カンボジア国
プノンペン水道公社（PPWSA）

カンボジア国
タクマウ上水道拡張計画
準備調査報告書

令和2年3月
(2020年)

独立行政法人
国際協力機構（JICA）

株式会社 日水コン
クラウンエイジェンツ・ジャパン株式会社

序　　文

独立行政法人国際協力機構は、カンボジア国のタクマウ上水道拡張計画にかかる準備調査を実施することを決定し、同調査を株式会社日水コン、クラウンエイジェンツ・ジャパン株式会社に委託しました。

調査団は、平成 31 年 3 月 17 日から 4 月 10 日（第 1 次現地調査）、令和 1 年 6 月 18 日から 7 月 2 日（第 2 次現地調査）、令和 1 年 8 月 25 日から 8 月 31 日（第 3 次現地調査）、令和 1 年 10 月 15 日から 10 月 23 日（第 4 次現地調査）、令和 1 年 11 月 17 日から 11 月 23 日（第 5 次現地調査）の 5 回にわたりカンボジアの政府関係者と協議を行うとともに、計画対象地域における現地踏査を実施し、帰国後の国内作業を経て、ここに本報告書完成の運びとなりました。

この報告書が、本計画の推進に寄与するとともに、両国の友好親善の一層の発展に役立つことを願うものです。

終わりに、調査にご協力とご支援をいただいた関係各位に対し、心より感謝申し上げます。

令和 2 年 3 月

独立行政法人国際協力機構

地球環境部

部長　武藤　めぐみ

要　約

１．国の概要

カンボジア国（以下、「カ国」）の総人口は約 1,650 万人 [1]、国土面積 181,000 km^2（日本の約 2 分の 1 弱）を有する。北部ラオスから国際河川であるメコン川が南に流れており、中央平原にはトンレサップ湖が存在する。トンレサップ湖からはトンレサップ川が流れ首都プノンペンでメコン川と合流している。国土の大部分は低地であるが、東北部、北部、北東部には山脈が存在する。また、ベトナム、ラオスと国境を接する北部、北東部は深い森林に覆われ、野生動物や原生林の宝庫となっている。

気象は、高温多湿な熱帯地域に属し、一年は大きく雨季（5 月から 11 月）と乾季（12 月から 4 月）に分けられる。特に、2 月～4 月は酷暑となり、日中気温が 35～40℃になる。カンボジアの年間降水量は 1,559 mm[2]である。

カ国の経済は、2018 年の一人当り国内総生産（GDP）は約 1,510USD[3]で近隣諸国に比べても低く、未だ後発開発途上国である。また、産業別内訳は農業が 23%、工業が 31%、サービス業が 40%である [4]。近年比較的安定した政治状況を保っており、2004 年から 2007 年までは平均国内総生産成長率が 4 年連続して 10%を超える著しい経済成長を果たしている。2008 年以降、原油・食糧価格の高騰、および世界金融危機の影響により成長率は低下し、2009 年の経済成長率は、0.1%にまで落ち込んだものの、2010 年は 6.0%まで回復した。2011 年以降は、ほぼ 7.00%を維持し続けている。また、1999 年の東南アジア諸国連合（ASEAN）加盟、2004 年の世界貿易機関（WTO）加盟など、地域経済及び世界経済との統合を強化している。

カ国はいまだに貧困層の割合が高く、2004 年には 50%を超えていた貧困率 が 2011 年には約 20%[5]まで大幅に低下したとはいえ、貧困の削減がカ国の重要課題となっており、貧困削減のためには、産業構造の多様化と生産性の向上に基づく包括的な成長が欠かせないとしている。

２．プロジェクトの背景、経緯及び概要

カ国の上水道セクターは 1990 年代中頃より本格的な施設の改修・拡充が開始され、首都プノンペン都を中心に整備が進んでいる。プノンペン都では、内戦終結後、1993 年に独立行政法人国際協力機構（以下、「JICA」）の支援により策定された「プノンペン市上水道整備計画」に基づき、わが国及び他ドナーが連携して、浄水場の建設及び改修、運営・維持管理技術にかかる技術支援が実施され、24 時間給水を実現し給水率は 90%以上に達した。他方、プノンペン都周辺地域における人口及び商業施設の増加により水需要が増加し、引き続き水供給能力を向上させることが急務である。

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[1] IMF April, 2019
[2] Department of Meteorology of Ministry of Water Resources and Meteorology
[3] “GDP per capita (current US$) - Cambodia” The world bank data (2020)
[4] カンボジア投資環境 2019 年 4 月 JICA カンボジア事務所
[5] The World Bank（April 2014）「Cambodia Poverty Assessment 2013」

プノンペン都の南に位置するカンダール州タクマウ市はバサック川を水源とする公営水道と井戸水による取水が中心であったが、複数の井戸からヒ素が検出される等、水質の問題や人口増加に伴う水需要の増加が課題となり、カ国政府による指示のもとプノンペン水道公社（以下、「PPWSA」）が2004年よりプノンペン都の給水区から直接配水管を接続し、給水を実施している。タクマウ市は低所得者層が多く住む居住地域であり、給水接続料の無償化や他地域に比べて水道料金が低めに適用設定されている等の措置が図られている。

タクマウ市の人口増加に対応するためには、新たな浄水場の整備が必要であるが、当該地区は貧困地域であり、採算の取れる商業レートの水道料金を徴収することができる利用者が少ない。商業レートの水道料金を徴収することができる利用者の多いプノンペンとの中心地域の利用者を対象とした浄水場であれば、有償資金を活用して施設整備をしても採算が取れるが、採算の取れない居住者レートの利用者の多い貧困地域を対象とした浄水場建設を有償資金で整備すると、事業採算が取れない。タクマウ市向けの浄水場の整備に有償資金を使うことは PPWSA の財政圧迫に繋がりかねないため、カ国側の要請も踏まえつつ、浄水場整備の初期投資を抑え、かつ浄水場の運営を通じて本邦の企業等のノウハウや知見・経験を活かすことを目的とし、インフラ輸出政策にも合致する事業・運営権対応型無償資金協力（以下、「事業権無償」）の適用による浄水施設の整備の可能性が検討されている。

加えて、プノンペン都水道マスタープラン(2017年改訂版)（Phnom Penh Water Supply Authority Third Master Plan- Period 2016-2030 ）（以下、「マスタープラン(2017年改訂版)」）によると、プノンペン都内における人口についても急激に伸びており、既存の浄水場による供給能力では対応しきれず、2020年には現給水能力が不足することが指摘されているため、プノンペン都内に関しては借款を通じた浄水場の拡張にかかる検討が開始されている。

３．調査結果の概要とプロジェクトの内容（概略設計、施設計画・機材計画の概略）

（1）調査結果の概要

前述の背景から JICA は、以下の通り計5回にわたり協力準備調査団をカ国に派遣した。

第1次現地調査：	2019年3月17日～同年4月10日
第2次現地調査：	2019年6月18日～同年7月2日
第3次現地調査：	2019年8月25日～同年8月31日
第4次現地調査：	2019年10月15日～同年10月23日
第5次現地調査：	2019年11月17日～同年11月23日

カ国側からの要請内容を確認し、プロジェクトの背景、目的及び内容を把握し、効果、技術的・経済的妥当性を検討のうえ、協力の成果を得るために必要かつ最適な事業内容・規模につき概略設計を行い、概略事業費を積算するとともに、プロジェクトの成果・目標を達成するために必要な相手国側分担事業の内容、実施計画、運営・維持管理等の留意事項などを提案することを目的とする本準備調査を実施した。

その結果、協力対象事業として、事業権無償により、30,000 m^3/日の浄水場を建設し、その運営を最大 10 年間の期間において特別目的会社（以下、「SPC」）が行うことをカ国側と合意した。

（２）プロジェクトの内容

本プロジェクトはタクマウ地域及び周辺地域への給水の為の浄水場（30,000m^3/日）を建設し、SPC により最長 10 年間の運営・維持管理（以下、「O&M」）が行われるものである。本邦企業による O&M が行われることにより、本邦技術の O&M の技術移転が行われるとともに、本邦企業による事業実施経験が培われるものである。協力の内容は以下のとおりである。

施設	タクマウ浄水場	取水・導水施設	取水能力：31,500 m^3/日、取水施設（取水塔方式） 導水施設
		浄水施設	浄水能力：30,000 m^3/日
		配水施設	配水池及び配水ポンプ、バルクメーター（１基）
		SCADA	浄水場内の中央監視システム
コンサルティング・サービス			入札補助
			設計確認
			施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務

４．プロジェクトの工期及び概略事業費

（１）プロジェクトの工期

本プロジェクトの実施工程は、工事内容・工期の関係から初年度に入札を行い、翌年度から工事（設計・施工・維持管理準備）を実施するものとする。工期は、入札期間が 12.5 ヶ月、設計・施工が 33 ヶ月である。

（２）概算事業費

１）日本側負担費用

費　　目	概算事業費（百万円）
取水施設の新設（取水塔方式）、導水施設の新設、浄水施設の新設、配水施設の新設、SCADA、バルクメーター、詳細設計	2,926
入札補助、設計確認、施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務	365
合計	3,291

注）　上記概算事業費は即交換公文上の供与限度額を示すものではない。US$1=111.21 円（平成 31 年 1 月から 3 月までの 3 か月平均）、KHR1= 0.026 円（平成 31 年 4 月 JICA 精算レート）

２）カンボジア側負担費用

	負担事項	内容	USD	百万円
1	浄水場建設用地整備	浄水場予定地の整地	-	-
2	料金徴収所の移設	料金徴収所の移設	61,000	-
3	電気工事	2 回線受電の手続き、工事等の負担費用 取水・浄水施設への一次側受電設備の工事負担費用	5,000	-
4	不発弾・地雷調査	プロジェクト対象用地に不発弾及び地雷等がないか事前に調査を行う費用	25,000	-
5	環境社会配慮	環境影響項目のモニタリング費用（2021-2024 年）	31,250	-
6	銀行手数料	銀行取決めに係る手数料	-	3.6
合　計			122,250	3.6

注）　施設建設完了の 2024 年までにかかる経費合計

５．プロジェクトの評価

（１）妥当性

プロジェクトの裨益対象

本プロジェクトによりタクマウ市住民への給水能力が改善され、タクマウ市の裨益人口が増加する。新規浄水場の建設に加え、現状の給水サービスの向上が図られるため、増加する給水人口に対する裨益のみならず、現在給水を受けている住民に対しても給水サービスが改善することとなる。また、現在プノンペン都からタクマウ市に配水している水量は、浄水場建設後からはプノンペン都に配水できるようになるため、プノンペン都の給水サービスも改善することとなる。よって、本プロジェクトの裨益を受ける人口はタクマウ市及びプノンペン都におよぶこととなる。

プロジェクトの緊急性

PPWSA は既存の水道システムを有してはいるが、現在の浄水能力では 2030 年時点でのタクマウ市における水需要の 6 割程度しかない。上水道施設の拡張による給水量の増加なしでは水不足が予測され、上水道施設の拡張が急務となっている。

プロジェクトの上位計画との整合性

カ国政府は、国家戦略開発計画（National Strategic Development Plan （NSDP））により、2025 年までに都市部人口の 100%に対して安全な水へのアクセスを確保するという目標を掲げており、本プロジェクトはタクマウ市において、その実現に寄与するものである。

我が国の援助政策との整合性

カ国に対する我が国の援助方針の事業展開計画（2016 年 9 月）では、カ国の開発目標達成を支援し、「社会開発の促進」を援助の重点分野の一つとし、「上下水道インフラの整備」を開発課題としており、本プロジェクトの実施は、我が国の援助政策と整合している。

