрусية مصادر احتلال، وإنشاء أحواض ترشيح للمياه العامة ومحطة مهنة في منطقة المخاير قد يكون بعض الازعاج العناصر والنفسي لعائليات الشهداء. وقد يتضمن المشروع بالقرب من المفقرة، باستثناء الازعاج يمكن أن يكون ذلك نسبياً. ولهذا السبب، يتضمن المشروع تشكيل مشكلة في حالة عدم اتخاذ الإجراءات الوقائية المناسبة لذلك.

إنشاء هذا المشروع سوف يكون له أثر اقتصادي إيجابي عن طريق إيجاد فرص عمل وتشغيل المقاولين الفلسطينيين للقيام بهذه الأعمال.

NGWWTP (B)

سيكون لمرحلة الإنشاء آثراً إيجابياً على فرص العمل، فخلال هذه المرحلة سيتم الاستفادة من مقاول الباطنة المحليين بالإضافة إلى خدمات المهندسين وخبراء.

جميع المراحل

في الأحوال الاقتصادية الحالية، لن يكون بالإمكان تطبيق نظم تعبيرية قادرة على استمرار جمع التكاليف بما فيها أداء مشروع واستخدام الاستثمارات الإضافية الأخرى من العائليات الفلسطينية. ولكن يمكن تطبيق نماذج لاستغلال التكاليف فيخلوح المرحلة الطارئة، حيث يتم المتوقع أن تتشكل هذه التكاليف 4% من متوسط النفق الشهري للعائلة، على جانب إضافة تكاليف خدمات المياه الحالية.

4.3

NGWWTP (A)

لن يكون هناك تأثيراً جوهرياً على التربة أثناء أعمال الإنشاء المحددة في الموقع الحالي لمحطة المعالجة (A) علاج إعادة تأهيل محطة المعالجة الحالية ومحطة الضغ التشريحي ووصلات المائي الجديدة.

NGWWTP (B)

حوالي 80 دونم من الأراضي الزراعية سوف يتم خسارتها نتيجة لأعمال الحفر. كما أن كميات هائلة من التربة الطينية (Loamy Clay) (900,000م م) سوف يتم إزالتها من الموقع ونقلها إلى موقع آخر. ويشكل عالم إن الكشفية الاستدامة في نظام الترشيح لازخار الجوف الناتج عن الاستخدام المتوقع في أسطح أحواض الترشيح والتي تؤدي إلى تقليص استخدام التربة.

تعتبر درجة ملوحة المياه المعالجة (EC=1.77 dS/m) على مدى الاعتدال.

NGWWTP (B)

سوف يتم تهيئة التربة الحاصلة لتربيتها بسبب المياه العادية في الموقع القديم عند تكشيف وإزالة برك محطة المعالجة القديمة فإن المدخل المعبأ والموقف القديم التي تبلغ مساحتها 8.2 هكتار من الأرض المغطاة أو شبه المغطاة. سوف يتم إعادة تأهيلها.

إذا ما استخدمت الأرض الجديدة نتيجة عن تخفيف البحرية لمشاريع بناء سوف بسبب ذلك ضياعاً لفروصة تحقيق تحقيق الظروف الفعالة للسكان المحليين، الذين عانوا كثيراً بسبب السبيل الكثيرة الناتجة عن جماورهم للبحرية حتى الآن.

NGWWTP (B)
من المتوقع أن تزداد كمية الحماة الناتجة عن نظم المعالجة. هذه الحماة المعالجة تحتوي على كمية كبيرة من المواد العضوية والمواد المعدنية للنباتات والضروورية لنموها. كما يمكن أن تحتوي الحماة على محتويات ملثية مثل الشوائب العضوية.

الصحة والسلامة

المراحل العتأرّف

تشمل النهريات الخالية التي تحيط ببلد من الرمال ذات الزيادة الشديدة وتحتوي على طبقة عميقة من الحماة المرئية في أماكن مختلفة. يلعبون دوراً رئيسياً في فصل الحماة المستهدفة. في المراحل البدائية، يمكن أن يكون من الصعب جداً إقناعهم. ومن ناحية أخرى فإن تخطيط مواد المياه يطلق عليه انعدام الفاتحة بشكل كبير.

مراجعات إنقاذها فإن الوضع الصحي للسكان المحليين يمكن أن يتصرف، وفي هذه الأثناء يخشى على الأقمار وجعلها ملثية.

المراحل الطازجة، دخول

في بداية الحماة المبكرات الناتج عن أعمال الإنشاء، فإن أهم عضور من عناصر الخطة الطازجة هو عملية ترشيح المياه المعالجة المنطقية إلى المياه الجوفية. هذا العمل الطازج يمكن أيضاً أن يكون بديلاً على الحماة الإستراتيجية في منطقة NGWWTP.

المراحل B (B ؛ B ؛ B ؛ B)

إذا لم يكن من الممكن نحن المياه المعالجة إلى الموقع الجديد والأعمال، فإن الработка تم بسرعتهم السابقة. في هذه الحالة، أو فائدة وفاآ بديلاً للحوض المعادلة. يستخدم في حالة حدوث مشاكل كبيرة في الموقع الجديد أو في حالة حدوث خراب كبير في الخط الناقل، ربما بحسب النشاط العملي، فإنه من الممكن أن تستغرق أعمال الإصلاح وفقاً لأولئك وثائق الاستشاري.كتابة عن فائدة إضافية للمياه المعادلة كما يوجد بإيجاد دليل في حالة حدوث هذا السيناريو الأول.

المراحل B (B ؛ B ؛ B ؛ B)

بجب أن تكون محطة المعالجة المركزة في عام 2008، سوف تبدأ عملية الترشيح للمياه المعالجة ذات الجودة العالية في أجزاء التشريبي. يُشير صور بعض الخلاصات إلى أن ترشيح المياه الجوفية من بيئات عام 2008، وعلى مدى بعيد (15-20 سنة) تشمل عملية الترشيح للمياه المعالجة بشكل كلي على تحسن جودة المياه الجوفية في المنطقة. سيكون من الجيد استعمال جزء من المياه المعالجة للأغراض الزراعية واستخدامها المباركة. كسماء، Compost ورشولة للماء المباركة، خاصة الحماة، اوثلين وفقدان ملاذ البيت.

وإذا كان يمكن التقليل بشكل كبير من الخسائر المحتملة للحماية والمياه العادية إذا ما تم معالجتها بشكل ناجح.

المراحل الكريبية

بجهة أن تبدأ عملية الترشيح للمياه المعالجة ذات الجودة العالية، سوف يُستخدم صورة بعض الخلاصات من بيئات عام 2008، وعلى مدى بعيد (15-20 سنة) تشمل عملية الترشيح للمياه المعالجة بشكل كلي على تحسن جودة المياه الجوفية في المنطقة. سيكون من الجيد استعمال جزء من المياه المعالجة للأغراض الزراعية واستخدامها المباركة. كسماء، Compost ورشولة للماء المباركة، خاصة الحماة، اوثلين وفقدان ملاذ البيت.

المراحل الطازجة

سوف يُعتمد استراتيجيّة المراحل الأكثر تأثيراً لمحات المعالجة في طين لاها، التحسينات الفنية للدولة الخالية خاصة أجزاء التهوية بالإضافة إلى الصيانة الجيدة والمرافق المتصلة أداء النظام سوف يؤدي بجذور خاص إلى تقلص كمية H₂S بشكل كبير حيث يصل إلى نظام المياه المعالجة عملية تخفيف الحرارة و上がって أطعمة سفوف ينتج عنها بعض الرشوات الكريبية والهواز سوف تكون بشكل مؤقت، ولا يمكن حجم ونوع الغازات المشتقة بشكل دقيق.

BWWTP (B ؛ B ؛ B ؛ B)

عندما تبدأ المحطة الجديدة في العمل في عام 2008 سوف يتم تجميع كل المياه العادية بالمناطق المحددة، ومن ثم نحنها إلى الموقع الجديد، وبعد إجراء عملية التصنيف والتدريب، والتي تتم في نظام مُغلق باستخدام مهارات غاز كيولوجيا. وعلى هذا يجب أن تكون مشاكل راحة ذات أهمية في حالات التشغيل

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الطبيعية. فقط في حالات الطوارئ عندما تكون البداية رقم 7 مليئة بالمياه العادية الحمام يمكن أن يتعرض السكان المجاورين إلى الإزعاج بسبب الرياح الكريهة، ودرجة الإزعاج تعتمد على اتجاه وسرعة الرياح.
NGWWTP (B) المرحلة

爺رة حرمة لل一刀ية العامة تحت ظروف غير هواية، سوف يتيك ذلك إلى تسريع إخراج غاز كربونيد الهيدروجين.

وهذا قد يسبب حصول تأكل وراثة كربون اتخاذ ستة المقالة كلما...

وكتيبا لإزالة الحمة ومعالجتها فإن كميات من الأمونيب سوف تتقلق في الهواء وهذا قد يسبب مشكلة راينة كربونية ولكن بشكل مؤقت. مع الخطر التعاون غاز H2S تم تقديرها اعتبارا في الدراسة السابقة وخبرة الاستماعي، وخلال جميع مراحل المشروع فإن خط المسوئي المسمى به ( plusieurs) لا يتعدي أبدا حدود المجازة، وكذلك فإن أقرب مكان حساس (المجرى) أن يتغير بمستوى عالي من كربونيد الهيدروجين.

Ecology.

4.6. المرحلة (B) الأثر البيئي

NGWWTP

流域 تجفيف البحيرة في المرحلة الطارئة سوف تؤثر على الحيوانات والنباتات البرية، تقلص مستوى المياه في البحر، يؤدي إلى حصول زيادة تركيز الأكسجين، وبالتالي إلى ترزيز القدرة على التنظيف ذاتي للبحرية في النهائية. يتسبب في تحسين جودة المياه وسوف يؤدي ذلك أيضا إلى تكون مناطق مضحلة وبالتالي إلى تحسين جودة البيئة لصالح طور المياه.

وخلال عملية تجفيف البحيرة، الكائنات النباتية أو الحيوانية، التي تعتمد على المياه المكشوفة أو الأرض الرطبة سوف تتغير تدريجيا، والكائنات الأخرى التي استفادت على الحياة في المناطق المفتوحة أو شبه الجافة سوف تتح مفحلاً.

NGWWTP مرحلة الطارئة

أن التأثير الرئيسي لمشروع على الحياة البرية يمثل في فقدان المفقود كميات من النباتات والحيوانات البرية. عمليات الحفر الكبيرة (230,000,000 م3) وأعمال التنسيقية سوف تؤثر بشكل علامة على سطح الموقع كله. وسبب الإزاحة الناتجة عن أنماط الرياح، من الموقع أن تؤثر الحيوانات البرية في مناطق أخرى. أو ما يركز المكان فقط أثناء الانتهاء خالص النشاطات العمل فقط أثناء وجود الضحية والتغيير الناتج عن أعمال الرفع والنقل النموذج للناحية لحماية الحياة البرية، وبالتالي فإن كائنات جديدة وحاسة التي تعيش في الماء أو الأرض الرطبة، وبالتالي فإن كائنات جديدة وحاسة التي تعيش في الماء أو الأرض الرطبة سوف تعيش في المنطقة وتسكنها كملجا لها ومصدر للطعام والكثير.

BLWWTP (B) المرحلة

عندما تتحلل المياه بشكل كامل من البحيرة، فإن المنطقة الجافة سوف يتم في الغالب زيوتها بواسطة المثال المستخدم كمصدر حولها وذلك لإغلاق الحفر في المنطقة، ومن ذلك الوقت، وتعقدا على استخدام المستوى للأرض إلا للبسكر أو للزراعة فإن الحياة البرية في منطقة البحيرة سوف تغير بشكل دائم.
1. تم تفتيح خطة الإدارة البيئية (EMP) للمشروع والتي يمكنها تخفيف الآثار البيئية السلبية للمشروع. اقترحوا جملة من التخفيفات تتعلق بمساحة الأراضي التي تنتمي فيها: إجراءات التخفيف التسولية. إجراءات الإدارة البيئية. إجراءات المرافق وطرق تطبيقها. بناء الفواتير.

2. الفواتير الدقيقة تتضمن أن أهم التوصيات المقدمة للتخفيف من الآثار السلبية للمشروع:

- تضمن أن السيطرة على النفايات مصفحة تقع قبالة الأراضي الم котор المعلوم مع وظائف مياه الصرف السائل الضروري في شارع غزة (NGWWTP) (وهو مركبة تدفق في شهر مارس).

- الأمر الأول: هو الخطر المتفق الذي تشكله البنية على حياة السكان في منطقة بيت لاهيا. المرحلة الطازجة هذا الخط وغيره نحن السيناريو الطويل في تلك المرحلة.

- الأمر الثاني: هو الاعتماد على المرحلة الطازجة للمشروع فقط. فلقة طويلة يمكن أن يسبب تباطأ لا يمكن تكرارها على نوعية المياه في المناخ الجوي في فترة المرحلة الطازجة.

- بناء على ذلك، تم تدفق ذو أثر سلبي صعب التativos في: أ. بدء تنفيذ المشروع الطاري، والذي سيقوم جزءًا من المشروع المكون لمنطقة الشمال، ب. تأمين بقية الأموال اللازمة على وجه السرعة لدى المشروع المكمل.

- يجب أن يتوقف توفر في أي مشروع مسطح تطوي في حالة أو احتفالات بما أن نقطة بين لها.

3. سوف تكون موقعة لجِمِع مياه الصرف الصحي من جميع محاور شمال شرق شاسع إلى محطة المعالجة الجديدة يجب التفكير بالعديد من مصبات المصرف الصحي المعتادة في حالة توقف هذا المياه إلى الموقع الجديد. مما يجعل المحطة الجديدة في حالتها، بلسع خطيرة في نظام المعالجة.

4. خفífة القتال، والترشيح الأخلاقي المتوقفة على نوعية المياه في الخزان الجوفي يوصي

5. يتم تحسين منشأ استثمار المياه السالبة في المحطة الفنيدقية لتمكننا إزالة أفضل للمواد العالية الكبيرة والرمل. 

6. تنطلق ركبة 1 و 2 من المحطة الفنيدة، ويتم تشغيل التهوية في البكاء من المحطة، ويتم التحكم في تدفق OBJW (المياه التجارية) من محطة معالجة المياه التجارية والبيئية. 

7. تدفق OBJW (المياه التجارية) من محطة معالجة المياه التجارية والبيئية ويعود بالآذان على بعض منها.

8. يتم تخفيف التكييف التعليقي، تخفيف الذرات عن طريق استخدام أخذ FACTOR المثبت عبر الدورة.

9. يتم تخفيف التكييف التعليقي، تخفيف الذرات عن طريق استخدام أخذ FACTOR المثبت عبر الدورة.

10. يتم تخفيف التكييف التعليقي، تخفيف الذرات عن طريق استخدام أخذ FACTOR المثبت عبر الدورة.
8. في أسوأ الأحوال إذا لم يتم إنشاء وتشغيل محطة المعالجة الجديدة قبل عام (2008) وإذا استمرت عملية التشغيل باستخدام مياه صرف صحي معالجة جزئيا، يجب إنشاء نظام ضخ حول أحواض التشريحة لاستغلال المياه المضافة قبل أن تلوث أجزاء الخزان الجوفي، هذا النظام يجب أن يحتوي

9. أكبر معاينة بالمبنى من المياه المضافة.

10. يوصي بنقل الجزء الأكبر من الأجزاء المتصلة الناتجة عن الحفر إلى المناطق المنخفضة الموجودة جنوب شرق محطة المعالجة الحالية. بالكمية التي يمكن أن تكون على المزارعين أكبر، عند استخدامها للتحسين.

11. بسما أن يتكون من أحواض الترشيح بدون فيه مستوى منخفض، كمية المياه المضافة، ملاحظات عن نمو الحيوانات، نوعية المياه المستخدمة في التشغيل، كما يجب تدوين أوقات بداية ونهاية فترات الفيضان والتجريف وعملية التجفيف والحرث والتجريف.

12. تركز المواد السامة في التربة الزراعية نتيجة استخدام الأملاح يجب أن لا تتجاوز العوائق المسحو بها محيويا ودوليا (راجع ملحق II). معدل استخدام الأملاح يتم بناءا على محتوى النترات والفوسفور أيهما يكون العامل المحدد الأكبر. إذا ما أثرت قيمة التربة إلى مدى تخصيص المادة إلى الفوسفور يجب عدم استخدام الأملاح كاسما. معاملات استخدام الأملاح أيضا يجب أن تحدد بناء على مدى تزامن الخصائص الثبوتية في التربة، وكذلك على مستوى وتركيز الأحماض فيها ونسبة المادة العضوية.

13. إذا انrwاب مساحة الطاردة يوصى دائماً بوضع سور واقع حول منطقة البذور أو تشغيل حرواب حتى تم عملية تجهيز البذور بشكل كامل.

14. القوانين الخاصة باستخدام مياه الصرف الصحي المعالجة في الزراعة والتي تحدد استخدام نوعية معينة حسب نوع المزروعات يجب أن تتفق ويراقب تنفيذها بشكل دقيق حيث أن هذه من غير المقبول ويأتي شكل استخدام المياه المعالجة والماء كمسام للثروات التي تزيل مباشرة (مثل الخضرات غير المعبثة).

15. بسما يختصص مكان يكفي لتوزيع الأملاح الناتجة عن سنة كاملة من جزيء التشغيل (NGWWTP).

16. نظام التعرفة الذي يتسبب وقفة الدفع يجب أن يراعي احتياجات الإنسان الضرورية للبيت وهي (25 - 75) لكل يوم، وحتى يكون نظام التعرفة مقدر عليه بالنسبة للأساس الفلسطينية يجب أن لا يتجاوز مقدار المياه والصرف الصحي 40% من معدل دخل الأسرة. ونظراً لتردد الغرض الاقتصادي الحالي فإنه لن يكون بالإمكان فرض نظام تعرفة لاستغلال جميع تكاليف المشرع الشاملة تكاليف الاستثمار وتكييف التشغيل.

17. نظام التعرفة في المستقبل القريب يجب أن يكون على أساس استغلال تكاليف الصيانة والتشغيل. تكاليف الاستثمار الأولية يجب تحصيلها من مصادر مالية خارجية على مدى البعد نظام التعرفة يجب أن يكون مبنياً على مقدار التكاليف، العدة الاجتماعية، المرونة في التعامل، الكفاءة البيئية.

Engineering and Management Consulting Center  xvii
EXECUTIVE SUMMARY

1 Introduction

1.1 Existing Situation of Beit Lahia Wastewater Treatment Plant

1. The Beit Lahia Wastewater Treatment Plant (BLWWTP) was constructed in 1976 in the northern part of Gaza Strip at the outskirts of Beit Lahia town.

2. The system was designed as a secondary treatment plant with a capacity of 5,000 m³ per day and to serve a population of 50,000 in the municipality of Jabalia. During the original design phase of the plant the idea was to use the effluent, of the treatment plant for irrigation of the neighboring agricultural areas. This idea, however was never realized. Conveying the BLWWTP effluent to the sea was also considered (including preparation of tender documents) but the riparians (Isreali authorities) would accept a sea outfall only in an emergency situation and not as a permanent solution. As a result, the treated effluent was simply let out into the sand dunes at the western side of the plant. In the first few years of operations this practice did not cause problems because the effluent quality was good and the sandy soil was able to handle the volume of effluent through natural infiltration.

3. During the past few years the situation escalated. Many communities were provided with sewerage networks and were connected to the BLWWTP. The presently served population is about 180,000 and that includes the municipalities of Jabalia, Beit Lahia, Beit Hanoun, and Um Al Nasir. Consequently, the volume of wastewater inflow to the plant (currently estimated at more than 12,000 m³/day) has exceeded the plant’s treatment capacity by far.

4. The combination of increasing volumes of generated wastewater and insufficient treatment capacity at the BLWWTP has led to deterioration of the effluent quality. The great volumes of poorly treated wastewater have led to clogging effects in the neighboring sand dune areas. The ongoing decrease of the infiltration capacity of the flooded areas and the increasing wastewater volumes have resulted in the formation of enduring ponds and finally a lake.

5. Sand dams have been erected in order to confine the lake and to prevent the surrounding settlements and agricultural areas from being flooded. Any time when the water level in the lake reached the top level of the dam, the height of the dam would be increased with sand.

6. As immediate measures to slow down the rising of the water level in the lake and to reduce the risk of imminent flooding of neighboring residential areas, the following actions, have already been implemented by PWA:

   (a) Using the existing storm water basin to infiltrate the excess effluent from the lake through raft pumps.

   (b) Building one additional emergency effluent infiltration basin with an area of 13,000 m² south of BLWWTP.

   (c) Building a new pumping station at the northern edge of the lake to pump the effluent from the lake into the new effluent infiltration basin and the existing storm water infiltration basin.

   (d) Building a pressure main to connect both the new effluent infiltration basin and the existing storm water infiltration basin with the new effluent pumping station.
7. Today, with all the implemented emergency measures, the BLWWTP and the effluent lake are at their utmost limit and in a very delicate balance especially concerning the water volumes. The difference of the water levels between the last treatment pond (No. 7, polishing pond) and the lake is today slightly more than 20 cm. In some occasions, the water level of the lake was equal to the water level of the polishing pond. As a result the whole treatment system at BLWWTP was blocked.

8. Today the lake, including the small emergency ponds, covers about 35 ha, is almost 1 km long, up to 9 m deep and has a volume of nearly 1.5 million m³. The water level in the lake is several meters higher than most parts of the neighboring areas in the west and north east (Beit Lahia and Um Al Nasir). The largest difference between the surface of the lake and the surrounding areas with about 9 m can be seen in the north-western part of the lake.

9. The effluent lake creates a direct and permanent physical risk for human health. The lake is not fenced and children may fall into the lake and drown. Flooding has already occurred, when the sand barriers in the southwest side collapsed. The consequent flooding caused two casualties, health problems and nuisance to many local residents and resulted in substantial damage to residential buildings in Beit Lahia. According to the Palestinian Water Authority (PWA), thousands of people will be affected directly or indirectly if the barriers of the lake break. The foul water will flood the neighboring communities.
1.2 Previous studies

10. In 1999, two Environmental Impact Assessments were conducted in connection with the problematic situation of the BLWWTP. Both studies were financed by the Swedish International Development Agency and conducted by Boliden Contech and Montgomery Watson in association with local Palestinian consulting firms.

11. The first study “Environmental Impact Assessment of Improvements to Beit Lahia and Associated Developments” assessed the impact of (a) improvement of the BLWWTP (inlet works, pipe-works, sludge reception facility), (b) rehabilitation of the Abu Rashid Storm Water Collection Pond (pumping stations, rising main, landscaping), (c) construction of a new storm water infiltration pond adjacent to the existing BLWWTP lagoons, and (d) construction of a sea outfall for BLWWTP effluent (pumping station, transfer pipeline, outfall facility). At the time this EA was conducted, the sea outfall was considered as the best solution for BLWWTP effluent discharge.

12. The second study “Environmental Impact Assessment of Proposed New Wastewater Treatment Works” assessed the environmental impacts and benefits of the construction and operation of a new Northern Gaza Waste Water Treatment Plant (NGWWTP). This EA covered the NGWWTP (mechanical and biological treatment facilities, infiltration basins), the sewage transfer from the existing BLWWTP to the new site (pipelines, pumping stations), and the activities associated with the decommissioning of BLWWTP.

13. As the nitrate concentration in the groundwater near the NGWWTP was very high (50 - 300 mg NO₃/l), the EA recommended that the total nitrogen concentration should not exceed 10 mg/l to be an acceptable standard for aquifer recharge. The EA also recommended that the effluent should be treated to a level that is suitable for irrigation in the surrounding agricultural areas for crops that are not eaten raw. That was decided based on a survey conducted on the farmers.

1.3 Project Description and Project Area

14. Because of financial constraints, the construction of the complete new NGWWTP in one step, as it was described and assessed in the previous EAs, is not possible at present. The complete NGWWTP project will therefore be implemented as follows:
   - Part A: NGEST Project
   - Part B: NGEST Project
   - Completion of NGWWTP

15. **Part A: NGEST Project:** The World Bank has agreed to finance a “Northern Gaza Emergency Sewage Treatment” (NGEST) project. This project comprises immediate measures to prevent human and ecological disaster in the densely populated Beit Lahia area by draining the existing effluent lake and conveying its partly treated effluent to the new infiltration basins at NGWWTP site. In specific, the NGEST project, consists of:
   - A terminal pumping station at the site of the existing BLWWTP. It will be constructed in Year 2006 for target capacity up to Year 2015 flow.
   - Pressure pipeline to transfer the effluent from BLWWTP and the effluent lake to the infiltration basins (Figure 2).
   - Nine infiltration basins with a total maximum infiltration capacity of 35,600 m³/day. This capacity is equivalent to the expected wastewater volumes in Year 2012.
16. These activities that will be implemented under this component will actually be an integral part of the future operation of the NGWWTP. The terminal pumping station and the pressure pipeline will be used to transfer the raw wastewater from BLWWTP site to the NGWWTP upon the decommissioning of BLWWTP.

17. **Part B: NGEST Project:** This consists of the first phase of the new wastewater treatment plant (primary treatment, sludge treatment, odor control). It is designed to handle a maximum wastewater volume of 35,600 m³/day (expected by 2012). This part is scheduled to start construction in 2006 and be completed in 2008.

18. **Completion of NGWWTP:** This consists of Phases II and III of NGWWTP which will increase the treatment capacity of the plant to handle a maximum wastewater volume of 65,000 m³/day (expected by 2025).

19. The scope of this EA covers the activities that will be implemented from Part A and Part B as described above. The environmental and social issues associated with the increased volume of effluent (approximately 30,000 m³/day) would have to be addressed in another update to the previous EAs. In particular, the alternative wastewater treatment technologies for tertiary treatment, as well as the distribution and monitoring techniques for wastewater re-use in agriculture would need to be evaluated in the future updated EA. Currently the alternatives that are being considered are: (a) a new infiltration treatment basin area for effluent; (b) tertiary treatment with direct use by agriculture; and (c) other alternatives.

![Figure 2: The Route of Proposed Pressure Pipe](image)

20. **Project Location.** The BLWWTP and the lake are located in the Northern Governorate of the Gaza Strip in a densely settled area, close to the northern border with Israel. As the area is almost completely used for human purposes (housing, agriculture), only very few remnants of the originally rich natural animal or plant species spectrum can
be found. Due to its size and the fact that there is open surface water available throughout
the year, the lake has a certain ecological value especially for water and wetland birds.
21. The site of the NGWWTP is located in an agricultural area close to the eastern
border with Israel.
22. The route of the pipeline between the BLWWTP site and NGWWTP site will
mainly follow existing roads.

1.4 Objectives of the EA Study
23. This EA assignment covers the activities described above as part of the NGEST
Project. The wastewater effluent in these phases, between 2006 and 2012, will be used
entirely for aquifer recharge.
24. This EA is an update for the previous EAs mentioned previously in Section 1.2. It
also includes a detailed environmental management and monitoring plan (EMP), and
recommendations to be carried out for remedial works.
25. The supplemental work carried out in this EA (as compared to the work under the
previous EAs) includes:
   (a) Incorporating any design changes that took place since the preparation of the EAs
       in 1999, including the emergency phase of draining the effluent lake into the new
       infiltration basins.
   (b) Ensuring that the project will not have irreversible negative impacts on the
       environment and specifically on the quality of the aquifer.
   (c) Identifying both impacts and benefits of the planned project.
   (d) Developing actions and measures to mitigate unavoidable impacts.
   (e) Consulting with all stakeholders concerned to ensure their awareness of the project
       and consider their views and comments.

1.5 The Study Team
26. This Study has been elaborated by the Engineering and Management Consulting
    Center (EMCC, Gaza) with the support of Dorsch Consult (Germany), and is based on two
    previous EAs (Montgomery Watson 1999), and on several contributions by local scientists
    and experts.

1.6 Disclosure and Consultations
1.6.1 Public Consultations Prior to this EA
27. A comprehensive public participation program was conducted through 1999 EA
    studies. Governmental agencies, NGOs, community representatives, neighboring
    landowners, and other stakeholders were involved in the process. The consultation process
    was performed by direct interviews, filling questionnaires, and public meetings. Most of
    the environmental issues, including wastewater reuse, sludge reuse, socioeconomics,
    aquifer water quality, were discussed in great details.

1.6.2 Consultations during the EA process
28. The public consultation during this EA was performed through a public scoping
    meeting that involved most of the stakeholders and concerned parties. The new project
    components were presented in front of them and their concerns were taken into
consideration. The process also involved head-to-head meetings with the project main parties such as the Palestinian Water Authority, the Israeli Water Commission, the World Bank, Environment Quality Authority, Ministry of Health, and Ministry of Agriculture.

1.6.3 **EA Outcomes**

29. The results and findings of the EA study were presented through a public hearing workshop that involves the different stakeholders, NGOs, and other concerned parties. All their comments and concerns were considered during the preparation of the final report.

2 **Legal and Administrative Structures and Requirements**

2.1 **World Bank Requirements**

30. The World Bank requires an EA for all projects financed by the Bank in order to ensure that these projects are environmentally sound and sustainable.

31. Due to its size and environmental relevance, the Northern Gaza Waste Water Project has been classified as a Category A project. According to the Bank’s Operational Policy on Environmental Assessment (Operational Procedure 4.01, OP 4.01), a full EA is necessary for this project. This Assessment has been elaborated mainly according to the Bank’s OP 4.01.

2.2 **Palestinian Environmental Assessment Policy (PEAP)**

32. Based on the PEAP, this project (NGEST) was classified under the group of projects for which a Full EA is obligatory. The terms of reference were reviewed by the Palestinian Environment Quality Authority (EQA).

33. According to the PEAP, EQA requires that a scoping session be held in order to finalize the specific scope of the EA, Study boundaries, and to raise any specific environmental issues to be considered in the preparation of the EA.

34. EQA has actively participated in the scoping workshop, and their comments and concerns were taken into consideration during the preparation of this EA. The outcomes of this EA were presented to EQA through the public hearing workshop. The draft report was sent to their approval. EQA was satisfied with the EA outcomes and the draft report. They would intend to undertake the final review and issue an approval for the project upon the receipt of the final EA report.

3 **Potential Environmental Impacts and Benefits**

35. The following sections briefly summarize the significant environmental impacts and benefits of the proposed project. The impacts and benefits will consider the three different locations: the old site (BLWWTP), the new pipeline between the old and the new site, and the new site (NGWWTP). The impacts and benefits will also be for the construction and the operations phases.

3.1 **Impacts and Benefits at the BLWWTP Site**

3.1.1 **Project Part A (Emergency activities under NGEST)**
3.1.1.1 **Construction**

36. A new Terminal Pumping Station (TPS) including inlet facilities will be constructed at the southern end of the polishing pond (Fig. 1, No. 7). The impacts due to the construction works (traffic of construction vehicles, noise, dust, sealing of areas) are only temporary and all construction activities will take place within the BLWWTP site. Therefore, these impacts are regarded as not significant.

37. After the lake is completely dry further assessment should be conducted on the lake bottom sediments and soil to check for toxic material and heavy metals. Based on the outcome of the lake bottom assessment, the appropriate site restoration actions will be implemented. Such activities may temporarily and locally cause dust and noise. With proper management of the construction activities, these impacts are regarded as not significant.

3.1.1.2 **Operation**

38. The old WWTP will continue its operation during the emergency phase, and the partially treated effluent from the polishing pond will be pumped to the new infiltration ponds at NGWWTP. Therefore, during the emergency phase the existing situation concerning odor emissions from the existing BLWWTP site is not expected to change.

39. The most relevant aspect concerning flora and fauna in the emergency phase is the drying of the lake. The shrinking water level improves the presently problematic relationship between water surface and volume, which will lead to an enrichment with oxygen, to a better self cleaning ability of the lake, and finally to a better water quality. This will improve the habitat quality for water birds temporarily. During the further drying process of the lake, however, animal or plant species which are depending on open water or wetlands will more and more disappear and species adapted to arid or semi-arid conditions will take over the new habitats.

40. During the drying process the partly filled lake with steep sand dams and the deep sludge at the bottom is a potential danger for anybody who may fall into it. Children may break through dry crusts over deep sludge. It may be very difficult to rescue them. On the other hand, lowering of the water level reduces the risk of a breaking of the sand dams.

41. Once a rehabilitation plan with appropriate environmental mitigation measures is decided, the living conditions of the local residents will be considerably improved, and it will encourage new residents to live in the surrounding area.

42. Pumping the low quality effluent to the new site will reduce the ground water pollution in the Beit Lahia area. This and the ongoing infiltration of storm water (lower pollution level than in the effluent) in the storm water infiltration basins will improve the ground water quality at the long run.

43. Due to the fact that the volumes of infiltrated effluent at the old site will be reduced drastically a significant lowering of the ground water level, locally by some meters, is expected.

3.1.2 **Project Part B**

3.1.2.1 **Construction**

44. When the infiltration ponds and Phase I of the NGWWTP is constructed, the Terminal Pumping Station (TPS) will start pumping the raw wastewater from BLWWTP
site to the new NGWWTP. Ponds No. 1 to 6 as well as the inlet works of BLWWTP will be dismantled. By de-construction of the old wastewater treatment ponds and the surrounding access roads, about 8.2 ha of sealed or partly sealed areas will be sampled for contamination. Based on that a rehabilitation plan will be prepared and implemented.

45. It is anticipated that once zones of contaminated sediments/soils are identified, that these soils will be contained or treated. The goal is to allow the dried lake area and the cleaned-up BLWWTP site to be used for recreational purposes, agriculture, or for new residential areas. The environmental value of this area and possible impacts due to new construction activities depend on the further usage. In general the removal of the ponds will lead to a great social and health improvement as this will reduce health risks and provide a better and cleaner living environment for the local inhabitants.

3.1.2.2 Operation

46. Due to the planned noise and odor control measures at the new TPS no significant noise or odor impacts are expected during normal operations.

3.1.2.3 Potential Impacts under a Worst Case Scenario

47. If the TPS is out of order for whatever reason, the polishing pond No. 7 will function as an emergency facility and retention basin for the incoming wastewater. The retention time of this basin, however, is only a few days and this retention time will be reduced with time due to the ongoing increase of the incoming wastewater volumes. It is quite risky to rely on quite short retention times. If there are substantial problems at the new plant site or a severe damage of the pipeline (as for example due to military activities), there is a possibility that the repair works would take more time.

48. A flooding of neighboring areas with wastewater is a potential impact. Also in the case of a flooding of Pond No. 7 with raw wastewater, odor nuisance may be expected for neighboring settlements depending on the climatic conditions (wind direction, wind velocity, temperature, etc.).

3.2 Impacts and Benefits at the NGWWTP Site

3.2.1 Project Part A (Emergency activities under NGEST)

3.2.1.1 Construction

49. Around 80 dunums of agricultural land will be affected by the excavation activities and huge quantities of mainly clay soil (900,000 m³) will be removed from the site and transferred to other locations. These activities have significant, large scale and long-term impacts on the soil ecology.

50. The construction traffic, especially the transfer of the huge amounts of clay soil partly through residential areas, will cause nuisance for the local population (noise, dust, exhaust fumes). Traffic jams seem to be of minor relevance, due to the low numbers of vehicles in the relevant areas.

51. Due to the disturbance caused by the construction activities wildlife species in the surrounding areas may migrate to other places or leave the place at least during the daily working hours when there are noise and dust from the construction site and the access roads.
52. Constructing wastewater facilities in the vicinity of the Islamic cemetery could cause psychological problems to the families of the deceased.

53. The construction activities at the NGWWTP site will have positive social-economic effects due to the creation of temporary jobs provided that Palestinian contractors and workers are hired for the construction activities.

3.2.1.2 Operation

54. The operation of the new infiltration basins with partially treated waste water in the emergency phase may cause nuisance for surrounding settlements, depending on the climatic conditions (wind direction, wind velocity). However, these effects are expected to be mainly temporary and local due to the fact that the prevailing winds are coming from western directions and the area east of the NGWWTP is not inhabited.