（２）有効性

本プロジェクトの有効性に関しては、以下の定量的効果及び定性的効果が見込まれる。

定量的効果

タクマウ浄水場の新設をすることにより、下表に示すような効果が期待できる。

No.	指標	基準値 2015 年)	目標値(2027 年) (供用開始後 3 年)
1	日平均給水量	11,440 m^3/日	30,000 m^3/日

定性的効果

定性的効果は以下の通りである。

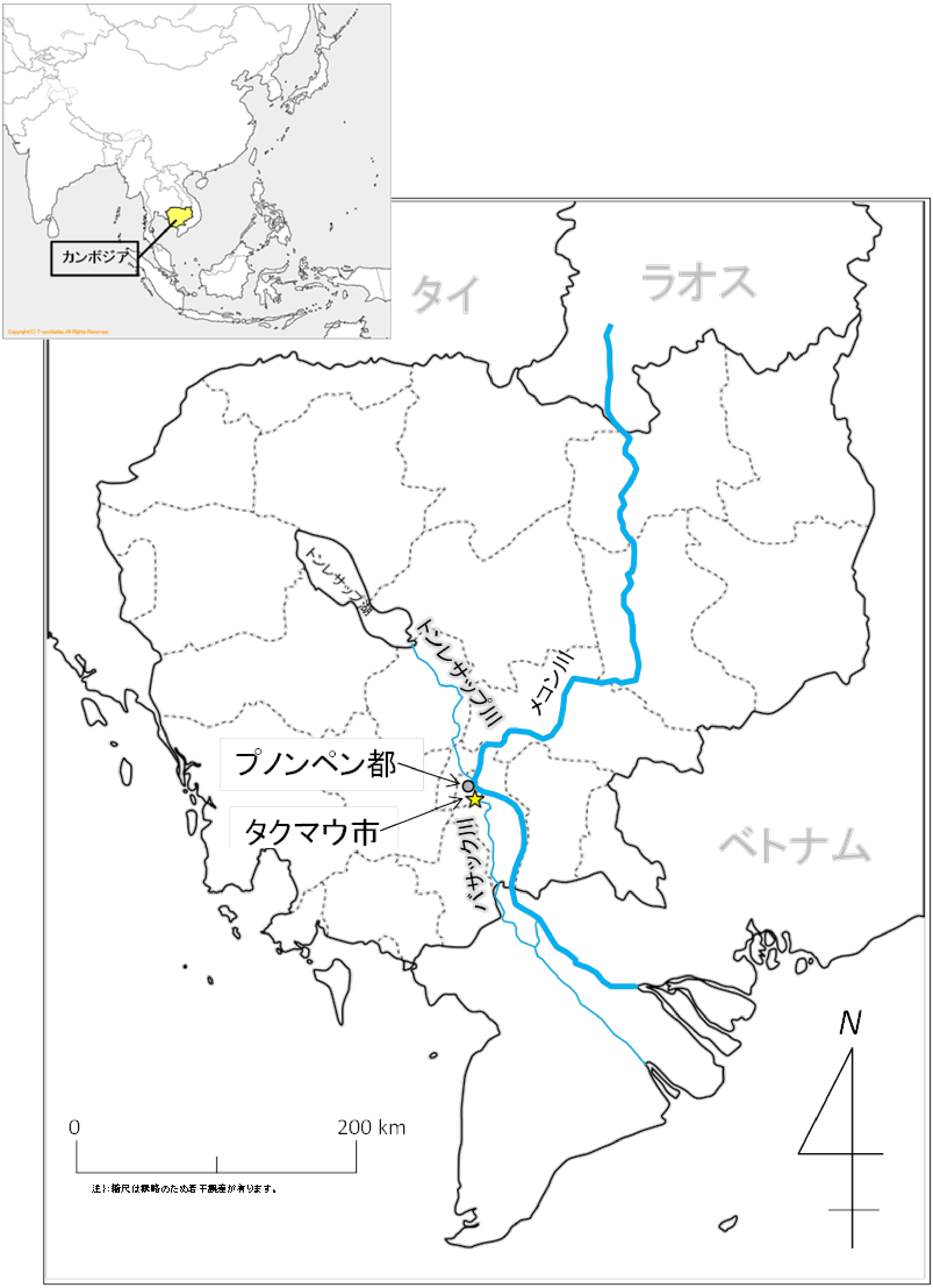
① 給水栓からの水量・水圧不足の改善
② 貧困層への接続の促進

③ 貧困層に適用している水道料金の維持
④ 浄水場の運営・維持管理に関する技術移転による運営・維持管理能力の向上
⑤ 公衆衛生の向上

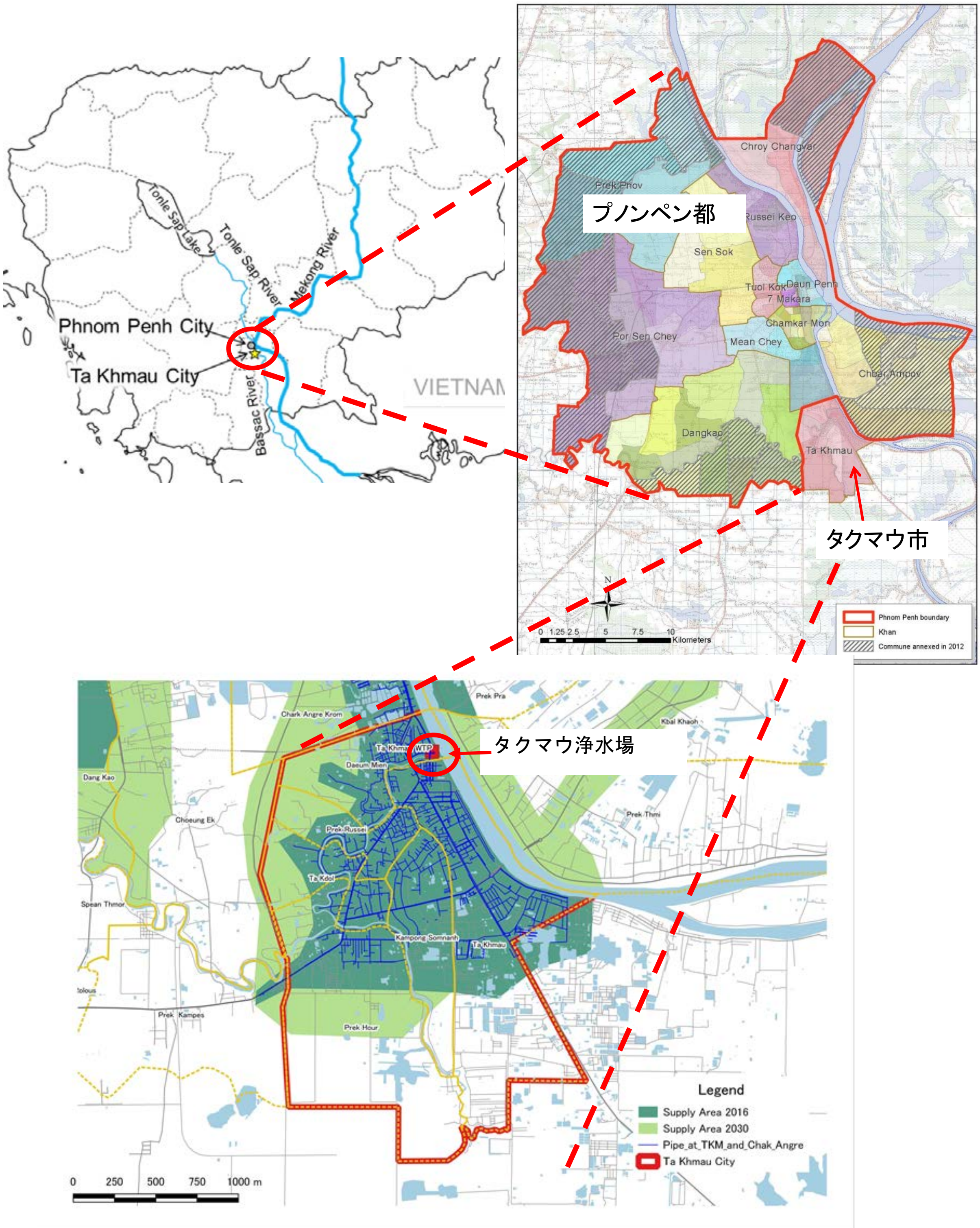
以上の内容により、本プロジェクトの妥当性は高く、また有効性が見込まれると判断される。

目　　次

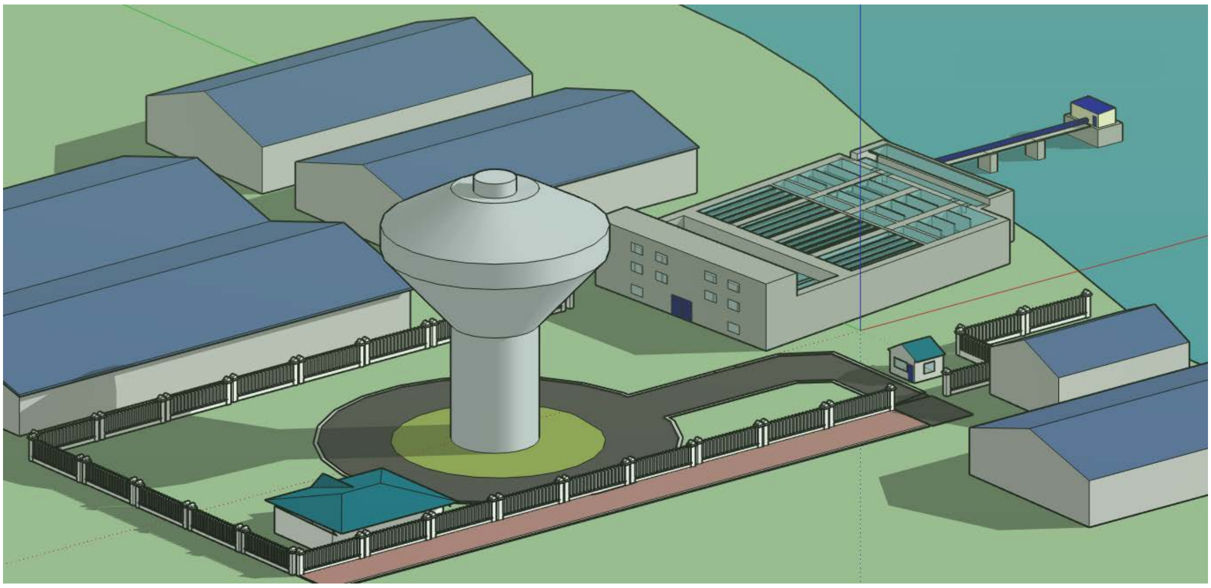
［資　料］


カンボジア
タイ
ラオス
ベトナム
トンレサップ湖
トンレサップ川
メコン川
プノンペン都
タクマウ市
バサック川
N
0
200 km
注）：縮尺は概略のため若干誤差が有ります。

プロジェクト位置図


Tonle Sap Lake
Tonle Sap River
Mekong River
Phnom Penh City
Ta Khmau City
Bassac River
VIETNAM
プノンペン都
Prek Phnov
Chroy Changvar
Russei Keo
Sen Sok
Tuol Kok
Daun Penh
7 Makara
Chamkar Mon
Por Sen Chey
Mean Chey
Chbar Ampov
Dangkao
Ta Khmau
タクマウ市
Phnom Penh boundary
Khan
Commune annexed in 2012
0 1.25 2.5 5 7.5 10 Kilometers
タクマウ浄水場
WTP
Prek Pra
Chark Angre Krom
Kbal Khaoh
Daeum Mien
Dang Kao
Choeung Ek
Prek Thmi
Prek Russei
Ta Kdol
Spean Thmor
Kampong Somnanh
Prek Kampes
Prek Hour
Legend
Supply Area 2016
Supply Area 2030
Pipe_at_TKM_and_Chak_Angre
Ta Khmau City
0 250 500 750 1000 m

プロジェクト概要図



完成予想図

写　真

写真-1：タクマウ浄水場建設予定地の現状

浄水場建設予定地は、PPWSA の料金徴収所として利用されており、タクマウ浄水場の建設のため PPWSA により建設開始までに移設される予定である。

写真-2：タクマウ浄水場建設予定地の現状

料金徴収所敷地内に建設されている高架水槽で、タクマウ市への配水に利用されている。

写真-3：タクマウ浄水場浄水施設の建設予定地

PPWSA の料金徴収所の敷地内の浄水施設の建設予定地である。

写真-4：タクマウ浄水場取水施設の建設予定地

バサック川に面したタクマウ浄水場取水施設の建設予定地である。

写真-5：　タクマウ市中心街の現状

タクマウ市の中心街の状況である。給水接続及び管路工事は PPWSA により実施されることとなっている。

写真-6：タクマウ市低所得者住居の現状

タクマウ市の低所得者住居の状況である。給水接続及び管路工事は PPWSA により実施されることとなっている。

図表リスト

略　語　表

ADB	Asian Development Bank	アジア開発銀行
AfD	Agence Française de Développement (French Development Agency)	フランス開発庁
ASEAN	Association of Southeast Asian Nations	東南アジア諸国連合
CAPEX	Capital Expenditure	資本的支出
CDC	The Council for Development of Cambodia	カンボジア開発評議会
CMAC	Cambodian Mines Action Centre	カンボジア地雷対策センター
CNDWQS	Cambodian National Drinking Water Quality Standard	カンボジア飲料水水質基準
CNMC	Cambodia National Mekong Committee	カンボジアメコン川委員会
CPI	Consumer Price Index	消費者物価指数
DD	Detail Design	詳細設計
GDP	Gross Domestic Product	国内総生産
GOJ	Government of Japan	日本国政府
DBO	Design, Build and Operate	設計、建設、運営
DSCR	Debt Service Coverage Ratio	元利金返済カバー率
EDC	Electricité du Cambodge	カンボジア電力公社
EIA	Environmental Impact Assessment	環境影響評価
EMP	Environmental Management Plan	環境管理計画
EPC	Engineering, Procurement and Construction	設計・調達・建設
GDT	General Department of Taxation	カンボジア租税総局
HDPE	High Density Polyethylene	高密度ポリエチレン
HWL	High Water Level	高水位
IEE	Initial Environmental Examination	初期環境調査
IEIA	Initial Environmental Impact Assessment	初期環境影響評価
ILO	International Labour Organization	国際労働機関
IMF	International Monetary Fund	国際通貨基金
ISO	International Organization for Standardization	国際標準化機構)
JICA	Japan International Cooperation Agency	国際協力機構
JIS	Japanese Industrial Standard	日本工業規格
JV	Joint Venture	合弁事業
LCC	Life Cycle Cost	ライフサイクルコスト
LWL	Low Water Level	低水位
M/D	Minute of Discussion	討議議事録
MEF	Ministry of Economy and Finance	経済財政省
MIH	Ministry of Industry & Handicraft	工業・手工芸省
MoE	Ministry of Environment	環境省
MoWRAM	Ministry of Water Resources and Meteorology	水資源気象省
MSL	Mean Sea Level	平均海面
NRW	Non-Revenue Water	無収水
NSDP	National Strategic Development Plan	国家戦略開発計画
NSSF	National Social Security Fund	国家社会保険基金
NGO	Non Governmental Organizations	非政府組織
O&M	Operation and Maintenance	運営維持管理
ODA	Official Development Assistance	政府開発援助
OPEX	Operating Expense	運営費
OSH	Occupational Safety and Health	労働安全衛生
PaAs	Protected Areas	保護地域
PAC	Polyelectrolyte Aluminium Chloride	ポリ塩化アルミニウム
P/Q	Pre-Qualification Exercise	入札参加資格事前審査
PPP	Public–Private Partnership	官民連携
PPWSA	Phnom Penh Water Supply Authority	プノンペン水道公社
QCBS	Quality and Cost Based Selection	総合評価落札方式
QIP	Qualified Investment Project	適格投資プロジェクト
RGC	Royal Government of Cambodia	カンボジア政府
SCADA	Supervisory Control And Data Acquisition	監視制御システム
SEA	Strategic Environmental Assessment	戦略的環境評価
SOP	Standard Operating Procedures	標準運営手順
SPC	Special Purpose Company	特別目的会社
TOR	Terms of Reference	委託事項
UXO	Unexploded Ordnance	地雷・不発弾

VAT	Value Added Tax	付加価値税
WB	World Bank	世界銀行
WTO	World Trade Organization	世界貿易機関
WTP	Water Treatment Plant	浄水場

第1章 プロジェクトの背景・経緯

1-1 当該セクターの現状と課題

1-1-1 現状と課題

カンボジア国（以下、「カ国」）の上水道セクターは 1990 年代中頃より本格的な施設の改修・拡充が開始され、首都プノンペン都を中心に整備が進んでいる。プノンペン都では、内戦終結後、1993 年に独立行政法人国際協力機構（以下、「JICA」）の支援により策定された「プノンペン市上水道整備計画」に基づき、わが国及び他ドナーが連携して、浄水場の建設及び改修、運営・維持管理技術にかかる技術支援が実施され、24 時間給水を実現し給水率は 90%以上に達した。他方、プノンペン都周辺地域における人口及び商業施設の増加により水需要が増加し、引き続き水供給能力を向上させることが急務である。

プノンペン都の南に位置するカンダール州タクマウ市はバサック川を水源とする公営水道と井戸水による取水が中心であったが、複数の井戸からヒ素が検出される等の水質の問題や人口増加に伴う水需要の増加が課題となり、カ国政府による指示のもとプノンペン水道公社（以下、「PPWSA」）が 2004 年よりプノンペン都の給水区から直接配水管を接続し、給水を実施している。タクマウ市は低所得者層が多く住む居住地域であり、給水接続料の無償化や他地域に比べて水道料金が低めに適用設定されている等の措置が図られている。

タクマウ市の人口増加に対応するためには、新たな浄水場の整備が必要であるが、当該地区は貧困地域であり、採算の取れる商業レートの水道料金を徴収することができる利用者が少ない。商業レートの水道料金を徴収することができる利用者の多いプノンペン都の中心地域の利用者を対象とした浄水場であれば、有償資金を活用して施設整備をしても採算が取れるが、採算の取れない居住者レートの利用者の多い貧困地域を対象とした浄水場建設に有償資金を活用して整備すると、事業採算が取れない。タクマウ市向けの浄水場の整備に有償資金を活用することは PPWSA の財政圧迫に繋がりかねないため、カ国側の要請も踏まえつつ、浄水場整備の初期投資を抑え、かつ浄水場の運営を通じて本邦の企業等のノウハウや知見・経験を活かすことを目的とし、インフラ輸出政策にも合致する無償資金協力（事業・運営権対応型無償資金協力、以下、「事業権無償」）の適用による浄水施設の整備の可能性が検討されている。

加えて、プノンペン都水道マスタープラン(2017 年改訂版)（Phnom Penh Water Supply Authority Third Master Plan- Period 2016-2030 ）（以下、「マスタープラン(2017 年改訂版)」）によると、プノンペン都内における人口についても急激に伸びており、既存の浄水場による供給能力では対応しきれず、2020 年には現給水能力が不足することが指摘されているため、プノンペン都内に関しては借款を通じた浄水場の拡張にかかる検討が開始されている。

1-1-2　　開発計画

1-1-2-1　四辺形戦略（Rectangular Strategy）

2004 年 7 月 16 日の第三次政権成立後の初閣議においてフン・セン首相が表明した国家開発戦略で、戦略の四辺に①農業分野の強化、②インフラの復興と建設、③民間セクター開発と雇用創出、④能力構築と人材開発を掲げ、その中心部に「良き統治（グッドガバナンス）」を置いている。「良き統治」の内容としては、汚職撲滅、法・司法改革、行財政改革及び国軍改革を優先課題としている。

1-1-2-2　国家戦略開発計画（National Strategic Development Plan: NSDP）

国家戦略開発計画 2014～2018 年（以下、「NSDP」）は、カ国の国家戦略である「四辺形戦略 Rectangular Strategy)」を実施するためのアクションプランとして位置付けられている。水道分野については、目標値として 2018 年までに都市部の 85%が水道システムへのアクセスを得ること、2025 年に都市部での安全な水にアクセスできる人の割合を 100%としている。また、都市給水の優先課題として下記のように示している。

- 法制度（水道法等）の整備
- 中央省庁による経済的技術的な規制の下での地方分権の推進
- 地方水道局の国営企業としての自立（公社化）
- 資金調達の増加（開発戦略・ビジネスプラン等の策定、プライベイトセクターの活用、”Water for All” program の実施等）
- 業績及び水道普及の改善（既存施設の更新、課題の抽出と解決、人材育成、水道協会設立、PPWSA の有効活用、適切な水質管理システム等）
- 水源保全

1-1-2-3　　マスタープラン（2017 年改訂版）

PPWSA では、フランス政府の支援により、マスタープラン(2017 年改訂版）を作成し、今後の計画的な整備計画が立案されている。マスタープラン(2017 年改訂版）の整備計画を**表 1-1.1** に示す。

表 1-1.1　上水道マスタープラン（2017 年改訂版）の整備計画

期間	実施内容
Phase1 (2016-2018)	Chamcar Mon 浄水場の改修
Phase2 (2019-2022)	Bakheng 浄水場一期の建設、Phun Prek 浄水場の改修及び Ta Khumau 浄水場の建設
Phase3 (2023-2024)	Bakheng 浄水場二期の建設及び Phun Prek 浄水場の拡張

出典：マスタープラン(2017 年改訂版）

マスタープラン（2017 年改訂版）では、2030 年の需要を満たすために、プノンペン都の南部にタクマウ浄水場を建設し、タクマウ市の給水に充てることが計画されている。これにより、タクマウ市の給水能力増強に加え、これまでタクマウ市へ給水していた Niroth 浄水場や Chamcar Mon 浄水場がプノンペン都の南部及び西部へ給水されることとなり、これらの地域の給水状況の改善に寄与することになる。マスタープラン(2017 年改訂版）では、タクマウ浄水場の建設に関する計画給水区域[6]が計画されている。計画給水区域を**図 1-1.1** に示す。

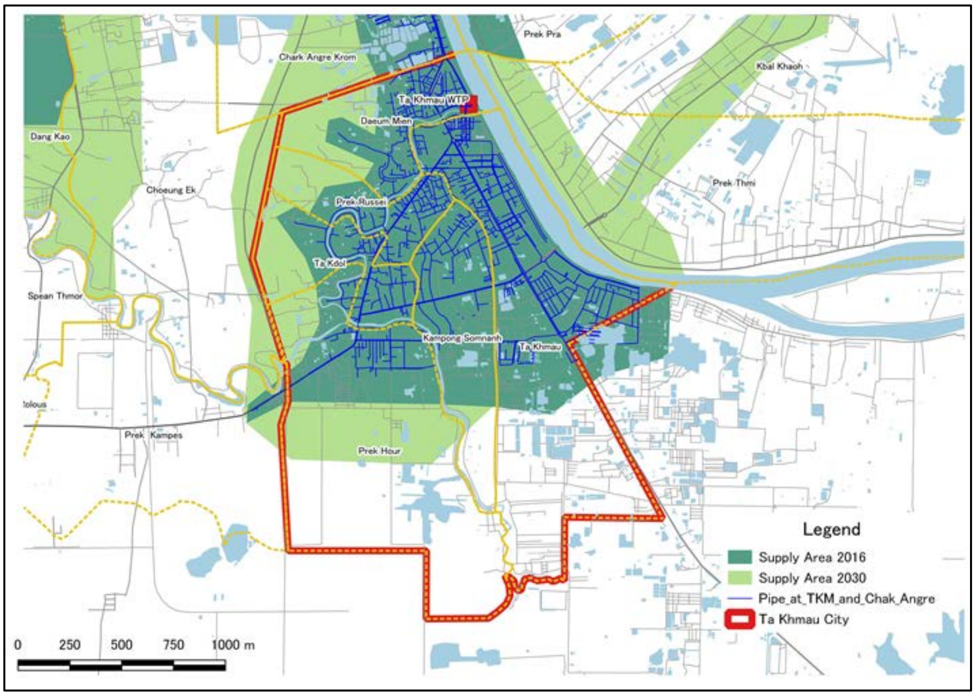


図 1-1.1　想定されている計画給水区域

出典：PPWSA

マスタープラン（2017 年改訂版）では、目標年次である 2030 年のタクマウ市内の水需要を**表 1-1.2** のように試算している。

表 1-1.2　タクマウの水需要予測

		2015	2020	2025	2030
Consumption	m^3/day	11,668	14,854	19,556	21,966
NRW	%	8	10	10	10
Leakage Amount	m^3/day	1,015	1,650	2,173	2,441
Average Demand	m^3/day	12,683	16,504	21,729	24,407
Peak factor	-	1.15	1.15	1.15	1.15
Maximum Demand	m^3/day	14,585	18,980	24,988	28,068

出典：マスタープラン（2017 年改訂版）

2030 年の水需要は約 28,100m^3/日と予測しており、後述する本プロジェクトの浄水場の処理能力として 30,000m^3/日は妥当であるといえる。

[6]対象コミューンは、タクマウ市の 6 つのコミューン（Daeum Mean, Ta Khmau, Prek Russei, Kompong Samnanh, Ta Kdol, Prek Hour）

1-1-3　経済社会状況

カ国の経済は、2018 年の一人当り国内総生産（GDP）は約 1,510USD[7]で近隣諸国に比べても低く、未だ後発開発途上国である。また、産業別内訳は農業が 23%、工業が 31%、サービス業が 40%である[8]。近年比較的安定した政治状況を保っており、2004 年から 2007 年までは平均国内総生産成長率が 4 年連続して 10%を超える著しい経済成長を果たしている。2008 年以降、原油・食糧価格の高騰、および世界金融危機の影響により成長率は低下し、2009 年の経済成長率は、0.1%にまで落ち込んだものの、2010 年は 6.0%まで回復した。2011 年以降は、ほぼ 7.00%を維持し続けている。また、1999 年の東南アジア諸国連合（ASEAN）加盟、2004 年の世界貿易機関（WTO）加盟など、地域経済及び世界経済との統合を強化している。

図 1-1.2　カ国の経済成長率

出典：National Institute of Statics of Cambodia

カ国はいまだに貧困層の割合が高く、2004 年には 50%を超えていた貧困率 が 2011 年には約 20%[9]まで大幅に低下したとはいえ、貧困の削減がカ国の重要課題となっており、貧困削減のためには、産業構造の多様化と生産性の向上に基づく包括的な成長が欠かせないとしている。

なお、本プロジェクトは、事業運営権の取得を伴う事業であることから、カ国のインフレ率は事業運営における重要な要素となる。カンボジア市場のインフレ率は、過去 10 年間の平均インフレ率が 2.8%、最新の国際通貨基金（IMF）による 2019 から 2024 年の予想インフレ率の平均値は 2.7%、2022 年以降の予想インフレ率は 3.0%となっている。

[7] GDP per capita (current US$) - Cambodia” The world bank data (2020)
[8] カンボジア投資環境 2019 年 4 月　JICA カンボジア事務所
[9] The World Bank　（April 2014）「Cambodia Poverty Assessment 2013」

図 1-1.3　カ国のインフレ率

出典：IMF2019

1-2　　無償資金協力の背景・経緯及び概要

タクマウ市の人口増加と水需要に対応するためには、新たな浄水場の整備が必要であり、カ国政府は我が国に対して、タクマウ浄水場を新設することにより、水需要への対応と安全な水へのアクセス率向上を図ることを目的とした無償資金協力事業の要請を行った。

カ国側からの要請書に記載されている要請内容は**表 1-2.1** の通りである。

表 1-2.1　本プロジェクトの要請内容

項目	内容
プロジェクト内容	1).　施設 － 取水・導水施設（33,000 m^3/日）、取水ポンプ場（揚水量 22m^3/分、揚程 23m）、導水管（口径 600mm、100m） － 浄水場（浄水処理能力： 30,000 m^3/日、急速ろ過方式、太陽光発電システム（146kW）） － 配水施設（配水ポンプ（揚水量 20m^3/分、揚程 50m）） 2).　機材 － 水質分析機器 － 機械電気設備維持管理用機材 － 各戸接続用資機材 3).　コンサルティング・サービス、ソフトコンポーネント － コンサルティング・サービス：入札補助、施工・調達監理 － ソフトコンポーネント：なし
対象地域	カンボジア国　カンダール州　タクマウ市
関係官庁・機関	実施機関（主管官庁）：工業・手工芸省（Ministry of Industry & Handicraft: MIH） 事業実施機関（水道事業実施機関）：プノンペン水道公社（Phnom Penh Water Supply Authority: PPWSA） 関連機関：経済財政省（Ministry of Economy and Finance: MEF）