55. Significant odor problems may affect visitors to the Islamic cemetery west of the NGWWTP.

56. The infiltration of great volumes of water will lead to a local increase of the ground water level. At the end of the emergency phase (2008), the groundwater level beneath the infiltration basins will be about 3.7 m higher than today. The water mound will extend about 700 m towards the sea, 300 m inland, 250 m north and south of the infiltration basins.

57. About 13% of the infiltrated water may cross the border to Israel during the emergency phase.

58. A significant improvement in the total recharge quantity (7.3 Mm$^3$/year) will result from the infiltration during the emergency phase.

59. It takes about 250 days for the plume to reach the nearest agricultural well (200 m north of infiltration basins edge). None of the drinking water wells will be affected by the infiltrated water even at the long run (beyond 2015).

60. Regarding chloride, compared to the original water quality around the infiltration basins (330-780 mg/l), the infiltrated water (250 mg/l) will improve the aquifer water quality significantly. At the end of the emergency phase, the infiltrated water will fully replace the original groundwater in a zone covering 200-300 m from the edge of the infiltration basins.

61. Regarding nitrogen, at the end of the emergency phase, the infiltrated water will fully replace the original groundwater 250 m west, 150 m east, 200 m north and south of the infiltration basins edge. Beyond the full displacement zone there will be a transition zone due to mixing and dilution effects. At least 4 agricultural wells will pump water with NO$_3$-N more than 40 mg/l. None of the Israeli wells will be affected. The recovered water quality, however, is suitable for agriculture uses.

62. Regarding pathogenic bacteria, the area within a distance of 150 m from the infiltration site receives infiltration water with a shorter residence time than 6 months. Within this radius of 150 m, drinking water wells could potentially be compromised; however, no potable drinking water wells are located within 150 m. Beyond this 150 m distance, the bacteriological aspect will not be relevant.

63. The main problem in infiltration system for aquifer recharge is the expected clogging of infiltration surfaces which leads to a reduction in infiltration capacity.
64. When the infiltration ponds begin operating they will attract animals, especially open water and wetland species. New species, especially water and wetland species will inhabit the area and use it as shelter, food source and probably as breeding grounds.

65. The necessary maintenance and monitoring activities at NGWWTP will create permanent jobs, a very important aspect in an area where the unemployment rate is estimated to be about 41%.

3.2.2 Project Part B

3.2.2.1 Construction

66. According to the present time schedule the construction in the first phase of NGWWTP will be completed by the year 2008. All the construction activities will take place at the site itself, on relatively small areas compared to the construction activities in Part A. The new site is relatively far from the next settlement/residential areas. Therefore, the construction activities in Part B are regarded as not significant.

3.2.2.2 Operation

67. The operation of the NGWWTP will have long-term positive effects on employment. Permanent or temporary job opportunities will be created for skilled and unskilled workers directly at the site itself. In addition the application of treated sludge in agricultural activities is a potential positive benefit provided that internationally recognized standards are respected to mitigate against sanitary and health risks.

68. The rising water table under the infiltration basins would reach steady state conditions after approximately 8 years (2014). The conducted simulations show that the ground water level beneath the infiltration area will rise to about 6.5 m at that time. In the long run (2025), 120 agricultural wells will be affected by the resulting water mound. At that time the water mound will extend about 2,200 m towards the sea, 1,100 m inland, 1,700 m north and south of the infiltration basins. These predictions were based on the assumption that all the effluent will be infiltrated at the plant site that can only accept 35,000 m³/day. Once this quantity is exceeded and additional infiltration sites are located, these preliminary predictions should be updated.

69. About 18% of the infiltrated water may cross the border to Israel during the long term phase (after 2012). The present lateral flow in the reverse direction, to the west, will be reduced to half due to the infiltrated water mound.

70. A significant improvement in the total recharge quantity (13 Mm³/year) will result from the effluent infiltration, providing that the full infiltration capacity is reached (after 2012).

71. The proposed project will reduce the seawater intrusion to a minor extent (the projected seawater intrusion in the year 2025 without infiltration is 30 Mm³/year while with infiltration 24 Mm³/year), but the problem of seawater intrusion will remain due to the aquifer imbalance.

72. In the long run, after the steady state is reached, the infiltrated water will fully replace the original groundwater 500 m west, 200 m east, 400 m north and south of the infiltration basins edges. Beyond the full displacement zone there will be a transition zone due to mixing and dilution effects.
73. In the long run up to 2025, the good quality water will replace the contaminated water as a result of three processes: (1) dilution; (2) repeated cycles of pumping and recharging into the ground water; and (3) \( \text{NO}_3 \) decay if the water passed through a soil layer (clay) that is rich with organic material. In this process part of the nitrogen load will be lost due to de-nitrification and plant uptake. The contaminant plume will not exceed 2,200 m in the western direction due to the steady state inflow-outflow balance.

74. The treated sewage sludge has significant organic matter and can be used as a soil conditioner and fertilizer in agriculture. It can also contain potential contaminants such as heavy metals, organic contaminants and pathogens and must therefore be analyzed regularly. Consequently an intensive monitoring program is described in the Environmental Management Plan (EMP).

75. As the economic situation and the water and the wastewater services improve, cost recovery can be possible and should be considered in designing the future tariff system.

### 3.2.2.3 Potential Long term Irreversible Impacts under a Worst Case Scenario

76. The worst case scenario was assessed assuming that Part B will not be implemented in the near future and the infiltration with the partially treated sewage will continue for over two years (after 2008). The performance of the existing BLWWTP is expected to decline due to the expected increase in the influent. This would most probably cause severe long-term irreversible impacts in the groundwater beneath the infiltration basins and the nearby surrounding areas (up to 2.2 km west, 0.5 km east, 1.2 km north and south) unless immediate mitigation is implemented through construction of recovery wells and related facilities for the infiltrated water.

### 3.3 Impacts of the Transfer Pipeline between BLWWTP and NGWWTP

#### 3.3.1.1 Construction

77. All significant impacts in connection with the transfer pipeline will take place at the beginning of Part A.

78. The construction activities will cause temporary nuisance for the local population (noise, dust, exhaust fumes, accessibility). Traffic jams seem to be of minor relevance, due to the low numbers of vehicles in the relevant areas.

79. Due to the disturbance caused by the construction activities wildlife species in the surrounding areas may migrate to other places or leave the place at least during the daily working hours when there is noise and dust from the construction site and the activities on the access roads.

80. The construction activities at the NGWWTP site will have positive social-economic effects due to the creation of temporary jobs provided that Palestinian contractors and workers are hired for the construction activities.

#### 3.3.1.2 Operation

81. After the construction works are finished no relevant impacts are expected in the normal operation modus.
3.3.1.3 Potential Impacts under a Worst Case Scenario

82. Breaking of the pipeline for whatever reason would cause local spillage of sewage until the TPS is switched off. An emergency plan for such a case, including immediate remediation and repair measures, must be developed. A team of trained specialists must be permanently available to execute the necessary works.

4 Environmental Management Plan (EMP)

83. The EMP comprises mitigation measures, monitoring plan and capacity building activities.

84. The local standards of the water quality for different uses, treated wastewater quality, air pollution, noise pollution, etc. will be applied. In case these standards are not available, the applied standards in the region will be considered.

85. During the construction and operation phases, the Project Management Unit (PMU) is responsible for coordination with the municipalities, in the Northern Gaza Governorate, which later will be part of Coastal Municipalities Water Utility (CMWU). Also, it is the responsibility of the PMU to ensure proper implementation of the EMP and to discuss any issue in coordination with the relevant local governmental entities. The PMU will be strengthened with a consultant during the construction phase for survey and management of the construction activities and for control of their compliance with the laws and standards. Another consultant will be commissioned to assist in environmental monitoring and quality assurance.

86. The contractors during the emergency phase are responsible for construction activities. The PMU with the help of the consultant will be responsible for quality control and for the contractor compliance with the standards and regulations. During the operation phase, the CMWU supported by the operator will take over the responsibility of the quality control and the quality assurance.

4.1 Mitigation measures

4.1.1 Part A

87. During all construction activities an adequate construction site management, including a regular supervision by an environmental expert, should minimize health risks and nuisances for the local population as well as impacts on the natural environment as much as possible.

88. During the emergency phase and in order to minimize the expected impacts on aquifer water quality, the following measures are recommended at BLWWTP:

   (a) Upgrading of the inlet works for better performance of debris screening and sand removal.

   (b) Cleaning of the first two ponds and installation of aerators in ponds No. 3 and 4. Ponds No. 3 and 4 should be fully aerated with at least 100 KW aeration power.

89. At the beginning of the emergency phase, only the effluent from the polishing pond at BLWWTP (currently 12,000 m³/day and increasing) should be used for infiltration. The infiltration of water from the lake should continue at the two existing storm water infiltration facilities until the lake level is brought down at least by 4 to 5 m.
90. It is proposed to fence and to guard the wastewater lake as soon as possible, at least at the beginning of the emergency phase. Still the alternative of creating temporary jobs for about 20 guards is preferred over fencing, which is very costly and only necessary until the lake is completely dry.

91. At the new site it is also recommended not to use Basins 7 and 9 of the infiltration basins (far east) in order to minimize the trans-boundary impacts. These two infiltration basins could stay unused until the NGWWTP starts to operate and the increasing effluent volumes demand their use.

92. One day flooding followed by 2-3 days drying is a recommended infiltration operation cycle. The optimal operation cycle, however, can only be developed based on practical experience. Regular cleaning of the infiltration ponds (plowing) is required to restore the infiltration capacity.

93. Periodically, scraping and excavation will be required to remove silt and organic matter from the bottom of the infiltration basins. This may be done with a front-end loader twice a year. The excavated material should be washed in a sand-washing unit and the clean sand is refilled into the pond.

94. In all phases of the project, no well should be operated within a distance of 6-month residence time from the edge of infiltration basins (150 m from the edge of the infiltration basins). Beyond this distance, the water is considered hygienically safe.

95. Considering the worst case scenario (if the NGWWTP is not implemented and infiltration with partially treated sewage continues after 2008), recovery facilities around the infiltration site MUST be implemented. Alternatively once the lake levels are reduced, the pumping could be stopped until the wastewater treatment plant is operating. The recovery facilities (taking into account the nearby agricultural wells) should be able to pump 10% more than the effluent that is infiltrated in order to avoid irreversible long-term impacts due to further spreading of the plume of contaminated ground water.

96. In all phases, the operation of the agricultural wells by local farmers in the surrounding areas of the infiltration basins should be closely monitored and actions taken by PWA in order to ensure that all the infiltrated effluent is recovered. The quality of the abstracted water should be strictly monitored to ensure health and safety of the users. In case of any problem in any of the water quality parameters, the necessary action should be decided and enforced by PWA.

4.1.1.1 Part B

97. The best way to minimize environmental impacts of the emergency phase is to keep the emergency phase as short as possible by starting the full operation of the NGWWTP as soon as possible.

98. One day flooding followed by 2 days drying is a recommended infiltration operation cycle. The optimal operation cycle, however, can only be developed based on practical experience. Regular cleaning of the infiltration ponds (plowing) is required to restore the infiltration capacity.

99. Periodically, scraping and excavation will be required to remove silt and organic matter from the bottom of the infiltration basins. This may be done with a front-end loader once a year. The excavated material should be washed in a sand-washing unit and the clean sand is refilled into the pond.
100. Sludge application rates using internationally accepted standards should be based on the content of nitrogen or phosphorous (macronutrient) whichever is the more limiting factor. When the soil test does not recommend phosphorus fertilization, sewage sludge should not be applied.

101. Internationally accepted standards for the use of treated wastewater as irrigation water in agriculture, which specify the quality of treated wastewater for certain crops and soil types, must be applied. Strict local regulations should be developed by the relevant Palestinian health and environmental authorities for the application of sludge and treated wastewater in agriculture, as based on the international accepted standards.

102. Affordable water and wastewater tariffs should be developed to meet the human needs for a household (25 l/h/d - 75 l/h/d). The future tariff should be based upon recovery of operating and replacement costs and that the initial investment in infrastructure must come from other sources. In the long run, the future tariff should take into consideration cost recovery, social equity, flexibility, and environmental efficiency.

4.2 Monitoring Plan

103. The Environmental Monitoring plan sets out a framework for monitoring the environmental situation at all project sites (BLWWTP, NGWWTP and Pressure Pipeline). In order to ensure that the reality complies with the demands of the EMP, environmental monitoring should be carried out concerning the following aspects:
   (a) Construction and transport activities.
   (b) Health and safety measures (construction and operation workers, local inhabitants).
   (c) Site cleaning, solid waste removal, hauling and disposal.
   (d) Efficiency of the treatment process.
   (e) Quality of treated wastewater.
   (f) Aquifer water quality in the vicinity of the infiltration ponds.
   (g) Monitoring of unexpected leakages or system failures.
   (h) Top soil of the infiltration basins against clogging issues.
   (i) Agricultural soil subjected to sludge or treated wastewater application.

104. The monitoring actions are summarized in Table 4.2 and Table 4.3 for Part-A components and in Table 4.5 and Table 4.6 for Part-B components.

4.2.1 Capacity Building

4.2.1.1 Part A

105. The current staffs of the PMU, CMWU, PWA and EQA have the basic skills that enable them to follow-up the implementation of mitigation measures and execute the monitoring plan during the construction and operation phases of the emergency phase. However, during the inception phase of the emergency phase, it is necessary to hire a consultant to conduct the following proposed workshops:
   (a) Project components and schedule.
   (b) Description of the EMP components.
   (c) Institutional arrangements and coordination methodologies.
   (d) Quality control and assurance plans.

106. A qualified consultant is proposed to be responsible for construction management.
107. The EMP specified in Chapter IV of this study should be fully implemented including its four basic components: detailed mitigation plan; institutional setup; monitoring and enforcement requirements; and capacity building requirements.

4.2.1.2 Part B

108. In addition to the workshops explained above, an international consultant is required to conduct training for the representatives of PWA, PMU, CMWU and the Operator in the following subjects:

(a) Advanced training course in treatment process, plant components and functions.

(b) Advanced training in testing and monitoring inlet quality, outlet quality, sludge removal and treatment, odor removal, etc.

(c) Re-use of treated wastewater and sludge in agriculture applications.

5 Summary of Main Issues

109. The emergency phase should start immediately and should be kept as short as possible in order to minimize environmental impacts and risks. While this EA is being finalized, PWA has received good news that the funding for Part B is secured. This means that the construction of Part B will start sooner than what had been planned. It is now planned to start Part B in July 2006, and then finish construction and begin operations in autumn 2008.

110. Before starting the infiltration of partially treated sewage, some upgrading measures for the existing BLWWTP including increasing aeration capacity and pond cleaning are recommended.

111. At the beginning of Part A (first year), only the effluent from BLWWTP should be used for infiltration. The infiltration of the lake water should continue at the two existing storm water infiltration facilities.

112. Natural biological treatment is anticipated as appropriate for lake bottom remediation. Upon drying of the lake, representative soil samples are necessary to be tested for toxic material. Based on these sampling results, the appropriate restoration plan will be decided and implemented.

113. Most of the excavated clay from the new site can be transported to the existing depressions south east of BLWWTP. Some of the clay can be given or sold to farmers with poor soil quality in order to improve their farmland.

114. At the new site infiltration, Basins 7 and 9 (far east) should not be used during Part A.

115. In all phases of the project, no well (potable or agricultural wells) should be operated within a distance 150 m from the edge of the new infiltration basins.

116. If Part B is not implemented after two years (i.e., by 2008), recovery wells and related facilities around the infiltration site MUST be implemented in order to allow the continued infiltration of partially treated sewage. The only other alternative is to stop pumping partially treated sewage from the effluent lake to the infiltration basins.

117. In all phases, the operation of the agricultural wells in the surrounding areas of the infiltration basins should be regulated by PWA in order to ensure that all the infiltrated
effluent is recovered. The quality of the abstracted water should be strictly monitored to ensure health and safety of the users.

118. Strict regulations meeting international standards should be developed by the relevant authorities for the application of sludge and re-use of treated wastewater in agriculture.

119. In the immediate future, tariff should be based upon recovery of operating and replacement costs and that the initial investment in infrastructure must come from other sources. In the long run, the future tariff should take into consideration cost recovery, social equity, flexibility, and environmental efficiency.

120. PWA must carry out a new Environmental Assessment for the completion of the NGWWTP (that is, Phases 2 and 3) to evaluate how to manage the effluent in excess of 35,600 m$^3$/day.

121. The EMP specified in Chapter IV of this study should be fully implemented and should be integrated into the construction contracts.
1 INTRODUCTION

1.1 Preface

1.1 As part of its efforts to improve the environmental and health conditions in the Gaza strip in general and in the North Gaza area in particular (Figure 1.1), PWA has channeled considerable investments from different donors, towards the construction of infrastructure projects in Northern Gaza. However, and despite those investments, Northern Gaza is still facing a huge environmental problem that is caused by the lack of an appropriate wastewater treatment facility.

1.2 PWA through technical assistance from a Swedish consultant has prepared the design of this treatment facility, but due to the lack of financial resources the construction of a complete wastewater treatment plant has been postponed until securing sufficient funds. Meanwhile, the existing wastewater treatment plant continues to discharge the effluent into a huge random lake which threatens the surrounding areas.

1.3 As an emergency intervention to protect the surrounding areas from the risks and effects of the sewage pond, the World Bank has agreed to finance an emergency project, which comprises a new terminal pumping station at the existing location, the pressure lines between the old and the new site and the infiltration basins at the new site. This emergency project aims at alleviating the immediate threats for human life and health of the continuously increasing lake by discharging the partially treated sewage into the infiltration basins at the new site.

1.4 Since this action – the infiltration of partially treated sewage – was not considered in the environmental assessment study that was carried out for the new treatment plant, the World Bank guidelines demand an update of the original study.

1.5 PWA has contracted the Engineering and Management Consulting Center (EMCC) to conduct this update of the previous EA, which was conducted by Montgomery Watson in 1999.

1.2 Existing Situation of Beit Lahia Wastewater Treatment Plant

1.6 The Beit Lahia Wastewater Treatment Plant (BLWWTP) was constructed in 1976 in the northern part of Gaza Strip at the outskirts of town of Beit Lahia (Figure 1.2).

1.7 The system was designed as a secondary treatment plant with a capacity of 5,000 m³/day to serve a population of 50,000 in the municipality of Jabalia. During the original design phase of the plant the idea was to use the effluent of the treatment plant for irrigation of the neighboring agricultural areas. This idea, however, was never realized. Conveying the BLWWTP effluent to the sea was also considered (including preparation of tender documents) but the riparians (Isreali authorities) would accept a sea outfall only in an emergency situation and not as a permanent solution. As a result, the treated effluent was simply let out into the sand dunes at the western side of the plant. In the first few years of operations this practice did not cause problems because the effluent quality was good and the sandy soil was able to handle the volume of effluent through natural infiltration.

1.8 During the past few years the situation escalated. Many communities were provided with sewerage networks and were connected to the BLWWTP. The presently served population is about 180,000 and includes the municipalities of Jabalia, Beit Lahia, Beit Hanoun and Um Al Nasir. Consequently, the volume of wastewater inflow to the
plant (currently estimated at more than 12,000 m³/day) has far exceeded the plant’s treatment capacity.

1.9 Increasing volumes of generated wastewater and insufficient treatment capacity at the BLWWTP have led to deterioration of the effluent quality. The great volumes of poorly treated wastewater have led to clogging effects in the neighboring sand dune areas. The ongoing decrease of the infiltration capacity of the flooded areas and the increasing wastewater volumes have resulted in the formation of enduring ponds and finally a lake.

Figure 1.1: Location of BLWWTP at the North of Gaza Strip

1.10 Sand dams have been erected in order to confine the lake and to prevent the surrounding settlements and agricultural areas from being flooded. Any time when the water level in the lake reached the top level of the dam, the height of the dam would be increased with sand.
1.11 From May 2001 to April 2004 the water level in the lake went up by 2.5 m. Today, the BLWWTP and the effluent lake are at their utmost limit and in a very delicate balance especially concerning the water volumes. The difference of the water levels between the last treatment pond (No. 7, polishing pond) and the lake today is slightly more than 20 cm. In some occasions, the water level of the lake was equal to the water level of the polishing pond. As a result the whole treatment system at BLWWTP was blocked.

1.12 Today the lake, including the small emergency ponds, covers about 35 ha, is almost 1 km long, up to 9 m deep and has a volume of nearly 1.5 million m³. The water level in the lake is several meters higher than most parts of the neighboring areas in the west and north east (Beit Lahia and Um Al Nasir). The largest difference between the surface of the lake and the surrounding areas with about 9 m can be seen in the north-western part of the lake.

1.13 The effluent lake creates a direct and permanent physical risk for human health. The lake is not fenced and children may fall into the lake and drown. Flooding has already occurred, when the sand barriers in the southwest side collapsed. The consequent flooding caused two casualties, health problems and nuisance to many local residents and resulted in substantial damage to residential buildings in Beit Lahia. According to the Palestinian Water Authority (PWA), thousands of people will be affected directly or indirectly if the barriers of the lake break. The foul water will flood the neighboring communities.

1.3 Short Term Intervention Measures

1.14 As immediate measures to slow down the rising of the water level in the lake and to reduce the risk of imminent flooding of neighboring residential areas, the following actions, have already been implemented by PWA:

- Using the existing storm water basin to infiltrate the excess effluent from the lake through raft pumps.
- Building one additional emergency effluent infiltration basin with an area of 13,000 m² south of BLWWTP.
- Building a new pumping station at the northern edge of the lake to pump the effluent from the lake into the new effluent infiltration basin and the existing storm water infiltration basin.
- Building a pressure main to connect both the new effluent infiltration basin and the existing storm water infiltration basin with the new effluent pumping station.

1.15 Although the above actions are not considered as a permanent solution, they would increase the ground infiltration capacity of the BLWWTP by a maximum of 8,000 m³/day, which is 2/3 of the daily sewage inflow (about 12,000 m³). In parallel, the PWA is also regularly reinforcing the embankment around the lake in order to reduce the risk of a sudden failure. However, all these actions are short-term emergency measures in order to stop the rising of the water level in the lake and consequently reduce the risk of a breaking of the sand dams and a flooding of the local communities.
1.6 With these emergency measures, there is hope that the water level in the lake will at least stay constant, but unusual circumstances like heavy rainstorms may end up in a catastrophe. Immediate actions must be taken to eliminate the continuous risk of flooding and the consequences it might have on human life and the environment.

1.4 Funding Status

1.17 For Part A components, 11.3 Million US Dollars (MUS$) is made available from the World Bank (WB) and European Investment Bank (EIB). While this EA is being finalized, PWA has received good news that the funding for Part B (NGWWTP) is secured (25.9 MUS$ from the WB, SIDA, and AFD. This means that the construction of Part B will start sooner than what was planned. Construction of Part B will start in July 2006 and operations will begin in the fall of 2008.

1.5 Objectives of the Northern Gaza Emergency Sewage Treatment Project

1.18 As the situation at the BLWWTP is already dangerous and worsens day by day the Northern Gaza Emergency Sewage Treatment (NGEST) Project has been developed. The main objectives of the proposed NGEST Project are to prevent human and ecological disaster in the Beit Lahia area and to prepare the ground for a future safe and sustainable wastewater treatment for the whole Northern Gaza in line with the previous planning by:
a. Eliminating flooding threat at the BLWWTP site by draining the existing effluent lake by pumping the (partly) treated effluent to the infiltration basins of the NGWWTP east of Jabalia.

b. Preparing the preconditions for a satisfactory long-term solution to the treatment of wastewater for the Northern Governorate in Gaza through implementing parts of the planned NGWWTP.

1.6 Objectives of the EA Study

1.19 This EA assignment covers the activities described above as part of the NGEST Project. The wastewater effluent in these phases, between 2006 and 2012, will be used entirely for aquifer recharge.

1.20 This EA is an update for the two previous EAs described in the Executive Summary. It also includes a detailed environmental management and monitoring plan (EMP) and recommendations to be carried out for remedial works.

1.21 The supplemental work carried out in this EA (as compared to the work under the previous EAs) includes:

   a. Incorporating any design changes that took place since the preparation of the EAs in 1999 including the emergency phase of draining the effluent lake into the new infiltration basins,
   b. Ensuring that the project will not have irreversible negative impacts on the environment and specifically on the quality of the aquifer,
   c. Identifying both impacts and benefits of the planned project,
   d. Developing actions and measures to mitigate unavoidable impacts,
   e. Consulting with all stakeholders concerned to ensure their awareness of the project and consider their views and comments.

1.7 EA Approach and Methodology

1.22 Guideline for the conduction of this assessment is the Bank’s Operational Policy on Environmental Assessment (OP 4.01). In order to prepare the Environmental and MP and achieve its objectives, as outlined in the terms of reference for this study, the consultant carried out the following activities (see Annex I for more details):

1 **Data Collection**, The study team reviewed the available relevant documents including environmental studies, design reports, wastewater quality tests as well as state standards, policies and regulations.

2 **Impact Assessment**, The study team conducted the environmental assessment and evaluated the environmental impacts of all project parts and phases. The study team used the tool of water modeling to predict potential impacts or benefits in connection with the planned project. The potential impacts are described and evaluated for the construction and operation stages of the project. In order to minimize environmental impacts, mitigation measures are defined in form of an Environmental Management Plan (EMP), which must be enforced by the responsible authorities.

3 **EMP Development**, Based on the previous impact assessment, the assessment team developed an Environmental Management Plan (EMP) for the project, which includes feasible and cost effective measures to minimize or mitigate negative
impacts and the actions to be adopted during the screening process and implementation phases of the project.

1.23 In the planning stage only existing reports have been reviewed and general considerations on the future situation have been made concerning population projections, water demand projections, wastewater treatment capacities, and required measures. Thus, conclusions reached in this report will need to be reviewed on a regular basis, in order to ensure that any new project components or revisions of the present planning are assessed in a similar manner.

1.8 Organizations, Legislation and Standards

1.24 A detailed survey about the organizational Structures, the relevant draft or adopted laws, standards and policies is given in Annex (II).

1.25 Following the Autonomy Agreement between the Palestinian Liberation Organization (PLO) and Israel in 1994, the Palestinian Water Authority (PWA) was established in January 1996.

1.26 Until November 1996 the governmental organization basically consists of two levels: central and local levels. In November 1996 a new intermediate level was introduced as Governorate, thus three levels were established: central, regional and local governments. Now, in the Gaza Strip, there are five Governorates: Northern, Gaza, Middle, Khan Younis, and Rafah. All ministries were announced in 1994 and, since that time, a major effort has been made to consolidate these ministries and to develop administrative capacity.

1.27 The planned project is located in the Northern Governorate. The current institutional framework has been reviewed concerning related ministries, governmental and non-governmental organizations. The organizations concerned with the planned project have been consulted and their regulations, standards, and requirements were thoroughly studied. Also the future plans for water management in Gaza Strip through Coastal Management Water Utility were considered.

1.28 The study reviewed the available standards concerning water quality, wastewater quality, air pollution, noise pollution, etc. Reference was always made to local relevant standards. In case, the local standards were not available the applicable regional or international standards were identified. The environmental assessment of the project was conducted according to the World Bank Operational Policy OP 4.01.
CHAPTER TWO
Environmental Assessment Study – Draft Report
Project Description

2 PROJECT DESCRIPTION

2.1 Brief Description

2.1 Because of financial constraints, the construction of the complete new NGWWTP in one step, as it was described and assessed in the previous EAs, is not possible at present. The complete NGWWTP project will therefore be implemented in two parts.

- Part A: NGEST Project
- Part B: NGEST Project
- Completion of NGWWTP

2.2 Part A: NGEST Project: The World Bank has agreed to finance a “Northern Gaza Emergency Sewage Treatment” (NGEST) project. This project comprises immediate measures to prevent human and ecological disaster in the densely populated Beit Lahia area by draining the existing effluent lake and conveying its partly treated effluent to the new infiltration basins at NGWWTP site. In specific, the NGEST project, consists of:

- A terminal pumping station at the site of the existing BLWWTP. It will be constructed in year 2006 for target capacity up to year 2015 flow.
- Pressure pipeline to transfer the effluent from BLWWTP and the effluent lake to the infiltration basins (Figure 2.1);
- Nine infiltration basins (Figure 2.3) with a total maximum infiltration capacity of 35,600 m³/day. This capacity is equivalent to the expected wastewater volume in year 2012.

2.3 These activities that will be implemented under this component will actually be an integral part of the future operation of the NGWWTP. The terminal pumping station and the pressure pipeline will be used to transfer the raw wastewater from BLWWTP site to the NGWWTP upon the decommissioning of BLWWTP.

2.4 Part B: NGEST Project: This consists of the first phase of the new wastewater treatment plant (primary treatment, sludge treatment, odor control). It is designed to handle a maximum wastewater volume of 35,600 m³/day (expected by 2012). This part is scheduled to start construction in 2006 and be completed in 2008.

2.5 Completion of NGWWTP: This consists of Phases II and III of NGWWTP which will increase the treatment capacity of the plant to handle a maximum wastewater volume of 65,300 m³/day (expected by 2025).

2.6 The scope of this EA covers the activities that will be implemented from Part A and Part B as described above. The components of this last part have been fully covered in the old EA and will not be part of this study.

2.7 Chapters 2.2 below, describes the different project components of Part A, while chapter 2.3 describes the details of the two last parts of the project.

2.2 PART A: North Gaza Emergency Sewage Treatment Project

2.2.1 The Terminal Pumping Station

2.8 The terminal pumping station (TPS) comprises two debris/stone chambers, two screen channels, two pump station chambers, and pumping room for dry well pumps. Associated equipment that includes a transformer, switch gear rooms, and two standby generators is also included. Provision for future extension has been incorporated into the
phase I components such as the debris chambers, screens, pump suction chambers, and the rest of the civil work facilities.

**Pumping Capacities**

2.9 The total flow of wastewater to be transferred from BLWWTP to the NGWWTP will increase over the period to year 2025. Therefore, the terminal pumping station (TPS) will be implemented in phases. The maximum capacity for the different phases are as follows:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Target: Maximum Flow</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>2015</td>
<td>1,400 l/sec = 5,040 m³/h</td>
</tr>
<tr>
<td>Phase II</td>
<td>2025</td>
<td>1,800 l/sec = 6,480 m³/h</td>
</tr>
</tbody>
</table>

**TPS Structures**

2.10 The TPS structures includes:

   a. Split chamber
   b. Debris and stone removal
   c. Medium screens
   d. Emergency outflow to pond 7 if the flow exceeds the peak flow.
   e. Pump suction chamber
   f. Terminal pumps (5 in duty and 2 standby for phase I, for phase II one additional pump will be installed)
   g. Control instrumentation to achieve the optimal equipment control and the required operational safety

**Noise Control**

2.11 All pieces of equipment producing noise levels above 72 dB(A) are located inside buildings. The building is designed to absorb the generated noise.

**Odor Control**

2.12 Biological filters for treating noxious odors will be installed to treat air from the inlet, the screen building, and the suction chamber. The odor control system is a comprehensive system to collect and treat air from locations where bad odor may arise. These areas include:

   a. Debris and stone chambers
   b. Screen channels and emergency overflow
   c. Suction pit chambers
   d. Screening and container room

2.13 All units will be covered and the air will be exhausted by a fan and conveyed to the filters through pipe work in the buildings and below ground to feed each group of filters.

**Security Wall**

2.14 The TPS site will be surrounded by a wall selected to provide security for the plant installations. The site entrance will be provided with a gate according to local standards.

**2.2.2 The Pressure Main**

2.15 A ductile iron sewage pipe with 800 mm diameter and 8 kilometer length to transfer the effluent from BLWWTP to the infiltration basins. The pressure main will flow
the route of existing roads. Figure 2.1 and Figure 2.2 show the route of the proposed pressure pipe and the proposed emergency measures.

2.2.3 The Infiltration Basins

2.16 The infiltration basins are essential part of the NGWWTP but they will be constructed and operated at the emergency phase before the construction and operation of the full treatment plant. The top layer of the NGWWTP site consists of alluvial clay completely covering the permeable kurkar layer at varying depths (Annex IV). About 900,000 m$^3$ of the clayey topsoil will be removed in order to improve the infiltration rate to the planned figures.

2.17 The maximum capacity of the infiltration basins is based on the design criteria regarding the produced effluent from phase 1 of the NGWWTP, which was predicted for the year 2012. This means that the infiltration basins are designed to accommodate 35,600 m$^3$/d as shown in Table 2.1.

2.18 The area that is required for infiltration of the treated wastewater was based on two main factors; the inlet flow rate (35,600 m$^3$/d) and the maintenance and operation schedule for the basins. The allocated land area for the infiltration basins is 80,000 m$^2$.

2.19 Table 2.1 shows the previously expected average effluent and the associated hydraulic load at the infiltration basins based on one day flooding and two days drying.
operating cycle. The current BLWWTP effluent is about 12,000 m$^3$/day which is less than the flow which has been predicted in the previous EA. The reason may be that not all of the predicted connection plans could be realized in time. Large areas from the northern governorate, which are not yet connected to the sewer system, are expected to be connected in the next two years and as a result, the effluent inflow will follow the originally predicted figures.

![Figure 2.2: Present Situation at BLWWTP](image)

Table 2.1: Infiltration Rate and Hydraulic Load 2005-2012.

<table>
<thead>
<tr>
<th>Year</th>
<th>$Q$ average, m$^3$/d</th>
<th>Infiltration Rate, m/d</th>
<th>hydraulic Load, m$^3$/m$^2$/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>19,670</td>
<td>0.75</td>
<td>89</td>
</tr>
<tr>
<td>2006</td>
<td>21,946</td>
<td>0.84</td>
<td>99</td>
</tr>
<tr>
<td>2007</td>
<td>24,221</td>
<td>0.92</td>
<td>110</td>
</tr>
<tr>
<td>2008</td>
<td>26,497</td>
<td>1.01</td>
<td>120</td>
</tr>
<tr>
<td>2009</td>
<td>28,773</td>
<td>1.09</td>
<td>131</td>
</tr>
<tr>
<td>2010</td>
<td>31,049</td>
<td>1.18</td>
<td>141</td>
</tr>
<tr>
<td>2011</td>
<td>33,324</td>
<td>1.26</td>
<td>152</td>
</tr>
<tr>
<td>2012</td>
<td>35,600</td>
<td>1.35</td>
<td>162</td>
</tr>
</tbody>
</table>

2.20 The infiltration report issued by SWECO INT has recommended a hydraulic load of 120 m$^3$/m$^2$/year in order to achieve the most efficient performance of the infiltration basins. This will not be achieved before 2008. The hydraulic load in the year 2012 will be 162 m$^3$/m$^2$/year exceeding the recommended value. After the year 2012 it is planned to lower the load to the recommended value and to direct the surplus effluent to another infiltration scheme or direct use for irrigation since the effluent quality will be suitable for unrestricted irrigation. During the emergency phase the effluent quality (see section 2.1.3) will be of lower quality than the required infiltration standards. Hence, lower loading rate and more frequent maintenance are necessary to avoid clogging of the top surface of the infiltration basins.

2.2.4 BLWWTP Performance and Effluent Quality

Effluent, Sludge and Soil Tests

2.21 As part of this assignment, the effluent, soil, and sludge of the BLWWTP were sampled and analyzed. The analysis included two composite samples from the polishing pond effluent, three samples from the lake representing the whole water column at different locations, three samples from the sludge layer at the bottom of the lake, and three samples from the top soil layer at the bottom of the lake. The analysis results were discussed considering also the historical results from other references. The details of these tests and related discussion are included in Annex (iii). These tests were carried out by the Islamic University Laboratories, Environmental and Rural Studies Laboratory as part of the EA requirements.

2.22 Table 2.3 outlines some of the parameters that are of particular importance in this EA assignment. It shows the adopted values that will be used for evaluating the impacts based on the discussion in Annex III.

2.23 The depth of each pond was measured in order to assess the operation of BLWWTP under the existing conditions. Table 2.2 shows the original design depth and the existing depth. The combination of existing aeration capacity (88 KW) and enough retention time can produce a relatively good effluent (BOD < 50mg/l) for flow up to 14,000 m$^3$/day. According to EU standards, it is required to provide 5 KW aeration capacity for every 1000 m$^3$ of influent. As the influent increases to about 18,000 m$^3$/day, the retention time will be less than 1.2 days which is not enough for aeration. As a result the treatment efficiency will decrease. The existing ponds should be cleaned to restore the depths to their original design values in order to increase the treatment efficiency.

Table 2.2: Depth of Ponds in BLWWTP.

<table>
<thead>
<tr>
<th>Pond No.</th>
<th>Design Depth</th>
<th>Existing Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anaerobic</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>Anaerobic</td>
<td>2.4</td>
</tr>
<tr>
<td>3</td>
<td>Aerated</td>
<td>2.4</td>
</tr>
<tr>
<td>4</td>
<td>Aerated</td>
<td>2.4</td>
</tr>
<tr>
<td>5</td>
<td>Facultative</td>
<td>2.96</td>
</tr>
<tr>
<td>6</td>
<td>Facultative</td>
<td>2.96</td>
</tr>
<tr>
<td>7</td>
<td>Polishing</td>
<td>6.75</td>
</tr>
</tbody>
</table>

2.24 It is obvious from the Table 2.2 that the level of the water has increased by at least 15 cm over the maximum designed levels. Raising the water level is necessary most of the year to create a little hydraulic head between the BLWWTP ponds and the effluent lake which is now almost the same water level as the treatment plant. If the water level in the
lake is allowed to rise slightly the flow from the treatment plant to the lake will be blocked and the whole treatment system will be disabled.

**Industrial wastewater contribution**

2.25 The main source for industrial wastewater is Beit Hanoun Industrial Estate which contributes less than 5% of the BLWWTP influent. Additional industrial wastewater is also discharged from small establishments in Jabalia and Beit Lahia. In total, less than 7% of the influent is attributed to industrial wastewater. A field survey conducted in 2002 showed that the pre-treatment processes were almost absent, and in the best case they were very simple, represented by sediment tanks.

2.26 According to EQA, industrial installations are classified into three categories according to the hazards arising from these installations in terms of gaseous, liquid or solid waste affecting the human health and the environment. Class A represent the group of industries with the least toxic waste, Class B with medium toxic wastes, and Class C with the most toxic waste. The industries in the northern area form about 20.5% (295) of the total industries in Gaza Strip (1436). Of the 295 industries present in the northern area, 29 were classified as Class A, 199 as Class B, and 67 as Class C (EQA – Baseline Budget, 2004).

2.27 Under the worst case scenario of the industrial wastewater production in terms of quality and quantity, the existing treatment plant is able to absorb all amounts of pollutants and the final effluent is considered clean for agriculture and other reuse applications (Shomar, 2004). As shown in Table 2.3, the risk of heavy metals accumulation is negligible in comparison to the limit values from US, Israel and EU countries due to the low concentrations of potential toxic heavy metals in soil and the sludge from the bottom of the lake.

**Table 2.3: Sampling Result from BLWWTP.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean value from the polishing pond</th>
<th>Mean value from the lake, different locations</th>
<th>Mean value from the sludge, bottom of lake</th>
<th>Mean value from the soil, bottom of lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.5</td>
<td>7.6</td>
<td>8.8</td>
<td>9.0</td>
</tr>
<tr>
<td>EC µS</td>
<td>1600</td>
<td>1760</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS mg/l</td>
<td>1050</td>
<td>1130</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSS mg/l</td>
<td>19</td>
<td>59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOD mg/l</td>
<td>98</td>
<td>138</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na mg/l</td>
<td>65</td>
<td>75</td>
<td>80</td>
<td>79</td>
</tr>
<tr>
<td>Mg mg/l</td>
<td>82</td>
<td>76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>52</td>
<td>62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl mg/l</td>
<td>239</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO₃ mg/l</td>
<td>5.5</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₄ mg/l</td>
<td>64</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TKN mg/l</td>
<td>75</td>
<td>104</td>
<td></td>
<td>0.02%</td>
</tr>
<tr>
<td>Cd mg/l</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.043</td>
<td>0.048</td>
</tr>
<tr>
<td>Cu mg/l</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>HG mg/l</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pb mg/l</td>
<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Zn mg/l</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cr mg/l</td>
<td>0.055</td>
<td>0.1</td>
<td>0.07</td>
<td>0.14</td>
</tr>
</tbody>
</table>
### Table

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean value from the polishing pond</th>
<th>Mean value from the lake, different locations</th>
<th>Mean value from the sludge, bottom of lake</th>
<th>Mean value from the soil, bottom of lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni mg/l</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.019</td>
</tr>
<tr>
<td>Fe mg/l</td>
<td>1.08</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F.C cfu/100ml</td>
<td>26x10³</td>
<td>21x10³</td>
<td>1.15x10³</td>
<td>0.36x10³</td>
</tr>
<tr>
<td>Nematode Eggs</td>
<td>Nill</td>
<td>Nill</td>
<td>Nill</td>
<td>Nill</td>
</tr>
</tbody>
</table>

2.28 With all upgrading activities at BLWWTP realized, the effluent levels of BOD, SS and Total N would be significantly lower than the present values. Previous records in 2001 and 2002 (during full aeration in the aerated lagoons), showed that the BOD was about 45 mg/l (Shomar, 2004).

### 2.2.5 Operation and Maintenance of Infiltration Basins

2.29 The infiltration area is divided into nine ponds with a total effective area of approximately 80,000 m². Figure 2.3 shows the layout and the surface area of each of the infiltration basins. Based on the original design, the infiltration basins are divided into three groups; Basins 1-2-3, Basins 4-5-7; and Basins 6-8-9 Figure 2.3. The effluent will be distributed only to one of the three basin groups at a certain time. After flooding for a certain period, 0.5-2 days, the flooded basins are allowed to dry and the water is directed to the next basin group. Due to the change in the effluent quality, the flooding and drying cycles for the emergency period will be different from the cycles during the operation of NGWWTP. The optimal design of the drying the flooding cycles will be based on practical experience during operation.

![Figure 2.3: Infiltration Basins Layout and Effective Surface Area](image)
2.3 Part B (North Gaza Wastewater Treatment Plant)

2.3.1 Background and Previous Considerations

2.30 As part of its long-term intervention measures, PWA through SIDA fund has conducted several studies in which transferring the existing WWTP to the eastern part of Jabalia was examined. Among those studies, which are the basis for the present investigation, are:

a) Boliden Contech and Montgomery Watson (1999). Environmental Impact assessment of Improvements to BLWWTP and Associated Developments. The study assesses the environmental impacts of the fast track construction works that aimed at improving the Existing BLWWTP.

b) Boliden Contech and Montgomery Watson (1999). Environmental Impact assessment of proposed new wastewater treatment Works. The second study is substantially linked to the current EA study where the environmental impacts of the construction of the NGWWTP were assessed. The 1999 assessment was based on the selection of one option among 5 other options. These options were:

Option 1: Oxidation ditch and Thermal Drying
Option 2: Sequencing of Batch reactor and Thermal Drying
Option 3: Oxidation ditch and Sludge Digestion
Option 4: Sequencing Batch Reactor and Sludge Digestion
Option 5: Up flow Anaerobic Sludge Blanket, oxidation ditch and Sludge Drying

The preferred option of the study was option 3. The NGWWTP system also incorporates an infiltration pond system. The infiltration system in the previous consideration comprised 6 ponds with a total infiltration capacity of 65,300 m³/day. The previously proposed treatment standards for the effluent as recommended in the previous EA are presented in the Table 2.4.

<table>
<thead>
<tr>
<th></th>
<th>Marine discharge</th>
<th>Agricultural reuse</th>
<th>Aquifer recharge</th>
<th>Proposed Treatment Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD mg/L</td>
<td>-</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>TSS mg/L</td>
<td>-</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Total N mg/L</td>
<td>-</td>
<td>50</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Ammonia mg N/L</td>
<td>-</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td>Nitrate mg N/L</td>
<td>-</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td>Total P mg/L</td>
<td>-</td>
<td>N/a</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td>Faecal Coliform No/100ml</td>
<td>10,000</td>
<td>1000</td>
<td>N/a</td>
<td>1000</td>
</tr>
<tr>
<td>Helminthes No/Liter</td>
<td>-</td>
<td>&lt;1</td>
<td>N/a</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Residual chlorine</td>
<td>-</td>
<td>No</td>
<td>N/a</td>
<td>No</td>
</tr>
</tbody>
</table>

c) SWECO INTERNATIONAL during the years 2002-2003 has conducted a series of studies including desk top study, final detailed evaluation, soil investigation and infiltration study for the NGWWTP. Following the same concept of the previously selected option (oxidation ditch) and considering the recent changes in the recommended treatment and reuse standards, the final detailed evaluation has considered four alternatives which are:

- Plug Flow + Sludge Dewatering (AI).
2.31 The Circular/Complete Mixed process with Primary Clarification and Anaerobic Sludge Digestion with Energy Reuse (Option B2:1) was recommended to be implemented for the NGWWTP.

2.32 The wastewater treatment system selected by SWECO is essentially similar to the system proposed in the feasibility study conducted by Boliden Contech and Montegomery Watson with some modifications in the secondary treatment and the tertiary treatment. The preliminary and primary treatments are essentially the same. Both systems proposed mechanical bar screening, grit and grease removal, in addition to primary sedimentation.

2.33 Regarding the biological treatment, both systems use oxidation ditches with final sedimentation as a secondary treatment. However, the proposed circular loop configuration proposed by the SWECO consultant is more efficient than the one loop (race track) configuration proposed by Boliden Contech and Montegomery Watson in terms of de-nitrification. This is a positive modification when recharging the effluent into the aquifer.

2.34 The tertiary treatment proposed by Boliden Contech and Montegomery Watson which includes sand filtration and Ultraviolet disinfection is excluded from the new design. This modification can be accepted if the treated sewage is used for recharge only. Excluding the sand filtration step may lead to the increase in the maintenance frequency of the infiltration basins due to the rapid accumulation of solids in the basin bed. This occurs due to variations of the final sedimentation tanks efficiency encountered as a result of operational problems such as sludge bulking, leading to high concentrations of the suspended solids in the effluent and consequently endangering the infiltration process.

2.3.2 Process Design Criteria and Considerations

(Mainly based on information from the final detailed evaluation by SWECO, 2002)

2.3.2.1 Implementation Phases

2.35 The Pumping Stations will be implemented in two phases with the first phase construction in year 2006 of capacity 2015 and the second in year 2015 of capacity year 2025. Preliminary, Secondary (Biology), and Sludge Treatment at the NGWWTP will be implemented in three phases with expected start up in the year 2008:

- Phase 1 constructed in 2008, target capacity 2012
- Phase 2 constructed in 2011, target capacity 2018
- Phase 3 constructed in 2017, target capacity 2025

Figure 2.4 shows the layout of the treatment plant.

2.36 Previously, the start up year was planned to be 2004, but due to the delay in securing enough fund, the operation of the first phase is now scheduled to start in 2008.
The plant has been designed for Phase 1, but the two following phases have been taken into consideration to achieve an optimal layout not only in Phase 1 but also in Phase 2 and Phase 3. The location of effluent pumping station has also been revised, as well as the pipeline system and the infiltration basins for recharge of the aquifer.

![Figure 2.4: NGWWTP General Layout.](image)

### 2.3.2.2 Influx and Loads

2.37 Based on the detailed evaluation report, the Average Daily Flows forecast to the NGWWTP were:

- Year 2008 26,497 m$^3$ per day
- Year 2015 45,403 m$^3$ per day
- Year 2025 65,336 m$^3$ per day

2.38 The significant increases for Phase 3, capacity year 2025, in flow are mainly due to the following five factors:

- Population growth of 2.0 to 3.3% per annum.
- Increase in service area during the design period equivalent to about 50,000 persons.
- Increase in consumption from 114 l/c/d to 150 l/c/d.
- Increase in connected population from 70 to 100%.
- Decrease in Non Return flow from 42 to 20%.

### 2.3.2.3 Influent and Sludge Design Criteria

2.39 The facility has been designed for the influx conditions presented in Table 2.5. These parameters were the basis for the comparison in the detailed evaluation.
Table 2.5: Design Criteria of the Influent

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>1,054</td>
<td>968</td>
<td>915</td>
</tr>
<tr>
<td>BOD₅</td>
<td>mg/l</td>
<td>551</td>
<td>506</td>
<td>479</td>
</tr>
<tr>
<td>Total-N</td>
<td>mg/l</td>
<td>106</td>
<td>98</td>
<td>92</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>mg/l</td>
<td>87</td>
<td>80</td>
<td>76</td>
</tr>
<tr>
<td>Total-P</td>
<td>mg/l</td>
<td>19</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>SS</td>
<td>mg/l</td>
<td>580</td>
<td>533</td>
<td>504</td>
</tr>
</tbody>
</table>

2.40 The concentration of NH₄--N is expected to be less than 1.0 mg/l in the effluent from the new plant. The oxygen concentration is expected to be between 3.0 to 5.0 mg/l. The chloride concentration is expected to be 200-300 mg/l, based on the quality of the incoming wastewater quality.

2.41 The effluent quality criteria for the NGWWTP are as follows:
- BOD₅: 10-20 mg/l
- SS: 15-20 mg/l
- N-tot: 10-15 mg/l
- Helminth: <1 No/l
- Faecal Coliform: <200 MPN/100 ml

2.42 Design of the Plant has also considered that the effluent requirements will be met under the following conditions for Phase 1 of capacity of year 2012:
- Daily load ±20 % of the design values during a maximum period of 3 days once per month.
- Flow peaks of up to 4,750 m³ per hour for a maximum duration of 3 hours per day. If the duration is longer than 3 hours, the flow will be treated but the results from the effluent analyses during this period of time may not meet the effluent requirements. The plant should meet effluent requirements within 48 hours after the flow has subsided to average dry weather conditions (1,975 m³ per hour).
- The Total Nitrogen requirement is an annual average of 24-hours composite, flow proportional samples taken out at least twice every week the whole year.
- The maximum value for BOD shall be fulfilled in 80 % of one year's 24-hour composite flow proportional samples.
- Maximum value for SS shall be fulfilled in 80 % of 3 month's 24-hour composite flow proportional samples.
- The Average Design Temperature is assumed to be 20 C.
- The quality of the treated effluent concerning Suspended Solid, Ammonia Nitrogen, and Nitrate Nitrogen shall not exceed a certain values during a certain period (see clause 2.36).

2.43 The evaluated sludge treatment considered mechanical dewatering for extended aeration processes, and anaerobic digestion and mechanical dewatering in the activated sludge processes. The dewatered sludge is proposed to be stored for 100 days during which time it will dry and stabilize to a certain extent.

2.44 There is a slight modification in the sludge treatment in the selected system compared to that proposed by Boliden Contech and Montgomery Watson. The pre-pasteurization tank is replaced by a sludge storage silo (Figure 2.5 and Figure 2.6). This modification is justified since storage is an effective way for pathogen reduction which
compensates for the pasteurization step. The proposed storage residence time (100 days) should be enough for this process.

2.3.3 Wastewater Treatment Processes

2.45 Process layout drawings are presented at the end of this chapter (Figure 2.5 and Figure 2.6). In the Process Design it is assumed that if one unit is out of operation for maintenance in each process step for a certain period, the other units in operation can still operate at the maximum hydraulic flow.

2.3.3.1 Preliminary Treatment

2.46 The Preliminary Treatment consists of; Pre-Aeration, Fine Screening, Grit and Grease Removal and Flow Measurement. All treatment steps are designed to allow development to Phase 3 that will serve to year 2025.

Pre-Aeration

2.47 As the distance of the pressure mains between the New Terminal Pumping Station and the NGWWTP is about 8,000 meter, the retention time during night time (small wastewater volumes) is high just after commissioning in year 2008. The combination of high wastewater temperature of 20 to 30°C and Sulphate content up to 100 mg/liter accelerates the creation of Hydrogen Sulphide. This might cause corrosion and odor problems in the whole treatment plant. It is therefore very important to oxidize the influent by aeration in pre-aeration basins to avoid conditions creating those problems. The basins are covered and the excess air is transferred to odor treatment (bio filters) to minimize the H₂S-content and other odor producing components. The design parameters are presented in Table 2.6.

<table>
<thead>
<tr>
<th>Table 2.6: Design Parameters for Pre-Aeration.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Number of units</td>
</tr>
<tr>
<td>Volume, each</td>
</tr>
<tr>
<td>Volume, total</td>
</tr>
<tr>
<td>Area, each</td>
</tr>
<tr>
<td>Area, total</td>
</tr>
<tr>
<td>Length x Width each</td>
</tr>
<tr>
<td>Depth</td>
</tr>
<tr>
<td>Retention time Q_{design}</td>
</tr>
</tbody>
</table>

Fine Screening

2.48 Three fine screens and one stand-by are designed for the hourly maximum flow of 6,480 m³ per hour in Phase 3. All these screens will be installed under Part B, but maximum flows will not occur until 2025. Each screen has a capacity of 2,160 m³/hour. The fine screens have a bar distance of 2 mm. With 2 mm bar distance the subsequent treatment units are well protected against coarse objects, which could create obstructions in the process equipment such as pumps. The expected amount of fine screening material (wet, drained and washed) is 4.4 m³/day. The yearly volume for disposal of screenings is
estimated at 1,600m³ in Phase 1. The screening material will be disposed of at appropriate landfill disposal sites.

**Grit and Grease Removal**

2.49 The grit and grease chambers are designed for the maximum flow of 6,480 m³/hour. The treatment is performed in two parallel units. The grit chambers have a total volume of 550 m³. This gives a hydraulic retention time of 9 min at design flow in Phase 3, well designed to remove sand particles in range of 0.15 to 0.2 mm. Floating grease is collected in a separate chamber located along the grit chamber. Collected grease is transported by surface scrapers to the grease pits. Those are located beside the grit chambers. From the grease pits, the grease is pumped to a combined storage tank for grease and floating sludge from the primary clarifiers. A truck transports the fat and grease to a legal disposal site outside the WWTP. All air volumes are treated in the odor treatment unit. With this system the possibility of odor occurring from grease and fat at the site is minimized. Design data for the grit and grease chambers are presented in Table 2.7 and Table 2.8.

**Table 2.7: Design Parameters for Grit Removal**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units</td>
<td>units</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Volume, each</td>
<td>m³</td>
<td>275</td>
<td>275</td>
<td>275</td>
</tr>
<tr>
<td>Volume, total</td>
<td>m³</td>
<td>550</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Area, each</td>
<td>m²</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Length x Width</td>
<td>m x m</td>
<td>20 x 4</td>
<td>20 x 4</td>
<td>20 x 4</td>
</tr>
<tr>
<td>Area, total</td>
<td>m²</td>
<td>160</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Depth</td>
<td>m</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Retention time t_Qd</td>
<td>minutes</td>
<td>17</td>
<td>12</td>
<td>9</td>
</tr>
</tbody>
</table>

**Table 2.8: Design Parameters/or Grease Removal - NGWWTP.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units</td>
<td>units</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Volume, each</td>
<td>m³</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Volume, total</td>
<td>m³</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Area, each</td>
<td>m²</td>
<td>82.5</td>
<td>82.5</td>
<td>82.5</td>
</tr>
<tr>
<td>Length x Width, Area</td>
<td>m x m</td>
<td>20x4.1</td>
<td>20x4.1</td>
<td>20x4.1</td>
</tr>
<tr>
<td>Total</td>
<td>m²</td>
<td>165</td>
<td>165</td>
<td>165</td>
</tr>
<tr>
<td>Depth</td>
<td>m</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Surface Load Qd</td>
<td>m/hour</td>
<td>12</td>
<td>17</td>
<td>22</td>
</tr>
</tbody>
</table>

2.50 The aeration system is designed for an air supply capacity of 12-15 m³/meter tank length and hour. Hydraulically one unit can operate the maximum capacity. During Phase 1, year 2012 the grit volume is estimated to 4,900 m³/year.

**Flow Measurement**

2.51 The flow measurement after the grit and grease chambers is designed as two Parshall flumes. This type of measurement gives an accuracy of the flow measuring of
±0.5 %. Each Parshall flume is designed for the future maximum flow 3,240 m³/hour in Phase 3. It is important to have two flumes to achieve sufficient accuracy in the start of year 2005.

2.3.3.2 Primary Treatment

Primary Clarification

2.52 Equal flow to each of the rectangular primary clarifiers is achieved at all rates of flow by a weir to each clarifier. Rectangular clarifiers are preferable to circular clarifiers in the new design because less piping is needed and a more compact layout is required to achieve a larger area for the infiltration basins. Design data for the primary clarifiers are presented in Table 2.9.

Table 2.9: Design Parameters for Primary Clarifiers - NGWWTP.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units</td>
<td>units</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Area, each</td>
<td>m²</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Area, total</td>
<td>m²</td>
<td>900</td>
<td>1,200</td>
<td>1,500</td>
</tr>
<tr>
<td>Length x Width Volume, each</td>
<td>m x m</td>
<td>50 x 6</td>
<td>50 x 6</td>
<td>50 x 6</td>
</tr>
<tr>
<td>Volume, total</td>
<td>m³</td>
<td>3,150</td>
<td>4,200</td>
<td>5,250</td>
</tr>
<tr>
<td>Depth</td>
<td>m</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Retention time design</td>
<td>Hours</td>
<td>1.6</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Surface Load Q_{design}</td>
<td>m/ha</td>
<td>2.2</td>
<td>2.3</td>
<td>2.4</td>
</tr>
</tbody>
</table>

2.53 The clarifiers are designed for the following reductions at influent pollution loads in Table 2.10. The relatively shallow tanks and the high surface load result in a lower retention time and lower reduction compared with deeper tanks.

Table 2.10: Assumed Reduction in Primary Clarifiers - NGWWTP.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reduction</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>%</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>BOD₅</td>
<td>%</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>N total</td>
<td>%</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>SS</td>
<td>%</td>
<td>55</td>
<td>55</td>
<td>55</td>
</tr>
</tbody>
</table>

2.54 The assumed reductions were verified by sedimentation tests at the BLWWTP site. Each primary clarifier has sludge thickening hopper at the inlet of the tank. The dry solids content achieved was 3.5 to 6.0. No further thickening is needed.

Biological Treatment (Circular/Complete Mixed activated Sludge system)

2.55 In the circular/complete mixed process the incoming wastewater and the return sludge are mixed together in the first aeration zone. Activated sludge moves in the endless channel through successive nitrification and denitrification zones. This process combines the features of complete mixing and plug flow. The complete mixing feature results from the fact that the total liquid volume included in the circulatory process is about 30 to 50
times greater than the influent flow rate. Thus the process can provide a marked buffer effect. The plug flow feature is due to the great distance covered by one circuit. Improved de-nitrification results in a reduced oxygen concentration in some parts of the aeration tank.

2.56 The sludge age, nitrification and de-nitrification rate have been used for the design of the volumes. The nitrification and de-nitrification rates have been selected from several plants in operation during several years with the value 3.5 gram NH4-N per kg VSS hour and 3.1 gram NO3-N per kg VSS hour respectively. The Sludge Yield used for the design is 0.65 kg VSS per kg BOD-Removal and the organic part of the sludge, MLVSS, is expected to be 70% of the MLSS, which is 3.5 kg MLVSS per m3. A summary of the design parameters is presented in Table 2.11 for year 2012.

Table 2.11: Summary of Design Parameters for Circular/Complete Mixed System.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units</td>
<td>Units</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Volume, each</td>
<td>m³</td>
<td>10,100</td>
<td>10,100</td>
<td>10,100</td>
</tr>
<tr>
<td>Volume, total</td>
<td>m³</td>
<td>30,300</td>
<td>40,400</td>
<td>50,500</td>
</tr>
<tr>
<td>Depth</td>
<td>m</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Sludge age</td>
<td>days</td>
<td>11.2</td>
<td>11.8</td>
<td>11.9</td>
</tr>
</tbody>
</table>

2.57 Special features of the process are that it can accommodate large variations in both the quantity and quality of incoming sewage. Mechanical submersible mixers are used to create sufficient current velocity in the wastewater in order to prevent the settling of sludge.

2.58 The aeration system is recommended to be a rubber membrane system, partly covering the base of the tank in the anoxic/oxic and the oxic zones. It is divided into three sections in each tank; one in the anoxic/oxic zone and two in the oxic zone. In front of each diffuser section a propeller is creating the hydraulic horizontal velocity throughout the tank. The recycled return sludge is combined in this circular chapter and no return pumps for nitrified sludge are needed. It is also possible to adjust the oxygen profile and decrease the dissolved oxygen (DO) in the end of the oxic zone in the pre-denitrification process. The specific oxygen consumption is assumed to be 3.0 kg O₂ per kWh.

Secondary Clarification

2.59 The flow from the activated sludge system will pass secondary Clarifiers of the circular type. The design of the Clarifiers is based on the surface load as well as the depth to give sufficient settling efficiency and sludge handling capacity. The clarification is performed in three circular clarifiers in year 2012 Phase 1. The clarifiers have circular bottom scrapers at the total diameter of the tank from which the sludge is sucked from several points to ensure an equal sludge withdrawal along the bottom surface. The clarifiers are equipped with deflection discs. Design data for the secondary clarifiers are presented in Table 2.12.
### Table 2.12: Design Parameters for Secondary Clarifiers.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units</td>
<td>units</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Area, each</td>
<td>m²</td>
<td>1,100</td>
<td>1,100</td>
<td>1,100</td>
</tr>
<tr>
<td>Area, total</td>
<td>m²</td>
<td>3,300</td>
<td>4,400</td>
<td>5,500</td>
</tr>
<tr>
<td>Diameter</td>
<td>m</td>
<td>37.4</td>
<td>37.4</td>
<td>37.4</td>
</tr>
<tr>
<td>Volume, each</td>
<td>m³</td>
<td>5,060</td>
<td>5,060</td>
<td>5,060</td>
</tr>
<tr>
<td>Volume, total</td>
<td>m³</td>
<td>15,180</td>
<td>20,240</td>
<td>25,300</td>
</tr>
<tr>
<td>Depth</td>
<td>m</td>
<td>4.6</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Surface Load Q_{design}</td>
<td>m/ hour kg</td>
<td>0.60</td>
<td>0.62</td>
<td>0.65</td>
</tr>
<tr>
<td>Sludge Load Q_{design}</td>
<td>MLSS/m², h</td>
<td>1.7</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Retention Time</td>
<td>hours</td>
<td>7.7</td>
<td>7.4</td>
<td>7.0</td>
</tr>
</tbody>
</table>

2.60 Each final clarifier is supplied with a withdrawal system, which transports the evacuated scum/water mixture through the pipe to the chamber for floating sludge. The scum/floating sludge has to be taken care of separately and shall not be recycled to the process again.

#### 2.3.3.3 Tertiary Treatment

2.61 The previous studies for the NGWWTP have considered sand filtration and disinfection for Tertiary Treatment. Since there will be no direct reuse of the effluent at phase 1, tertiary treatment will not be necessary. During infiltration the soil layers above the aquifer will be sufficient to perform this task (Soil Aquifer Treatment - SAR).

### 2.3.4 Sludge Treatment

#### Primary Sludge Production

2.62 The design data for the sludge production is presented in the following table. The efficiency with respect to dry solids content in the thickened primary sludge varies between 3.5 % and 6.0 % with an assumed average of 5.0%.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incoming SS</td>
<td>kg SS/day</td>
<td>20,658</td>
<td>26,280</td>
<td>32,844</td>
</tr>
<tr>
<td>Reduction of SS in PC</td>
<td>%</td>
<td>55</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Dry solids out from PC</td>
<td>%</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Primary Sludge Production</td>
<td>kg DS/day</td>
<td>9.448</td>
<td>11,941</td>
<td>14,851</td>
</tr>
<tr>
<td>Sludge Volume</td>
<td>m³/day</td>
<td>227</td>
<td>289</td>
<td>361</td>
</tr>
</tbody>
</table>

#### Secondary Sludge Production

2.63 The sludge age in the biological treatment is assumed to be an average of 21 days, at the start up year and 11 days in Phase 1, year 2012. The sludge production is estimated to be 0.60 kg DS per kg BOD removed at the start up year and 0.65 kg DS per kg BOD removed in Phase 1, 2 and 3. Secondary sludge production is estimated to those figures presented in Table 2.14.
Table 2.14: Design Parameters for Secondary Sludge Production

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry solids Secondary Sludge %</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Spec Sludge Production</td>
<td>Kg SS/kg BOD removed</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>Sludge Production</td>
<td>kg DS/day</td>
<td>9,448</td>
<td>11,941</td>
<td>14,851</td>
</tr>
<tr>
<td>Sludge Volume at 0.8 %</td>
<td>m³/day</td>
<td>1,181</td>
<td>1,493</td>
<td>1,856</td>
</tr>
</tbody>
</table>

2.64 The Primary Sludge is pumped from the sludge hoppers in the Primary Clarification Basins to one sludge silo with a volume of 100 m³ and a Dry Solids Content of 5%. The sludge is then pumped to the Anaerobic Digestion.

2.65 The secondary sludge is mechanically thickened with the addition of polyelectrolyte. The system is equipped with two polyelectrolyte units, one in spare. The design parameters are summarized in Table 2.15. The Thickened sludge is pumped to the Anaerobic Digestion with total dry solids of 5%.
Table 2.15: Design Parameters for Mechanical Thickening

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units</td>
<td>pcs</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Capacity volume Total</td>
<td>m³/h</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Sludge Load In</td>
<td>kg DS/day</td>
<td>9,448</td>
<td>11,941</td>
<td>14,851</td>
</tr>
<tr>
<td>Dry solids Content in</td>
<td>%</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Sludge Volume In</td>
<td>m³/day</td>
<td>1.181</td>
<td>1,493</td>
<td>1,856</td>
</tr>
<tr>
<td>Dry solids Content Out</td>
<td>%</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Sludge Volume Out</td>
<td>m³/day</td>
<td>189</td>
<td>239</td>
<td>297</td>
</tr>
</tbody>
</table>

Sludge Anaerobic Digestion

2.66 It is assumed that the Volatile Solids Content of 70 % in the sludge pumped to the digester. The degradable part is 50 %. The sludge load will be reduced with 35 % and the remaining part will be 65 % of the inlet sludge load. Design data for the digesters are as follows in Table 2.16.

Table 2.16: Design Parameters for Anaerobic Digesters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge Load In</td>
<td>kg DS/day</td>
<td>20,810</td>
<td>26,395</td>
<td>32,815</td>
</tr>
<tr>
<td>Dry Solids Content In</td>
<td>%</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Volatile Solids In</td>
<td>%</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
</tr>
<tr>
<td>Sludge Volume In</td>
<td>m³/d</td>
<td>416</td>
<td>528</td>
<td>658</td>
</tr>
<tr>
<td>Number of Units</td>
<td>units</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Volume, Per Unit</td>
<td>m³</td>
<td>4,000</td>
<td>4,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Volume, Total</td>
<td>m³</td>
<td>8,000</td>
<td>12,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Retention Time</td>
<td>days</td>
<td>19.2</td>
<td>22.7</td>
<td>18.2</td>
</tr>
<tr>
<td>Volatile Solids Load</td>
<td>kg VDS/m³/d</td>
<td>1.8</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>VDS Content Out</td>
<td>%</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Reduction of Sludge Load of the inlet</td>
<td>%</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Remaining Sludge load of the inlet</td>
<td>%</td>
<td>65</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Sludge Load out</td>
<td>kg DS/day</td>
<td>13,527</td>
<td>17,156</td>
<td>21,395</td>
</tr>
<tr>
<td>Sludge Volume out</td>
<td>m³/d</td>
<td>416</td>
<td>528</td>
<td>658</td>
</tr>
</tbody>
</table>

2.67 Temporary non-function of one digester may occur when maintenance is performed inside the digester. This is a planned interruption in the operation of one or two months. The retention time is around 10 days, which is enough to maintain the gas production. The heat exchangers and circulation pumps are designed to maintain a temperature in the digesters of 35°C.

2.68 From each digester, the digested sludge is pumped to two sludge storage silos, 2 x 500 m³ each. The sludge is homogenized and degassed with air supply.
Gas Treatment

Design data for the gas treatment are presented in 2.69 Table 2.17.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDS Removed</td>
<td>%</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Gas Production</td>
<td>Nm³/kg VDS removed</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Gas Volume</td>
<td>Nm³/d</td>
<td>7,284</td>
<td>9,238</td>
<td>11,520</td>
</tr>
</tbody>
</table>

Gas Generators

2.70 The produced gas is burned in Gas Generators. The energy production is calculated with a specific energy content of 6.5 kWh per Nm³ biogas. Design data for the co-generator at full load is presented in the following Table.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Production</td>
<td>kWh/Nm³</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Electrical Production</td>
<td>%</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Heat Production</td>
<td>%</td>
<td>65</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Electrical Energy</td>
<td>kWh/day</td>
<td>14,913</td>
<td>18,915</td>
<td>23,588</td>
</tr>
<tr>
<td>Heat Energy</td>
<td>kWh/day</td>
<td>27,696</td>
<td>35,128</td>
<td>43,806</td>
</tr>
<tr>
<td>Number of Units</td>
<td>unit</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total Effect Average</td>
<td>kW</td>
<td>2,150</td>
<td>4,300</td>
<td>4,300</td>
</tr>
<tr>
<td>Total Electric Effect</td>
<td>kW</td>
<td>750</td>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>Total Heat Effect</td>
<td>kW</td>
<td>1,400</td>
<td>2,800</td>
<td>1,700</td>
</tr>
</tbody>
</table>

2.71 Provision is also made for one unit to burn LPG gas at the start-up of the anaerobic digesters. The gas generators are designed for 20 hours operation time.

Sludge Dewatering

2.72 The digested primary sludge and thickened secondary sludge are dewatered in two centrifuges equipped with two polyelectrolyte units, one as a spare. The centrifuges are designed to operate on an average of 25% dry solids by weight in the cake. Two polyelectrolyte make-up and dosing units support the centrifuges to condition the digested sludge before dewatering. The units are located in a separate room adjacent to the centrifuges. The maximum of polyelectrolyte dosage is 8 kg per ton DS. Design data for the centrifuges are presented in Table 2.19. The dewatered sludge is transported with two pumps to the sludge storage.
Table 2.19: Design Parameters for Dewatering Centrifuges

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Phase 1 Year 2008 to 2012</th>
<th>Phase 2 Year 2012 to 2018</th>
<th>Phase 3 Year 2018 to 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Units</td>
<td>pcs</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Capacity Volume, Total</td>
<td>m³/h</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Sludge Load in</td>
<td>kg DS/day</td>
<td>13,527</td>
<td>17,156</td>
<td>21,395</td>
</tr>
<tr>
<td>Dry Solids Content in</td>
<td>%</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Sludge Volume in</td>
<td>m³/day</td>
<td>416</td>
<td>528</td>
<td>658</td>
</tr>
<tr>
<td>Dry Solids Content out</td>
<td>%</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Sludge Volume out</td>
<td>m³/day</td>
<td>54</td>
<td>67</td>
<td>86</td>
</tr>
<tr>
<td>Sludge Volume out Out</td>
<td>m³/week</td>
<td>379</td>
<td>480</td>
<td>599</td>
</tr>
</tbody>
</table>

Sludge Storage

2.73 The thickened sludge is pumped to the sludge storage with a retention time of 100 days where drying of the sludge is undertaken. The sludge storage has an area of 3,600 m² and a volume of 5,400 m³ at Phase 1, year 2012. It is recommended to provide an area which is large enough to store the sludge production of one year, as the farmers usually fertilize their fields only once per year, in winter time.