出典：要請書

この要請を受けて JICA は、事業規模の妥当性を検討した上で、無償資金協力として適切な概略設計を行い、事業計画を策定し、概略事業費を積算することを目的とする本協力準備調査（以下、「本業務」）を実施した。

本業務期間中に行った協議の結果、事業権無償の適用による浄水施設の整備の実施を合意した。尚、要請内容のうち、太陽光発電システムは、無償部分から除外すること、水質分析機器及び機

械電気設備維持管理用機材は、建設費の一部として取り扱うこと、各戸接続用資機材は PPWSA との協議により除外することで合意した。

カ国側との協議内容を踏まえカ国側と要請内容の変更を確認した結果、要請内容は**表 1-2.2** の通りである。

表 1-2.2　カ国側と確認された要請内容結果

項目	内容
プロジェクト内容	1).　施設 － 取水・導水施設（31,500 m³/日）、取水ポンプ場（揚水量 22m³/分、揚程 23m）、導水管（口径 600mm、100m） － 浄水場（浄水処理能力： 30,000 m³/日、~~急速ろ過方式、~~太陽光発電システム（146kW）） － 配水施設（配水ポンプ（揚水量 20m³/分~~、揚程 50m~~）） － バルクメーター － **SCADA** 2).　機材 － 水質分析機器 － 機械電気設備維持管理用機材 ~~－ 各戸接続用資機材~~ 3).　コンサルティング・サービス、ソフトコンポーネント － コンサルティング・サービス：入札補助、設計確認、施工監理 － ソフトコンポーネント：なし
対象地域	カンボジア国　カンダール州　タクマウ市及び周辺地域
関係官庁・機関	実施機関（主管官庁）：プノンペン水道公社（**Phnom Penh Water Supply Authority: PPWSA**） 事業実施機関（水道事業実施機関）：プノンペン水道公社（Phnom Penh Water Supply Authority: PPWSA） 関連機関：経済財政省（Ministry of Economy and Finance: MEF）

（注）XXX は変更箇所

1-3　我が国の援助動向

我が国によるカ国に対する過去の都市水道分野に関連する援助を**表 1-3.1**、**表 1-3.2** に示す。

表 1-3.1　技術協力及び有償資金協力プロジェクトの実績（都市給水分野）

協力内容	実施年度	案件名/その他	概要
技術協力プロジェクト	2003～ 2006 年度	水道事業人材育成プロジェクト	プノンペン水道公社における水道施設の運転・維持管理能力の強化に資する協力
	2007～ 2011 年度	水道事業人材育成プロジェクト・フェーズ 2	地方 8 州都の公営水道局における水道施設の運転・維持管理能力の強化に資する協力
	2012～ 2017 年度	水道事業人材育成プロジェクト・フェーズ 3	地方 8 州都の公営水道局における水道事業体運営及び経営管理能力の強化に資する協力
	2018～ 2022 年度（予定）	水道行政管理能力向上プロジェクト	工業・手工芸省における水水道行政管理能力の強化に資する協力
開発計画調査型技術協力プロジェクト（旧開発調査）	1992～ 1993 年度	プノンペン市上水道整備計画	プノンペン市の上水道マスタープラン及び既存施設の緊急改修計画の策定
	1996～ 2000 年度	シェムリアップ市上水道整備計画調査	シェムリアップ市の上水道マスタープランの策定及び優先プロジェクトのフィージビリティ調査の実施
	2004～ 2005 年度	プノンペン市上水道整備計画（フェーズ２）	プノンペン市及びカンダール都市部における上水道マスタープランの策定及び優先プロジェクトのフィージビリティ調査の実施
	2009～ 2011 年度	シェムリアップ上水道拡張整備事業準備調査	上水道施設の拡張に係る新規水源及び取水方式の選定、施設整備計画の策定及びフィージビリティ調査、地下水使用の現状評価の実施
有償資金協力	2008 ～ 2013 年度	ニロート上水道整備計画（供与限度額：35.13 億円）	プノンペン市における上水道施設の整備。フランス開発機構との協調融資
	2011～ 2023 年度（予定）	シェムリアップ上水道拡張整備計画（供与限度額：71.61 億円）	上水道設備の拡張（トンレサップ湖を水源とする取水施設・導水管建設，浄水場施設・配水管の建設）及び人材育成・組織強化の支援

表 1-3.2　我が国の無償資金協力実績（都市給水分野）

実施年度	案件名	供与限度額（億円）	概要
1993～ 1994 年度	プノンペン市上水道整備計画	17.71	プンプレック浄水場の改修と一部配水施設を整備。
1997～ 1999 年度	第 2 次プノンペン市上水道整備計画	21.12	漏水量の削減を目的とする配水管更新と給水区域拡張を目的とする配水管新設を含む。
2000～ 2003 年度	プンプレック浄水場拡充計画	0.60 25.80	詳細設計 プンプレック浄水場の拡張と一部の老朽化した施設の改修。
2004～ 2005 年度	シアムリアップ上水道整備計画	15.37	従前の一部配水施設を活かし、取水施設／浄水施設を含むほぼ全面的な水道施設整備の実施。
2010～ 2013 年度	地方州都における配水管改修及び拡張計画	27.60	プルサット、シハヌークビル、バッタンバンの各州都における配水管網の更新・拡張工事
2013～ 2016 年度	コンポンチャム及びバッタンバン上水道拡張計画	33.55	コンポンチャム市及びバッタンバン市における上水道施設の拡張。
2016～ 2018 年度	カンポット上水道拡張計画	29.85	カンポット市における上水道施設の拡張。
2019 年度～	コンポントム上水道拡張計画	32.71	コンポントム州都で給配水施設を建設することにより、地域の給水能力の増強。
2020～ 2022 年度（予定）	プルサット及びスバイリエン上水道拡張計画		プルサット市及びスバイリエン市における上水道施設の拡張。

1-4　　他ドナーの援助動向

他ドナーの援助動向として、フランス政府の支援により、プノンペン都のマスタープラン（2017年改訂版）の第一期として、Chamcar Mon 浄水場及び基幹配水管の建設が 2017 年に開始され、2019年の 10 月の完工している。Chamcar Mon 浄水場の建設状況を**図 1-4.1** に示す。

マスタープラン（2017 年改訂版）の第二期として、Bakheng 浄水場（第一期）は 2019 年の 6 月に入札、10 月から工事を開始し、2022 年の完成を予定、Bakheng 浄水場（第二期）は、2025 年の完成予定である（**表 1-4.1**）。

表 1-4.1　プノンペン及びタクマウ地域における AfD による援助（都市給水分野）

実施年度（実施期間）	機関名	案件名	金額（百万 US$）	援助形態	概要	上位計画に果たす役割
2017-2019（3 年間）	フランス開発庁 (AfD)	Chamcar Mon 浄水場拡張計画	40.000	有償	52,000 m^3/日の浄水場の拡張	プノンペン都の水需要に対応する
2019-2022（3 年間）	フランス開発庁 (AfD)	Bakheng 上水道整備計画（I）	176.690	有償	195,000 m^3/日の浄水場の新設	プノンペン都の水需要に対応する
2023-2025（3 年間）	フランス開発庁 (AfD)	Bakheng 上水道整備計画（II）	100.829	有償	195,000 m^3/日の浄水場の増設	プノンペン都の水需要に対応する

浄水場建設状況　　取水場建設状況

図 1-4.1　Chamcar Mon 浄水場の建設状況

第2章　プロジェクトを取り巻く状況

2-1　　　プロジェクトの実施体制

2-1-1　　組織・人員

プロジェクトの実施機関並びに事業実施機関はどちらも PPWSA である。PPWSA の組織図を**図 2-1.1** に、主要部署の業務内容を**表 2-1.1** に示す。

プロジェクト実施は PPWSA の Planning and Project Department が担当するが、最終的に Director General が取締役会に諮って決定される。

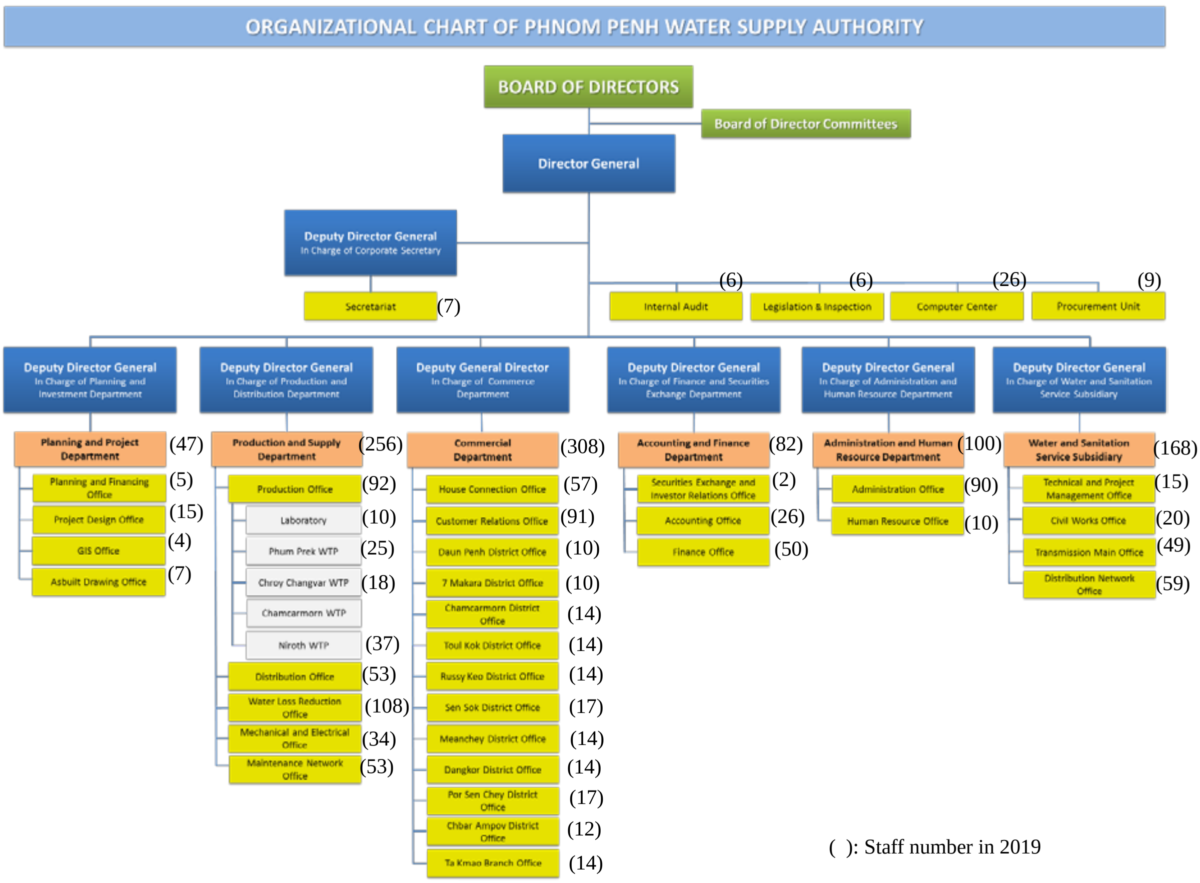


図 2-1.1　PPWSA の組織図

出典：PPWSA

表 2-1.1　主要部署の業務内容の概要

部署名	業務内容
Planing and Project Department	− 年間の維持管理計画、整備計画の作成; − 短期、中期、長期計画の作成 − 統計指標及び財務指標の作成 − PPWSA の外国の資金源を含む予算計画の作成と管理 − 配管布設や検査に関する土木技術者の育成計画の作成 − 調達管理
Production and Supply Department	− 浄水処理及び配水の実施 − 水処理施設および管理事務所の設備の設置、保守、修理
Commercial Department	− 顧客情報の管理 − 請求書の管理。 − 無収水削減のための配水量分析 − 各戸給水接続の管理
Accounting and Finance Department	− PPWSA の会計管理 − PPWSA の会計システムの運用と管理。 − 財務管理
Administration and Human Resources Department	− 一般的な事務、セキュリティ、短期、中期、長期の雇用計画と人材開発
Water and Sanitation Service Subsudiary	− 主要な送水ネットワークの維持、修理、整備 − 無収水対策

出典：PPWSA

2-1-2　財政・予算

2-1-2-1　カ国における社会経済状況

2018 年のカ国の一人当たり GDP は約 1,510[10]USD であり、低中所得国である。1998-2018 年の平均経済成長率は 8%[11]と非常に高かった。2017 年の一人当たり平均可処分所得（月額）はプノンペンで 695,000 KHR、タクマウを含むプノンペン以外の都市部で 602,000 KHR と、プノンペンとそれ以外の都市部で 1.15 倍程度の差しかない。さらに 2017 年の一人当たり平均支出(月額)について、プノンペンは 662,000 KHR、それ以外の都市部で 574,000 KHR と、プノンペンとそれ以外の都市部で 1.15 倍程度の差がある [12]。上述の通り、収入、支出においては、プノンペンとそれ以外の都市部は大きな差がないといえる。

表 2-1.2　一人当たり平均可処分所得及び支出

項目	一人当たり平均可処分所得（2017）(KHR)	一人当たり平均支出 (2017)(KHR)
国全体	464,000	454,000
Phnom Penh	695,000	662,000
Other Urban	574,000	574,000
Other Rural	413,000	409,000

出典： National Institute of Statistics, Ministry of Planning Phnom Penh, “Cambodia Socio-Economic Survey 2017”