2.3.5 Noise and Odor Control

Noise Control

2.74 All equipment that produces significant noise levels is contained within buildings. The maximum noise level from an individual piece of equipment is estimated to be approximately 100 dB(A). Noise levels outside the building will not exceed 72 dB(A).

Odor Control

2.75 The odor control system is a comprehensive system to collect and treat air from locations where bad odors may occur. Air is conveyed from these locations to the two odor control plants, one located adjacent to the pre-treatment building and one located at sludge storage area both consisting of Bio-Filters. The composition of the air which has been the basis for the design of the plant is as follows:

- Hydrogen Sulphide: 0.2-15 mg/Nm³
- Methyl Mercaptane: 0.05-5 mg/Nm³
- Methyl Disulphide: 0.05-5 mg/Nm³
- Dimethyl Disulphide: 0.02-1.5 mg/Nm³
- Odor Units: 300-25,000
- Hydro Carbon (CH4 > 95%): 200-400 mg CH4 equivalent/Nm³

2.76 In addition to the mentioned components small amounts of Ammonia, Skatole and Methyl Amine will be in the air flow. The Bio-Filters shall treat the air/odor from wastewater treatment area in:

- Pre-Aeration basins - completely covered volume
- Inlet channel and outflow - covered
- Fine screens - completely covered volume
- Grit/grease removal channels
- Grit/screening container room.
And from sludge treatment area in:
- Sludge storage silos
- Process units as thickeners, dewatering units, conveyors and sludge hoppers.

2.77 For each group of Bio-Filters when one Bio-Filter is taken out of use to replace the media, the loading on the other filters is designed for this situation. Air will be conveyed to the filters through pipe work below ground and will be fed to each group of Bio-Filters. Valves will be provided to isolate a Bio-Filter when it is taken out of use for maintenance.

2.78 A system of perforated pipes is provided at the base of the filters to distribute the air around the filter. These pipes are surrounded by stones, which further diffuses the air to give an even distribution across the area of the filter. The filter media where the air is treated biologically is located directly above the stone layer. A number of material mixtures have been used successfully as the media. A mix of 80% peat and 20% polyurethane has been used and the use of this material is considered in the first instance. To prevent the media from drying out a sprinkler system fed by treated effluent drawn prior to disinfection will be incorporated into the filter.

2.79 Covered process units in the wastewater pre-treatment are the debris and stone pit, the inlet channel, grit and grease chambers. In the sludge treatment units, the sludge silos for secondary sludge, sludge silos for digested sludge and raw sludge silos are covered and connected to the air suction system. Mechanical equipment units such as screens, grit dewaterer and centrifuges are totally enclosed to avoid odor in the rooms. Each unit is connected to the air suction system that is connected to odor treatment. All conveyor units will be closed and provided with equipment for air suction. Containers for disposal of screenings and grit are provided with hoods connected to the air suction system. The potential for odor nuisance from primary clarifier has been minimized by having a low retention time.

2.80 It is important for the design of the Bio-Filter to know the Hydrogen Sulfide Content and the Sulfate Content into the raw wastewater and retention time in the sewers network. The following assumptions have been considered:

<table>
<thead>
<tr>
<th>Wastewater Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of air to be treated</td>
</tr>
<tr>
<td>Loading Rate</td>
</tr>
<tr>
<td>Area of filter required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sludge Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of air to be treated</td>
</tr>
<tr>
<td>Loading Rate</td>
</tr>
<tr>
<td>Area of filter required</td>
</tr>
</tbody>
</table>

2.81 The Bio-Filters are proposed to be a compost bio filter system. As the main part of the air to be treated is coming from the Preliminary treatment the design refers to Phase 3.

2.4 Investment Cost

2.4.1 Capital Cost

2.82 The total cost for the whole proposed project is estimated at US$43.05 million including the emergency phase. The emergency phase cost is estimated at US$13.15 million including the technical assistance and contingencies. This component includes the
construction of the terminal pumping station, the transmission line to drain part of the lake and the infiltration basins, which will be built at the site of the NGWWTP.

2.4.2 Operation and Maintenance Cost

2.83 The operation and maintenance cost for the emergency phase is shown in Table 2.20. This was based on 35,600 m³/day flow.

Table 2.20: O&M Cost for the Emergency Phase.

<table>
<thead>
<tr>
<th></th>
<th>US$/m³</th>
<th>MUS$/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage transfer and infiltration</td>
<td>0.16</td>
<td>2.08</td>
</tr>
<tr>
<td>Existing pumping station and sewer network</td>
<td>0.08</td>
<td>1.04</td>
</tr>
<tr>
<td>Total</td>
<td>0.24</td>
<td>3.12</td>
</tr>
</tbody>
</table>

2.84 O&M Cost breakdowns for the wastewater treatment and sludge treatment selected option under consideration have been made for Year 2012. Summary of the results are presented in Table 2.21.

2.85 The energy consumption is the main costs, around 28% for the selected alternative B2:1 including the reuse of energy. The energy reuse with anaerobic digestion of primary and secondary sludge is 59% of the total electrical energy consumption. The labor costs increase with 25%. The reasons for this are more monitoring instruments, more mechanical equipment installations, more analysis on the sludge side to supervise the anaerobic digesters and operation and maintenance for the gas generators and cooling equipment. Operation and Maintenance cost for the startup year is expected to be higher than Year 2012 due to expert/expatriate staff in the initial stage of the plant.

Table 2.21: O&M Cost at Year 2012

<table>
<thead>
<tr>
<th>O&amp;M Costs</th>
<th>Thousand US$/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>648</td>
</tr>
<tr>
<td>Power recovery</td>
<td>-381</td>
</tr>
<tr>
<td>Poly. electrolyte</td>
<td>123</td>
</tr>
<tr>
<td>Chlorine</td>
<td>9</td>
</tr>
<tr>
<td>Ferric Chloride</td>
<td>11</td>
</tr>
<tr>
<td>Transport</td>
<td>69</td>
</tr>
<tr>
<td>Labor</td>
<td>180</td>
</tr>
<tr>
<td>Maintenance</td>
<td>433</td>
</tr>
<tr>
<td>Total O&amp;M</td>
<td>1,091</td>
</tr>
</tbody>
</table>
Figure 2.5: Phase II - NGWWTP Layout
Figure 2.6: Treatment Process of NGWWTP
3 ASSESSMENT OF ENVIRONMENTAL IMPACTS AND BENEFITS

3.1 The impacts of the proposed project were described and evaluated for construction, operation and maintenance stages. The estimated or measured impacts were described and evaluated based on well-defined criteria. The total impact values considering the different stages of the project were assessed and used for comparing the alternatives. The assessment of significance was done by thorough scoping and discussion meetings involving interdisciplinary expertise.

3.1 Water Quality and Water Resources

3.1.1 Baseline Information

3.1.1.1 General Geology of the Coastal Aquifer

3.2 Gaza aquifer is part of the regional coastal aquifer which lies along the southeastern edge of the Mediterranean Sea and extends from the foothills of Mt. Carmel southward to Gaza and northern Sinai. It is composed of calcareous sandstone from the Pliocene-Pleistocene age, unconsolidated sands, and layers of clays. In the Gaza Strip, the aquifer extends about 15-20 km inland, where it overlies chalks from the Eocene and limestone or the Saqiye Group from the Miocene-Pliocene. The Saqiye Group is a 400-1000-meter thick sequence of marls, marine shales, and claystones. Approximately 10- to 15-km inland from the coast, the Saqiye Group pinches out, and the coastal aquifer rests directly on Eocene chalks and clastic sediments from the Neogene. Figure 3.1 presents a generalized geological cross-section of the coastal aquifer.

![Figure 3.1: Generalized Geological Cross Section of the Coastal Aquifer](image)

3.3 Near the coast in the Gaza Strip, clay layers subdivide the coastal aquifer into four separate sub-aquifers (Figure 3.1). They extend inland about 2 to 5 km, depending on location and depth. Further east, the marine clays pinch out and the coastal aquifer can be regarded as one hydro-geological unit.

3.4 Within the Gaza Strip, the thickness of the Kurkar Group increases from east to west, and ranges from about 70 m near the Gaza border to approximately 200 m at the coastline. Layers of clay with a low permeability are found in the Kurkar group. These layers are more predominant closer to the coast.
3.1.1.2 Current Water Quality

3.5 The ambient water quality in this study is reviewed with respect to chloride, nitrate, and pathogenic bacteria. For simplicity, the reference level over which the water is to be considered a source and under which the water is to be considered a sink is set as follows based on the World Health Organization drinking water guidelines:

- 50 mg/l for NO₃⁻
- 250 mg/l for Chloride
- 0 cfu/100 ml for Faecal Coliform.

3.6 The highest chloride sources are expected in the areas affected by seawater intrusion and the deeper groundwater layer. High nitrate concentrations are expected in the vicinity of local anthropogenic sources including agriculture and wastewater leakages. Figure 3.2 and Figure 3.3 show the water quality testing results for the municipal wells and some of the monitoring wells for Chloride and Nitrate concentration. These figures represent the average quality values for the year 2003 until March 2004. Generally, the chloride concentrations in the abstracted water exceed 250 mg/l in most of the Gaza Coastal Aquifer.

3.7 Figure 3.3 shows that the Nitrate concentration in the abstracted water by far exceeds the WHO drinking water guidelines in most of the Northern Gaza aquifer. In the area around the proposed infiltration site the average Nitrate concentration is below 30 mg/l. At the proposed infiltration site itself the maximum nitrate concentration in the groundwater, is about 30 mg/l, the lowest chloride concentration is around 270 mg/l and the pH is generally between 7 and 8. Table 3.1 shows the mean and the range figures for some of the important groundwater parameters (SWECO INT., 2003). Also, more details about the effluent quality from the existing wastewater treatment plant at Beit Lahia can be found in Annex (III).

Table 3.1: Water Quality Summary for the Infiltration Site

<table>
<thead>
<tr>
<th>Physical or chemical property</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity K (m/d)</td>
<td>55</td>
<td>28-93</td>
</tr>
<tr>
<td>Specific yield, S_y</td>
<td>20%</td>
<td>14%-24%</td>
</tr>
<tr>
<td>Groundwater level (M from MSL)</td>
<td>0.25</td>
<td>-0.28-1.06</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>24</td>
<td>18-36</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>496</td>
<td>270-786</td>
</tr>
<tr>
<td>Calcium (mg/l)</td>
<td>42</td>
<td>11-75</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/l)</td>
<td>1590</td>
<td>1050-2130</td>
</tr>
<tr>
<td>pH</td>
<td>7.4</td>
<td>7.8-8.1</td>
</tr>
</tbody>
</table>

3.8 Pathogenic bacteria should be expected in the groundwater near to the existing wastewater treatment plant as the partially treated sewage has been infiltrated into the aquifer since years. However, the most recent water quality analyses for the monitoring wells show that the groundwater is free from pathogenic bacteria. The fecal Coliform in well A/36 and well A/14 was 12 and 10 cfu/100 ml respectively in October 2002 (PWA, 2004). No fecal Coliform was found in the rest of the monitoring wells at the same time. The infiltration ponds and the unsaturated zone may be regarded as sinks for Pathogenic bacteria due to production and activity of bio-skins in the ponds and due to adsorption and...
natural decay in the unsaturated zone. Sinks for pathogenic bacteria are also found in the native groundwater.

![Figure 3.2: 2003 Chloride Concentration (mg/l) in the Shallow Aquifer](image)

![Figure 3.3: 2003 Nitrate Concentration (mg/l) in the Shallow Aquifer](image)

3.1.2 No Project Impacts

**BLWWTP Site:**

3.9 Without changes there will be an ongoing deterioration of the groundwater quality due to the infiltration of partly treated sewage into the aquifer. Figure 3.4 and Figure 3.5 show significant increase in the chloride and nitrate concentration in the last four years in
two of the monitoring wells. These wells are located down stream of the natural groundwater flow from the existing effluent pond as shown in Figure 3.4.

![Figure 3.4: Location of Existing Monitoring Wells Around Beit Lahia Treatment Plant](image)

A/62 Quality Trend

![Figure 3.5: Chloride and Nitrate Monitoring for Well A/62](image)

A/46 Quality Trend

![Figure 3.6: Chloride and Nitrate Monitoring for Well A/46](image)

3.1.3 Impacts during operation of the (Emergency Phase and Part B)
3.1.3.1 Flow Model Results
NGWWTP Site:

3.10 The initial effluent quantities that will be infiltrated into the aquifer are listed in Table 3.2. The results show that the rising water table reaches steady state conditions after approximately 8 years. The effect on groundwater levels caused by infiltration is best described by comparing simulated groundwater levels before infiltration has begun (Figure 3.7) and after steady state conditions have been reached (Figure 3.8). The simulations show that the groundwater level under the infiltration area will rise to about 6.5 m. The results show that at the long run 120 wells will be affected by the resulted water mound. The resulted water mound will extend about 2,200 m towards the sea, 1,100 m inland, 1,700 m north and south of the infiltration basins. Figure 3.9 shows more details about the resulted steady state water mound.

<table>
<thead>
<tr>
<th>Start of Year</th>
<th>Infiltration Quantity (m$^3$/day)</th>
<th>Expected Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>20,000</td>
<td>12,000 from the Existing BLWWTP + 8,000 from the effluent lake</td>
</tr>
<tr>
<td>2007</td>
<td>20,000</td>
<td>Existing BLWWTP</td>
</tr>
<tr>
<td>2008</td>
<td>20,000</td>
<td>Existing BLWWTP</td>
</tr>
<tr>
<td>2009</td>
<td>28,800</td>
<td>New NGWWTP</td>
</tr>
<tr>
<td>2010</td>
<td>31,000</td>
<td>New NGWWTP</td>
</tr>
<tr>
<td>2011</td>
<td>33,300</td>
<td>New NGWWTP</td>
</tr>
<tr>
<td>2012</td>
<td>35,600</td>
<td>New NGWWTP</td>
</tr>
<tr>
<td>2025</td>
<td>35,600</td>
<td>New NGWWTP</td>
</tr>
</tbody>
</table>

Figure 3.7: Water Level before the Start of Infiltration.

Figure 3.8: Steady State Water Level Contours and the Extent of Water Mound.

3.11 Figure 3.10 shows the water level contours at the end of emergency period (2008). The groundwater level beneath the infiltration basins will rise about 3.7 m. the resulted water mound will extend about 700 m towards the sea, 300 m inland, 250 m north and south of infiltration basins.
3.12 In order to study the lateral groundwater flow across the borders the model domain is divided into 3 different zones (Figure 3.11). Zone 3 represents the aquifer beneath the infiltration basins and the nearby surrounding areas (300m from the infiltration site).

3.13 The model shows that 13% to 18% of the infiltrated water may cross the border to Israel during the emergency phase and the long term phase respectively. The lateral flow in the reverse direction, to the west, will be reduced to half due to the infiltration.

### Table 3.3: Lateral Groundwater Flow across the Borders in the Vicinity of the Site.

<table>
<thead>
<tr>
<th></th>
<th>Before infiltration (m³/day)</th>
<th>Emergency period (m³/day)</th>
<th>Long term (m³/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 3 total recharge rate</td>
<td>350</td>
<td>20,350</td>
<td>35,950</td>
</tr>
<tr>
<td>Flow from Zone1 to Zone3</td>
<td>3300</td>
<td>1,600</td>
<td>1,500</td>
</tr>
<tr>
<td>Flow from Zone3 to Zone1</td>
<td>60</td>
<td>2,700</td>
<td>6,600</td>
</tr>
</tbody>
</table>

3.14 Table 3.4 shows the long term water balance for Gaza part of the model domain. Compared to the figures from CAMP Model (see table IV-2), you can notice a significant improvement in the total recharge quantity (~35,600*365=13 M m³/year). On the other hand, the lateral inflow is reduced by about 25%. Overall, the Gaza part of the aquifer will gain 13 and will loose 6 as lateral outflow due to the proposed infiltration. The proposed
project will contribute a little in reducing the sea water intrusion (the projected seawater intrusion in the year 2025 without infiltration is 30 Mm$^3$/year while with infiltration it will be 26 Mm$^3$/year for the same year). The problem of seawater intrusion will remain due to the aquifer imbalance.

![Figure 3.10: Water Level at End of Emergency Phase.](image1)

![Figure 3.11: Modeling Zones for Zone Budget](image2)

**Zone 1:** Israeli part of the model  
**Zone 2:** most of Gaza part of the model  
**Zone 3:** the infiltration basins and the vicinity

**Table 3.4: Long-term North Gaza Aquifer Water Budget (2025).**

<table>
<thead>
<tr>
<th>Inflows (Mm$^3$/year)</th>
<th>Long term balance, (Mm$^3$/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total recharge</td>
<td>60.16</td>
</tr>
<tr>
<td>Sea water intrusion</td>
<td>26.33</td>
</tr>
<tr>
<td>Lateral inflow</td>
<td>15.86</td>
</tr>
<tr>
<td><strong>Outflows (Mm$^3$/year)</strong></td>
<td></td>
</tr>
<tr>
<td>Total abstraction</td>
<td>99.97</td>
</tr>
<tr>
<td>Outflow to sea</td>
<td>2.00</td>
</tr>
<tr>
<td>Lateral outflow</td>
<td>1.07</td>
</tr>
</tbody>
</table>

**BLWWTP Site:**

3.15 If the NGWWTP project is fully implemented, no more partially treated sewage will be infiltrated into the groundwater aquifer. Only the storm water from Jabalia will be infiltrated using the existing storm water infiltration basins. At the long run (2025), the continuous abstraction activities will cause about a two-meter drop in the groundwater table in a 3 kilometer diameter circle around the BLWWTP site. This drop will be less by one meter if the effluent lake remains in place.
3.1.3.2 Advective Transport

3.16 In order to study which part of the aquifer that will be directly influenced by the infiltration, the module Modpath was used to simulate the advective transport. The Modpath results (Figure 3.12 and Figure 3.13) indicate that the plume will extend about 2,200 m towards the sea, 500 m inland, and 1,200 m transversely from the edge of the infiltration basins. These represent the long term conditions if all the infiltration basins are utilized.

![Figure 3.12: Extent of Flow Paths at the End of Emergency Phase](image)

3.17 At the end of the emergency phase (2008) the plume will extend about 500 m towards the sea, 200 m inland, and 300 m transversely from the edge of the infiltration basins. These results are in line with the Modflow results to a great extent in all directions except for the inland direction. The reason is that a part of the upstream groundwater mound will result from the blocking of the natural flow from the east by the infiltrated water.

3.18 It takes about 250 days for the plume to reach the nearest agricultural well (200 m north of infiltration basins edge). The nearest domestic well is 2050 m west of the infiltration basin (Q/68). Other nearby domestic wells (Q/40B, R25, and R66/B) are located at a distance 2,350 m or greater west and southwest of the infiltration basins. These wells will not be affected by the infiltrated water even at the long run.
3.1.3.3  Advection-Dispersion Transport Model

Chloride

3.19  Chloride is a conservative, water soluble element which will follow the water and which will be unaffected by any degradation and sorption processes. This means that the concentration in the infiltration water will remain constant along the water path, except for dispersion and dilution in the distant parts of the infiltration water plume.

3.20  In order to study the transport due to advection-dispersion, MT3D module simulation has been performed using chloride. The infiltration water was given a chloride concentration of 250 mg/l and the chloride concentration in the aquifer was set to 0 mg/l. This simulation allowed for a clear picture of the spreading of the infiltration water, since, any deviations from the zero level are a direct effect of the infiltration.

3.21  Figure 3.14 shows the extent of the chloride plume at the end of the emergency phase (2008) if all the proposed infiltration basins are used. The inner circle in the figure (about 200 - 300 m from the edge of infiltration basins) represents the part of the aquifer with 100% infiltrated water. The outer circle in the figure represents the part of the aquifer where 20% of infiltrated water is mixed with the original groundwater. Regarding chloride, compared to the original water quality around the infiltration basins (330-780 mg/l), the infiltrated water will improve the aquifer water quality significantly.

3.22  Figure 3.15 represent the long term extent of the chloride plume (after 10 years of infiltration). Infiltrated water will fully replace the native groundwater 500 m west, 200 m east, 400 m north and south of the infiltration basins edge. Mixing and dilution with native groundwater will only be effective in the transition zone between the original groundwater and the infiltration water plume. The circles around this central zone represent areas with 80%, 60%, 40%, and 20% mixing with infiltrated water. Compared to the ambient water quality in the affected areas (320-780 mg/l), the infiltrated water will improve the aquifer water quality significantly.
Figure 3.14: Chloride Plume at the End of Emergency Phase

Figure 3.15: Chloride Plume after 10 Years from the Start of Infiltration

Nitrates

3.23 In order to study the transport due to advection-dispersion, MT3D module simulation has been performed using nitrates expressed as NO₃-N. The nitrate concentration in the aquifer was set to 0 mg/l. This simulation allowed for a clear picture of the spreading of the infiltration water, since, any deviations from the zero level is a direct effect of the infiltration. Partially treated wastewater from BLWWTP is characterized by high N-content in all forms. The Lack of aeration in the aerated lagoon hinders the formation of nitrate and degradation of the organic matter. Moreover the
lagoon system is unfit for de-nitrification process. Using large area infiltration basins with more days for drying cycles will enhance the nitrification process in the soil top layers and de-nitrification in the deeper layers. The partially treated wastewater will supply Carbon to the deeper soil layers. A good C / N ratio enhances bacterial activities and stimulates de-nitrification processes, but this may not go deeper than a few meters.

3.24 Regular drying of the flooded basins will supply enough oxygen that will enhance the nitrification process. As a result it is assumed that 90% of the Kjeldal nitrogen in the effluent will finally end up as nitrate in the aquifer. This may be an overestimation of the resulting concentration of nitrogen compounds in the groundwater, but there are no scientific data available to quantify these effects. The emergency period may last for three years before the start of the full operation of the new WWTP. Thereafter, the infiltrated effluent quality is expected to comply with the infiltration regulations and standards.

3.25 Figure 3.16 shows the extent of the NO$_3$-N plume at the end of the emergency phase if all the proposed infiltration basins are used. The infiltrated water will fully replace the native groundwater 250 m west, 150 m east, 200 m north and south of the infiltration basins edge. Mixing and dilution with native groundwater will only be effective in the transition zone between the original groundwater and the infiltration water plume. The circles around the inner zone represent areas with 85%, 70%, 55%, 40%, 25%, and 10% mixing with infiltrated water. At the end of emergency phase, at least 4 agricultural wells will pump water with NO$_3$-N more than 40 mg/l. None of Israeli wells will be affected. The recovered water is good for use in agriculture. For example citrus needs 17.4 kg/1,000m$^2$ of nitrogen per season which is equivalent to about 30mg/l nitrogen.

![Figure 3.16: NO$_3$-N Plume at the End of Emergency Phase](image)

3.26 Figure 3.17 illustrates the impact of changing the infiltrated water quality after 6 months from the start of the NGWWTP operation (2008 - using NO$_3$-N = 10). The new plume will start to push away and replace the contaminated water. The medium and long term impacts are shown in Figure 3.18 and Figure 3.19. In the long run, the treated effluent will replace the contaminated water as a results of three processes: 1) dilution; 2) repeated cycles of pumping and applying back to the ground in which part of the nitrogen
will be lost due to de-nitrification and plant uptake, 3) NO₃ decay if the water passed through a soil layer (CLAY) that is rich with organic material. The contaminant plume will not exceed 2,200 meters in the western direction due to the steady state inflow-outflow balance.

Figure 3.17: NO₃-N Plume after 6 Months of Infiltration with Good Quality Effluent

Figure 3.18: NO₃-N Plume at Year 2012

3.27 Medium-term some sections up to 200 meters beyond the eastern Gaza border line will receive NO₃-N concentrations of about 40 mg/l. No Israeli wells are located in that area. Long-term the nitrogen contamination in that area will be diluted and brought back to the original levels.
3.28 The worst case scenario can be assessed assuming the full treatment will not be implemented in the near future and the infiltration with the partially treated sewage will continue at the long run. The performance of the existing BLWWTP is expected to decline due to the expected increase in the influent. Figure 3.20 shows the extent of the nitrogen plume considering these assumptions. Notice the difference if compared to the model result in Figure 3.19.

![Figure 3.19: Long Term NO₃-N Plume at Year 2025](image1)

![Figure 3.20: Long Term NO₃-N Plume Considering Worst Case Assumptions](image2)

3.29 Regarding the bacteriological effects, the transport time is the crucial factor. The survival time in the ground water depends on the pathogen species. The simulations in the

**Pathogenic bacteria**

The performance of the existing BLWWTP is expected to decline due to the expected increase in the influent.
groundwater model indicate that an area within the distance of 150 m from the infiltration site receives infiltration water with a shorter residence time than 6 months (Figure 3.21). After this time span, the bacteriological aspect will not be an issue. The transport time in the unsaturated zone is about 16 days.

3.30 The migration of bacteria through soil generally depends on the retention of the bacteria in the soil in combination with the ability to survive (growth and decay) of the bacteria. The pathogenic bacteria that are of the greatest concern in drinking water are not indigenous to soil. They are adapted to a completely different life in the intestines of warm blooded animals. For this reason, they will most probably die in a hostile soil environment. In a survival experiment in filter sand from an infiltration pond, it was found that *Aeromonas* was the best survivor in this environment – half life time 6.4 days – while *Camylobacter* had the shortest half life time of 0.75 days. Beside these two species *Salmonella*, *Streptococcus*, *Yersinia* and *Escherichia coli* were also studied (SWECO, 2003 after Jorgensen, 2001). The studies were carried out at 15 °C and the decay rate is faster at a higher temperature. In another study, where manure was applied to soil, it was found that faecal coliform bacteria and faecal streptococci disappeared to the natural background level within 2 to 6 months (SWECO, 2003 after Stoddard et al., 1998).

3.2 Socio-Economy

3.31 Since the start of the Intifada, many of the demographic and socioeconomic structures of the Palestinian Territories have changed due to the Israeli incursions and destructions of houses, infrastructure, industrial and agricultural sites. A recent World Bank report indicates that some 47% of Palestinians live below the poverty line of USD 2.1/day while the average total per capita income is about 35% lower than the incomes before the Intifada according to the same report. Furthermore, recent labor force surveys

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1 World Bank, “Four Years-Intifada, Closures and Palestinian Economic Crises”, October.
published by the Palestinian Central Bureau of Statistics suggest that the unemployment rate was around the 30% mark over the past 4 years and will most likely continue to be in that range in the near future.

3.32 The problematic economic situation on the Palestinian households is measured by the World Bank by the Dependency Ratio which is the number of people supported by each worker including him or herself. Before the Intifada, this ratio was about 5 people/worker and increased to about 7.2 in mid of 2002. Most economic analysis of the Palestinian economic conditions suggest that the year 2003 showed some improvement in economic performance leading to lower the dependency ratio to about 6 people/worker.

3.33 The increased unemployment rates and dependency ratio, combined with lower incomes have affected the social structure of the Palestinian family. Prior to the Palestinian Intifada, there was a tendency to move away from the family house into separate housing units as seen during the 1994-1999 period where construction of apartments increased drastically. During this time, private construction constituted about 80% of the investments in the construction sector. With the start of the Intifada, private investment in construction fell drastically by more than 50% due to the problematic economical situation.

3.2.1 Baseline Conditions

BLWWTP Site:

3.34 The current wastewater treatment plant is located in Beit Lahia and serves the residents of Beit Lahia, Beit Hanoun, Jabalia, and Um Al Nasser. Due to the increasing transfer of sewage from newly connected areas to this WWTP, the effluent has been flooding the surrounding areas. The following assessment provides an insight on the economic and social conditions of the Beit Lahia area, the most affected area due to the effluence of the wastewater.

Demography

3.35 The existing wastewater treatment plant is located in the Beit Lahia area in the Northern Gaza Strip that is characterized by being dependable mainly on agriculture with some small industries.

3.36 The population growth of the Gaza Strip is estimated at about 4.08% according to the Palestinian Central Bureau of Statistics (PCBS). However, this rate differs between urban and rural areas. It is thus estimated that North Gaza area has an average population growth of about 5.5% annually. According to the latest population projections by PCBS, the North Gaza Area served by the current WWTP has a population of about 267,000\(^2\). Although official statistics state that 12,000 m\(^3\)/day are now discharged into the Beit Lahia WWTP, the population figures sited by PCBS suggest that total discharge as of end 2004 stands at about 17,000 m\(^3\)/day.

Economic Conditions:

\(\text{Economic Activities}\)

3.37 The Beit Lahia area mainly depends on agriculture with some small industries such as garment, plastic and footwear.

\(^2\) The Palestinian Central Bureau of Statistics (http://www.pcbs.org/populati/est_n1.aspx)
3.38 The agricultural sector in Beit Lahia produces two main cash crops, namely Strawberries and Flowers. Some other crops also exist in small areas such as citrus and vegetables. In the season 2002-2003, the total area planted with Strawberries was 1,768 donums that produced about 5,660 tons of strawberries sold for US$5,650,000. As for flowers, the total area planted with Carnations was 15 donums that produced 2,250,000 flowers sold at about US$5,640,000.

3.39 The current location of the wastewater pool prevents the use of private land surrounding the pool, especially the Um Al Nasr area, for productive economic activities; agricultural commercial or industrial due to the high-risk hazard in these areas.

3.40 Furthermore, continued Israeli incursions into the Beit Lahia area damaged many agricultural and industrial establishments and thus adding to the worsened economic conditions. According to information obtained from Al Mezan Center for Human Rights in October 2004, about 13,000 donums of land belonging to 21,977 people in the Northern Gaza Strip (mainly Beit Hanoun and Beit Lahia) have been destroyed. In addition, industrial and commercial establishments have been destroyed during these incursions as well.

**Labor Force Conditions**

3.41 The latest survey from PCBS indicates that the unemployment rate in the Gaza Strip is about 41%. It is expected that the unemployment rate in the Beit Lahia area is higher than the overall average of Gaza Strip due to the high dependency of the labor force on work in the agricultural sector, which has been badly hit during the continued Israeli incursions.

**NGWWTP Site:**

3.42 The emergency project area is located east of Jabalia neighboring the Martyrs Cemetery. This is an area that has not been significantly used for any economic activities in the past. However, its proximity to the cemetery might have some social consequences if used for wastewater treatment.

**Affordability**

3.43 Affordability to pay for water and wastewater charges is difficult to judge, particularly in the absence of accurate data on per capita income by socio-economic category in various regions or settlements. It is well established that the design of any water tariff should take into account the basic human needs for water supply affordable to the poorest population segment. Affordability to pay for water charges is normally based on the household ability to pay for the price of water consumed and the sewage disposal services. Willingness to pay for these services also stems from the customers' satisfaction of the level of services provided.

3.44 A certain minimum quantity of water is needed to meet the daily human basic needs for personal hygiene and basic amenities. This has been estimated to range from as low as 25 l/h/d in the most arid region to as high as 75 l/h/d for piped water supply in regions where potable water supply is considered relatively sufficient. It is well

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3 Ministry of Agriculture Report
4 This is the relaxed definition of unemployment which includes those discouraged workers who stopped looking for work. The unemployment rate according to the International Labor Organization (ILO) standard is estimated at about 37%.
established in the concept of adequate water tariff that the lowest price water tariff block should be designed to meet the above mentioned human needs for a household.

3.45 One of the key elements of the previous tariff studies was to define the poverty line, as this is considered to be relevant in established the first block of the tariff. Before intifada, basic statistics indicated that an average monthly income for the low-income family was US$273 in the project area. This number has certainly decreased by more than 35% in the project area. Agricultural sector which is the main source of income in the northern area has been considerably damaged in the last four years due to the political situation. Hence the average monthly income for the low-income family is less than US$180.

3.46 According to information collected in 1999, the average combined cost for water and wastewater services in the municipalities of Jabalia, Beit Lahya and Beit Hanoun was 0.22 $/m³, 0.17 $/m³, and 0.24 $/m³, respectively. Almost 80% of these costs were related to water services. Based on these figures the charges for water services is equivalent to less than 2% of the average monthly family income in the study area. Previous studies also concluded that households are willing to pay 30% more for water for improved water supply and services.

3.47 Taking into account the average household income estimated by different sources, current expenditures on water and wastewater services range from 5% for the lowest income estimates to less than 1% for household with average monthly income of US$1,000 and more, as shown in the Table 3.5.

Table 3.5: Expenditures on Water and Wastewater Services as a Percentage of the Household Monthly Income

<table>
<thead>
<tr>
<th>Estimated Average hh Income (US$)</th>
<th>Jabalia Block A 0-50 m³</th>
<th>B. Lahia &amp; B. Hanoun Block A 0-30 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 or less</td>
<td>3.75%</td>
<td>4.80%</td>
</tr>
<tr>
<td>275</td>
<td>3.41%</td>
<td>4.26%</td>
</tr>
<tr>
<td>303</td>
<td>3.07%</td>
<td>3.87%</td>
</tr>
<tr>
<td>399</td>
<td>2.34%</td>
<td>2.94%</td>
</tr>
<tr>
<td>415</td>
<td>2.24%</td>
<td>2.82%</td>
</tr>
<tr>
<td>638</td>
<td>1.47%</td>
<td>1.84%</td>
</tr>
<tr>
<td>1,000</td>
<td>&lt;1.00%</td>
<td>&lt;1.00%</td>
</tr>
</tbody>
</table>

3.48 Obviously, significant differences in the household expenditures on water and wastewater services among various income groups have been found. Inequality is mainly attributed to the unjust and rigid one block water tariff rather than to the intrinsic variations in the household income level. For the same quantity of water consumed, between 0-50 m³/month, (equivalent to an average consumption of 238 l/h/d), equal payment of US$7.5 is charged to the poor as well as rich families.

3.49 It is generally accepted that, to be affordable, water and wastewater charges should not exceed 4% of income. The expected average income within the project area is US$270/month and therefore it is considered that the average family can afford to pay up to US$10.1/month for water related services. Assuming an average family size of 7 and consumption of 100 l/h/d, the water and wastewater charge can be up to approximately US$0.48 for each m³ of water supplied.
Based on the feasibility study conducted for the NGWWTP project, the required tariff for wastewater services would be 0.38 $/m³ for coverage of O&M cost only, while full cost recovery would require 0.55 $/m³. Additional 0.66 $/m³ to 0.89 $/m³ should be added to include water services for full recovery based on LEKA and CAMP studies. During the emergency phase the required O&M cost would be 0.24 $/m³.

3.2.2 No Project Impacts

BLWWTP Site:

3.51 The figures above show that Beit Lahia population is increasing at an accelerated pace. If this growth rate continues as projected by PCBS, the population of Beit Lahia will almost double from 1997 and 2010. This phenomenon of the accelerated population growth is also seen in other areas of the Northern Gaza Strip such as in Beit Hanoun and Jabalia served by the WWTP.

3.52 If current population rate and sewerage connection projects continue, by year 2008, the discharge level will reach about 26,500 m³/day aggravating the problem and causing additional social and economic stress in the Beit Lahia area.

3.53 In addition to the land bulldozed by the Israeli Forces, the overflow will consume additional agricultural and residential land in Beit Lahia.

NGWWTP Site:

3.54 The project in the emergency area is expected to create some temporary employment in the construction phase. In addition, some fixed employment opportunities will be created to maintain the new site. Without this project, there would most probably be no new job opportunities during the construction phase and also no perspective of permanent employment.

3.2.3 Emergency Project Impacts

BLWWTP Site:

- Transferring treated wastewater from the Beit Lahia WWTP will provide additional land due to the removal of the effluent lake. This land can in the short term be used for recreational purpose but may also be suitable for construction of new residential projects.
- The wastewater pipe will mainly follow roads connecting the existing and the proposed site. The construction of the pipeline might temporarily cause some disruptions.
- The construction of the carrier pipe will have some negative impact due to noise and obstruction of traffic and use of agricultural land during the construction stages but these are minimal negative impacts compared to the positive impacts discussed above.
- The removal of the effluent pond will have a positive social impact, as this will reduce risks of diseases.

NGWWTP Site:

- The Martyrs cemetery is regarded by Palestinians as a symbol of their struggle against occupation, constructing a wastewater pond in the area of the cemetery could cause some psychological problems to the families of the deceased or Martyrs.
- The construction of the new site will have positive economic effect through employment generation and use of Palestinian contractors for construction activities.
• The construction of the pond near the Martyrs cemetery will cause some discomfort to the families of the deceased during the burial ceremonies. Odor and mosquitoes can be a problem if not properly mitigated for.
• A long-term impact for the construction of the new affluent pond near the cemetery is that it will prevent any future expansion of the cemetery to the east.
• A positive social effect is that the proposed site is far from any neighborhoods and thus will cause the least disruption to the quality of life of local residents.
• Under The current economic conditions, recovery of all costs, including capital costs for the project and additional sewerage investment is not affordable for average families. However the O&M cost during the emergency project will be affordable as it would be within 4% of the average family income even if the current water services cost is added.

3.2.4 Impacts at Full Operation of the NGWWTP

• Pumping of wastewater from Beit Lahia to the new NGWWTP will make new lands available due after rehabilitation of the lake and the WWTP area. The new empty areas can be used, if no sanitary and health hazards exist for commercial, agricultural and residential purposes.
• Benefits described above for the emergency project phase regarding the improvement in the land blocks along the road connecting the existing and the new WWTP are also true for Part B components. Moreover, lands around the existing WWTP will also increase in price and commercial value due to the removal of the wastewater ponds.
• The construction phase will have positive effects on employment. During the construction phase, services of local subcontractors will be used which will generate job opportunities for skilled and unskilled workers in addition to professional services of engineers and others.
• The construction of the carrier line will improve the road network connecting the existing and the emergency area.
• The construction of the carrier pipe will have a small negative impact in the construction phase due to the noise and traffic disruptions.
• The removal of the ponds will lead to a great social and health improvement as this will reduce health risks and provide a better and cleaner living environment for people in the area.

3.3 Soil

3.3.1 Baseline Conditions

3.56 A general description of the soil and the surface geology is given in the previous EA. The surface geology of Gaza was laid down during the Quaternary Era during the Holocene and Pleistocene. It consists of the marine Kurkar formation which is permeable and forms a good aquifer. The Kurkar formation is a layer of shell fragments and quartz
sand cemented together with calcareous material. Layers of relatively impermeable clay divide the formation.

3.57 Due to its variable hardness the Kurkar formation has been weathered into a series of ridges which form the topography of Gaza. In the northern area, there are four ridges: the Coastal Ridge which rises to 20 masl, the Gaza Ridge which rises to 50 masl, the el Muntar Ridge with a maximum height of 80 masl, and the Beit Hanoun Ridge which peaks at 90 masl. The valleys between the ridges have been filled by alluvial and wind deposits and material eroded from the ridges.

BLWWTP Site:

3.58 The size of the area of the BLWWTP is around 140 dunums. The soil of the plant site and the adjacent area is mainly sand without a marked profile. Textures in the top few meters are usually uniform (sedimentary sandy soil), consisting of fine to medium quartz sand with a low water-holding capacity. The soils are moderately calcareous (5-8% CaCO₃), very low in organic matter and infertile. According to concentrations of basic ions in raw wastewater (Na, Ca and Mg), low SAR (around 2) and the salinity (EC = 1.77 dS/m) minimize the risk of soil sodification. In the adjacent lake where the partially treated effluent is collected, suspended solids settle down at the bottom and form a sewage sludge layer. As shown in Annex (III) concentrations of heavy metals in soil and sludge from the bottom of the lake are so far below the limit values from US, Israel and EU that, without relevant changes in the wastewater quality, a problematic accumulation of toxic substances in soil must not be feared even in the next decades.

NGWWTP Site:

3.59 The total area of the proposed location of the NGWWTP is around 300 dunums located east of Jabalia Town adjacent to the eastern border with Israel. The northwestern boundary is adjacent to the Martyrs Cemetery. The soil cover of the proposed new WWTP site is dark brown loamy clay of 7-23 m depth with a well-developed structure laying over marine Kurkar Formation (Calcareous sandstone). The site selected is currently used for the cultivation of grain crops, which is considered to be rain-fed agriculture. Farming practices have modified the natural soil and increased organic matter content and nutrient levels. The site is far away from industrial sites and landfill areas and therefore there are no direct or indirect impacts from those areas.

3.3.2 No Project Impacts

BLWWTP Site:

3.60 If the present situation continues there will be an accelerating load of organic and inorganic substances, which are streaming to the site with the increasing wastewater flow. Depending on their mobility and environmental stability some of the substances will accumulate finally in the sludge of the basins and especially in the lake.

3.3.3 Emergency Project Impacts

BLWWTP Site:

3.61 There will be no significant impacts on the soil during the low-scale construction activities at the existing BLWWTP (rehabilitation of the inlet works, new pumping station, new sewer connection) because the mainly sandy soil without a specific structure is not sensitive to construction impacts and all construction activities will take place in areas, where the soil has already been heavily disturbed previously.
3.62 The chemical analyses of samples from the lake bottom sludge and soil showed no significant levels of heavy metals or other toxic substances. Drying of the lake will have a positive impact on the lake bottom soil as it will allow natural biological process to perform the remediation.

NGWWTP Site:

3.63 Around 80 dunums of soil will be lost by excavation and huge quantities of loamy clay soil (900,000 m³) will be removed from the site and transferred to other locations. Only a small amount of the excavation material will be used for leveling and construction of the terraces. The nature of soil in that area, impermeable topsoil, may contribute to increase the costs of excavation activities as well as the time required for excavation. In general construction works have negative impacts on the soil ecology. Even outside the immediate construction site the soil may be affected significantly e.g. by densification of the topsoil layers due to heavy construction equipment and vehicles.

3.64 During the operation phase, the main problem in infiltration system for artificial recharge is the expected clogging of infiltration surface which results in reduction in infiltration capacity. Clogging is caused by physical, biological or chemical processes as follows:

- Physical processes are accumulation of inorganic and organic suspended solids in the effluent. For the lake effluent with SS = 59 mg/l, the suspended solids would accumulate on the bottom of the basin producing a clogging layer and declining infiltration rate. Another physical process is the downward movement of fine particles in the soil that found in the applied effluent or in the soil itself.
- Biological clogging processes include accumulation of algae and bacterial flocks in the effluent on the infiltration surface and growth of microorganisms on and in the topsoil to form bio-films and biomass that block pores and or reduce pore sizes.
- Chemical clogging processes include precipitation of calcium carbonates and phosphates and other solids and deposits in the soil. Algal growth during flooding of basins due to effluent high content of N (105 mg/l). This will cause raising pH of effluent to high value as a result of CO₂ consumption by algae and then leading to CaCO₃ precipitation.

3.65 Effluent salinity (EC = 1.77 dS/m) is considered as moderate saline which may increase the salinity of soil. As a result of the project, more water as renovated (reclaimed) water will be available for irrigation of crops, which means more land could be changed from rain fed agriculture to irrigated agriculture resulting more agricultural input. During the emergency phase there are no expectations for generation of sludge.

3.3.4 Impacts at Full Operation of NGWWTP

BLWWTP Site:

3.66 From Part A on all wastewater from the old site will be collected and pumped directly to the new NGWWTP. Only Pond No. 7 will be left as an emergency retention basin. Therefore the soil contamination by wastewater at the old site will be at its end. By de-construction of the old wastewater treatment ponds, the paved access roads and the old pumping station about 8.2 ha of sealed or partly sealed areas will be rehabilitated.

3.67 When the soil of the lake bottom has achieved an advantageous soil structure, due to the natural rehabilitation, it could be either used as green land or also for agricultural purposes, because it is rich in nutrients and it is not necessary to use huge amounts of
chemical fertilizers there. From an ecological point of view green land is the better option. Parts of the green area could also be used for recreational activities (sport sites, parks). This solution definitely would contribute to a better living quality for the local residents.

3.68 There are also ideas to elevate the lake bottom area and to use it for new settlements. Nowadays the population density in Beit Lahia and its surroundings is already extremely high and an additional built-up area would destroy the last wide open area, with all the well known side effects (permanent loss of all soil functions, negative effects for local climate and air quality, etc.). Building up the lake area would mean to miss the chance for a real improvement of the living quality of the local residents, who have been suffering under the heavy impairments caused by the neighboring lake so far.

NGWWTP Site:

3.69 The most significant aspect in the operation phase of the NGWWTP concerning the investigation factor soil is the increasing amount of sludge, which comes out of the system every day. The treated sewage sludge has significant organic matter content and contains macronutrients and micronutrients essential for plant growth. However, it can also contain potential contaminants such as heavy metals, organic contaminants and pathogens.

3.70 In principle there are three options to solve the sludge problem: deposition, burning and reuse in agriculture. The first option is very problematic in Gaza because there are hardly enough legal and orderly dumping sites to store the waste from the city. Deposition of the sludge would reduce the capacities of these legal dumping sites and it is very difficult to open new sites in this very densely settled area. The second option in theory would be a possible long-term solution, but the high investment and maintenance costs most probably do not allow such a solution. The third option seems to be the most realistic one. The main environmental concern about utilization of sewage sludge on agricultural land is the accumulation of heavy metals in soils and a possible contamination of the food chain. Most municipal wastes, sewage sludge in particular, contain high concentrations of mineral nutrients (N, P, Ca, etc.), but also toxic heavy metals. As heavy metals generally are much higher concentrated in sewage sludge than commonly found in soils, the concentration of extractable heavy metals in soils such as Cd, Zn, Cu and Ni can be increased by sludge application.

3.71 The fine particle structure of pure sewage sludge sometimes causes problems during application in agriculture. The fine particles have a low water retention capacity and – beside the nutrient supply – do not improve the soil quality, especially of sandy soils, significantly. It is much better to compost the sludge together with rough plant material and to use this compost in agriculture.

3.72 Considering the characteristics of Gaza sewage sludge and its negligible content of toxic substances, it could be safely used. To keep such condition of low pollutants, industrial wastewater should be separately disposed or treated at site to reduce its heavy metals content to acceptable values before it is discharged into the public sewer system.

3.4 Health and Safety

3.73 Especially in densely settled areas sewage treatment is a necessary part of the civil infrastructure that allows the population to remain healthy and to prevent ground water from pollution. Therefore the driving force for the proposed development is public safety. The name used for construction of sewers and sewage treatment plants in many places is "public health engineering".
3.74 One of the major problems concerning wastewater is the broad spectrum of pathogenic microorganisms - bacteria, viruses, protozoa and helminthes (intestinal worms) which can be found in the raw wastewater stream. Many of the pathogens are present in high concentrations, and can survive for days, weeks and some for months in wastewater, in wetted soil or on crops irrigated with raw wastewater. These pathogens may pose potential health risks to the workers or adjacent residents who may have direct contact to wastewater recycling activities, and also to the public who may consume wastewater irrigated crops or recreate on wastewater irrigated lawns or lakes.

3.75 The pathogens come from excreta of infected persons. The ability of the pathogens to survive in the environment and the infection paths determine the risk of infection.

3.76 An actual survey about water borne diseases in the Northern Gaza Governorate has been given in the previous EA for the NGWWTP (1999) and is summarized as follows. As shown in Table 3.6, the fecal coliform contamination is detectable the northern Governorate wells while Table 3.7 shows the 1999 Ministry of Health statistics for water borne diseases for the Northern Region of Gaza in addition to the recent data (2003) for the whole Gaza Strip. Other Ministry statistics show that over 60% of reported disease cases in Gaza generally are water borne (largely diarrhea and bloody diarrhea), about 10% are related to faeces. The continuous flooding of the adjacent pool of partially treated wastewater will worsen the health situation especially to the adjacent poor community.

Table 3.6: Fecal Coliform in the North Governorate Wells during 2003.

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of taken samples</th>
<th>Fecal Coliform (cfu/100 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>February</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>March</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>19</td>
<td>1</td>
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<td>May</td>
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<td>June</td>
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<td>July</td>
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<td>7</td>
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<td>August</td>
<td>32</td>
<td>3</td>
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<td>September</td>
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<td>3</td>
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<td>October</td>
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<td>0</td>
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<tr>
<td>December</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>285</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 3.7: Water Related Disease Cases

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholera</td>
<td>0</td>
<td>802</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>13</td>
<td>1358</td>
</tr>
<tr>
<td>Salminatlosis</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>Shingellosis</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Typhoid Fever</td>
<td>5</td>
<td>49334</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>4532</td>
<td>1630</td>
</tr>
<tr>
<td>Ascaris</td>
<td>470</td>
<td>5542</td>
</tr>
<tr>
<td>Hyman.Nana</td>
<td>16</td>
<td>5752</td>
</tr>
<tr>
<td>Total</td>
<td>5871</td>
<td>64459</td>
</tr>
</tbody>
</table>

3.77 Generally, the present situation constitutes a potential risk on human health and influences the residents psychologically. Therefore, treatment of sewage to a suitable level
at a location where the effects of a wastewater treatment plant will improve the living quality in the Beit Lahya area.

3.4.1 Baseline Conditions

BLWWTP Site:

3.78 The present situation constitutes a permanent risk for human health because:
- The open wastewater bodies (WWTP ponds and the lake) are not fenced and allow direct access. This is especially dangerous for children.
- There is an increasing risk that the sand dams holding back 1.5 million m³ of partly treated wastewater may break and neighboring settlement areas of Beit Lahya may be flooded. A flooding most probably causes casualties (drowning, collapse of houses) as well as indirect dangers for human health (pollution of living quarters and agricultural areas). Some years ago the sand dams of one of the additional, smaller emergency ponds south of the lake and caused two casualties.
- Direct contact with raw or partly treated wastewater, screening material and grit at the unfenced WWTP bears a high infection risk. Also in this case the situation is dangerous especially for playing children.
- Open, polluted water bodies are potential breeding grounds for pathogen vectors like mosquitoes.

NGWWTP Site:

Presently there is no specific or significant risk for human health in the agricultural area of the planned site.

3.4.2 No Project Impacts

BLWWTP Site:

3.79 There will be a continuous worsening of the situation due to the increasing wastewater volumes, the deterioration of the performance of the WWTP, and the increasing danger of a breaking of the sand dams. The worsening of the water quality leads to an increase of infection risks.

NGWWTP Site:

3.80 No relevant changes compared to the present situation could be identified.

3.4.3 Emergency Project Impacts

BLWWTP Site:

3.81 The effluent lake will continue to cause high risk on human life till it is completely dry. During the drying process, the partly filled lake with steep sand dams and the deep sludge at the bottom of the lake will be a potential danger for anybody who falls into the lake. In the dry season playing children may break through dry crusts over deep sludge. It may be very difficult to rescue them.

3.82 At the other hand the lowering of the water level reduces the risk for a breaking of the sand dams and the consequent flooding of living quarters and agricultural land.

3.83 When the lake has dried completely and has been rehabilitated the health situation for the local residents will have improved significantly.
Pressure Line

3.84 During the construction activities especially for the sewer line along public road there is a great variety of potential health hazards:
- Vehicle operation, especially operation at high speed
- Activities of heavy machinery in close proximity to workers, the use of powered hand tools and the movement of heavy equipment and materials.
- Open pits, unguarded holes and dangerous material can often be seen at construction sites
- Traffic congestions caused by construction sites and construction traffic
- Pedestrians crossing or passing by the construction sites or access roads

NGWWTP Site:

3.85 Beside the potential direct health risks in connection with the construction activities described above the most important aspect of the emergency phase on human health is the infiltration of partly treated wastewater into the ground water. This aspect is described in detail in chapter 3.1.

3.86 This exceptional emergency practice is only applied because there is immediate risk for human life in the area of BLWWTP and there is no other option to get rid of the wastewater. This practice of infiltration is only applied until the competed NGWWTP starts its operation in 2008.

3.4.4 Impacts at Full Operation of the NGWWTP

BLWWTP Site:

3.87 Beside the new pumping station, the inlet works, the infiltration basins No. 12 and 13 and the emergency Basin No. 7 (See Figure 1.2), all other technical structures will be dismantled.

3.88 In a worst case scenario, when the wastewater can not be pumped to the NGWWTP - for what reasons ever - Pond No. 7 will be used as an emergency basin. The retention volume of Basin No. 7 is about 180000 m³. With a daily inflow of about 26,500 m³ in 2008 the maximum retention time would be 6.5 days, in 2015 the daily inflow is 45000 m³ and the maximum retention time would be reduced to four days. In 2025 (Completion of NGWWTP) the daily inflow volume is estimated at 65,000 m³ and the maximum retention time would be 2.8 days.

3.89 It seems to be quite risky to rely on these quite short retention times. If there are substantial problems at the new plant site or a severe damage of the pipeline, maybe due to military activities, there is the possibility that repair works would take more time.

NGWWTP Site:

3.90 As soon as the completed WWTP starts its operation in 2008 the infiltration of a high quality effluent in the infiltration ponds will begin to compensate the negative effects on groundwater between 2006 and 2008. In the long term (15 to 20 years) the infiltration of fully treated wastewater with a high effluent quality will improve the ground water quality in the whole area.

3.91 From an environmental point of view it would be useful to irrigate at least a part of the treated wastewater effluent in agricultural areas and to use treated sludge, especially composted sludge, as a fertilizer.
3.92 An application of treated wastewater and sludge in densely settled areas as the Gaza Strip however requires strict regulations and constant monitoring in order to ensure that the activities are safe for human health and in line with the relevant regulations and standards.

**Reuse of Treated Sludge**

3.93 Currently there is no legislation in Gaza concerning the application of sewage sludge in agriculture. It may be formulated in the next few years. Until the local legislation sets up standards regulations and standards of other countries or international organizations will be considered in order to protect human health, livestock, plants, soil and ground water from undesirable effects. In principle the sludge, which is very rich in nutrients (N, P, K) could be used as fertilizer and replace chemical fertilizer, which are currently imported from Israel. Annex II shows the standards that control the use of treated sludge. However, the impacts of using the sludge in agriculture activities could include:

- Potential pollution of the raw eaten crops.
- Children are often present on the farms and fallen fruit may be picked off the ground.
- Labors and farmers at farms that are irrigated by treated wastewater or fertilized by sludge may be subjected to some danger of Ascaris.

**Reuse of Treated Wastewater**

3.94 The usage of the effluents from the NGWWTP for irrigation in agricultural areas is only recommended when the effluent has been treated to a high standard. This means irrigation with partly treated wastewater in the emergency phase is not recommended.

3.95 When the NGWWTP has been completed and works with full treatment efficiency, it would be possible and useful to take out a part of the effluent for irrigation of neighboring agricultural areas, given that the local and international standards for the quality of the irrigation water are kept (e.g. Engelberg Report (1985), WHO Wastewater Irrigation Guidelines (1989). Irrigation with fully treated effluent would provide nutrients for the crops and reduce the ecologically problematic application of chemical fertilizers.

3.96 Presently a study is conducted in Gaza concerning the reuse of treated sludge and wastewater in agricultural areas. This study will be finished in Summer 2005. The findings and recommendations of this study should be considered in the later project phases.

**3.5 Odor**

3.97 Any wastewater facility has the potential to create odor problems. Odor from wastewater is usually caused by gases produced by the decomposition of organic matter and is especially problematic when the decomposition has occurred in the absence of oxygen (anaerobic decomposition) and with available sulfur. The decay process produces a range of volatile compounds. Studies of gases generated at wastewater treatment works indicate that the main gas components are hydrogen sulfide, methyl mercaptan, ammonia, trimethyl amine, dimethyl sulfide and dimethyl disulfide. The most characteristic of these is the hydrogen sulfide that is known to be responsible for over 90% of unpleasant odor problems from WWTPs. Hydrogen sulfide is often used as an indicator of potential odor nuisance as it becomes easily detectable by the nose at extremely low concentrations.
3.98 In general, offensive odor can reduce the appetite, lower water consumption, impair respiration, and in extreme cases may cause vomiting and mental perturbation. In the long term offensive odors can lead to the deterioration of personal and community pride, interfere with human relations, inhibit capital investment, lower socio-economic status and economical growth. These impacts, to some extent, may result in a decline in market and rental property values, tax revenues, payrolls and sales.

3.99 Mainly based on the facts and findings of the two EAs (boliden contech – Montgomery Watson 1999) the following section describes the possible impacts and benefits and a suitable set of controls during all project phases from the present situation at the existing BLWWTP and the new location for the NGWWTP until the project is finalized.

3.5.1 Standards and Baseline conditions

3.100 Exposure of receptors (humans) to levels of hydrogen sulfide above 5 ppb can lead to odor nuisance. The Israel Ambient Air quality Standards limit the hydrogen sulfide in urban areas to:
   1. 0.161 ppb (0.245 mg/m³) for exposure time of 0.5 hour.
   2. 0.010 ppb (0.015 mg/m³) for exposure time of 24 hours.

3.101 The distance between the BLWWTP to the sea is about 4 km, the distance between the NGWWTP and the sea is about 8 km. So both WWTPs are relatively close to the sea, which can be a natural source of background hydrogen sulfide at levels of up to 2 ppb.

3.102 Very important aspects of odor assessments are the climatic conditions in the investigation area, especially the wind conditions. The velocity of the wind determines if odor gases are more or less diluted or concentrated, e.g. in times of inversions. The wind direction indicates what parts of the investigation area will be more or less affected.

3.103 In Northern Gaza most of the year the wind is coming from western directions. At the beginning of the year winds are generally light and come from south east to south west. By April the winds are still light and come from south east, north west and sometimes north east in the evening. By August wind speed increases but still south east to northern direction prevail. In October most wind come from south east in the morning and from north west to north east in the evening. Long-term observances show that winds blowing from east to west are quite rare in Gaza.

BLWWTP Site:

3.104 By means of portable detectors site surveys were carried out in 1999 in connection with the previous EA to measure concentrations of H₂S in the vicinity of the existing WWTP. The measurements, which were taken as random samples in three locations and during two days, ranged from 0.0 to 4.0 ppb in maximum, the average was 1.5 ppb. Of course these results are not representative as they are strongly influenced by momentary wind conditions (direction, velocity), the distance to the H₂S producing facilities and the treatment process (efficiency, water volumes, temperature, etc.).

3.105 For this study neither measurements nor emission calculations have been made. But the fact that the condition of the WWTP and the effluent lake today is by far worse than it was in 1999 indicates that the H₂S concentrations in the surrounding settlements most probably already exceed the Israeli Air Quality Standards and the present WWTP constitutes at least an odor nuisance for the neighboring settlements.
NGWWTP Site:

3.106 The planned location is mainly agricultural land and therefore a certain background of H₂S from animal manure and agricultural wastes is likely.

3.5.2 No project impacts

BLWWTP Site:

3.107 The nuisance for the local population near the BLWWTP is expected to increase due to the increasing wastewater volumes combined with the ongoing deterioration of the efficiency of the treatment system. The potentially most effected settlements would be Al Ezba, Um Al Nasser, Al Awda Towers and Al Nada. In those areas increasing levels of hydrogen sulfide would most likely cause serious odor nuisance.

NGWWTP Site:

3.108 At the proposed location of the NGWWTP the present situation of a generally good air quality without significant odor problems would prevail. There would be some short term variations at significant seasons related to agricultural activities, as it has always been, but the odor concentrations e.g. for H₂S would most probably not exceed even the strict Israel Ambient Air Quality Standards.

3.109 Recently, there is a proposal to move out all small industries and workshops from Gaza City to a new local industrial zone. The proposed location is closed to the proposed site of the NGWWTP and the Islamic cemetery. These activities in the future may cause more air pollution. The emission values and impacts depend on the type and the size of the industrial activities and the measures taken to avoid or reduce the emissions.

3.5.3 Emergency project impacts

3.110 The following odor effects in connection with the emergency project will only be temporary until the full wastewater treatment system at the NGWWTP starts working in 2008.

BLWWTP Site:

3.111 The proposed emergency project will reduce the most urgent problems in BLWWTP. The technical improvement of the existing facility, especially the aeration, together with appropriate maintenance and regular monitoring of the performance of the system will reduce especially the amount of H₂S from the treatment plant. The infiltration ponds are not considered to be significant sources of odor as they will only receive treated effluent.

3.112 The drying process of the lake and the rehabilitation of the dried lake bottom however will create some odor emissions. These emissions will be only temporary and neither the amount nor the types of gases can be predicted precisely.

NGWWTP Site:

3.113 During the construction of the infiltration ponds there may be temporary and minor local nuisance for visitors of the cemetery caused by exhaust fumes from transport vehicles moving to and from the construction site. The effects of moving vehicles on the site itself are not expected to cause significant effects beyond the area of the site.
3.114 Significant odor emissions from the site are possible as soon as the newly constructed infiltration ponds are filled with treated wastewater from BLWWTP. According to the project time schedule this will be the case at the beginning of 2006. From that time on until the new WWTP is completed in 2008 the emission zones, which have been calculated in the previous EA for project phase 3, most probably will be widened. This may lead to temporary nuisance especially of cemetery visitors, because at relatively rare occasions, when the winds are coming from the east, the 1 ppb H₂S zone, which is shown in Figure 3.22, may be widened and cover larger parts of the cemetery. The main annual wind directions however indicate that most time of the year the emissions will be shifted to empty agricultural areas in the east.

3.5.4 Impacts at Full Operation of the NGWWTP

BLWWTP Site:

3.115 When the completed NGWWTP starts to operate in 2008 all the raw wastewater will be collected at the old BLWWTP. After screening and sedimentation, which will be done in an almost closed system with biological gas filters, no significant odor problems must be expected under normal operation conditions.

3.116 In emergency cases pond No. 7 will be used as a retention basin for wastewater. The retention capacity for this basin in 2008 would be sufficient to store all incoming wastewater for slightly more than 6 days. Only in such an emergency situation, when pond No. 7 is filled with raw wastewater, the neighboring communities may be more or less exposed to significant odor nuisance, depending on the wind situation. These effects however are only temporary.

3.117 The two infiltration basins in future will be used for storm water only. In order to maintain the infiltration capacity the bottom of the basins must be ploughed. When the basins are drying there may be minor odor emissions, but these temporary effects are not regarded as being significant.

NGWWTP Site:

3.118 At the beginning of Phase 1, when the complete new treatment plant starts to operate the facts and findings which have been made in the previous EA for the proposed new wastewater treatment works (boliden contech and Montgomery Watson 1999) are still true. Because of the strictly limited time frame for this emergency study no new emission calculations have been made and the relevant text parts have been taken over from the previous EA report with only minor changes. In the previous EA the following statements have been made concerning odor emissions:

3.119 Odor nuisance arising from a WWTP depends on a number of factors including the type of treatment process, chemistry of sewage influent, and the local meteorological conditions. It is predicted that for the new WWTP the main contributors will be the following processes:

- Pre-Aeration basins Completely covered volume
- Inlet channel and outflow covered
- Fine screens completely covered volume
- Grit/grease removal channels
- Grit/screening container room
- Sludge removal and treatment
3.120 The pathogen kill tanks are not open to the air and will not therefore, produce odors. The digester plant is pressurized and sealed therefore it will not produce odors. The effluent storage tanks will store final effluent that has been treated to a level where it will not emit odors.

3.121 As the distance of the pressure line from the existing BLWWTP to the New NGWWTP is about 8 km. The combination of high wastewater temperature of 20 to 30°C and Sulphate content up to 100 mg/liter under anaerobic conditions accelerates the creation of Hydrogen Sulfide. This might cause corrosion and odor problems in the whole treatment plant. It is therefore very important to oxidize the influent by aeration in pre-aeration basins to minimize conditions creating those problems. As a result of sludge removal and treatment, amounts of Ammonia, Skatol and Methyl Amine will be set free and may create temporary odor problems.

3.122 The H₂S emission rates for each of the hydrogen sulfide producing processes have been estimated based on both published data and the Consultants experience. They are summarized in Table 3.8. The derived H₂S emission rates are for an "average / normal" sewage and for systems in good operating condition.

<table>
<thead>
<tr>
<th>Odor Source</th>
<th>Phase 3 H₂S</th>
<th>% of total ppb/s emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen/grit chambers</td>
<td>141</td>
<td>2%</td>
</tr>
<tr>
<td>Screenings skips</td>
<td>80</td>
<td>1%</td>
</tr>
<tr>
<td>PSTs</td>
<td>2,397</td>
<td>32%</td>
</tr>
<tr>
<td>Oxidation ditches</td>
<td>940</td>
<td>12%</td>
</tr>
<tr>
<td>FSTs</td>
<td>526</td>
<td>7%</td>
</tr>
<tr>
<td>Sand filters</td>
<td>71</td>
<td>1%</td>
</tr>
<tr>
<td>Centrate tank</td>
<td>67</td>
<td>1%</td>
</tr>
<tr>
<td>Cake storage area</td>
<td>825</td>
<td>11%</td>
</tr>
<tr>
<td>Odor control stack</td>
<td>2,476</td>
<td>33%</td>
</tr>
</tbody>
</table>

3.123 Through the old environmental study of the NGWWTP, a dispersion model had been carried out using the United States Environmental Protection Agency (USEPA) atmospheric dispersion model ISCST3. Regarding the H₂S emissions, the study team compared the old design with the new design and concluded that there is no difference. So the old model is valid to be used in the assessment of the new design of NGWWTP.

3.124 The modeling results for the full operation Phase 3 (target year 2025) are shown as contour lines of H₂S in Figure 3.22. They represent the H₂S levels which are likely to occur at any particular location on the few occasions during the year given the worst case weather conditions are prevalent, i.e. low wind conditions. During all phases of development the 5ppb contour line never crosses the plant boundary. During all Phases the nearest sensitive receiver, the cemetery area, is not affected by levels of hydrogen sulfide which may cause nuisance. Since there are no sensitive areas (living quarters, recreation areas, etc) nearby it is unlikely that, even during the rare times of low wind conditions, odors will be perceived by anyone in the area as a nuisance.
Therefore, providing that good maintenance, operational practices and good housekeeping methods are employed there is no indication that the proposed WWTP may cause significant odor impacts.

3.6 Exhaust Fumes and Dust

Exhaust fumes and dust are mainly related to construction activities and comprise exhaust fumes and dust caused by construction activities at the site and transport activities to and from the site due to delivery and handling of bulk materials, excavations and ground preparation. Minor emissions in the operation phase may be expected from heating equipment (burning of fuel) and transport vehicles (mainly sludge transport).

3.6.1 Baseline conditions

BLWWTP Site:

No records and measurements are available about fumes and dust in the area. The existing treatment plant is located in the Northern Gaza Governorate close to the Erez industrial area. Dust and fumes are mostly generated in the south-eastern part of the treatment plant. Due to the prevailing western wind directions most emissions from BLWWTP are shifted to the Erez industrial area. However, the main complaint of people in the area is the bad smell rising from the treatment plant.

NGWWTP Site:

The proposed site of the NGWWTP is located on a west-exposed hill slope. The unpaved access road is in a bad condition which allows only very low speed and due to the very low traffic there is neither any relevant dust nor an exhaust fume problem in connection with road traffic.

Because the soil in the area of the proposed site is mainly clay dust will locally only be produced when the fields are ploughed or harrowed. In the previous EA the Consultant observed clouds of dust reaching approximately 60 feet high from plough work in July. Therefore, the surrounding fields are already subject to significant temporary dust loads. The presence of Route 4 nearby also contributes to the fine particle load in the air as
high speed traffic raises fine particles into the atmosphere which may reach the site. In
addition strong winds carry high background levels of dust from more distant sandy areas.

3.130 There are no large scale fume sources in the wider area (e.g. power stations). Low
levels of exhaust fumes from diesel engines used on farms to generate electric power for
water pumps and the low local traffic produce a certain background level of exhaust fumes
in the vicinity of the site. Considering the general wind direction and the distance to the
cemetery this effect is not significant.

3.6.2 No project impacts

BLWWTP Site:

3.131 Without the planned project in the area of the BLWWTP the increase of exhaust
fumes and dust would just follow the general increase of pollution due to the increasing
population and the related activities (road traffic, development of infrastructure,
construction of buildings, increased industrial and commercial activities, etc.).

NGWWTP Site:
Without the construction of the planned WWTP the present situation at the site would not
change significantly.

3.6.3 Emergency project impacts

3.132 The most relevant dust and exhaust fume emissions will be caused by the
construction of the almost 8 km long pipeline from the BLWWTP to the NGWWTP. The
excavation and the refilling of the sewer trench causes dust and the construction vehicles
contribute exhaust fumes. As the sewer mainly follows existing roads the reconstruction of
the road, especially in paved road sections, causes additional emissions. However all these
activities are only local and temporarily.

BLWWTP Site:

3.133 In the emergency project phase relevant dust and exhaust fume emissions can only
be expected during the remediation activities in the 35 ha large area of the effluent lake.
When the lake is dry the area is expected to be recultivated. The earth works and the
movements of the construction vehicles will produce dust and exhaust fumes and may
cause temporary and local nuisance especially for Um Al Nassir, because of the
predominantly western wind directions.

NGWWTP Site:

3.134 During the construction of the WWTP facilities, dust emissions will arise during
excavation and transport and storage and of soil and construction material.

3.135 The local loess and clay soils have small grain sizes which may enhance dust
production in the dry season. Due to this soil structure, the large area of the site and the
high soil volumes which will be moved (excavation of about 900.000 m³ of mainly clay)
significant dust emissions and – to a minor extend – emissions of exhaust fumes must be
expected.

3.136 In principle a high background dust level ensures that plants growing naturally in
the area are resistant to this effect. However, agricultural and horticultural plant species in
the area may be affected by high levels of dust settling on their leaves and fruit thus
reducing photosynthesis and respiration and requiring special treatment before they can be
sold. As the neighboring areas are mainly used for agriculture, significant additional dust loads from the construction site should be avoided through the measures proposed in the EMP. With an appropriate management of the construction site, especially a competent site supervision, application of dust suppression techniques, covering of stored hazardous material and vehicles removing waste, use of water sprays, etc. the impacts on the local air quality can be minimized.

3.6.4 Impacts at Full Operation of the NGWWTP

3.137 During the operation phase of the NGWWTP, fumes will be produced from burning the methane produced from sludge digestion. Fuel or diesel for backup-systems (generators) will also be burned temporary. These fumes will be released to atmosphere through a chimney of suitable design. The level of these emissions is assessed to be negligible.

3.7 Archaeology

3.7.1 Baseline conditions

BLWWTP Site:

3.138 Looking into the historical data the village of Beit Lahia can be found among many villages in the vicinity of Gaza City during the Roman Byzantine period. It is shown on the Byzantine mosaic map of Madaba (in Jordan) discovered 100 years ago under the name “Bethelea”. During the Roman-Byzantine period Beit Lahia was a well-populated village possessing several temples, greatly venerated by the inhabitants for their antiquity and furnishing. The location of this village is identified with the site of Tell ad-dahab (the gold-mound), which was located to the west of the present day Beit Lahia and Tell al-Khirba (the ruins-mound) located in the eastern part of Beit Lahia. Many archaeological remains, such as pottery and glass fragments as well as coins were discovered in the soil of the two sites. Field surveys in the area of the BLWWTP did not identify any archaeological sites so far. The nearest archaeological remains in the area is Tell al-Khirb. It is situated in the eastern part of Beit Lahia, 500 m south of the WWTP. In the area archaeological remains such as mosaic fragments and pottery shards can be found over the whole of the mound. They are dated to be from the Roman Byzantine period.

NGWWTP Site:

3.139 Strategically the NGWWTP is located in a relative remote, agricultural area, which was neither important for military purposes nor for settlements. These facts may be the explanation for the absence of relevant archaeological sites in the project area. All available data (literature, maps, old photos) do not mention any archaeological remains or historical buildings in the area.

3.140 The archaeological investigation of the site, which was conducted in 1999 in connection with the previous EA, showed the following results:

- Presence of some pottery shards of the Roman-Byzantine type and local made. These movable archaeological surface remains are not an absolute indication for structures or dwellings existing under the surface of the project area. The surface of the area does not reflect any structural remains or build material.