カ国の貧困率は 2007 年に 47.8%であったのに対し、2014 年には 13.5%[13]と大きく減少した。タクマウ市はカンダール州の州都であり、カンダール州の貧困率は 16.0% (2013)と、プノンペンの

10 “GDP per capita (current US$) - Cambodia” The world bank data (2020)
11 The World Bank (Sep 25, 2019) “The World Bank in Cambodia, Overview”
12 National Institute of Statistics, Ministry of Planning Phnom Penh, Cambodia (2018) “Cambodia Socio-Economic Survey 2017”
13 The World Bank (Sep 25, 2019) “The World Bank in Cambodia, Overview”

9.8% (2015)と比較して高い[14]。2017 年のカ国の産業構造は主に一次産業が経済全体の 23%を占め、農業が主要産業となっている。また二次産業、三次産業は、経済全体の 31%、40%を占めており、二次産業では輸出向けの繊維産業、履物産業、三次産業では観光業が主要産業となっている[15]。

2011 年のカンダール州における事業所数は 41,000 件あり、国全体の 8%を占めている。プノンペンの 96,000 件 (19%)と比較しても半数近くの事務所があることから、多くの事業所が設立されていることがわかる[16]。ただし、州別の売上高においては、カンダール州の年間売上高は 3,123 億 KHR (775 百万 USD)と国全体の 6.1%を占めていることから、それぞれの事務所の規模は、相対的に小さなものであることがわかる[17]。さらに、カンダール州の一人当たり平均医療支出は 52,390 KHR と国全体で最も低く、プノンペンの 167 USD の約 8%程度であり、医療費に関する支出は非常に少ないと言える。

2-1-2-2 PPWSA の財政状況

PPWSA はカンボジア証券取引所に登録している上場企業であり、2012 年の上場以降堅調な業績で推移している。給水量の増加に伴い売上の拡大傾向が続く中、営業利益率及び純利益率は一定の水準を維持しており、2018 年の流動比率、自己資本比率、元利金返済カバー率（DSCR）はそれぞれ 165%、62.3%、134%と健全な財務体質となっている。

PPWSA が管轄するプノンペン都内及び郊外は､配水システム拡張投資を含めて採算の取れる商業レートの適用比率が高いエリアと、施設投資まで含めると採算が取れない居住者レートの適用比率が高いエリアに分かれている。PPWSA は、採算性の取れるエリアへの投資は有償で、採算性の取れないエリアの配水システム拡張投資は無償資金を活用しており、債務は拡大しているものの、売上及び資産の増加を考慮すると、健全な債務拡大であると考えることができる。株主配当も年々上昇傾向にあり、2018 年は約 134 億 KHR（約 4.8 億円 : 36KHR/円前提）を配当している。本プロジェクトの施設整備に無償資金を活用する前提においては、PPWSA の財務リスク・信用リスクは極めて限定的である。

[14] Ministry of Planning (2015) “Identification of Poor Household”
[15] カンボジア投資環境 2019 年 4 月 JICA カンボジア事務所
[16] National Institute of Statistics, Ministry of Planning, Phnom Penh, Cambodia (2012) “Economic Census of Cambodia 2011 National Report (Revised) on FINAL CENSUS RESULTS”
[17] National Institute of Statistics, Ministry of Planning, Phnom Penh, Cambodia (2012) “Economic Census of Cambodia 2011 National Report (Revised) on FINAL CENSUS RESULTS”

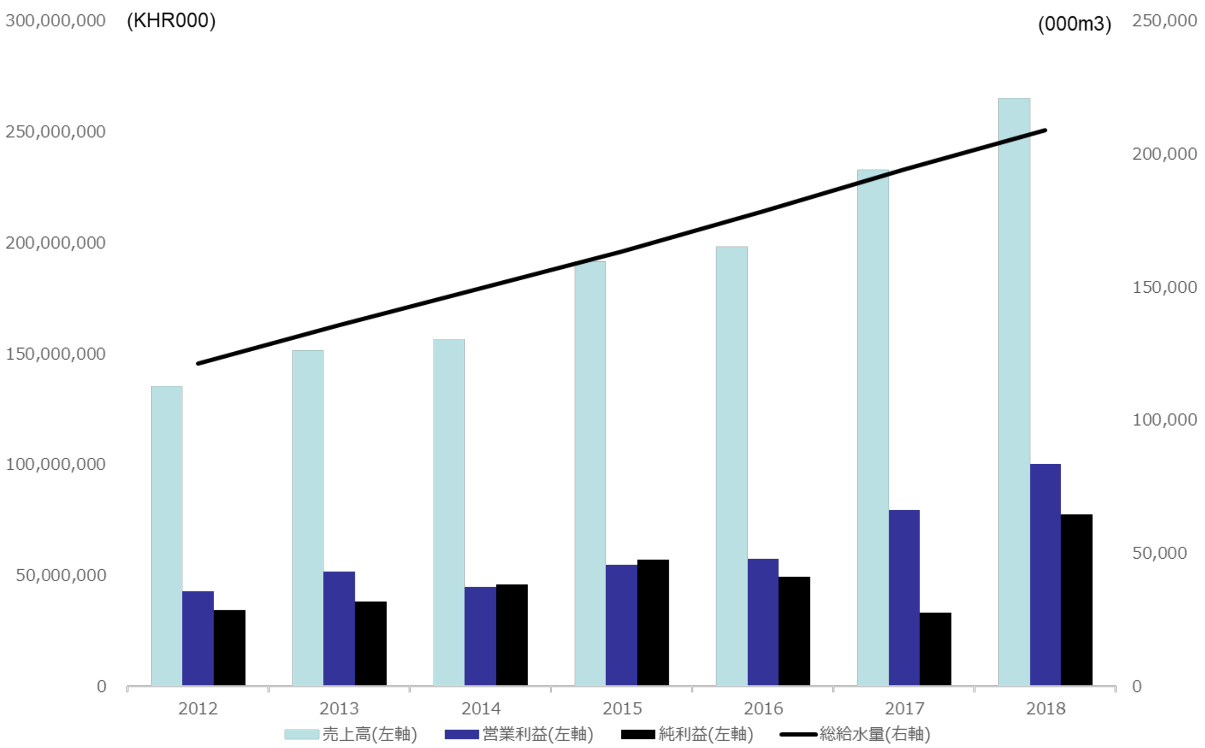


図 2-1.2 PPWSA の売上高・営業利益・純利益・総給水量の推移

出典：PPWSA

表 2-1.3 PPWSA の財務諸表

	2014	2015	2016	2017	2018
Statement of Comprehensive Income					
Revenues	156,542,849	191,348,246	198,179,874	232,893,089	265,093,293
Operating profit	44,651,578	54,642,638	57,469,473	79,486,598	100,142,223
Net profit	45,747,911	56,949,131	49,273,104	33,067,826	77,391,285
Statement of Financial Position					
Assets	1,166,051,073	1,245,432,128	1,297,729,600	1,362,011,777	1,449,204,814
(Cash and back accounts)	14,962,141	12,555,435	16,386,849	15,992,527	13,353,758
Liabilities	429,882,445	461,463,946	477,757,804	522,886,991	546,082,611
Equity	736,168,628	783,968,182	819,971,796	839,124,786	903,122,203
Statement of Cash Flows					
Cash from operating activities	84,204,478	78,919,844	100,564,035	83,383,404	82,906,841
Cash used in investing activities	-101,087,805	-81,663,015	-74,697,592	-60,123,881	-98,608,948
Cash (used in)/from financing activities	21,276,753	336,465	-22,035,029	-23,653,845	13,063,338
Net change in cash and cash equivalents	4,393,426	-2,406,706	3,831,414	-394,322	-2,638,769
	2014	2015	2016	2017	2018
Profitability					
Operating margin	28.5%	28.6%	29.0%	34.1%	37.8%
Net profit margin	29.2%	29.8%	24.9%	14.2%	29.2%
Solvency					
Current ratio	541%	472%	331%	204%	165%
Capital ratio	63%	63%	63%	62%	62%
Debt service coverage ratio (DSCR)	236%	177%	238%	143%	134%

出典：PPWSA

2-1-2-3　水道料金体系及び改定履歴

2019 年 4 月時点での PPWSA の水道料金体系は図 **2-1.3** の通りである。

Water Tariff
(January 2001 – April 2017)

Category of customer	Qty of water used (m^3/month)	Tariff (KHR/m^3)
Domestics	0 m^3– 07 m^3	550
	08 m^3–15 m^3	770
	16 m^3–50 m^3	1,010
	Over 50 m^3	1,270
Government institutions & distributors	Without consideration of Qty	1,030
Commercial, Autonomous State Authorities and retailers	0 m^3–100 m^3	950
	101 m^3–200 m^3	1,150
	201 m^3–500 m^3	1,350
	Over 500 m^3	1,450

water meter maintenance fee KHR50/mm/month.

Water Tariff
(May 2017 – Current)

Category of customer	Qty of water used (m^3/month)	Tariff (KHR/m^3)
Domestics	0 m^3– 03 m^3	400
	04 m^3– 07 m^3	500
	08 m^3–15 m^3	770
	16 m^3–50 m^3	1,010
	Over 50 m^3	1,270
Government institutions & distributors	Without consideration of Qty	1,030
Commercial, Autonomous State Authorities and retailers	0 m^3–100 m^3	950
	101 m^3–200 m^3	1,150
	201 m^3–500 m^3	1,350
	Over 500 m^3	1,450
Landlord	Without consideration of Qty	700

water meter maintenance fee KHR50/mm/month.

図 2-1.3　PPWSA の料金体系

出典：PPWSA

2017 年 5 月の料金改定によって 2018 年の平均水道料金は 1,002KHR/m^3 と前年比微減となっている。次回の料金改定は 2020 年を予定しており、使用水量が小さいセグメントの料金単価を引き下げ、大口の料金単価を引き上げることで全体として平均水道料金は 10 から 20%程度上昇する見通しとなっている。

2-1-2-4　水道接続状況

PPWSA は 2018 年時点で 367,032 個の水道メーターを接続している。同年の新規接続数は 33,744 個である。既存の水道管がある地域については、利用者の要望に基づいて新規接続の工事が行われ、既存の水道管がない地域については、PPWSA が水道管の延伸について事業性や技術可能性を精査して接続の可否を判断している。

2-1-3　　技術水準

プノンペン都では、内戦終結後、1993 年に JICA の支援により策定された「プノンペン市上水道整備計画」に基づき、我が国及び他ドナーが連携して、浄水場の建設及び改修、運転維持管理技術にかかる技術支援等が実施された。現在では、24 時間給水を実現し給水普及率は 90%以上に達しており、PPWSA は、現在 4 つの浄水場で総処理量 560,000 m^3/日の維持管理を問題なく行っ

ている。

また、技術協力プロジェクトとして、JICA が支援した水道事業人材育成プロジェクト・フェーズ 1 において技術支援が長年実施されてきた組織であり、飲料可能宣言がなされる程の水準にまで達していることから、その技術水準は高いと推察する。よって、本プロジェクトの事業実施に支障は無いといえる。

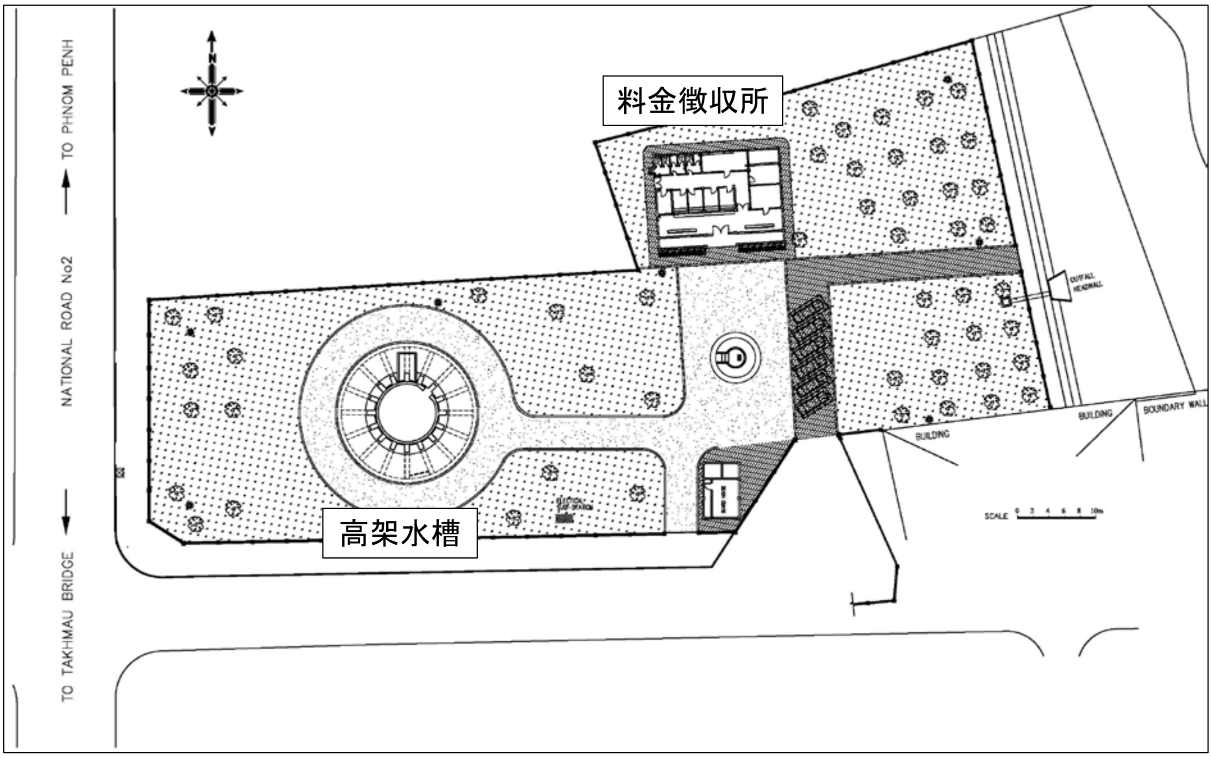
2-1-4　既存施設

2-1-4-1　タクマウ浄水場予定地の既存配水施設

タクマウ市への給水は、2004 年以前はカンダール州の水道局により実施されていた。2004 年以前のタクマウ浄水場の概要を**図 2-1.4** に示す。

図 2-1.4　タクマウ既存浄水場（2004 以前）の概要図

タクマウ市は、2004 年に PPWSA の給水区域となり、既存の浄水場は改修され、2009 年に世界銀行の支援により場内に高架水槽が建設された。現在では、タクマウ浄水場は、タクマウ市における配水場及び料金徴収所として機能している。タクマウ既存浄水場の現況を図 **2-1.5** に示す。