- An investigation of one-meter deep dug area and a dug for cultivation purposes (70cm deep) shows that there are no visible archaeological remains and – beside agricultural activities - the soil has a natural structure. Also a soil test was conducted in the middle
of the project area. The excavated soil down to 10 meter depth was checked. The excavated soil is muddy and clean. There is no indication for any archaeological remains.

- The field survey identifies a small mound about 10 meters high located 150 meters east of the project area, namely behind the green line, inside the Israeli territories. Some similar mounds in the country reflect in different cases archaeological structures.

- The nearest known archaeological site is located approximately 2000 meters away from the project area. The remains there are water cisterns and pottery shards scattered in some places. No archaeological excavations were carried out in these areas.

3.141 The most important structure of cultural value in the area is the Al Shuhada Islamic Cemetry which neighbors the proposed location.

3.7.2 No project impacts

3.142 During normal operation of the BLWWTP there would be no changes of the present situation. A breaking of the dams of the effluent lake however may endanger archaeological sites, because remediation measures after wastewater flooding with heavy machinery could impair the relicts.

3.143 At the proposed location of the NGWWTP, there would also be no changes of the present situation.

3.7.3 Emergency project impacts

3.144 According to the available data no relevant impacts concerning archaeology could be identified in connection with the planned activities. Since the project, especially the 8 km long pipeline will be constructed in an old settlement area with a very long history there is the chance that during the excavation works archaeological relicts may be found. In this case the construction works must be stopped and it is the duty of the construction supervision to take care that the relevant authorities (Ministry of Tourism and Antiques - MOTA) are informed immediately. A special archaeological survey will be done by a specialist. Based on the findings of this survey the following proceeding will be agreed between MOTA and PWA.

BLWWTP Site:

3.145 Almost all construction works at the existing site will be done in already built-up areas. Therefore no impacts on archaeology are expected at the existing site.

3.146 The remediation activities in the area of the lake must be conducted carefully, especially when the original soil surface is influenced e.g. by removing the bottom of the lake. The construction site supervision will be instructed to pay attention also for archaeological relicts.

NGWWTP Site:

3.147 Also the construction activities in the area of the new site lake must be conducted carefully. The construction site supervision will be instructed to pay attention also for archaeological relicts.
3.7.4 Impacts at Full Operation of the NGWWTP

BLWWTP Site:

3.148 Almost all dismantling works at the existing site will be done in already built-up areas. Therefore no impacts on archaeology are expected at the existing site.

NGWWTP Site:

3.149 The construction activities in connection with the completion of the new WWTP must be conducted carefully. The construction site supervision will be instructed to pay attention also for archaeological relicts.

3.8 Ecology

3.150 In the previous EAs for both sites, BLWWTP and NGWWTP, site investigations have been conducted. The principal conditions concerning wildlife have changed significantly due to Israeli incursions in the past few years. However, no new field surveys have been conducted for this study and the facts and findings of the previous EAs, literature sources and discussions with experts have been used as a basis for this assessment.

3.8.1 Baseline conditions

3.151 The open areas in the Northern Gaza Government show flora and fauna common to semi-arid desert regions. The previously unusual rich variety of animal and plant species in the wider region (approximately 2500 plant species in the West Bank and Gaza) however has been drastically reduced. Due to the already very high population density and the ongoing increase of the population the few remaining habitats in Northern Gaza are reduced almost day by day.

3.152 The flora and fauna in the Gaza strip suffered severe impacts especially during the last four years (2000-2004) due to the Israeli depletion and partly leveling of green areas and agricultural land. During this period, about 2829 hectare of agricultural or horticultural land including agricultural wells and irrigation networks were destroyed in the whole Gaza strip (Al Mezan, 2004). The Northern Gaza Governorate was especially affected by loosing 1315 ha, which is about 35 % of the total agricultural land in the Northern Gaza Governorate.

Flora

3.153 *Wild plant species:* A wide range especially of wild shrub and flowering plant species can be found in areas that are not cultivated or covered with settlements. However, no particularly protected or rare species have been identified during the surveys for the previous EAs. 10 wild tree species and about 70 weed species are documented (Annex VI).

3.154 *Forest:* In the whole Gaza Strip there is no land, which can be considered as a real forest area. This is mainly due to the continuous expansion of urbanization and the land limitation.

3.155 *Agricultural Crops:* There are 34 agricultural plants and 11 fruit tree species reported for the Gaza strip (Annex VI). Agricultural land nowadays occupies about 155 Km² from the total area of the Gaza Strip (it was about 175 Km² four years ago) which is close to 42% of the total area of the Gaza Strip. Traditionally, agriculture was based on irrigated or rainfed agriculture. Green houses have been introduced as a very important
improvement for agricultural production. In general, vegetables, citrus, fruits, strawberry, flowers (carnation) and rainfed crops are commonly seen in Northern Gaza Governorate. Other crops including potato, tomato, eggplants, pepper, beans, etc. are mainly cultivated in other parts of the Gaza Strip

3.156 Existing impairment: Especially in agricultural areas a great variety of chemicals (pesticides, fungicides, herbicides) is currently used, sometimes in very high concentrations, in order to combat the diverse problems in connection with intensive agriculture like weeds, insects, rodents and fungi.

Fauna

3.157 About 11 wild mammal species, 30 birds, 12 reptiles, and 14 domestic animals have been recorded in the Northern Gaza Governorate during the last years (Annex VI).

3.158 Mammals; Many species, which could be found in the area a few decades ago have disappeared nowadays due to increased population density, hunting, agricultural and residential expansion, use of chemical substances, and mechanical obstacles like fences between Israel and the Gaza Strip. Wolf, Porcupine, Red fox, Jackal, Striped, Hyaena and Wild Cat are examples for meanwhile extinguished mammal species. Most of the nowadays recorded mammals are rodents.

3.159 Birds; More than 30 bird species are recorded in the wider area (Annex VI). The populations of some species were severely diminished due to certain factors including the use of agrochemicals, hunting, and loss of habitats.

3.160 Reptiles and Amphibians; 5 species have been reported in the northern Gaza area (Annex VI).

3.161 Arthropods; There is a great variety of insects in the area. Mainly due to the insufficient handling of waste (illegal storing and dumping) insects like cockroaches, beetles and flies are abundant, forming a rich food basis for predators like praying mantis, dragon flies and carnivore beetles. Beside insects, scorpions and spiders are very common in the area.

3.162 Domestic Animals; Apart from wildlife, many domestic animals like cows, sheep, goats, donkeys, horses, hens, etc. are commonly seen in the area.

3.163 Existing risks: With the exception of the infiltration ponds Nr. 12 and 13 (Figure 2.2) all open water bodies (treatment ponds and effluent lake) are not fenced and allow direct access for animals. Especially larger mammals (sheep, cows) are endangered when they fall into the water, especially into the lake with its unstable and steep sand dams.

BLWWTP Site:

3.164 In densely settled areas like the Northern Gaza Governorate any area which is not intensively used for settlement or agriculture is a potential habitat for species which are sensitive against disturbance by human activities. There is no doubt that the effluent lake today possesses a certain ecological value mainly because of the facts that there are open water areas during the whole year and the inner lake area is not intensely used and disturbed by man.

3.165 Birds: The effluent lake area attracts birds, especially water birds. Today there is a great variety of bird species (Annex VI), some species could be seen in great numbers during site visits.
3.166 **Insects:** From the insects recorded in the BLWWTP area are the praying mantis, various beetles, crickets, bees, moths, aphids, dragonflies, grasshoppers, mosquitoes, flies....etc. Most people inhabiting the area are suffering from mosquitoes especially during the warm season.

3.167 **Flora:** Several wild tree species are recorded in Beit Lahia. The most common ones are *Acacia raddiana*, *Acacia nilotica*, *Opuntia sp.*, *Morus sp.*, *Pinus sp.*, *Ricinus sp.*, *Ziziphus lotus*, *Australis phramites*, *Tamarix nilotica*, and *Tamarix aphylla*.

3.168 **Wild Weeds:** Weeds are the main distinct plant cover noted in both agricultural and non-agricultural fields. Beit Lahian people used to utilize many weeds as food for people, fodder for grazing animals, medication timber production and preventing erosion (stabilizing of sand dunes and hillsides). Some weed species like *Citrullus colocynthis* and *Retama sp.* are locally endangered due to overgrazing or utilization for medical purposes. Some of the weed species are considered as pests or plant parasites, some are poisonous.

3.169 **Horticulture and Agriculture:** Most of the area around BLWWTP is used for horticulture and agriculture. The neighboring areas, especially west of the BLWWTP site, are mainly used for producing vegetables. Site visits and data collected showed that strawberry (*Fragaria Vesca*) was and is still considered to be the main crop in Beit Lahia. Many citrus orchards (orange, lemon, mandarin and grapefruit) and other fruit trees such as apples, pears, apricots are commonly cultivated in Beit Lahia.

3.170 **Existing impacts:** Many types of chemicals are currently being used in high amounts in the neighboring areas to fertilize the sandy soil and to combat the various impacts on agricultural production (weeds, insects, rodents and fungi).

**NGWWTP Site:**

3.171 In the area of the proposed location of the NGWWTP, about 10 wild mammal species, 32 birds, 12 reptiles and amphibians, and 13 domestic animals are recorded in the recent years (Annex VI).

3.172 The study area is also the habitat of wild plant species and important food crops. 13 wild tree species, more than 10 fruit tree species, about 55 beneficial and harmful weeds and 33 agricultural crops are recorded (Annex VI).

3.173 Generally the eastern belt of the Gaza Strip is used as an agricultural area mainly because of its good soils (Quaternary soil, mainly clay). The fertile soil in the study area favors the cultivation of many crops such as citrus, grains and different types of vegetables. Most of the land at the proposed site is cultivated with grain, in its vicinity there are olive and citrus orchards (orange, lemon, mandarin and valencia). These orchards extend from Road No. 4 (Karama Road) to the border line to Israel. Moreover, other fruit trees such as pears, apricots and figs are commonly found in the area.

**3.8.2 No project impacts**

**BLWWTP Site:**

3.174 The further operation of the BLWWTP, without any remedial action, would result in a deterioration of the water quality of the effluent lake, which at a certain pollution level impairs or even destroys the living conditions of animal species which depend on open water areas. With the decrease of the water quality the open lake constitutes a potential danger for animals which drink the polluted or even toxic water.
NGWWTP Site:

3.175 Without the NGWWTP no major changes are expected for the proposed site. The possible construction of the discussed industrial facilities in the vicinity of the site may change the habitat situation for the existing species. These changes depend on the type of industries, the emissions from the site, the facility management (wastewater handling, solid waste collection and handling, etc.)

3.8.3 Emergency project impacts

BLWWTP Site:

3.176 The most relevant aspect concerning flora and fauna in the emergency phase is the drying of the lake. As soon as the pumping station at pond No. 7 starts to work and all treated wastewater is pumped to the new site there will be no more inflow into the effluent lake. The existing pumping facilities (Figure 2.2, station 11, floating pumps 15) will push the water from the lake to the infiltration ponds (12, 13) in order to lower the water level as soon as possible. The shrinking of the effluent lake, which may last one year until the lake is dry, will have many consequences for the flora and fauna.

3.177 One the one hand there are positive effects. The shrinking water level improves the presently problematic relationship between water surface and volume, leads to an enrichment with oxygen, to a better self cleaning ability of the lake and finally to a better water quality. This and the setting free of shallow water areas improves the habitat quality for water birds.

3.178 On the other hand the steep sand dams and the deep sludge at the bottom of the lake are a potential danger for larger animals which may fall down the steep sand dams into the drying lake and are stuck in the sludge. In the dry season animals try to reach the last open water ponds, and they are often trapped when they break through dry crusts over deep sludge. These problems are well-known in arid zones.

3.179 During the drying process of the lake animal or plant species which are depending on open water or wetlands will more and more disappear and species adapted to arid or semi-arid conditions will take over the new habitats.

Pipeline Construction

3.180 The construction of the about 8 km long pipeline between the new pumping station at BLWWTP and the NGWWTP will mainly follow existing streets and roads within settlements or industrial areas. The crossing of agricultural land also causes only temporary disturbance. Therefore, the construction activities are unlikely to cause significant ecological impacts.

3.181 As the working width may be up to 25 m a large number of trees are potentially endangered by the project. As trees are quite rare in the densely settled areas measures should be taken to avoid felling of trees as far as possible e.g. by reducing the working width. Old trees next to the construction site should be mechanically protected by fencing. Loss of older trees will be compensated by replanting of trees after the construction activities have been finished.
NGWWTP Site:

3.182 The main impact of the project on ecology will be the permanent loss of the site area as a habitat for flora and fauna. The huge earthworks (excavation of about 900,000 m³) and the leveling works will affect the surface of the whole site severely. The site area is used to cultivate grains; mainly wheat and barely. The construction of the WWTP means a permanent loss as a productive area.

3.183 Due to the disturbance caused by the construction activities wildlife species in the surrounding areas may migrate to other places or leave the place at least during the daily working hours when there is noise and dust from the construction site and the activities on the access roads.

3.184 When the infiltration ponds start working they will attract animals, especially open water and wetland species. The new ponds may replace the present ones at BLWWTP, which will be dismantled in the later phase, as habitats to a certain extent. New species, especially water and wetland species will inhabit the area and use it as shelter, food source and for breeding.

3.185 The whole infiltration basin area will be fenced in order to keep away sheep, goats, cows and other animals from the ponds, especially in the emergency phase, when they are filled with only partly treated wastewater.

3.186 In order to control and avoid far-reaching effects especially concerning the ground water quality appropriate groundwater-monitoring is inevitable and will be conducted as described in chapter 3.1.

3.8.4 Impacts at Full Operation of the NGWWTP

BLWWTP Site:

3.187 When all water in the lake has disappeared completely by infiltration and evaporation the dry lake area will be leveled most probably using the sand dam material to fill up hollows in the area. From that time on and depending on the further land use as settlement or agricultural area the flora and fauna of the lake area will be changed permanently.

NGWWTP Site:

3.188 When the treatment plant is completed there will be two main factors which, due to the volumes, have significant ecological effects, the effluent from the plant and the sludge. The effects concerning the effluents are discussed in chapter 3.1.

3.189 From an environmental point of view it would be useful to irrigate at least a part of the treated wastewater effluent in agricultural areas and to use treated sludge, especially composted sludge, as a fertilizer. Presently the farmers use high quantities of chemical fertilizers and irrigation systems based on ground water. Irrigation with the nutrient rich effluent from the WWTP and fertilizing with preferably composted sludge could reduce the amount of chemical fertilizers. The usage of compost could improve the soil quality, especially in sandy areas. Irrigation with treated wastewater would not only provide the plants with nutrients but also lead to an additional effluent water treatment due to an improved oxygen supply, a partially uptake of nutrients the plant roots and the passage through the upper soil layers with all its microorganisms. All these effects finally contribute to an improved ground water quality in the project area.
3.9 Land Use and Infrastructure

3.9.1 Baseline conditions

BLWWTP Site:

3.190 The area around the existing WWTP is densely settled. South of the plant a new road was constructed to connect the area with its surroundings; the al Awda Towers, Al Nada neighborhood and Al Ezba. The existing WWTP reduces the willingness of people to construct new buildings in this area so far. The valley between the lake and Beit Lahya is used for agriculture, mainly to grow vegetables and fruits.

NGWWTP Site:

3.191 The proposed site is located at the northeast administrative boundary of Gaza City. It is about 7 km far from the Erez Industrial Zone at the northern borders between Gaza Strip and Israel, and about 4.5 km south of the existing BLWWTP. The proposed nearest urban centers to the site are Gaza City and Jabalia City. It is about 4 km from the downtown of Gaza city and 2 km from Jabalia center.

3.192 The land at the new site is Wakf Land, owned by the Ministry of Islamic Affairs.

3.193 There are no residential areas or houses on the site itself or near the site. The site itself is used as an agricultural area for wheat production, and it is sometimes used for grazing. There are some temporary shelters beside the cemetery.

3.194 The most obvious feature characterizing the area is the Al Shuhada cemetery located just to the west of the site.

<table>
<thead>
<tr>
<th>Category</th>
<th>Site Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical site</td>
<td>The site falls within the jurisdiction of Gaza Municipality. It is located at the northeast administrative boundary of Gaza City.</td>
</tr>
<tr>
<td>Size</td>
<td>Total area = 30 hectares, Initial phase area = 10ha</td>
</tr>
<tr>
<td>Relative location</td>
<td>Distance to downtown of Gaza city: 5 kilometers</td>
</tr>
<tr>
<td></td>
<td>Distance to Jabalia center: 4 kilometers</td>
</tr>
<tr>
<td></td>
<td>Distance to BLWWTP (Direct) 5 kilometers</td>
</tr>
<tr>
<td>Existing structures</td>
<td>There are a few existing structures on the entire proposed site. These include:</td>
</tr>
<tr>
<td></td>
<td>A sheep farm (about 6,600m2);</td>
</tr>
<tr>
<td></td>
<td>A cow farm with associated structures and six greenhouses</td>
</tr>
<tr>
<td></td>
<td>Three wooden sheds (3x3m)</td>
</tr>
<tr>
<td></td>
<td>5 Water wells</td>
</tr>
<tr>
<td></td>
<td>New greenhouses were being constructed on part of the land.</td>
</tr>
<tr>
<td>Grade and drainage</td>
<td>The area is gently sloping towards the northwest leading to El Qashash Wadi.</td>
</tr>
<tr>
<td></td>
<td>In general, the northwest side of the proposed WWTP is the lowest part of the area. The Wadi provides a natural drainage to the site. In some wet seasons, the surrounding areas have been subjected to flooding from the Wadi</td>
</tr>
<tr>
<td>Road access</td>
<td>The Shuhada Islamic Cemetery Street is the main access road to the proposed WWTP site. It branches from El Karama Road. Its planned width is 30m wide, currently paved 8m wide only.</td>
</tr>
<tr>
<td>Water supply</td>
<td>Water wells</td>
</tr>
<tr>
<td></td>
<td>There are 5 agricultural wells drilled within the site boundary, designated Q54-A, B, D, and E.</td>
</tr>
<tr>
<td></td>
<td>The chemical test results show that the chloride level is about 370 mg/l (in wells Q54-A and Q54-D) which is above the WHO maximum Standard (250mg/l). The nitrate content is of acceptable levels (less that 50 mg/l).</td>
</tr>
</tbody>
</table>
3.9.2 No project impacts

**BLWWTP Site:**

3.195 In the recent years large areas were used to construct the lagoons and infiltration basins to mitigate any emergency. If the existing situation continues or even worsens, more land will be acquired to construct infiltration basins.

**NGWWTP Site:**

3.196 At the NGWWTP, the main agricultural use is expected to remain the same. There are plans for a new industrial zone west of Al Shuhada cemetery. This development would not influence the NGWWTP project because it is not planned to built any new residential areas in the future. The land use planning for the area of concern is summarized in Figure 3.23.

![Figure 3.23: Land Use](image)

3.9.3 Emergency project impacts

**BLWWTP Site:**

3.197 The proposed emergency project will protect the settlement areas neighboring the existing site and the lake and allow long term planning for the further use of the rehabilitated area. The project is expected to encourage the responsible agencies; Common...
Services Council, Bait Lahya municipality and Um Al Nasser Village council to arrange for cleaning campaigns e.g. rubble and waste in order to improve the aesthetic features in the area.

NGWWTP Site:

3.198 The area is expected to be subjected of several agriculture activities to replant the destructed and leveled areas. The cemetery is bounded and regulated. So, there is no tangible impacts are expected. Only an idea to develop a small industrial zone and workshops area in the vicinity. This may increase the land prices and lead to minimize the cultivated areas.

3.199 Concerning the emergency project, the project has no conflict with the private properties. The main pipeline will follow the route of Al Shuhada road that is municipal property. Construction the project will reduce the recreational value of the area.

3.9.4 Impacts at Full Operation of the NGWWTP

BLWWTP Site:

3.200 The pond No 1 to 6 and their access roads as well as the old pumping station will have be demolished after the NGWWTP has been completed. Only lagoon no. 7 will be used in emergencies. The infiltration ponds No. 12 and 13 will be used for storm water infiltration only.

3.201 The rehabilitation of the lake and the WWTP will improve the living conditions of the local residents considerably and encourage the willingness to live in the surrounding area. The implementation of the emergency project will also have also positive effects on the agricultural sector. Stopping the uncontrolled infiltration of partially treated wastewater, the quality of irrigation water in the surrounding agricultural wells will be improved and allows higher quality of agricultural activities. In general, the project will positively influence the land prices in the project surrounding areas.

NGWWTP Site:

3.202 The operation of the NGWWTP will have no effect on the current agricultural land use around the site. Landscaping is necessary to minimize visual impacts especially for visitors of the cemetery. The cultivation of new agricultural plant species may be encouraged due to the reuse of treated wastewater in irrigation.

3.10 Landscape

3.10.1 Baseline conditions

BLWWTP Site:

3.203 The BLWWTP is located in an open, shallow valley between two parallel ridges, the Gaza ridge in the west (up to 50 masl) and the el Muntar Ridge in the east (up to 80 masl). The overall appearance of the valley is that of a mixed residential and agricultural area with almost no areas unaffected by man’s influence. The most significant landscape elements are the open water bodies of the treatment ponds and especially the large wastewater lake. Open water bodies are usually regarded as positive landscape elements, but in this case the knowledge of the purpose of these water bodies, and sometime the odor emissions, strongly impair the impression on the residents.
3.204 A view of the whole scenery is only possible from the top of the two ridges or form upper stories of higher houses in the neighboring settlements. In some parts of the area around the WWTP the uncontrolled disposal of grits, solid wastes and construction wastes severely disturbs the landscape. There are only a few single trees which contribute to a improvement of the picture.

NGWWTP Site:

3.205 According to the previous EA the proposed new WWTP site is planned on the eastern side of a shallow valley between two kurkar ridges, the el Muntar ridge in the west (up to 80 masl) and the Beit Hanoun Ridge (up to 90 masl) in the east. Route 4 runs about 0.5 km west of the site at the bottom of the valley. The site is located at a moderate western slope of the Beit Hanoun Ridge, with reaches 69 m masl in this section. To the east, beyond the ridge, the land falls slowly down to the border line with Israel. All land east of the planned site, also beyond the border in Israel, is undulating farmland without settlements or farm houses. There are no areas on the Israeli side of the border which overlook the proposed site. Only some parts of treatment plant buildings, which will be constructed in Phase 1 (2008) and which exceed 69 masl will be visible from the Israeli side.

3.206 The eastern slope of the valley varies from light industry and high housing density at the bottom to low density housing areas at the top of the ridge. From the upper parts of the eastern slope the planned site area is visible, but the distance to the site area is rather high.

3.207 The relatively low growing citrus plantations between Route 4 and the site effectively screen the side area from views from the west. The belt of trees around Al Shuhada Cemetery, which neighbors the planned site area, forms a 3 – 13 m high visual barrier along the western side of the site. The screening effects lead to the statement that views to the site area are mainly limited to distant views so that the site area is only a small part of the whole panorama. However, direct views to at least parts of the site are possible from high buildings and the upper parts in the west.

3.10.2 No project impacts

BLWWTP Site:

3.208 The deterioration of the treatment process at the WWTP will certainly lead to further impairments of the landscape. The same is true for the dumping of waste and construction material, if this practice is not stopped.

NGWWTP Site:

3.209 Without the construction of the new WWTP there will be no changes in the present landscape situation in the area of the site. The possible effects of a new industrial zone west of the Al Shuhada Cemetery on the landscape depend on the type and size of the industrial activities and will most probably reduce the quality of the landscape in the area.
3.10.3 Emergency project impacts

BLWWTP Site:

3.210 The construction activities at the site (new pumping station, sewer, movement of construction vehicles) will bring temporary visual impacts and noise and impair the landscape.

3.211 The drying out of the lake will change the present landscape significantly. In the emergency phase the negative optical effects are expected to dominate, due to the loss of wetland-vegetation (weed, some trees) and the sight of the sludge at the bottom of the lake. The rehabilitation off the area (earthworks, leveling) will also cause short-term impacts.

Pressure Pipe Line

3.212 During the construction of the sewer line there will be impairments of the landscape due to the construction activities (movement of construction vehicles, open earthworks, storing of construction material). However, these impacts are only short-term and local.

NGWWTP Site:

3.213 The most significant impacts on landscape in the emergency phase will be construction activities at the planned site. At the construction site (about 300 dunums) and the access roads to and from the site there will be movements of heavy construction vehicles with all the accompanying effects on the landscape (visual disturbance, noise, fume and dust emissions).

3.10.4 Impacts at Full Operation of the NGWWTP

BLWWTP Site:

3.214 After all wastewater is pumped to the new site the existing Ponds 1 – 6 will be demolished. These de-construction activities cause visual disturbance, noise, fume and dust emissions from the construction vehicles. The rubble should be transported to an official and orderly rubble deposit site.

3.215 Depending on the further land use of the rehabilitated lake area (built-up or agricultural area) there will be a new landscape. From an environmental point of view only agricultural land use would lead to a significant improvement of the present situation for the local residents. Lagoon No. 7, which will be used in emergency cases to retain the raw wastewater, may impair the landscape in future temporarily.

NGWWTP Site:

3.216 Technical structures of the treatment plant which will be built in 2008 range in height between 2 and 12 m. The tallest buildings would be located at the western edge of the site, which is also the lowest part of the site. The tallest buildings and the above ground tanks are clustered together forming a uniform block similar to three-storey building of a industrial nature. Similar structures can be found in many places in the Northern Gaza Governorate.

3.217 The site is already partly screened by surrounding tree rows (Al Shuhada Cemetery) and citrus plantations and allows direct views only at a far distance from the
ride in the west or its eastern slope. The most significant view to the new WWTP will be from the southern part of the cemetery. The most visible parts of the site will be the tall buildings 170 m away from the wall of the cemetery. These will largely block views of the rest of the works behind them. In the northern part of the cemetery views will be possible across the remaining triangle of farm land between the WWTP and the cemetery to the low tanks, stepped terraces and infiltration basins on the hill slope. All together the visual impact of the complete WWTP within the rural area is considered to be moderate.

3.218 A detailed landscape and architectural design was prepared by SWECO in 2004 or the NGWWTP. The main landscaping ideas concerning the exterior perspective were to achieve a nice view with forestry, water terraces and green slopes in addition to an attractive technical plant. According to the design, the site will be exposed from different parts of the surrounding landscape. Plantation that combines a good ecological structure with the use of vegetation for reducing the visibility of the plant from surrounding areas was considered in the design. Certain local trees will be planted to give a good green structure on the site and achieve a good impression from the outside. Gardening by means of grass, flowers, bushes and trees will cover the maximum possible area. The boundary to the cemetery and the area between the NGWWTP structures will be planted to minimize the effect from the wastewater plant to the surroundings.

3.11 Summary of Impacts

3.219 Table 3.9, Table 3.10 and Table 3.11 summarize the environmental impacts of the project on BLWWTP site, the pressure line route, and NGWWTP site, respectively.
### Table 3.9: Summary of Environmental Impacts at BLWWTP Site

<table>
<thead>
<tr>
<th>Phase / Issue</th>
<th>Impact</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre Construction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>Access to lands for topographic and subsoil surveys.</td>
<td>Negligible</td>
</tr>
<tr>
<td><strong>Construction Works</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Safety</td>
<td>Potential injury and death</td>
<td>Major negative</td>
</tr>
<tr>
<td>Noise and Construction</td>
<td>Nuisance value that may in extreme cases affect health</td>
<td>Major nuisance value.</td>
</tr>
<tr>
<td>Disturbance</td>
<td>Nuisance value that in extreme cases may affect health</td>
<td>Minor health impact</td>
</tr>
<tr>
<td>Air Quality (excl. dust)</td>
<td>Nuisance value that in extreme cases may affect health</td>
<td>Minor negative health impact</td>
</tr>
<tr>
<td>Dust</td>
<td>Traffic on local dirt roads</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Waste Soil Material</td>
<td>Removal and disposal of non usable soil materials</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Hydrogeology, Geology and Topology</td>
<td>Nuisance for local residents (construction, demolition works), drying and rehabilitation of the lake</td>
<td>Moderate negative (for biological treatment of the lake)</td>
</tr>
<tr>
<td>Fauna, Flora and Ecology</td>
<td>Loss of wetland and open water areas, Loss of relatively undisturbed habitats</td>
<td>Major negative (wetland species) Moderate (disturbance)</td>
</tr>
<tr>
<td>Archaeology/Cultural Heritage</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Project offices</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Materials Stockpiles</td>
<td>Access</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Equipment Maintenance and Cleaning</td>
<td>Storage and use of chemicals (fuel, oil), hazardous waste disposal (especially oils)</td>
<td>Moderate negative Sufficient cumulative impact to warrant attention</td>
</tr>
<tr>
<td>Access and Construction Traffic</td>
<td>Mix of heavy construction traffic and existing traffic will be a potential source of accidents.</td>
<td>Moderate negative</td>
</tr>
<tr>
<td><strong>Resource Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land consumption</td>
<td>Small scale construction (pumping station, inlet works)</td>
<td>Negligible</td>
</tr>
<tr>
<td><strong>Permanent Impacts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land consumption</td>
<td>Rehabilitation of the lake area and demolition of WWTP facilities (pumping station, ponds No 1 – 6)</td>
<td>Major positive!</td>
</tr>
<tr>
<td>Property take</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Cultural Properties</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Flora and Fauna</td>
<td>Minor</td>
<td>Moderate negative</td>
</tr>
<tr>
<td>Living quality for local residents</td>
<td>Rehabilitation of the lake area and the WWTP site reduces health risks and improves living quality for local residents</td>
<td>Major positive!</td>
</tr>
<tr>
<td>Dried Sludge</td>
<td>Disposal of large volume of material</td>
<td>Potentially Major negative (if not used in agriculture) Nil</td>
</tr>
<tr>
<td>Population relocation and settlement</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Productive land</td>
<td>Rehabilitation of the lake area and follow-up use as green or agricultural land</td>
<td>Major positive! (if the area is used for green land or agriculture) Nil</td>
</tr>
<tr>
<td>Employment</td>
<td>Rehabilitation of the lake area and follow-up use as built up area</td>
<td>Moderate positive</td>
</tr>
<tr>
<td></td>
<td>Rehabilitation of the lake area and follow-up use</td>
<td>Moderate positive</td>
</tr>
</tbody>
</table>
Table 3.10: Summary of Environmental Impacts of the Sewer Line between BLWWTP and NGWWTP

<table>
<thead>
<tr>
<th>Phase / Issue</th>
<th>Impact</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre Construction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
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</tr>
<tr>
<td><strong>Construction Works</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Safety</td>
<td>Potential injury and death</td>
<td>Major negative</td>
</tr>
<tr>
<td>Noise and Construction</td>
<td>Nuisance value that may in extreme cases affect health</td>
<td>Major nuisance value.</td>
</tr>
<tr>
<td>Disturbance</td>
<td>Nuisance value that may in extreme cases affect health</td>
<td>Minimal negative health impact</td>
</tr>
<tr>
<td>Air Quality (excl. dust)</td>
<td>Nuisance value that in extreme cases may affect health of general population. Vulnerable groups could have much higher health threat.</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Dust</td>
<td>Traffic on local dirt roads</td>
<td>Moderate negative</td>
</tr>
<tr>
<td>Waste Soil Material</td>
<td>Removal and disposal of non usable soil materials</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Hydrogeology, Geology and Topology</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Fauna, Flora and Ecology</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Archaeology/Cultural Heritage</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Project offices</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Materials Stockpiles</td>
<td>Access</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Equipment Maintenance and Cleaning</td>
<td>Storage and use of chemicals, industrial waste disposal (especially oils)</td>
<td>Moderate negative.</td>
</tr>
<tr>
<td>Access and Construction Traffic</td>
<td>Mix of heavy construction traffic and existing traffic will be a potential source of accidents.</td>
<td>Moderate negative</td>
</tr>
<tr>
<td><strong>Permanent Impacts (6.5)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land consumption</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Property take</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Cultural Properties</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Flora and Fauna</td>
<td>Temporary disturbance</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Population relocation and settlement</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Productive land loss</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Employment</td>
<td>Temporary jobs at the construction site</td>
<td>Moderate positive</td>
</tr>
</tbody>
</table>
### Table 3.11: Summary of Environmental Impacts at NGWWTP Site

<table>
<thead>
<tr>
<th>Phase / Issue</th>
<th>Impact</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre Construction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>Access to lands for topographic and subsoil surveys.</td>
<td>Negligible</td>
</tr>
<tr>
<td><strong>Construction Works</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Safety</td>
<td>Potential injury and death</td>
<td>Major negative</td>
</tr>
<tr>
<td>Noise and Construction Disturbance</td>
<td>Disturbance of visitors of the Al Shuhada cemetery</td>
<td>Major nuisance value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimal negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>health impact</td>
</tr>
<tr>
<td>Air Quality (excl. dust)</td>
<td>Nuisance value that in extreme cases may affect health of general population. Vulnerable groups could have much higher health threat.</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Dust</td>
<td>Traffic on local dirt roads</td>
<td>Negligible</td>
</tr>
<tr>
<td>Waste Soil Material</td>
<td>Removal and disposal of excavated soil (900,000 m³)</td>
<td>Major negative</td>
</tr>
<tr>
<td>Hydrogeology, Geology and Topology</td>
<td>Excavation and leveling</td>
<td>Moderate negative</td>
</tr>
<tr>
<td>Fauna, Flora and Ecology</td>
<td>Permanent loss of habitats (agricultural area)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Archaeology/Cultural Heritage</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Project offices</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Materials Stockpiles</td>
<td>Access</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Equipment Maintenance and Cleaning</td>
<td>Storage and use of chemicals, industrial waste disposal (especially oils)</td>
<td>Moderate negative.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sufficient cumulative impact to warrant attention</td>
</tr>
<tr>
<td>Access and Construction Traffic</td>
<td>Mix of heavy construction traffic and existing traffic will be a potential source of accidents</td>
<td>Moderate negative</td>
</tr>
<tr>
<td><strong>Resource Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground water</td>
<td>Temporary infiltration of partly treated wastewater in the emergency phase</td>
<td>Major negative</td>
</tr>
<tr>
<td></td>
<td>Medium-term infiltration of fully treated wastewater from Phase 1 on</td>
<td>Moderate positive</td>
</tr>
<tr>
<td></td>
<td>Long-term infiltration of fully treated wastewater</td>
<td>Major positive</td>
</tr>
<tr>
<td>Land consumption</td>
<td>Infiltration ponds, treatment facilities</td>
<td>Moderate negative</td>
</tr>
<tr>
<td><strong>Permanent Impacts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land acquisition</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Productive land loss</td>
<td>Loss of 80 donums fertile agricultural area</td>
<td>Minor negative</td>
</tr>
<tr>
<td>Property take</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Cultural Properties</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Flora and Fauna</td>
<td>Loss of habitats</td>
<td>Moderate negative</td>
</tr>
<tr>
<td></td>
<td>Creation of new habitats (wetland, open water)</td>
<td>Moderate positive</td>
</tr>
<tr>
<td></td>
<td>Disposal of large volume of material</td>
<td>Potentially major negative (if not re-used in agriculture)</td>
</tr>
<tr>
<td>Population relocation and settlement</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Employment</td>
<td>Creation of new permanent jobs</td>
<td>Major positive</td>
</tr>
</tbody>
</table>
4 ENVIRONMENTAL MANAGEMENT PLAN

4.1 Environmental Management Plan Objectives

4.1 The planned project has been classified as Category “A” under the World Bank Operational Policy (OP) 4.01. For all projects of Category “A” a comprehensive Environmental Assessment (EA) as well as an Environmental Management Plan (EMP) are obligatory. The implementation of the EMP is the means by which the adverse environmental impacts of the planned project, subject to mitigation measures, are effectively mitigated and by which the effectiveness of the mitigation is monitored.

4.2 The preparation of the EMP involves the identification of feasible and cost-effective measures that may prevent or reduce potentially significant adverse environmental impacts to acceptable levels.

4.3 This EMP has three basic components:
   - Environmental Mitigation.
   - Environmental Monitoring and Enforcement.
   - Capacity Building Requirements.

4.2 EMP for Part A: NGEST

4.2.1 Institutional Setup

4.4 A responsible entity is necessary to enforce and monitor the implementation of the EMP components. Some monitoring and mitigation measures require the contribution of other governmental institutions, in cooperation with the responsible entity. The institutional setup and capacity building section aims to coordinate the environmental policies, plans, programs and decisions of the various parties involved in the different environmental aspects of the project. This setup and related capacity building will ensure a proper implementation of the proposed mitigation measures.

4.5 In general, in the West Bank and Gaza Strip, the two leading bodies of the regulatory framework in the water and wastewater sector are the National Water Council (NWC) and the Palestinian Water Authority (PWA). The municipalities, village councils and joint service councils are responsible for operating and maintaining water and wastewater facilities. Figure 4.1 shows the proposed institutional setup framework for the Emergency phase. Three levels of institutional management are involved in the project as follows:

**Governmental Level Management**

4.6 The governmental level management is mainly represented by PWA supported by other ministries and governmental agencies including National Water Council, Environmental Quality Authority, Ministry of Local Government, Ministry of Planning, Ministry of Finance, Ministry of Religious Affairs, Ministry of Tourism and Antiquities, Ministry of Health, and Coastal Municipalities Water Utility (CMWU). PWA is responsible for coordination of activities with other agencies in order to ensure smooth implementation of the project from the inception phase of the project to construction and operation. PWA is also responsible for coordination with the Israelis to avoid any trans-boundary problems. PWA and other governmental agencies can form a Steering Committee for the project. The role of this steering committee will be finalized at the end of the construction phase and the specific tasks and duties for each involved entity will be defined according to their responsibilities in line with the laws and regulations. Annex II gives a survey of the existing governmental agencies and their responsibilities.
Project Management Unit (PMU)

4.7 In 2000, the PMU was created as a part of the PWA. The PMU consists of a project director, engineers, supervisors, administrative assistant and financial assistant. The PMU is responsible for day-to-day activities; procurement, higher supervision, accounting, evaluation, monitoring, variation orders, and reporting. During construction and operation phases the PMU is responsible for coordination with the municipalities (later will be part of CMWU) in the Northern Gaza Governorate. Also, it is the responsibility of the PMU director to coordinate with the representatives of other stakeholders to ensure proper implementation of EMP or to discuss any issue. The PMU is a temporary entity, which will be restructured most probably in 2008, after the Coastal Management Water Utility is established. As shown in Figure 4.1 the proposed institutional setup of the project outlines the responsibilities of the PMU at different phases of the project.

4.8 The PMU should be strengthened with a consultant during the construction phase for the management of the construction activities and for control of their compliance with the laws and standards. Another consultant should be commissioned to assist in monitoring, testing and quality assurance. There are some changes on the role of PWA and PMU during the different phases of the project and after establishment of the proposed Coastal Municipalities Water Utility (CMWU) which is proposed to operate all water and wastewater facilities in Gaza Strip. Therefore the relationship between, PWA, PMU and CMWU will change during the project phases according to the change of their responsibilities. However, reporting to the Steering Committee is the responsibility of PMU during the first three years (2006-2008) and the responsibility of CMWU after establishment of the CMWU in 2008.

PMU’s Proposed Staff

4.9 One of the PMU’s staff members should be an environmental specialist or an engineer with strong environmental background to participate in the environmental management and monitoring processes. The tasks of the environmental expert are:

(a) Environmental Auditing:

✓ Monitor all construction activities at BLWWTP and NGWWTP and the new sewer connection, including the transportation and storage of construction material by regular site visits.

✓ Ensure that the EMP is applied during all phases of the project by informing the responsible administrative entities and taking care that timely actions are taken in cases of non-compliance.

(b) Coordinate environmental training activities for staff, engineers and contractors.

(c) Coordinate with municipalities, EQA and other involved parties in order to mitigate the environmental impacts by providing instructions for the implementing agencies.

(d) Assistance in preparation of the progress reports during implementation of the EMP.

4.10 PMU is responsible for supervision during the emergency phase, which comprises one year of construction and two years of operation. A qualified international operator is now contracted to operate all water and wastewater services under the supervision of PMU. PWA in this stage will be a coordinating agency. After the new infiltration basins are constructed, the environmental expert is proposed to be relocated to the CMWU to perform the activities mentioned above during the operation phase.
4.11 To ensure building up the capacity of the involved parties, special training is necessary for the key members, i.e., PWA, CMWU, EQA, contractor and other monitoring and control agencies.

**Coastal Municipalities Water Utility (CMWU)**

4.12 PWA follows the strategy to combine all activities which are executed by several municipalities, village councils, and water and wastewater departments nowadays under the roof of one single, efficient Regional Water and Wastewater Utility. A Memorandum of Understanding for the creation of the CMWU and the outsourcing of water and wastewater services to private contractors has been signed. It is proposed that the CMWU, which will be the owner of the assets, will be responsible for setting and monitoring the key objectives in terms of service delivery, while PWA will mainly focus on regulatory environmental aspects (such as groundwater quality, groundwater abstraction, and wastewater quality and discharge) and some selected economic aspects (such as the adherence to national water tariff guidelines). The existing CSC will be integrated into the CMWU. During the first stage of the project, the CSC is responsible to facilitate construction of the infiltration basins.

4.13 A transitional period is proposed before the CMWU will have the full operational control of water and wastewater services. During this transitional period, the operator will have the responsibility for all managerial and operational aspects of the water and wastewater systems in the Gaza strip, including the use of the Operating Investment Fund. Depending on the type of contract, the operator may have other responsibilities outside the operation and maintenance of the proposed treatment plant. All procurements and services will be procured in accordance with World Bank guidelines.

**The Recommended Environmental Consultants**

4.14 In order to ensure smooth implementation of the proposed monitoring plan and mitigation measures it is necessary to conduct an intensive capacity building program for the involved parties during the inception phase of the project construction. The capacity building program is proposed to be organized as workshops (four workshops) to cover the following subjects:

- Project components and schedule.
- Description of the EMP components.
- Institutional arrangements and coordination methodologies.
- Quality control and assurance plans.

4.15 The needed consultant for the capacity building is clearly identified in the proposed institutional setup as environmental Consultant 1. The other capacity building programs such as on-the-job-training, staff training and training for contractors could be conducted by the same consultant as well be described in the capacity building requirements.

4.16 Another qualified consultant is proposed to be responsible for construction compliance supervision as Consultant 2. The duties of this consultant are direct compliance supervision, reporting to PMU, quality control and quality assurance of implementation.
Figure 4.1: Institutional Setup Framework for Part A
4.2.2 Mitigation Measures and Monitoring Actions

Avoiding or mitigation of environmental impacts is by far preferable to compensation or rehabilitation measures after an impact has happened.

It is the task of the EA and especially the EMP to identify significant impacts, to define measures to avoid or at least to minimize these impacts and to take care that these measures are properly applied at all project phases. The following paragraphs describe the proposed mitigation measures and monitoring actions for each project phase in general before the most significant measures are defined in detail.

As identified earlier, impacts during the one year long construction phase are primarily associated with the construction of the pressure line and the infiltration basins. The significant accompanying activities comprise land consumption, earthworks, material transport and movement of heavy machinery. Such impacts are mostly short-term, local, and caused by the contractors activities at the construction sites and the access roads and can be mitigated through proper construction management in coordination with the contractor and the authorities concerned. The contractor in cooperation with the monitoring agency and the environmental expert are responsible for implementing the mitigation measures during the construction phase.

Impacts during the operation phase of the emergency project, which is about 2 years, are primarily associated with ground water, soil, health and land use. The most significant impact at this phase is the infiltration of partially treated wastewater into the ground water.

Environmental monitoring is the timely and proper survey of the significant environmental impacts of a project during all project phases. Monitoring results help judge the success of mitigation measures in protecting the environment. They are also used to ensure compliance with environmental standards, and to identify necessary changes in the project design or operation.

The Environmental Monitoring plan sets out a framework for monitoring the environmental situation at all project sites (BLWWTP, NGWWTP and sewer line). In order to ensure that the reality complies with the demands of the EMP environmental, monitoring should be carried out concerning the following aspects:

- Construction and transport activities.
- Health and safety measures (construction and operation workers, local inhabitants).
- Site cleaning, solid wastes removal, hauling and disposal.
- Efficiency of the treatment process.
- Quality of treated wastewater.
- Aquifer Water quality in the vicinity of the infiltration ponds.
- Monitoring of unexpected leakages or system failures.
- Top soil of the infiltration basins against clogging issues.
- Agricultural soil subjected to sludge or treated wastewater application.

In addition, the PMU is responsible for monitoring and enforcing the various environmental issues as related to the project activities as outlined in Table 4.2 and Table 4.3. Also, the PMU is responsible for executing any necessary measure out of those highlighted in the table according to the prevailing conditions at the site. Environmental mitigation and
monitoring actions are presented in a simple matrix format. They include identification of the problems, mitigation measures, monitoring responsibilities, and the responsibilities to carry out the mitigation and monitoring measures. All the mitigation measures should be incorporated into the construction and supervision contracts.

4.24 The following section highlights the necessary monitoring actions and mitigation measure for the significant environmental issues:

4.2.2.1 Water Quality Mitigation Measures and Monitoring

BLWWTP Site:

4.25 Based on the effluent quality testing, considerable differences have been identified between the effluent from the polishing pond and the adjacent effluent lake especially concerning nitrogen, BOD, and SS. At the beginning of the emergency phase, the partially-treated effluent wastewater will be taken from the polishing pond at BLWWTP, pumped to the new site and recharged into the groundwater via the new infiltration ponds. The effluent quality in the polising pond is expected to improve due to the upgrading of the BLWWTP facilities (inlet works, aeration) at the beginning of the emergency phase. The combination of existing aeration capacity (88 KW) and enough retention time can produce a relatively good effluent (BOD < 50 mg/l) for flow up to 14,000 m³/day. According to EU standards, it is required to provide 5 KW aeration capacity every 1000 m³ of influent. As the influent increases to about 18,000 m³/day, the retention time will be less than 1.2 day which is not enough for aeration. As a result the treatment efficiency will decrease.

4.26 The following measures are recommended before infiltration phase begins at the new site:

- Upgrading of the inlet works for a better performance of debris screening and sand removal. Neither the existing screen nor the sedimentation facilities, which have to be cleaned manually, seem to be sufficient or sufficiently maintained for the pre-treatment of the incoming wastewater.
- Cleaning and installation of additional aerators in Ponds 3 and 4. These ponds should be fully aerated with at least 100 KW aeration power.
- Ponds 3 and 4 should be cleaned to increase the depth from 1.5 - 1.75 m currently to their original design (2.4 m).

4.27 When the infiltration at the new site begins, and with all upgrading activities at BLWWTP realized, the effluent levels of BOD, SS and Total N would be significantly lower than the present values. Previous records in 2001 and 2002 show that the BOD was about 45 mg/l (Shomar, 2004). Chloride concentration from both the polishing pond and the lake is suitable for infiltration and will have even positive effects on the high chloride concentration of the aquifer. Nothing significantly can be done in the emergency case within the available budget to reduce the total nitrogen concentration in the effluent. Using large area infiltration basins, low application depth, and more drying days than flooding will enhance the nitrification process in the soil top layers and de-nitrification in the deeper layers. Increasing the drying period will supply more oxygen to the soil that will enhance the nitrification process of Kejldal nitrogen to NO₃. Some decay will occur if the infiltrated effluent passes through soil layers that is rich with organic materials (Clay) but that part of the aquifer does not have enough of these lenses. High degree of treatment can be achieved by allowing
partially-treated sewage effluent to infiltrate into the soil. Soil Aquifer Treatment (SAR) removes SS, BOD, bacteria, viruses and Reduce N, Ph, Heavy Metals significantly.

4.28 The local infiltration of the lake water at the two storm water infiltration facilities should continue until the lake level has gone down at least by 4 to 5 m. During winter time storm water enhances leaching and dilution processes at the basin bottoms. The infiltration of the lake water can be done at a rate of about 4,000 m$^3$/day in summer and much lower in winter because of the incoming storm water. Natural evaporation will do part of the lake water level reduction (open water evaporation 840 mm/year). When the lake water level is reduced significantly, the sun light and oxygen can reach the whole depth and the lake will be an effective part of the treatment process.

**NGWWTP Site:**

4.29 In order to reduce the expansion of the nitrogen plume and to minimize any trans-boundary effects, the following measures are proposed:

- Infiltration Basins 7 and 9 will not be used during the emergency phase.
- Only the direct effluent from BLWWTP from the polishing pond (12,000 m$^3$/day and its natural increase) will be used for infiltration at the beginning.

4.30 Figure 4.2 and Figure 4.3 show the short and long term impacts of these measures. Comparing the results with Figure 3.16 shows that the nitrogen plume at the end of the emergency phase will extend about 200 m to the west and about 100 to the east of the infiltration site. Comparing the results shown in Figure 3.13 and Figure 4.3, it can be seen that the transport path will be confined to a smaller area at the long run. The reason is that the regional flow will surplus this small infiltration quantity and force it in the western direction.

![Figure 4.2: NO$_3$-N Plume at the End of Part A using 12,000 m$^3$/day and not using Infiltration Basins 7 and 9](image-url)
Monitoring for Year 2006-2008

4.31 Regarding the risk of pollution from pathogens, no well should be operated within a distance of 150 m (6-month residence time) from the edge of infiltration basins (contour line, Figure 3.21). The groundwater beyond that area will be hygienically safe.

![Figure 4.3: Long Term extent of Particle Transport if Basins 7 and 9 are not Used](image)

Recommendations for after 2008

4.32 Considering the worst case scenario (if the NGWWTP is not implemented and infiltration with partially treated sewage continues after 2008), recovery scheme around the infiltration site has to be implemented or pumping to the infiltration basins must be stopped.

4.33 Figure 4.4 shows the proposed locations of recovery wells. It is proposed to have 24 wells that are 100 m apart and are tentatively located about 200-300 m north and south and 400 west of the infiltration basins. The wells are located at the edge of agricultural lots near existing roads and inside the proposed industrial area as it will be easy to connect them in a regional irrigation scheme in the future. Figure 4.7 also shows nine private agricultural wells in the nearby areas (Q14, Q15, Q53, Q54A, Q54D, Q55, Q56, and R12) that can be upgraded or renovated and used as recovery wells in addition to the new wells. The recovery scheme in addition to the nearby agricultural wells should be able to pump 10% more than what is infiltrated. Figure 4.4 shows how the proposed recovery wells will be able to capture most of the infiltrated particles.

4.34 The operation of the agricultural wells in the surrounding areas of the infiltration basins should be regulated by PWA in order to ensure that all the infiltrated effluent is recovered. The quality of the abstracted water should be strictly monitored to ensure health
and safety of the users. In case of any problem in any of the water quality parameters, the necessary action should be decided and enforced by PWA.

4.35 Figure 4.5 also demonstrate the effectiveness of the proposed recovery system in reducing the expected extent of the contaminant plume compared with the model results shown in Figure 3.20. The proposed new wells will be able to pump 19,200 m³/day (800 m³/day for each well and screened between -10 to -30 from the mean sea level).

4.36 The exact location and design of the proposed wells should be part of PWA plans for a regional reuse scheme. The planning should take into consideration the tariff and how and where this pumped water will be used. And in order to be prepared for the worst case. The planning for this activity should start soon.

Figure 4.4: Impact of the Proposed Recovery System in Capturing the Contaminant Particles.
Locations for Monitoring Wells

4.37 At the infiltration site, the observation points have to cover the deep part of the aquifer and the zone between the water table before infiltration and the water table after infiltration. Some of the already implemented observation wells can be utilized. DB wells should be used to monitor the deep part of the aquifer beneath the infiltration site. SD2 or one of the SD group should be used to monitor the shallow part of the aquifer. Figure 4.6 shows the proposed location of the new monitoring wells.
4.38 At the west of the infiltration site 3 lines of observation wells should be considered. The line comprises two sets of three observation wells located at 200 m radius from the edge of infiltration basin (east and west of the infiltration basins). The second line comprises of two wells located at 350 m radius from the edge of infiltration basin. In addition to that one observation well should be located at 500 m distance from the edge of infiltration basins. All these wells should be screened somewhere between -20 to -5 m from MSL.

4.39 Table 4.1 shows a list of parameters that should be monitored at different frequency for the different project phases. This table was designed based on local experience and the experience from the Dan region monitoring program. Samples from the observation wells are taken after at least half an hour of pumping in order to exchange the water in the well. After the start of operation of the new NGWWTP measurements for influent and effluent should be performed daily for all the proposed parameters in the table.

4.40 The aquifer water quality monitoring should start upon the completion of construction of the infiltration basins to establish a baseline data for the new site. Some of the nearby existing wells (see Figure 4.7) that are now used for monitoring can also be utilized for this purpose (Q14, Q15, Q53, Q54A, Q54D, Q55, Q56, and R12).
Table 4.1: Proposed Monitoring Parameters during Part A Emergency Phase

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pumped Effluent (every month)</th>
<th>Aquifer water (every two weeks)</th>
<th>Aquifer water (every three months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Later level</td>
<td>N/A</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>pH</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>EC</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TDS</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SS</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>BOD</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>COD</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NO3</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NH3/NH4</td>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cl</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>SO4</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ca</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Mg</td>
<td>X</td>
<td>X</td>
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</tr>
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<td>K</td>
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</tr>
<tr>
<td>Na</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Faecal Coliform</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Total Coliform</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Detergents (HPLC)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Heavy metals</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Figure 4.7: Existing Production Wells that are Used for Monitoring
4.2.2.2 Environmental Health and Safety Mitigation Measures and Monitoring

4.41 As discussed in the preceding chapter, the expected impacts during construction phase are related to danger resulting from equipment and vehicles movement. Limiting the speed in the construction site and working hours to the day hours as well as enforcing the maintenance of mobile equipment will mitigate the impacts. Also, fencing the whole construction site will save workers and children from dangerous activities.

4.42 At the BLWWTP inlet works a mechanical screening and de-gritting system should be installed as soon as possible to avoid the risk for the workers, who presently have to enter the facility in order to remove waste and sediments. This measure has already been proposed in the previous EA in 1999 and was not realized.

4.43 During the emergency phase and in order to prevent people, especially children away from falling into the drying lake it is proposed to fence and to guard the wastewater lake as soon as possible, at least at the beginning of the emergency phase. As another alternative, creating jobs for about 20 guards is preferred more than fencing which is very costly and only necessary until the lake is completely dry.

4.2.2.3 Soil Mitigation Measures and Monitoring

4.44 Major part of the excavated clay from the new site (900,000 m3) can be transported to the existing depressions south east of BLWWTP. Many farmers will be interested in improving their farm soil with this clay. Hence, part of the clay can be sold to farmers at the transportation cost. Also part of the clay can be used for the Lake bottom soil remediation and leveling after the drying process.

4.45 For the rehabilitation of the lake bottom, an area of 340 dunums covered with sludge, the consultant proposes to use biological treatment methods. The first step in the treatment process happens automatically. As soon as the sinking water level of the lake reaches the bottom a better oxygen supply will initiate the microbiological decay of the bottom sludge. When the lake bottom is dry enough to be entered it could be planted with deep-rooting grass or weed species for some years. The roots of the plants break up the densified soil, contribute to a better oxygen supply also of deeper soil layers which enhances bacterial activity and accelerates the biological rehabilitation process including the decomposition of hazardous organic material. As the chemical analyses of samples from the lake bottom sludge showed no significant levels of heavy metals or other toxic substances the vegetation could be cut regularly by the farmers and be used as animal fodder.

4.46 It is highly recommended after draining of the lake to take few soil samples from the deeper parts of the lake to check for heavy metals and other toxic substances. The mitigation actions can be decided accordingly.

4.47 When the soil of the lake bottom has achieved an advantageous soil structure, due to the natural rehabilitation, it could be either used as green land or also for agricultural purposes, because it is rich in nutrients and it is not necessary to use huge amounts of chemical fertilizers there. From an ecological point of view green land is the better option. Parts of the green area could also be used for recreational activities (sport sites, parks). This solution definitely would contribute to a better living quality for the local residents.
The infiltration basins are operated in a cycle of flooding and drying. The cyclic drying of infiltration basins will restore the infiltration capacity by breaking up sludge layers and bio-films. Each pond is equipped with a level meter and when the level reaches a predetermined maximum value, the inflow is stopped. After operation for a certain time for example 3 days or when each of the ponds in operation has reached the predetermined maximum level of approximately 0.5 m, the next group of ponds in order is flooded. The ponds not subject to the flooding cycle are dried and this will ensure that infiltration capacity is maintained. The length of flooding and drying periods must be optimized by practical experience and observation of effect. An initial approach is that an average flooding period lasts for 0.5 - 1 day and is followed by a drying period of 2-4 days, or longer, if necessary. The short alternation of flooding and the drying periods will minimize algae growth and this will prevent a quick clogging of the ponds.

Periodically, scraping and excavation will be required to remove silt and organic matter. This may be done with a front-end loader once or twice a year. The excavated material washed in a sand-washing unit and the clean sand is refilled into the pond. Regular disking is sometimes used, however it should be avoided to practice this too often, because heavy machinery may compact underlying soils and they become less permeable. Further the practice of disking will mix the clogging materials with surface soil. The best practice for maintaining infiltration rates at the site will be found out during operation.

For each basin time related reports should be kept concerning water levels, water flow, observations of algae growth and remarks concerning the quality of the infiltration water. The reporting procedure should make it possible to combine the observations with the actual infiltration water quality. Time for start and stop of flooding/drying periods should be noted, as well as scraping and cleaning activities.

**Socio-economic Mitigation Measures and Monitoring**

**BLWWTP Site:**

The whole lake should be fenced and/or at least be guarded in order to prevent people, especially children, and livestock from falling into the lake. Because of the steep sand dams and the sludge at the bottom falling into the lake as well as rescue operations would be dangerous.

To reduce the small negative impact in the existing location, noise mitigation measures discussed in other parts of the report should be carefully implemented and observed to ensure that the impacts to the neighboring communities are minimized.

As for the temporary disruption for the use of agricultural land, this can be mitigated through direct compensation for their losses during the season. The agricultural season in this area starts mainly in October and ends in April or May, thus the project construction especially in agricultural areas can be done in off season times to minimize the negative impact.
NGWWTP Site:

4.54 A public awareness campaign is proposed to show the effects of the project on the overall economic and social conditions in the northern area of Gaza especially with respect to improved water quality and agricultural and commercial land.

4.55 High coordination with the Ministry of Religious Affairs to ensure their buy-in and the Islamic view of constructing this new project. This, if done properly, should also be used in the public awareness campaign.

4.56 The tariff should be planned based upon recovery of operating and replacement costs and that the initial investment in infrastructure must come from other sources, at least in the medium term. At the long run the future tariff should take into consideration the following factors:
- To achieve cost recovery
- To maintain social equity
- To adopt flexible price mechanism that discourages wasteful uses of water and raise awareness of the economic value of resources invested in this vital sector.
- To promote environmental efficiency aimed at effective preventive measures to preserve water resources.

4.2.3 Capacity Building during Emergency Phase

4.57 The current staff of the PMU, CMWU, PWA and EQA have the basic skills that enable them to follow-up the implementation of mitigation measures and execute the monitoring plan during the construction and operation phases of the emergency phase. However, during the inception phase of the emergency project, it is necessary to hire a consultant to conduct the following proposed workshops:
- Project components and schedule.
- Description of the EMP components.
- Institutional arrangements and coordination methodologies.
- Quality control and assurance plans.

4.58 The PWA project manager is responsible to arrange these workshops. The PMU, CMWU, PWA and EQA representatives should attend these workshops. The qualified contractor should be aware about the environmental mitigation measures, costing, schedule and institutional arrangements. This issue should be highlighted before the bidding stage and the EMP should be an essential annex of the project contract documents.
Table 4.2: Potential Environmental Impacts, Mitigation, and Monitoring Plan for the Construction Phase of the Emergency Project

|---------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|-----------------------------|----------------------------------------|
| Nuisance, noise and dust at the construction sites (1, 2, 3)                                           | - Definition of Noise and dust mitigation measures, the construction supervision takes care that these measures are applied  
- Proper activity scheduling and working hours and days and limit the activities to day times and prevent any construction activities at weekends.  
- Particulate emissions control unit such as scrubbers, cyclones, fabrics, or electric precipitators  
- Covering of stored spoil material and vehicles removing waste, use of dust suppression  
- Water spraying  
- Using relatively new construction and transportation vehicles with lower emissions  
- Ensure that noisy activities occur during daytime only and not during holidays or late at night | - Site supervision, public consultation, PWA | Contractor  
PWA | PWA |
| Risk of accidents and injuries (1, 2, 3)                                                              | - Follow safety instructions, worker should wear proper clothing  
- A first aid station with trained staff, which is able to coordinate with local hospitals in case of emergencies  
- Personnel will be trained in Environmental Health and Safety matters including accident prevention, safe lifting practices, safe chemical handling practices, proper control and maintenance of equipment and facilities  
- Warning signs and instructions in case of emergencies should be properly displayed, workers must be informed about these precautions  
- Requirements of Palestinian Labor Law especially regarding safety should be applied | - Training program  
- Site supervision  
- Public consultation | Contractor  
Operator  
CMWU  
PWA | CMWU  
PWA |
| Potential accidental break of existing infrastructure (pipelines, power lines, irrigation network etc. (1, 3). | - Consideration in the detailed design, construction supervision, in case of damage immediate repair. | - Report about compliance with the as-built drawings | Contractor  
PMU | PMU |
| Impairment of agricultural activities during the cultivation period from October until April or May (1, 2, 3) | - Construction activities in agricultural areas should be executed in winter to minimize impacts. If this is not possible farmers will receive compensation | - Site supervision, coordination with local farmers | Contractor  
PWA | PMU |
| Disturbance of the soil structure, densification (2, 3)                                                 | - Vehicle movement outside the construction site only on existing roads, no crossing of agricultural areas | - Construction supervision | Contractor  
PMU | PMU |
### Potential Impacts at
1. existing site – BLWWTP
2. new site - NGWWTP
3. pipeline between BLWWTP and NGWWTP

<table>
<thead>
<tr>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Producing huge piles of clayey soil due to excavations of infiltration basins (2)</td>
<td>- Public consultation</td>
<td>Contractor</td>
<td>PMU</td>
</tr>
<tr>
<td></td>
<td>- Transfer to depressions located southeast of existing BLWWTP</td>
<td>Site management and Coordination with local farmers</td>
<td>- PWA, - Palestinian Land Authority</td>
</tr>
<tr>
<td></td>
<td>- Selling to farmers at transportation cost</td>
<td></td>
<td>- Palestinian Land Authority</td>
</tr>
<tr>
<td>- Loss of agricultural area (1, 2)</td>
<td>- Partly compensated by rehabilitation of the lake area which may be used for agriculture</td>
<td>Coordination of authorities and local residents</td>
<td>PMU</td>
</tr>
<tr>
<td>- Obstruct the accessibility or property and impairment of the local traffic in the vicinity of the construction sites; risk of traffic accidents (1, 2, 3).</td>
<td>- Proper planning of construction activities, monitoring of risky activities such as excavation and backfilling.</td>
<td>Contractor</td>
<td>PMU</td>
</tr>
<tr>
<td></td>
<td>- Provision of adequate notification procedures for any road closures.</td>
<td>PWA, Police</td>
<td></td>
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<tr>
<td></td>
<td>- Monitoring the use of safety measures and tools.</td>
<td></td>
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<tr>
<td></td>
<td>- Traffic management (signs, traffic flow)</td>
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<td></td>
<td>- Speed limits for construction vehicles</td>
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<tr>
<td>- Local traffic is expected to increase due to the movements of heavy trucks which transport construction material to the site and the excavated clay outside the site (3).</td>
<td>- Traffic signs to ensure proper routing and distribution of traffic</td>
<td>Contractor</td>
<td>PMU</td>
</tr>
<tr>
<td></td>
<td>- Provision of adequate notification procedures for any road closures</td>
<td>PWA, Police</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Traffic Management Plan</td>
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<tr>
<td>- Loss of older trees along the roadsides (3)</td>
<td>- Minor local modifications of the pipeline route in order to avoid tree felling</td>
<td>Construction supervision</td>
<td>Contractor</td>
</tr>
<tr>
<td></td>
<td>- Replanting of trees.</td>
<td></td>
<td>PWA</td>
</tr>
<tr>
<td>- Archaeological remains could be discovered (1, 2, 3)</td>
<td>- Monitoring of site excavations</td>
<td>Construction supervision</td>
<td>Contractor</td>
</tr>
<tr>
<td></td>
<td>- In case of findings information of the concerned agency (MOTA) and additional survey</td>
<td>PMU</td>
<td></td>
</tr>
<tr>
<td>- Impact on nearby flora and fauna (1, 2, 3)</td>
<td>- Dust generating activities such as excavations and back-filling should be avoided during flowering period of the plants (March to May) as much as possible</td>
<td>- Good planning for activities</td>
<td>Contractor</td>
</tr>
<tr>
<td></td>
<td>- Rare plants could be transferred to safe places</td>
<td>Site investigation</td>
<td>MOA</td>
</tr>
<tr>
<td></td>
<td>- Avoiding of disturbance of breeding activities of rare birds (March to May)</td>
<td></td>
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</tbody>
</table>
### Table 4.3: Potential Environmental Impacts, Mitigation, and Monitoring Plan for the Operation Phase of Emergency Project

<table>
<thead>
<tr>
<th>Potential Impacts at 1 - existing site – BLWWTP 2 - new site - NGWWTP 3 – pipeline between BLWWTP and NGWWTP</th>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Improper disposal and pile up of construction materials (1, 2, 3)</td>
<td>- Cleaning and removal of wastes or deposits to landfills or designated areas.</td>
<td>- Construction supervision, - Complaint monitoring</td>
<td>Contactor</td>
<td>PMU</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>- Grit, sand, and debris entering treatment pond No.1 and impairing the treatment process (1).</td>
<td>- Upgrading the screen and grit removal structure and maintenance to perform effective screening and sedimentation. - Cleaning of the ponds 3,4 from sand and installation of aerators in the first two ponds. The aerators should be fully operated in the first four ponds. - Proper design of wastewater facilities - Draw emergency plans - The planning and operations should be carried out according to the master plans and the operator (&amp; CMWU) should be informed - Planning of new areas should consider the design constraints of the NGWWTP and proposed future serviced areas.</td>
<td>- Frequent observation</td>
<td>CMWU PWA</td>
<td>PWA, CMWU</td>
</tr>
<tr>
<td>- Flooding in wastewater networks due to mixing of storm water with sewage during heavy rains (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Aquifer pollution at the new infiltration site (3) ▪ expansion of the nitrogen plume ▪ salinity ▪ pathogenic bacteria (Fecal coliform)</td>
<td>- Regular daily manual cleaning for the sand sedimentation is necessary - Infiltration basins 7 and 9 will not be used during the emergency phase. - only the direct effluent from the polishing pond at BLWWTP (12,000m3/day) will be used for infiltration. - no wells should be operated within a distance of 6 month residence time from the edge of infiltration basins (&gt;150 meters) - Follow alternate operations plan (short flooding and drying periods) - Regular cleaning of the infiltration ponds (scraping, sediment removal) is required to remove silt and organic material</td>
<td>- Regular infiltration performance check - Comprehensive aquifer water quality and water level monitoring program (Section 4.4.1.3, Table 4.1, Figure 4.5)</td>
<td>CMWU - PWA</td>
<td>- PWA,</td>
</tr>
<tr>
<td>- Over pumping due to potential drilling of new wells and rehabilitation of existing wells (3)</td>
<td>- Proper spatial distribution of new wells - Controlling measures, penalties for non compliance, employing guards and installing fencing (to prevent the illegal use of water in basins for</td>
<td>- Comprehensive testing program</td>
<td>PWA MOA CMWU</td>
<td>- PWA</td>
</tr>
</tbody>
</table>
### Potential Impacts for the Operations of the Emergency Project

1 - existing site – BLWWTP  
2 - new site - NGWWTP  
3 - pipeline between BLWWTP and NGWWTP

#### Mitigation Measures

<table>
<thead>
<tr>
<th>Impact</th>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
</table>
| - Hazards during drying out of the lake (after pumping) in the old site of BLWWTP (1) | - Creating jobs for about 20 guards to prevent people, especially children away from falling into the drying lake (it is preferred more than fencing which is very costly and only necessary until the lake is completely dry)  
- The first layer of sand after drying the lake should be left to dry enough | - Site visits  
- Reporting (guards) | Operator | PMU, CMWU |
| - Risk of Accident and injuries (1, 2) | - Follow safety instructions, worker should wear proper clothing  
- A first aid station with trained staff, which is able to coordinate with local hospitals in case of emergencies  
- Warning signs and instructions should be properly displayed  
- Requirements of Palestinian Labor Law especially regarding safety will be applied | - Testing programs  
- Awareness  
- Complaint monitoring  
- Site visits | Operator | PMU CMWU  
PWA |
| - Impact to landscape, disturbance of aesthetic features, expansion of built-up areas (1, 2) | - Landscaping (esp. screening by planting of trees, substitution of cut-down trees)  
- Following all mitigation impacts that minimize and/or control the dust, odor, noise, and aesthetic features.  
- Proper land use plan for the lake area should be considered  
- Considering of not only onsite but also offsite effects  
- Proper operations and maintenance management, and reshaping of construction sites | - Supervision  
- Site visits | Operator | PMU MOTA |
| - Livestock (sheep, cows), could drown in the infiltration basins (2) | - Proper fencing should be installed around the facility. | - Site Visit | - Designer, contractor | - PMU  
- CMWU |
| - negative publicity and misconceptions (2) | - Public information campaigns before the project is executed | | PWA | PMU, PWA |
4.3 EMP of Part B (NGEST)

4.3.1 Institutional Setup

4.59 The proposed institutional setup for Part B (NGEST) is similar to the proposed institutional setup for the emergency phase. Some special arrangements are necessary according to the variations of construction period and involved institutions. PWA, PMU and CMWU have the same responsibilities of those during emergency phase. Figure 4.8 shows the proposed institutional setup for Part B components.

4.60 One of the expectations during the operation of NGWWTP is that the CMWU will have the full responsibilities for operation and maintenance of all water and wastewater facilities in Gaza Strip.

4.61 Most of responsibilities of the PWA will be moved to the PMU and the CMWU during the operation phase and PWA will act as a regulator agency.

4.62 It is recommended to engage an international consultant to train the involved agencies and operator about the implemented treatment process. This treatment process is a new technology and local people are not familiar with its requirements. The international consultant is clearly identified as consultant (3) in Figure 4.8.

4.3.2 Mitigation Measures and Monitoring Plan for Part B (NGEST)

4.63 The construction impacts are similar to those expected during the emergency phase. Such impacts are mostly short-term, local, and caused by the contractors activities at the construction sites and the access roads and can be mitigated through proper construction management in coordination with the contractor and the authorities concerned.

4.64 Impacts during this long-term phase mainly concern ground water, soil and human health. These impacts are long term impacts either direct or indirect. The proposed mitigation measures will minimize the impacts as far as possible. The operator is responsible for the implementation of all mitigation measures. The expected impacts and the proposed mitigation measures during construction and operation phases are detailed in Table 4.5 and Table 4.6. The Environmental Monitoring plan for Part B components sets out a framework for monitoring the environmental situation at all project sites (BLWWTP, NGWWTP and sewer line). In order to ensure that the reality complies with the demands of the EMP environmental, monitoring should be carried out concerning the same issues that were considered during the emergency phase.