料金徴収所　　場内の状況

図 2-1.5　タクマウ浄水場（現況）の概要図

既存高架水槽は、容量 1,410m^3 で、流入水位が+30mASL（現地盤高さが+11m）で、流出管高さが+36.7m であることから有効水深は、6m 程度である。（図 **2-1.6**）

タクマウ高架水槽の状況
容量：1,410m^3、HWL：36,7 mASL、LWL：30 mASL

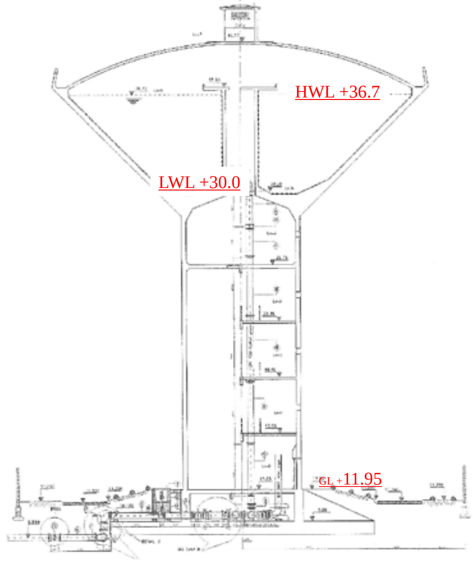


図 2-1.6　タクマウ既存浄水場高架水槽の概要図

2-1-4-2　タクマウ地域の既存配水システム

タクマウ市の配水は、2004 年に PPWSA の給水区域となってから 2017 年の 8 月まで、主に Chamcar Mon 浄水場からタクマウ浄水場の高架水槽に送水され、高架水槽からタクマウ市内に配水されていた。現在は、Niroth 浄水場第二期の完成に伴い、Chamcar Mon 浄水場の改修工事が 2017 年 10 月より始まり、2019 年に 10 月に完工が予定されている。そのため、Chamcar Mon 浄水場の完工までは Niroth 浄水場からタクマウ浄水場の高架水槽に送水され、高架水槽からタクマウ市内に配水されている。既存配水システムの概要を**図 2-1.7** に示す。

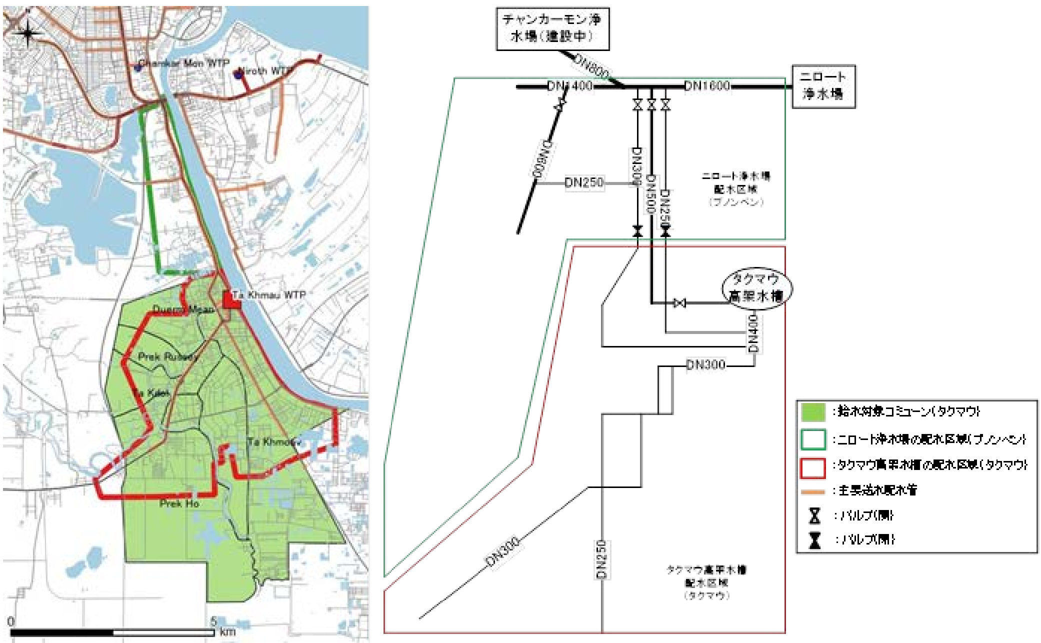


図 2-1.7　既存配水システムの概要

高架水槽には、**図 2-1.8** に示すように流量計、水圧計、水位計が設置されている。PPWSA は、Phum Prek 浄水場の中央監視システムにこれらの情報を約 15 分毎のデータを記録・監視しながら配水コントロールを実施している。

図 2-1.8　タクマウ既存浄水場のモニタリング状況

2-2　　　プロジェクトサイト及び周辺の状況

2-2-1　　関連インフラの整備状況

2-2-1-1　道路

タクマウ市は、プノンペンから南に延びる国道 2 号線沿線にあり、プノンペン都内からも 1 時間以内の距離にある。タクマウ市内の道路網は、アスファルトやコンクリートによる舗装が整備されている。

2-2-1-2　電力

タクマウ市の 2019 年の電力事情は、乾季に電力の供給不足が予想されることから、計画停電が 3 月から 5 月まで行われた。今後も計画停電が想定されるが、浄水場の運転のための電力供給は、別々の変電所からの 2 回線受電が可能であり、カンボジア電力公社（以下、「EDC」）との事前協議により、同時停電を避けることが可能であるため、安定した受電を行うことが可能である。

浄水場への通常時の電力供給に問題はなく、施設の建設・運転で使用する電力量がタクマウ市の電力供給に大きな負荷を与える可能性は低いと考えられる。

2-2-2　　自然条件

事業予定地の基礎資料として、測量調査、地盤及び土質調査、水源水質調査及び地下埋設物調査を実施した。各調査の概要は以下の通りである。

なお、「**2-2-3 環境社会配慮**」に詳細な自然状況や事業予定地について記載する。

2-2-2-1　測量調査

取水施設予定地及び浄水施設予定地にて測量調査を実施した。浄水施設予定地は、現地盤高 GL+12m 付近の平坦な用地であった。取水施設予定地は、バサック川の護岸の横断測量を実施しており、護岸形状は比較的なだらかな勾配であった。

2-2-2-2　地盤及び土質調査

取水施設及び浄水施設予定地にて、地盤及び土質調査を実施した。その結果、現況地盤高から 20m 付近まではN値10程度、30m付近でN値30程度、45～50m付近においてN値50以上の粘性土が堆積していることが確認された。この結果より、主要構造物は現況地盤高から 30m 付近の締まった粘土層が支持層となり、杭基礎が想定される。

2-2-2-3　水源水質調査

原水の水源・水質調査の結果を**表 2-2.1** に示す。

表 2-2.1　原水の水源・水質調査の結果

No.	Item	Unit	No.1	No. 2	No. 3	No. 4	No. 5	No. 6	CNDWQS
	Sampling Date		Mar. 29	Apr. 29	May 29	Jul. 3	Aug. 21	Sep. 11	
1	pH	^{o}C	7.64	7.30	6.75	7.90	7.65	7.07	6.5-8.5
2	Water Temp.	-	32.0	33.0	31.0	28.5	31.8	25.3	No value
3	Turbidity	NTU	18	6	48	12	142	300	<5.0
4	Colour	TCU	65	55	110	75	40	35	<5.0
5	Total Hardness	mg/L	110	130	170	124	95	140	<300
6	Total Alkalinity	mg/L	61	95	119	84	80	23	No value
7	COD_{Mn}	mg/L	5.88	3.33	5.00	0.86	2.54	5.88	<8.0[4)]
8	CN^-	mg/L	0.007	0.006	0.004	0.003	0.003	0.003	<0.02
9	NH_4-N	mg/L	0.017	1.09	3.35	0.44	0.08	0.19	1.5
10	Odor	-	No smell	No smell	No smell	No smell	No smell	No smell	Acceptable
11	F^-	mg/L	0.79	1.04	0.01	0.002	0.012	0.001	<1.5
12	NO_2-N	mg/L	0.03	0.09	0.14	0.10	0.01	0.02	<0.92
13	NO_3-N	mg/L	5.00	3.70	1.40	0.40	1.70	1.20	<11.3
14	SO_4^{2-}	mg/L	4.16	23	26	19	20	2.0	<250
15	Cl^-	mg/L	32.1	17.9	16.9	18.2	7.9	9.0	<250
16	Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001
17	Cr	mg/L	0.002	0.007	0.001	<0.0005	<0.0005	<0.0005	<0.05
18	Al	mg/L	<0.00003	<0.00003	0.002	<0.00003	0.035	0.035	<0.2
19	Cd	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.003
20	Cu	mg/L	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<1
21	Fe	mg/L	0.66	0.08	0.14	<0.013	<0.013	0.20	<0.3
22	Pb	mg/L	<0.0002	<0.0002	<0.0002	0.0010	<0.0002	<0.0002	<0.01

No.	Item	Unit	No.1	No. 2	No. 3	No. 4	No. 5	No. 6	CNDWQS
23	Mn	mg/L	0.138	0.019	0.046	<0.0003	<0.0003	0.0244	<0.1
24	Zn	mg/L	0.005	<0.001	0.007	<0.001	0.001	<0.001	<3
25	Total Coliforms	MPN/ 100ml	1.5×10^2	7.5×10^2	2.1×10^3	2.1×10^3	2×10^2	4.3×10^2	0
26	Geosmin	mg/L	0.000010	-	-	<0.000001	<0.000001	-	<0.00001[3)]
27	2-MIB[1)]	mg/L	0.000014	-	-	0.000002	0.000001	-	<0.00001[3)]
28	THMFP[2)]	mg/L	0.10	-	-	0.04	0.06	-	<0.1[3)]
29	Phenols	mg/L	<0.0005	-	-	0.0014	<0.0005	-	<0.005[3)]

CNDWQS: Cambodian National Drinking Water Quality Standard.
1) 2-MIB: 2-Methyl-Isoborneol
2) THMFP: Trihalomethane Formation Potential.
3) Japan Drinking Water Quality Standard.
4) Value of Cambodian water quality standard in public water areas.

除去が困難な有害物質等は検出されておらず、COD が高い傾向があるものの、水道水源として特に問題はない。濁度は 6NTU から 300NTU 程度である。アンモニア濃度が高い傾向及び取水地点上流の排水の影響により、原水中の大腸菌の濃度が高くなっているが、浄水施設で塩素処理を計画しているため、除去できるものと考える。

2-2-2-4　地下埋設物調査

地下埋設物調査は、既設管確認 1 箇所（Pit#3）、基礎杭の残置確認 2 箇所（Pit#1 及び Pit#2）にて調査を実施した。調査位置を**図 2-2.1** に示す。

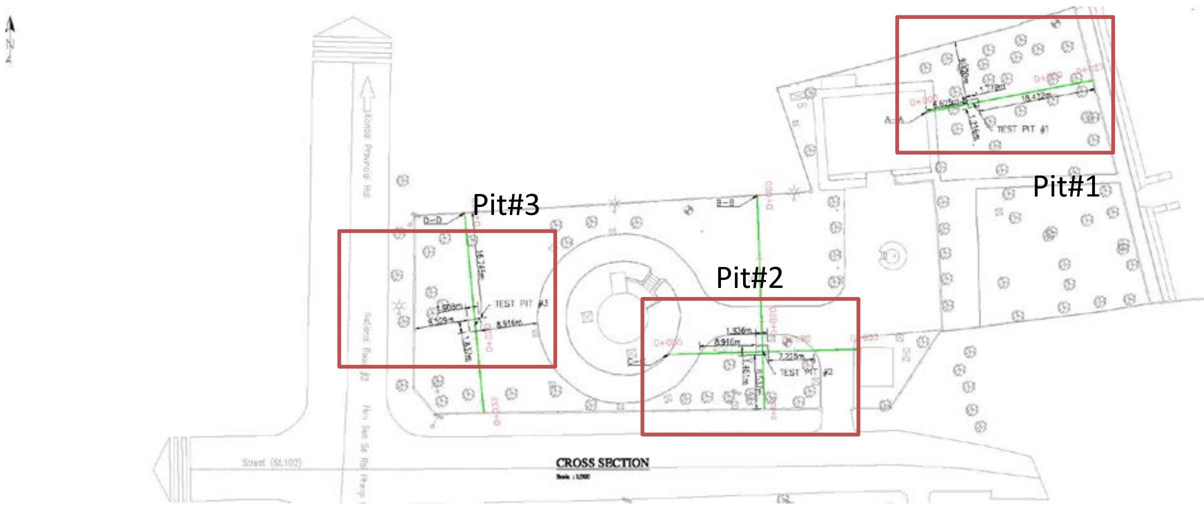


図 2-2.1　地下埋設物調査の調査位置

調査結果を**表 2-2.2** 及び**図 2-2.2** に示す。

表 2-2.2　地下埋設物調査の結果

	目的	試掘内容
Pit#1	基礎杭の残置確認	基礎杭の残置は確認されなかった
Pit#2	基礎杭の残置確認	試掘深さ約 3.3m にて基礎杭口径 400mm の残置を確認
Pit#3	既設管確認	試掘深さ約 2.2m にて既存配管 HDPE DN400 の確認

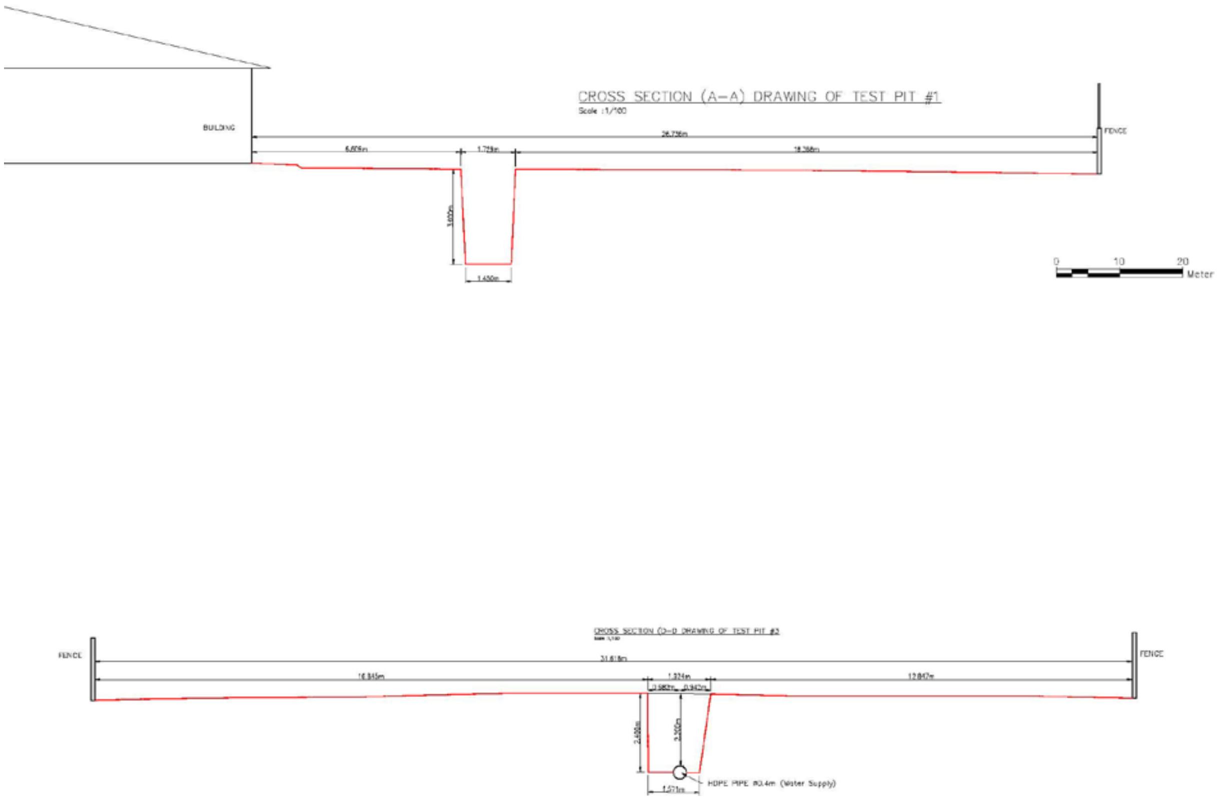


図 2-2.2　地下埋設物調査の結果

地下埋設物調査より、既存浄水場の改修時に、Pit#2 において構造物が残置されていることが確認された。

2-2-3　環境社会配慮

2-2-3-1　環境影響評価

本プロジェクトは JICA「環境社会配慮ガイドライン」（2010 年 4 月）が掲げる、影響を及ぼしやすい特性及び影響を受けやすい地域には該当せず（既存浄水場敷地内に浄水場建設)、環境カテゴリーB に分類される。カ国関連法（Sub-Decree on Environmental Impact Assessment Process）によると、初期環境影響評価（IEIA）/環境影響評価（EIA）は、1 万人以上を給水対象とする案件において必要となる。本プロジェクトは、将来の給水人口が 12 万人程度であるため、IEIA/EIA が必要である。また、カンボジア環境省（以下、「MoE」）は本プロジェクトの内容などを考慮し、IEIA 報告書のみの提出を承認した。本プロジェクトに関する IEIA 調査は、JICA 調査団及び MoE に登録された現地コンサルタント SUSTINAT Green Co., Ltd.の支援を受け、PPWSA より実施し、IEIA 報告書は 2019 年 8 月に MoE へ提出した。

2-2-3-2　環境社会影響を与える事業コンポーネントの概要

(1)　事業名称

- 「カンボジア国タクマウ上水道拡張計画準備調査」
- 「Project for Expansion of Water Supply System in Ta Khmau in the Kingdom of Cambodia」

(2)　対象地域

本プロジェクト対象地域は**図 2-2.3** に示す。タクマウ浄水場建設予定地は、プノンペン都南約 10 km にある PPWSA の既存の高架水槽及び料金徴収所の敷地内である。

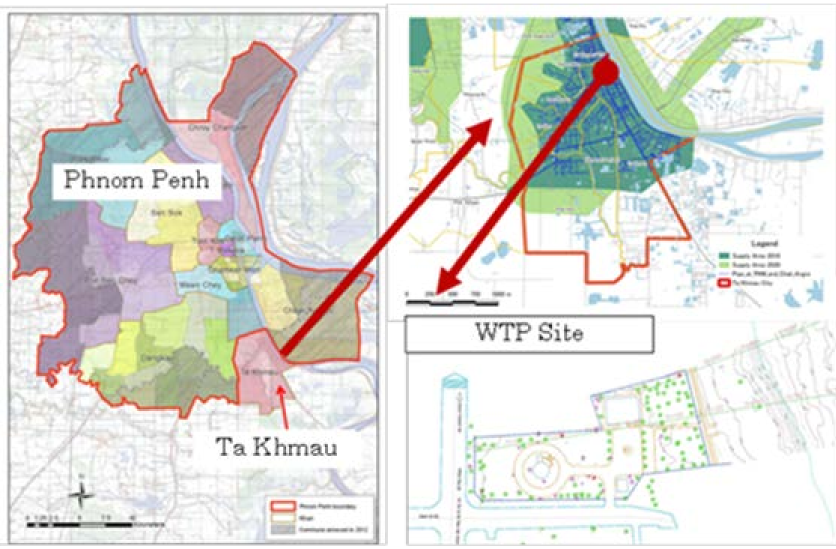


図 2-2.3　本プロジェクト対象地域の位置図

(3)　　施設の概要

本プロジェクトの構成要素は、取水施設、浄水場、配水池（浄水場敷地内）から成る。浄水場は PPWSA の所有地（既設施設の敷地）内に建設予定。全てのコンポーネントに関して住民移転は発生しない。プロジェクトの概要を**表 3-1.1** に示す。

2-2-3-2-2　　ベースとなる環境の状況

(1)　　自然環境

1)　　気象

プノンペン及びタクマウ市の気候区分は熱帯性モンスーン気候であり、雨季は 5 月から 11 月、乾季は 12 月から 4 月まで、1988 年から 2013 年までの平均最低気温は 22℃、平均最高気温は 35℃である。プノンペン及びタクマウ市の月平均降水量および気温を**図 2-2.4** に示す。

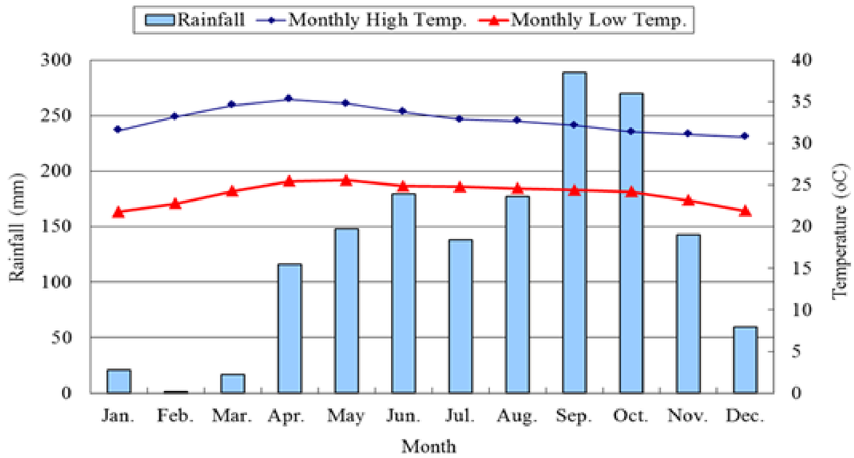


図 2-2.4　月平均降水量(2014-2018)・気温(1988‐2013)

出典：Department of Meteorology of Ministry of Water Resources and Meteorology

2)　　地形・地質

プノンペンはカ国の中央南部に位置し、カンダール州に囲まれている。 プノンペンとその周辺地域は、地盤高 GL+12m の典型的な洪水氾濫原地域で構成されている。プノンペンの土地利用計画を**図 2-2.5** に示す。

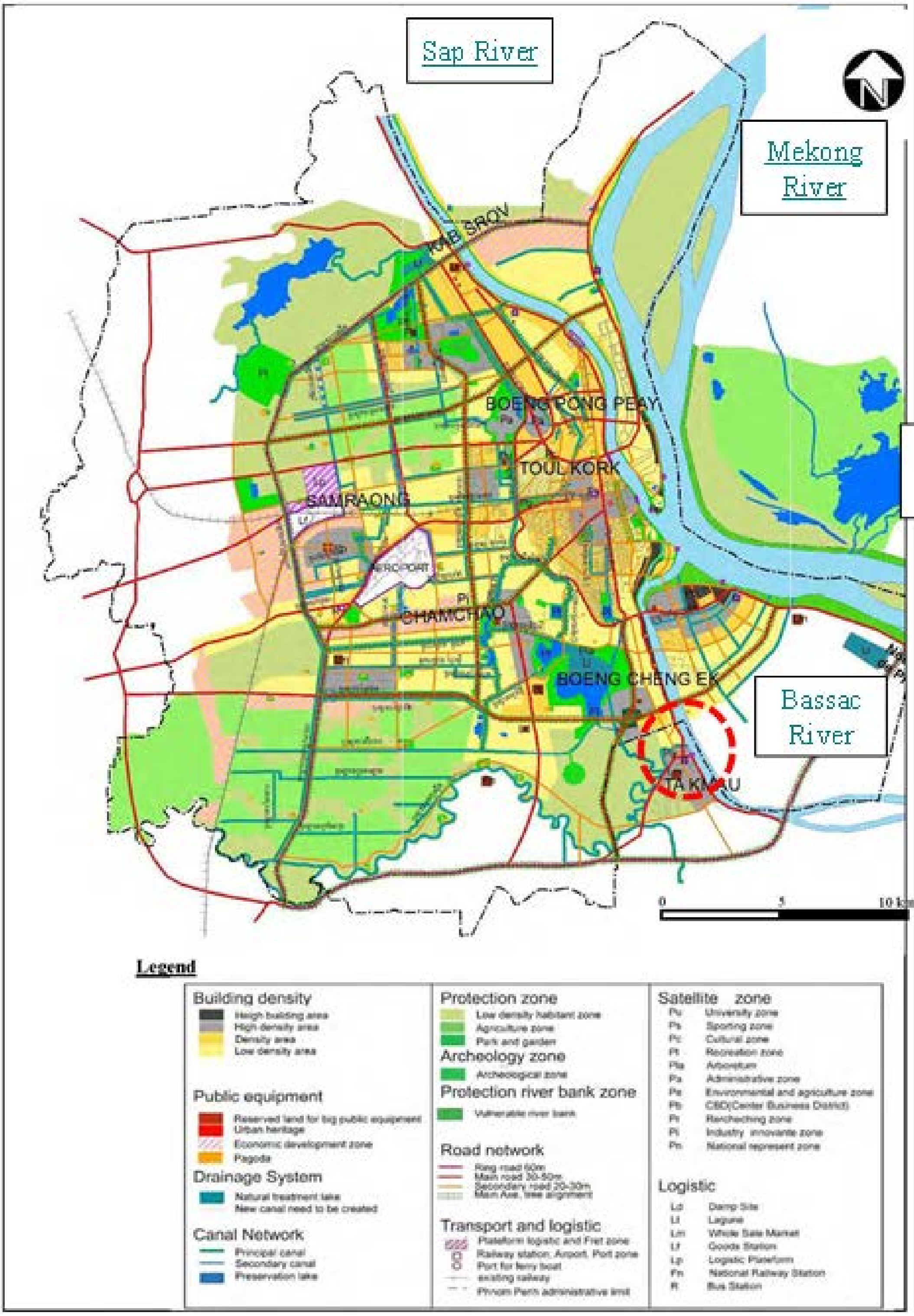


図 2-2.5　プノンペンの土地利用計画(2035)