4.3.2.1 Water Quality Mitigation Measures and Monitoring

4.65 After completion of the NGWWTP (Phase 1) the full treatment process will produce high quality effluent that will be suitable for infiltration that will allow the subsequent direct use for unrestricted irrigation according to both local and international quality guidelines. The model simulation results did not show any negative impact to the aquifer water quality. Therefore, no mitigation measures are required but the aquifer water will be subject to regular and comprehensive monitoring.
**NGWWTP (Phase I & II) (Immediate Start of NGWWTP)**

**Construction Phase**
- **PWA** responsible for regulation, contracting, financing, and coordination with other stakeholders.
- **PMU** responsible for supervision, procurement and coordination with stakeholders during construction and for logistic support during operation.
- **Consultant (2)** construction management - Construction Quality Control.
- **Contractors** construct the infiltration basins, terminal PS and pressure line.

**Operation Phase**
- **PWA** responsible for regulations.
- **PMU** responsible for monitoring and logistic support during operation.
- **CMWU** responsible for contracting, financing, and coordination with other stakeholders, operation, maintenance, monitoring and quality assurance.
- **Operator** responsible for operation and quality control.

**Figure 4.8: Institutional Setup Framework for NGWWTP**

- **Full Control & Follow up**
- **Coordinate and provide support**
4.66 The effect of the infiltration of the treated wastewater should be subject to thorough monitoring for both water level and water quality in the aquifer. In order to make a suitable selection of the number and location of the observation points, the following selection criteria are used:

- The geographical distribution in relation to hydraulic stresses (the center and the extent of the water level mound).
- The half-life time of pathogenic bacteria.
- The extent and the variation of contaminant plume.
- Availability of existing monitoring wells that can be utilized.

The proposed monitoring wells are shown in Figure 4.6.

4.67 The existing production wells were not designed as formally constructed observation wells but they can be used to support the data taken from the designed monitoring wells. In the immediate vicinity of the site there are several production wells which may be used for monitoring (Q14, Q15, Q53, Q54A, Q54D, Q55, Q56, and R12).

4.68 Table 4.4 shows a list of parameters that should be monitored at different frequency for the different project phases. This table was designed based on local experience and the experience from the Dan region monitoring program. Samples from the observation wells are taken after at least half an hour of pumping in order to exchange the water in the well. After the start of operation of the new NGWWTP measurements for influent and effluent should be performed daily for all the proposed parameters in the table.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Every Month</th>
<th>Every Month</th>
<th>Every Six-month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Later level</td>
<td>N/A</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>pH</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>EC</td>
<td>X</td>
<td>X</td>
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<tr>
<td>TDS</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>SS</td>
<td>X</td>
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<tr>
<td>BOD</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>COD</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NO3</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>NH3/NH4</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Cl</td>
<td>X</td>
<td>X</td>
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<tr>
<td>SO4</td>
<td>X</td>
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<td>P</td>
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<td>Ca</td>
<td>X</td>
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<td>Mg</td>
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<td>K</td>
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<tr>
<td>Na</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faecal Coliform</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Total Coliform</td>
<td>X</td>
<td></td>
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<tr>
<td>B</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Detergents (HPLC)</td>
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<td>X</td>
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<tr>
<td>Heavy metals</td>
<td>X</td>
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<td></td>
</tr>
</tbody>
</table>

4.3.2.2 Environmental Health and Safety Mitigation Measures and Monitoring

4.69 The NGWWTP projects include a 100 day storage place for the sludge. Almost all the farmers in Gaza apply organic fertilizers in November and April. For the rest of the
year the sludge or the organic fertilizer is rarely used. Hence, additional storage place for sludge should be provided to accommodate at least one year sludge production. There is additional place within the NGWWTP site than can be utilized for that.

4.70 Although vegetables are grown on 40% of the cultivated area in Northern Gaza they have not been included in the potential area for sludge use. Even though the sludge will be pasteurized it is considered unacceptable for application to ground crops which are eaten raw. This is because a double protection barrier for health is preferred, just as proposed for effluent reuse. In other countries sludge is used for vegetables which are cooked but a high degree of control on application and cropping constraints is required to ensure safety. That degree of control is less easy to apply where a large number of small farms will be supplied with sludge. The attitudinal research carried out also indicates that farmers and consumers are suspicious about sludge on vegetable crops.

4.71 During the de-construction works the application of the safety measures and competent site supervision reduces the risk of accidents.

4.72 If the wastewater cannot be pumped to the NGWWTP, Pond No. 7 will be used as an emergency basin. The retention time of this basin is only a few days. Emergency repairs and actions should be planned in advance and implemented quickly.

4.3.2.3 Soil Mitigation Measures and Monitoring

4.73 The application of sewage sludge to land in member countries of the European Community is governed by Council Directive No. 86/278/EEC, 1986. This directive prohibits the sludge from sewage treatment plants from being used in agriculture unless specified requirements are fulfilled, including the testing of sludge and soil. Parameters subject to provisions of the Directive include the following:

- Dry matter (%)
- Organic matter (% dry sludge)
- pH
- Salinity
- Nitrogen, total and ammoniacal (% dry sludge)
- Phosphorous, total (% dry sludge)
- Potential toxic metals like (mg/kg dry solids): Zn, Cu, Ni, Cd, Pb, Pb, Hg, Cr,
- Mb, Se, Ar and Fl are four parameters added by UK department of environment.

4.74 Sludge must be analyzed for the Directive parameters at least once every 6 months and every time significant changes occur in the quality of the sewage treated. The frequency of analysis for the additional four parameters by UK may be reduced to not less than once in five years provided that their concentrations in the sludge are consistently no greater than the following reference concentrations (mg/ kg dry solids): Mb=3, Se=2, Ar=2 and Fl=200. Therefore, strict regulations and constant monitoring of the sludge quality must be applied as well as a regular control of the soil structure and soil quality where the sludge is applied.

4.75 The concentration of potentially toxic elements in arable soils must not exceed certain determined limits within the normal depth of cultivation as results of sludge application (see Annex II). Application rates should be based on the content of nitrogen or phosphorous (macronutrient) whichever is the more limiting factor. When the soil test does not recommend phosphorus fertilization, sewage sludge should not be applied. Application rates should also be limited by the soil’s cumulative pollutant load of heavy metals based on the suggested soil limits recommended in Annex (II).
4.3.2.4 Socio-economic Mitigation Measures and Monitoring

4.76 A public awareness campaign to show the impact of the project on the overall economic and social conditions in the northern area of Gaza especially in terms of improved water quality and agricultural and commercial land.

4.77 High coordination with the Ministry of Religious Affairs to ensure their buy-in and the Islamic view of constructing this new project. This, if done properly, should also be used in the public awareness campaign.

4.78 In cooperation with local police, the project management should plan for the least disruption of traffic by providing alternative routes approved by the police department in the area.

4.79 At the long run the future tariff should take into consideration the following factors:
   - To achieve cost recovery.
   - To maintain social equity.
   - To adopt flexible price mechanism that discourages wasteful uses of water and raise awareness of the economic value of resources invested in this vital sector.
   - To promote environmental efficiency aimed at effective preventive measures to preserve water resources.

4.3.3 Capacity Building

4.80 An international consultant is required to conduct training about wastewater reuse and sludge monitoring for the representatives of PWA, PMU, CMWU and the operator in the following subjects:
   - Advanced training in testing and monitoring inlet quality, outlet quality, sludge removal and treatment, odor removal, etc.
   - Reuse of treated wastewater and sludge in agriculture applications.

4.81 During the implementation of the NGWWTP, a training program would be designed to be implemented by this recommended consultant. The training would target three levels:
   - On-the-job training for a selected project staff to direct activity planning, design, and implementation with respect to environmental protection.
   - Staff Training. The training should be provided through short duration seminars and workshops. Oriented site visits and intensive training, one-month duration, should also be provided for selected staff members.
   - Training for contractors should be provided, including one or two-day’s workshops for local contractors, focusing on: preparation and use of the appraisal/mitigation forms, use of environmental guidelines, and implementation of mitigation measures. Also, they should be trained on safety measures for construction works, proper construction wastes disposal and cleaning measures during construction.

4.82 Representatives of the involved agencies; PWA, PMU and CMWU are proposed to attend the training sessions. As part of the comprehensive capacity building program, the purpose and outcomes of the EA and EMP reports will be explained and the further development of a database based on the information collected during the assessment could enhance the EMP.
<table>
<thead>
<tr>
<th>Potential Impacts at</th>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
</table>
| 1 - existing site – BLWWTP 2 - new site - NGWWTP 3 – pipeline between BLWWTP and NGWWTP | - Definition of Noise and dust mitigation measures, the construction supervision takes care that these measures are applied  
- Proper activity scheduling and working hours and days and limit the activities to day times and prevent any construction activities at weekends.  
- Particulate emissions control unit such as scrubbers, cyclones, fabrics, or electric precipitators  
- Covering of stored spoil material and vehicles removing waste, use of dust suppression  
- Water spraying  
- Using relatively new construction and transportation vehicles with lower emissions  
- Ensure that noisy activities occur during daytime only and not during holidays or late at night | - Site supervision, public consultation, | Contractor | PWA CMWU |
| - Nuisance, noise and dust at the construction sites (1, 2, 3) | - Follow safety instructions, worker should wear proper clothing  
- A first aid station with trained staff, which is able to coordinate with local hospitals in case of emergencies  
- Personnel will be trained in Environmental Health and Safety matters including accident prevention, safe lifting practices, safe chemical handling practices, proper control and maintenance of equipment and facilities  
- Warning signs and instructions in case of emergencies should be properly displayed, workers must be informed about these precautions  
- Requirements of Palestinian Labor Law especially regarding safety should be applied | - Training program  
- Site supervision  
- Public consultation | Contractor | CMWU PWA |
| - Risk of accidents and injuries (1, 2, 3) | - Consideration in the detailed design, construction supervision, in case of damage immediate repair. | - Report about compliance with the as-built drawings | Operator | CMWU PWA |
| - Potential accidental break of existing infrastructure (pipelines, power lines, irrigation network etc. (1, 3). | - Coordination with the Ministry of Religious Affairs to ensure their acceptance of the project  
- public awareness campaign | - Public campaign | PWA MWRA | PWA MWRA |
<table>
<thead>
<tr>
<th>- Nuisance and psychological problems concerning the construction and operations of the new WWTP on the Existing Cemetery (2).</th>
<th>- Construction activities in agricultural areas should be executed in winter to minimize impacts. If this is not possible farmers will receive compensation</th>
<th>- Site supervision, coordination with</th>
<th>PMU,</th>
<th>PWA CMWU</th>
</tr>
</thead>
<tbody>
<tr>
<td>May (1, 2, 3)</td>
<td>local farmers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Disturbance of the soil structure, densification (2, 3)</td>
<td>- Vehicle movement outside the construction site only on existing roads, no crossing of agricultural areas</td>
<td>- Construction supervision - Public consultation</td>
<td>PMU, PWA, CMWU</td>
<td></td>
</tr>
<tr>
<td>- Producing huge piles of clayey soil due to excavations of infiltration basins (2)</td>
<td>- Transfer to depressions located southeast of existing BLWWTP - Selling to farmers at transportation cost</td>
<td>- Site management and Coordination with local farmers</td>
<td>PMU, PWA, CMWU</td>
<td></td>
</tr>
<tr>
<td>- Loss of agricultural area (1, 2)</td>
<td>- Partly compensated by rehabilitation of the lake area which may be used for agriculture</td>
<td>- Coordination of authorities and local residents</td>
<td>- PWA, - Palestinian Land Authority</td>
<td></td>
</tr>
<tr>
<td>- Obstruct the accessibility or property and impairment of the local traffic in the vicinity of the construction sites; risk of traffic accidents (1, 2, 3).</td>
<td>- Proper planning of construction activities, monitoring of risky activities such as excavation and backfilling. - Provision of adequate notification procedures for any road closures. - Monitoring the use of safety measures and tools. - Traffic management (signs, traffic flow) - Speed limits for construction vehicles</td>
<td>- Site monitoring - Complaint monitoring</td>
<td>Contractor PMU Police - PWA MOT</td>
<td></td>
</tr>
<tr>
<td>- Local traffic is expected to increase due to the movements of heavy trucks which transport construction material to the site and the excavated clay outside the site (3).</td>
<td>- Traffic signs to ensure proper routing and distribution of traffic - Provision of adequate notification procedures for any road closures - Traffic Management Plan</td>
<td>- Complaint monitoring</td>
<td>Contactors, PMU Police - PWA MOT</td>
<td></td>
</tr>
<tr>
<td>- Loss of older trees along the roadsides (3)</td>
<td>- Minor local modifications of the pipeline route in order to avoid tree felling - Replanting of trees.</td>
<td>Construction supervision</td>
<td>Contractor PWA PMU</td>
<td></td>
</tr>
<tr>
<td>- Archaeological remains could be discovered (1, 2, 3)</td>
<td>- Monitoring of site excavations - In case of findings information of the concerned agency (MOTA) and additional survey</td>
<td>- Construction supervision</td>
<td>Contractor PMU - PWA MOTA</td>
<td></td>
</tr>
<tr>
<td>- Impact on nearby flora and fauna (1, 2, 3)</td>
<td>- Dust generating activities such as excavations and back-filling should be avoided during flowering period of the plants (March to May) as much as possible - Rare plants could be transferred to safe places</td>
<td>- Good planning for activities - Site investigation</td>
<td>Contractor PMU PWA</td>
<td></td>
</tr>
</tbody>
</table>
### Potential Impacts at
1 - existing site – BLWWTP  
2 - new site – NGWWTP  
3 – pipeline between BLWWTP and NGWWTP

<table>
<thead>
<tr>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Avoiding of disturbance of breeding activities of rare birds (March to May)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Improper disposal and pile up of construction materials (1, 2, 3)</td>
<td>- Cleaning and removal of wastes or deposits to landfills or designated areas.</td>
<td>- Construction supervision, - Complaint monitoring</td>
<td>Contactor PMU</td>
</tr>
</tbody>
</table>

### Table 4.6: Potential Environmental Impacts, Mitigation, and Monitoring Plan for the Operation of NGWWTP

| Potential Impacts for the Operations of the Emergency Project  
1 - existing site – BLWWTP  
2 - new site – NGWWTP  
3 – pipeline between BLWWTP and NGWWTP | Mitigation Measures                                                                 | Monitoring Measure & Method               | Responsibility of Execution | Monitoring & Enforcement Responsibility |
|----------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------|-----------------------------|-----------------------------------------|
| - Grit, sand, and debris entering pressure station and impairing the treatment process (2).  
- Flooding in wastewater networks due to mixing of storm water with sewage during heavy rains (2).  
- Increase of wastewater quantities is expected after developing the non-serviced areas (2) | - Upgrading the screen and grid removal structure and maintenance to perform effective screening and sedimentation.  
- Proper design of wastewater facilities  
- Draw emergency plans  
- The planning and operations should be carried out according to the master plans and the operator (& CMWU) should be informed  
- Planning of new areas should consider the design constraints of the NGWWTP and proposed future serviced areas.  
- Implement proper tariff structure (for both water and wastewater)  
- Planning of new areas should consider the design constraints of the NGWWTP and proposed future serviced areas. | - Frequent observation | Operator TCMWU, PWA |                                          |
| - Increase the level of toxic contaminants | - The aquifer water will be subjected to comprehensive monitoring  
- Public awareness  
- Proper operations and maintenance plans  
- Issued a restrict regulations and standards  
- Implement a periodic testing program | - Complaint monitoring  
- Site visit  
- Random quality assurance | Operator CMWU | PWA |
### Potential Impacts for the Operations of the Emergency Project

1. **existing site – BLWWTP**
2. **new site - NGWWTP**
3. **pipeline between BLWWTP and NGWWTP**

#### Mitigation Measures

<table>
<thead>
<tr>
<th>Potential Impact of Sludge and irrigation by WW (2)</th>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Potential Impact of Sludge and irrigation by WW (2)</td>
<td>- Control the use of sludge for specific crops with restricted standards (Specific regulation to control the use of treated wastewater in irrigation according to the quality of treated wastewater and according to soil structure). - no sludge to be used with out treatment - Public Awareness program for the neighboring communities (using the available media is recommended) - Provide workers with appropriate protective clothing including rubber gloves, boots, long sleeved shirts and pants. - train workers to wash hands and faces frequently with soap and water and make both available - Test samples from active chamber and mature chamber after fallow period for Ascaris eggs and fecal coliforms - Treat sludge before secondary use and don’t allow disposal in or near water bodies.</td>
<td>- Testing programs - Awareness - Complaint monitoring</td>
<td>Operator CMWU</td>
<td>MOA, PWA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>- Risk of Accident, injuries and handling of toxic and hazardous materials (1, 2)</th>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Follow safety instructions, worker should wear proper clothing - A first aid station with trained staff, which is able to coordinate with local hospitals in case of emergencies - Employees will be trained on the hazards, precautions and procedures for safe storage, handling and use of all potentially harmful materials relevant to each employee’s task and work area. - Warning signs and instructions should be properly displayed - The work place should have proper ventilation to refresh oxygen and reduce temperature (labs, control rooms, etc.). - Requirements of Palestinian Labor Law especially regarding safety will be applied</td>
<td>- Testing programs - Awareness - Complaint monitoring - Site visits</td>
<td>Operator CMWU</td>
<td>PWA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impact, change the soil structure (1 &amp;2)</th>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The site should be cultivated with grass to take up the existed trace elements. - The grass should be cut three times a year, this process will guarantee the site cleaning (phytoremediation). - Planting fodders and grass is recommended. - Industrial wastewater should be separately disposed or patiently treated in site to reduce its heavy metals content to acceptable values to be discharge to the public sewer system</td>
<td>- Complaint monitoring</td>
<td>Contractor PWA CMWU</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bad smells from the wastewater treatment process (2)</th>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Proper design, construction and operations of the odor control system stack - Suitable design of the chimney</td>
<td>- Random checking - Complaint monitoring</td>
<td>Operator CMWU</td>
<td>PWA</td>
<td></td>
</tr>
</tbody>
</table>
## Potential Impacts for the Operations of the Emergency Project

1. **Existing site – BLWWTP**
2. **New site – NGWWTP**
3. **Pipeline between BLWWTP and NGWWTP**

### Mitigation Measures

<table>
<thead>
<tr>
<th>Impact Description</th>
<th>Mitigation Measures</th>
<th>Monitoring Measure &amp; Method</th>
<th>Responsibility of Execution</th>
<th>Monitoring &amp; Enforcement Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise generation by some activities (1 &amp; 2)</td>
<td>- Ensure that noisy activities occur during daytime and not during holidays or late night times.</td>
<td>- Random Checking</td>
<td>- Operator</td>
<td>PMU</td>
</tr>
<tr>
<td>Air pollutant generated by traffic, construction activities and electricity generators</td>
<td>- Using relatively new construction and transportation vehicles with lower emissions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Control the air pollutants of the power generators.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Control the activities and movement routes in the site to specify the construction area.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncontrolled expansion of built up areas (make them subjected to uplift pressure and danger) (1&amp;2)</td>
<td>- Proper land use plan should be considered.</td>
<td>- Site visits</td>
<td>- Municipality of Gaza</td>
<td>- MOLG MOP</td>
</tr>
<tr>
<td></td>
<td>- Ensure aesthetic view of the WWTP</td>
<td>- Random checking</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Offsite and onsite design should be integrated.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Planting of trees and bushes, trees, and flowers. Planning and implementing of appropriate landscaping program (planting should be planned carefully to far enough from the WWTP fence to ensure a natural aeration of wastewater in the logons)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disturb of aesthetic features (1&amp;2)</td>
<td>- Proper fencing should be installed around the facility.</td>
<td>- Site visits</td>
<td>- PMU</td>
<td>PWA</td>
</tr>
<tr>
<td></td>
<td>- Ensure aesthetic view of the WWTP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Offsite and onsite design should be integrated.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Planting of trees and bushes, trees, and flowers. Planning and implementing of appropriate landscaping program (planting should be planned carefully to far enough from the WWTP fence to ensure a natural aeration of wastewater in the logons)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock (sheep, cows), could drown in the infiltration basins (2)</td>
<td>- Proper fencing should be installed around the facility.</td>
<td>- Site Visit</td>
<td>- contractor - PMU</td>
<td>CMWU</td>
</tr>
<tr>
<td>negative publicity and misconceptions (2)</td>
<td>- Public information campaigns before the project is executed.</td>
<td>Public campaign</td>
<td>PWA</td>
<td>PWA, MOH, EQA</td>
</tr>
</tbody>
</table>
4.4 EMP Cost Estimate and Schedule

4.83 The cost of the Environmental Management Plan (EMP) is divided into several parts to reflect the different phases of the project and the requirements of each phase. Table 4.7 lists the main components of EMP and the related estimated costs.

4.84 The cost of EMP includes the costs of the capacity building and the quality control requirements. The costs of implementation of mitigation measures and monitoring (except for short term water quality and BLWWTP effluent quality) are excluded for the following reasons:

- The implementation of the mitigation measures is the responsibility of the PMU during construction and the responsibility of the operator during operation phase. The costs of implementation of mitigation measures will be included in the cost of contract.
- Monitoring costs were excluded because the monitoring as outlined in the EMP requirements is part of the duties of the local agencies. So, they will monitor the implementation without any extra costs. Only the costs for training, consultancies and other specific issues will be considered.

Table 4.7: EMP Cost Estimates (US$)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Cost US$</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Operation</td>
</tr>
<tr>
<td>Part A – 2006-2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultant 1: Environment Specialist hired to train in techniques for monitoring, testing and wastewater reuse</td>
<td>workshops</td>
<td>4</td>
<td>1,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Consultant 2: Local Environment Specialist hired to ensure compliance to EMP</td>
<td>workshops</td>
<td>4</td>
<td>1,500</td>
<td>6,000</td>
</tr>
<tr>
<td>Quality Test for Existing BLWWTP effluent and infiltrated water including aquifer monitoring</td>
<td>Yearly</td>
<td>2</td>
<td>48,000</td>
<td>96,000</td>
</tr>
<tr>
<td>Construction of Monitoring Wells (9 wells)</td>
<td>LS</td>
<td>LS</td>
<td>150,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Environmental Auditing</td>
<td>Yearly</td>
<td>2</td>
<td>5,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Miscellaneous*</td>
<td>Yearly</td>
<td>3</td>
<td>3,000</td>
<td>6,000</td>
</tr>
<tr>
<td>Total (Part A)</td>
<td></td>
<td></td>
<td></td>
<td>US$275,000</td>
</tr>
<tr>
<td>Part B – 2008-2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultant 3: International Consultant hired to train the local institutions at the NGWWTP project components and Process (operation)</td>
<td>Training Programs (week/each)</td>
<td>3</td>
<td>5,000</td>
<td>15,000</td>
</tr>
<tr>
<td>On-the-job training</td>
<td>Month</td>
<td>3</td>
<td>2,500</td>
<td>7,500</td>
</tr>
<tr>
<td>Quality Test for influent and effluent of NGWWTP and aquifer monitoring</td>
<td>Yearly</td>
<td>4</td>
<td>48,000</td>
<td>192,000</td>
</tr>
<tr>
<td>Environmental Auditing</td>
<td>Yearly</td>
<td>4</td>
<td>5,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Miscellaneous*</td>
<td>Yearly</td>
<td>5</td>
<td>4,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Total (Part B)</td>
<td></td>
<td></td>
<td></td>
<td>US$260,000</td>
</tr>
</tbody>
</table>

Any unexpected emergency mitigation measure will be covered from this amount.
A schedule for the implementation of the various activities of the Environmental Management Plan is prepared and shows the duration of the activities and timing of the proposed periodic assessments as shown in Table 4.8

**Table 4.8: Tentative EMP Implementation Schedule**

<table>
<thead>
<tr>
<th>Item</th>
<th>Details</th>
<th>Yearly Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1st year</td>
</tr>
<tr>
<td><strong>Emergency Phase</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultant hired to train the local institutions at the emergency project (construction and operation)</td>
<td>workshops</td>
<td>XXXX (4 Work-shops)</td>
</tr>
<tr>
<td>Quality Test for Existing BLWWTP effluent and infiltrated water including aquifer monitoring.</td>
<td>Quality Tests (Yearly)</td>
<td>X</td>
</tr>
<tr>
<td>Environmental Auditing</td>
<td>Yearly</td>
<td>X</td>
</tr>
<tr>
<td>Miscellaneous*</td>
<td>Yearly</td>
<td>X</td>
</tr>
<tr>
<td><strong>NGWWTP (Including Emergency)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Qualified Consultant hired to train the local institutions at NGWWTP (Parts 1 and 2) project (construction)</td>
<td>workshops</td>
<td>XXXX</td>
</tr>
<tr>
<td>International Consultant hired to train the local institutions at the NGWWTP project components and Process (operation).</td>
<td>Training Programs (week/each)</td>
<td></td>
</tr>
<tr>
<td>On-the-job training</td>
<td>Month</td>
<td></td>
</tr>
<tr>
<td>Quality Test for influent and effluent of NGWWTP and aquifer monitoring</td>
<td>Quality Tests (Yearly)</td>
<td>X</td>
</tr>
<tr>
<td>Environmental Auditing</td>
<td>Yearly</td>
<td>X</td>
</tr>
<tr>
<td>Miscellaneous*</td>
<td>Yearly</td>
<td>X</td>
</tr>
</tbody>
</table>
5 Main Issues and Recommendations

5.1 Main Issues

5.1 Based on the understanding of the project components, phasing and scheduling, the environmental resources that are of particular interest to the project were investigated. Through thorough assessment and evaluation of all environmental concerns, the proposed project will have an overall positive impact on the environment and social conditions of northern Gaza. On the other hand, some of the project components are envisaged to have a temporary or short term negative impacts depending on the different phases of the project. These impacts were discussed in great details in chapter 3 of this report. Some of the environmental issues of special concern are summarized below.

5.2 Water resources and water quality: during all phases, the project will have positive impacts on the water balance in the aquifer as it will contribute 7.3 to 13 MCM of reusable water per year to the aquifer recharge in Part A and Part B respectively. Regarding chloride, the infiltrated water (250 mg/l) will improve the aquifer water quality significantly at all phases of the project. The high nitrogen concentration of the existing BLWWTP effluent will negatively affect the native groundwater quality in the aquifer during the emergency phase. The infiltrated water will be good for agricultural purposes but extra care should be taken (through the EMP) to prevent this water from reaching the domestic water wells. Regarding pathogenic bacteria, the groundwater model simulations indicate that an area within the distance of 150 m from the infiltration site receives infiltration water with a shorter residence time than 6 months. Within this 150 m, there are no domestic potable water wells. After this time span, the bacteriological risk will not be an issue.

5.3 BLWWTP: The current performance of the BLWWTP is much below the required treatment standards for aquifer recharge. The inlet facilities do not prevent sand accumulation in the first four ponds and as a result reduce the retention time required for the necessary biological treatment. The continuous increase in the volume of the influent also hinders the performance efficiency. The effluent quality in the adjacent lake is even worse than the plant effluent quality.

5.4 Soil: Around 80 dunums of soil will be lost by excavation and huge quantities of loamy clay soil (900,000 m³) will be removed from the site and transferred to other locations. In general these activities will have short term negative impacts on the soil ecology. Another problem in infiltration system for artificial recharge is the expected clogging of infiltration surface which results in reduction in infiltration capacity. Effluent salinity (EC = 1.77 dS/m) is considered moderately saline which may increase the salinity of soil.

5.5 Treated sewage sludge: The NGWWTP will produce great quantities of treated class A sludge that will be suitable for agriculture. However at certain times of the year excess sludge will be accumulated and will need proper storage space and proper management. The treated sewage sludge has significant organic matter content and contains macronutrients and micronutrients essential for plant growth. It can also contain potential contaminants such as heavy metals, organic contaminants and pathogens.

5.6 Health and safety: The continuous growing effluent lake with steep sand dams and the deep sludge at the bottom of the lake poses a great risk and continuous nuisance for all of the neighboring population. Lowering of the water level reduces the risk for a breaking of the sand dams and enhances the biological treatment processes in the lake itself and
hence improves the quality. When the lake is dried completely and rehabilitated, the health situation for the local residents will be improved significantly.

5.7 **Socio-economic:** The construction phase will have positive effects on employment. During the construction phase, services of local subcontractors will be used which will generate job opportunities for skilled and unskilled workers in addition to professional services of engineers and others. Transferring treated wastewater from the Beit Lahia WWTP will provide additional land due to the removal of the effluent lake. This land must be tested for contaminants, and then rehabilitated, most likely for a park and recreational purposes. The rehabilitation and construction work will have positive economic effect through employment generation and use of Palestinian contractors for construction activities. The construction of the wastewater treatment plant near the Martyrs cemetery will cause some discomfort to the families of the deceased during the burial ceremonies. Odor and mosquitoes can be a problem if not properly mitigated for.

5.2 **Recommendations**

5.8 In order to alleviate the expected negative impacts and to make the project environmentally sounder, an EMP (Chapter 4) was prepared, and it includes: the mitigation plan; the necessary institutional setup; the monitoring and enforcement requirements; and the capacity building requirements. All the recommendations below should be financed by the emergency credit, and incorporated in the construction and supervision contracts. The paragraphs below summarize some of the main recommendations to mitigate the negative impacts of the project.

**General Recommendations**

5.9 Several negative impacts have been identified during Part A. The best way to minimize these impacts and to restore the site is to start Part B as soon as possible. On one hand, people in the surrounding area of BLWWTP are now facing enormous danger. Part A will definitely eliminate the risk; on the other hand, relying on Part A for long term will create irreversible impacts on the aquifer water quality. Hence, to solve both problems and to stay in the reversible side, work should be done in two parallel lines: (a) start Part A immediately as it will be an integral part of Part B; and (b) secure the remaining funds to start Part B immediately. While this EA was being finalized, PWA has received good news that the funding for Part B is secured. This means that the construction of Part B will start sooner than what was planned.

5.10 For any environmental project an emergency arrangement should be provided to account for worst case scenarios. Beit Lahia site will be the hub for the whole wastewater in the northern area, after the decommissioning of the BLWWTP. If an accident or emergency arises and wastewater cannot be pumped to the NGWWTP, then Pond No. 7 will be used as an emergency basin. The retention time of this basin however is only a few days. Emergency repairs and actions need to be planned in advance and implemented immediately.

5.11 The institutional setup proposed in Chapter 4, should be adopted and followed to ensure smooth implementation as well as clear classification of duties and responsibilities among the involved agencies.

5.12 Training and capacity building activities should be conducted during the different phases of the project implementation.
5.13 To minimize local disruptions to residents, limit the project activities to day time, prevent any construction activities on weekends, control traffic management and speed limits to minimize the pollution of dust, noise and other air pollutants.

5.14 A first aid station with trained staff in Environmental Health and Safety matters, are necessary to respond to emergencies.

5.15 A public information campaigns before the project execution should be implemented to avoid negative publicity and misconceptions.

**Water resources and water quality:**

5.16 During Part A and in order to minimize the expected impacts on aquifer water quality, the following measures are necessary: (a) Upgrading of the inlet works for a better performance of debris screening and sand removal; (b) Cleaning and installation of additional aerators in Ponds 3 and 4. These ponds should be fully aerated with at least 100 KW aeration power.

5.17 At the beginning of emergency phase, only the effluent from BLWWTP (currently 12,000 m³/day and its natural growth) should be used for infiltration. The infiltration from the lake water should continue at the two existing storm water infiltration facilities until the lake level has gone down at least by 4 to 5 m. During winter time, storm water enhances leaching and dilution processes at the basin bottoms. The infiltration of the lake water can be done at a rate of about 4,000 m³/day in summer and much lower in winter to allow mixing with storm water. When the lake water level is reduced significantly, the sunlight and oxygen can reach the whole depth and as a result the quality of the effluent in the lake will be improved and can then be transferred to the new infiltration site.

5.18 During Part A, it is also recommended not to use all of the infiltration basins. If Basins 7 and 9 are not used during the emergency phase, the trans-boundary impacts on the aquifer will be eliminated or significantly minimized. One-day flooding followed by 2 / 3-day drying is the recommended operation cycle. The optimal operation cycle can only be decided based on practical experience and visualization of the impacts. Regular cleaning of the infiltration ponds (scrapping, sediment removal) is required to remove silt and organic material.

5.19 In all phases of the project, no wells should be operated within a distance of 6-month residence time from the edge of infiltration basins (150 m from the edge of the infiltration basins). Beyond this distance, the water is considered hygienically safe.

5.20 Considering the worst case scenario (if the NGWWTP is not implemented and infiltration with partially treated sewage continues after 2008), a recovery scheme around the infiltration site MUST be implemented or the pumping from BLWWTP MUST be stopped. The recovery scheme in addition to the nearby agricultural wells should be able to pump 10% more than what is infiltrated.

5.21 In all phases, the operation of the agricultural wells in the surrounding areas of the infiltration basins should be regulated by PWA in order to ensure that all the infiltrated effluent is recovered. The quality of the abstracted water should be strictly monitored to ensure health and safety of the users.

5.22 Thorough monitoring for both water level and water quality in the aquifer as specified in section 4.4.1.3 should be implemented.
Soil

5.23 The majority of the excavated clay from the new site (900,000 m³) can be transported to existing depressions south east of BLWWTP. Many farmers will be interested in improving their farm soil with this clay. Hence, part of the clay can be sold to farmers at the transportation cost. Also part of the clay can be used for the remediation and leveling of the bottom of the BLWWTP effluent lake.

5.24 Periodically, scraping and excavation will be required to remove silt and organic matter. This may be done with a front-end loader once or twice a year. The excavated material washed in a sand-washing unit and the clean sand is refilled into the pond. Regular diskimg is sometimes used, however it should be avoided to practice this too often, because heavy machinery may compact underlying soils and they become less permeable. Further the practice of diskimg will mix the clogging materials with surface soil. The best practice for maintaining infiltration rates at the site will be clarified based on operational experience.

5.25 For each basin time related reports should be kept concerning water levels, water flow, observations of algae growth and remarks concerning the quality of the infiltration water. The reporting procedure should make it possible to combine the observations with the actual infiltration water quality. Time for start and stop of flooding/drying periods should be noted, as well as scraping and cleaning activities.

Health and safety issues

5.26 It is proposed to fence and to guard the wastewater lake as soon as possible, at least at the beginning of Part A. As another alternative, creating jobs for about 20 guards is preferred more than fencing which is very costly and only necessary until the lake is completely dry. The first layer of sand after drying the lake should be left to dry enough.

5.27 Specific regulation to control the use of treated sludge. Even though the sludge will be pasteurized it is considered unacceptable for application to ground crops which are eaten raw. This is because a double protection barrier for health is preferred, just as proposed for effluent reuse.

5.28 After the operation of the NGWWTP, additional storage place for sludge should be provided to accommodate at least one year sludge production.

5.29 Strict regulations and constant monitoring of the sludge quality must be applied as well as a regular control of the soil structure and soil quality where the sludge is applied. Sludge must be analyzed for the parameters specified in section 4.4.3 at least once every 6 months and every time significant changes occur in the quality of the sewage treated.

5.30 The concentration of potentially toxic elements in arable soils must not exceed certain determined limits within the normal depth of cultivation as results of sludge application (see Annex II). Sludge application rates should be based on the content of nitrogen or phosphorous (macronutrient) whichever is the more limiting factor. When the soil test does not recommend phosphorus fertilization, sewage sludge should not be applied. Application rates should also be limited by the soil’s cumulative pollutant load of heavy metals based on the suggested soil limits recommended in Annex (II).
Socioeconomic issues

5.31 Affordable water and wastewater tariff should be designed to meet the human needs for a household (25 l/h/d - 75 l/h/d). To be affordable, water and wastewater charges should not exceed 4% of income. Under current economic conditions, recovery of all costs, including capital costs for the project and additional sewerage investment is not affordable for average families.

5.32 The future tariff should be based upon recovery of operating and replacement costs and that the initial investment in infrastructure must come from other sources. At the long run the future tariff should take into consideration the cost recovery, social equity, flexibility, and environmental efficiency.
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