出典：White Book on Development and Planning of Phnom Penh, PPCC

プノンペンの南に位置するタクマウ市は、カンダール州の州都且つ最大都市であり、面積は 30.47km^2 である。タクマウ市の就労人口の約 60%はプノンペンを勤務地としている。

3) 水環境

(a) 水質

バサック川（本プロジェクトの水源）は、取水予定地の上流でメコン川とサップ川が合流しており、バサック川の水質はメコン川とサップ川の影響を受けている。バサック川、メコン川、サップ川の主要水質項目を**表 2-2.3** に示す。

表 2-2.3　バサック川、メコン川、サップ川の水質

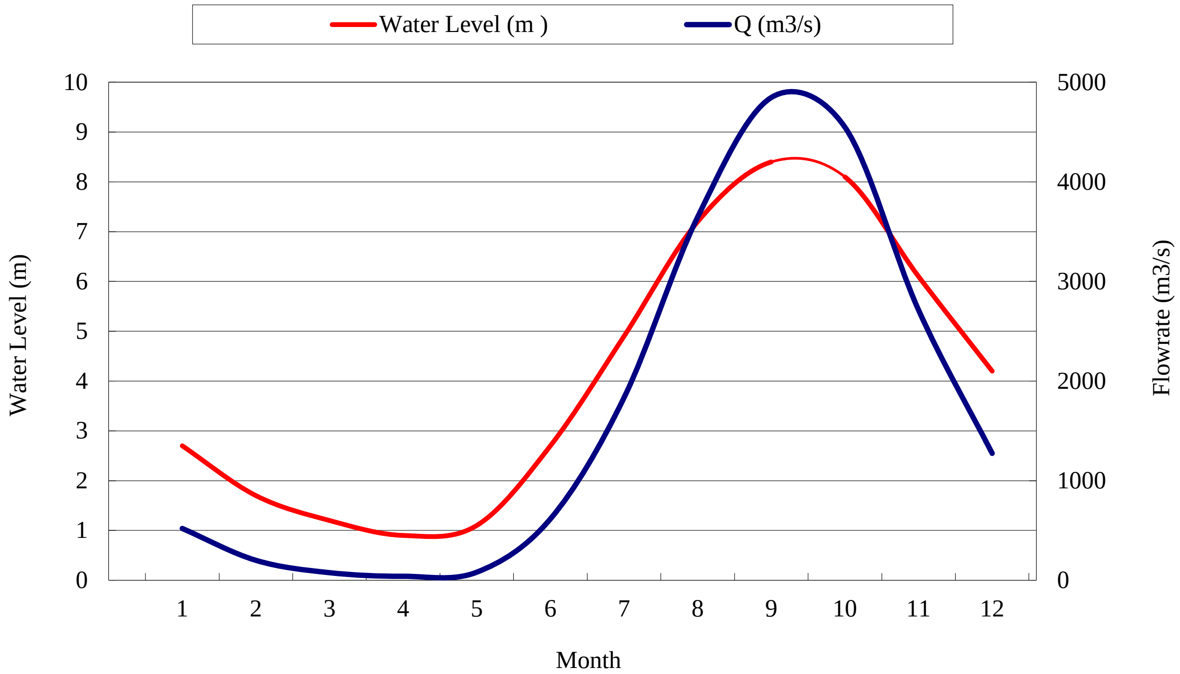
Parameter		Unit	Sap River[a]	Mekong River[b]	Bassac River[c]	CNDWS[d]
Physical	1. Temperature	℃	23.8 - 32.8 [1] 28.8 [2]	22.4 - 32.6 28.7	25.0 - 31.5 28.5	-
	2. pH	-	6.6 - 8.4 7.2	6.8 - 8.6 7.8	7.0 - 8.3 7.7	6.5-8.5
	3. Turbidity	NTU	8 - 1,000 111	9 - 913 113	7 - 972 105	5
	4. DO	mg/L	0.7 - 8.1 5.3	4.0 - 9.4 6.8	6.1 - 8.4 7.5	- (>5 [3])
	5. Color	TCU	5.3 - 80 25	0 - 132 26	5.3 - 80 25	5
Mineral	6. Conductivity	µs/cm	61 - 233 106	60 - 226 148	76 - 281 165	-
	7. Total hardness	mg/L	16 - 88 40	24 - 96 60	32 - 118 68	300
Chemical	8. Organic matter	mg/L	4 - 42 18	0.8 - 57 10	7.1 - 22 13	-
	9. Ammonia nitrogen	mg/L	0 - 1.63 0.37	0 - 0.48 0.13	0.10 - 1.81 0.59	1.5
	10. Iron	mg/L	0 - 6.4 0.6	0 - 3.4 0.26	0.09 - 1.95 0.67	0.3
	11. Manganese	mg/L	0 - 0.12 0.03	0 - 0.2 0.02	0.02 - 0.06 0.03	0.1
Biological	12. E. Coli	cfu/100mL	0 - $3*10^3$ $7*10^2$	0 - $3*10^4$ $7*10^2$	0 - $3*10^3$ $7*10^2$	0

Note: 1) Minimum and maximum values
2) Average values.
3) Japanese environmental standards for rivers (Class B, the lowest level of the water source for water supply)

出典: a) Third Master Plan 2016-2030 (Raw water quality of Phum Prek WTP)
b) Third Master Plan 2016-2030 (Raw water quality of Chroy Chanvar WTP)
c) JICA Survey Team based on the information provided by PPWSA (Raw water quality of Chamcar Mon WTP, 2016)
d) CNDWS: Cambodia National Drinking Water Standard

(b) 水量・水位

バサック川の平均水量と平均水位を**図 2-2.6** に示す。バサック川の水量は、乾季である 4 月に最小流量（40 m^3/秒）となる。タクマウ浄水場（33,000 m^3/日＝0.38 m^3/秒）の取水能力は、乾季のバサック川の水量の約およそ 0.95%を占める。



Monthly Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Q (m^3/s)	520	200	76	40	81	616	1,833	3,647	4,847	4,549	2,713	1,274	1,700
Water Level (m)	2.7	1.7	1.2	0.9	1.1	2.7	4.9	7.2	8.4	8.1	6.1	4.2	4.1

図 2-2.6　バサック川の水量・水位変動(1960-2014)

出典：Rehabilitation and Extension of Chamcar Mon WTP, SAFEGE, January 2016

尚、水位については、最低水位が 0.2m MSL（1960 年 5 月 4 日）、最高水位が 10.18mMSL（2000 年 9 月 20 日）を記録している（Chamcar Mon 浄水場の FS 調査）。また、2014 年—2018 年のデータ（水資源気象省、以下「MoWRAM」）によると、4 月の最低水量及び最低水位は 17 m^3/s と 1.59m であった。一方、最大流量及び最高水位は 5,229 m^3/s と 9.95m であった。

4) 保護区

2017 年までに、MoE は、国土の 41%に相当する 750 万ヘクタール以上をカバーする 50 の保護地域を指定した。当該保護地域は、**図 2-2.7** に示すように、プノンペンと本プロジェクト対象区域近辺には存在しない。

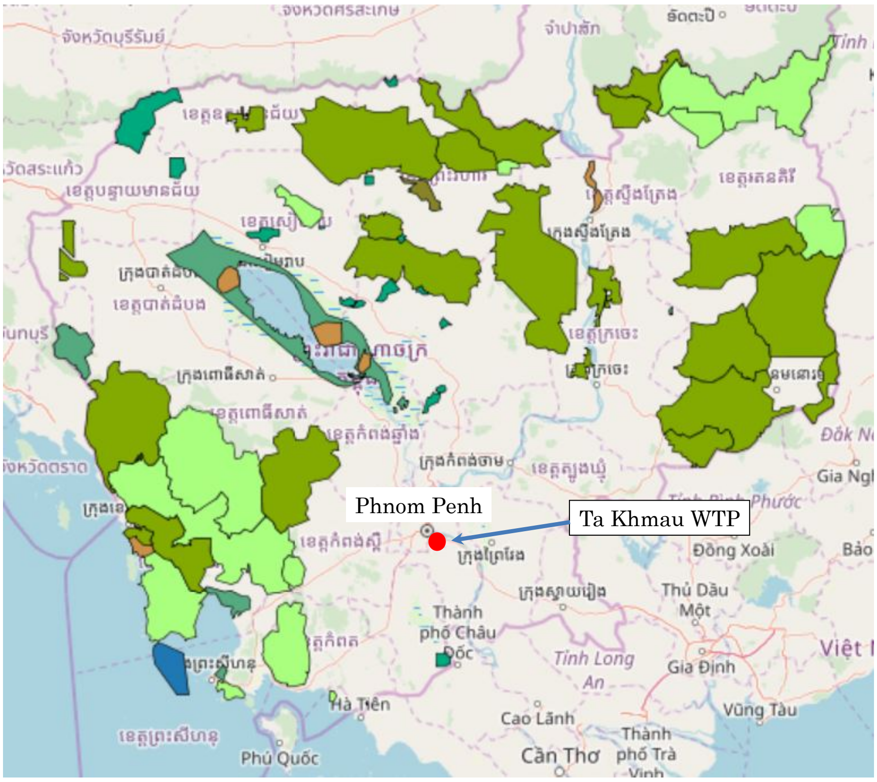


図 2-2.7 保護地域位置図

出典：MoE

(2) 社会環境

1) 人口

NCDD（National Council for Democratic Development）の 2013 年国勢調査によると、タクマウ市の面積と人口はそれぞれ 30.47 km^2 と 71,497 人である。 平均人口密度は約 2,346 人/ km^2 である。タクマウ市のコミューン毎の人口を**表 2-2.4** に示す。

表 2-2.4 タクマウ市面積と人口

No.	Sangkat (Commune)	Surface (km^2)	Population (2013) (person)	Density (2013) (person/km^2)
1	Daeum Mean	2.91	14,143	4,860
2	Ta Khmau	9.34	21,702	2,324
3	Prek Russei	2.07	9,388	4,535
4	Kompong Samnanh	3.42	12,421	3,632
5	Ta Kdol	2.49	5,587	2,244
6	Prek Hour	10.23	8,256	807
Total	-	**30.47**	**71,497**	-

出典: National Council for Democratic Development (NCDD)

2) 社会経済状況

タクマウ市の主要地区である Daeum Mean 及び Ta Khmau の両コミューン 98 世帯に対するインタビュー調査結果を**図 2-2.8** に示す。世帯最低収入は月間約 600,000KHR、最高収入は月間約 5,000,000KHR である。

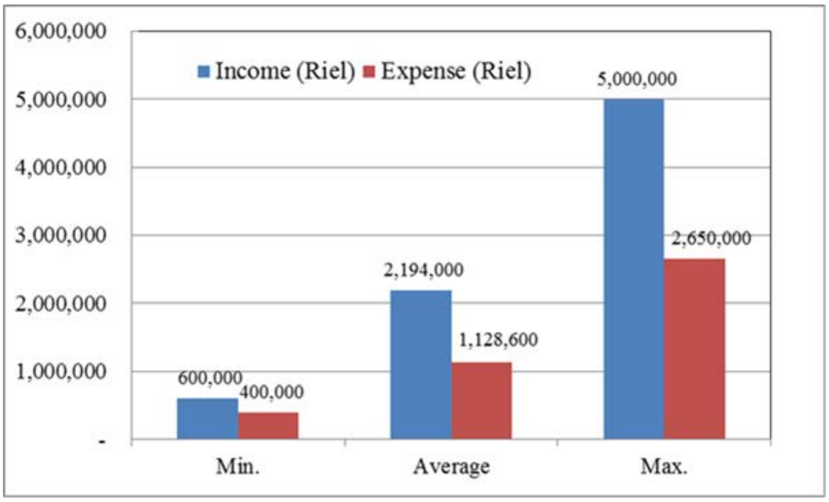


図 2-2.8 Daeum Mean 及び Ta Khmau コミューンにおける世帯の平均収入と支出

出典：Interview data, 21-22 June 2019

2-2-3-2-3 相手国の環境社会配慮制度・組織

(1) カンボジアの環境社会配慮関連法規の概要

カ国における環境社会配慮に関する法制度を**表 2-2.5** に示す。

表 2-2.5 カンボジアにおける環境社会配慮に関する法制度

No.	Law and Regulation	Date
1	Law on Environmental Protection and Natural Resource Management	Nov. 1996
2	No. 72 ANRK.BK, Anukret (Sub-decree) on Environmental Impact Assessment (EIA) Process	Aug. 1999
3	No. 376 BRK.BST, Prakas (Declaration) on General Guideline for Developing IEIA/EIA Reports	Sep. 2009
4	Prakas (Joint Declaration) between MoE and MEF on Determination of Service Fee for EIA Reviewing and Monitoring	2000 2012
5	No. 215 BRK, Prakas (Declaration) on Registration of Consulting Firm for Studying and Preparing Environmental and Social Impact Reports	May 2014
6	No.27 ANRK/BK, Anukret (Sub-decree) on Water Pollution Control	Apr. 1999
7	No.36 ANRK.BK, Anukret (Sub-decree) on Solid Waste Management	Apr. 1999
8	No. 42 ANK/BK, Anukret (Sub-decree) on the Control of Air Pollution and Noise Disturbance	Jul. 2000
9	Law on Water Resources Management	Jun. 2007
10	No. NS/RKM/0208/007, Law on Protected Area Management (Protected Areas Law)	Feb. 2008

(2) カンボジアの EIA 制度と JICA ガイドラインの乖離

カ国における環境影響評価制度については、JICA ガイドラインから大きな乖離はないが、戦略的環境アセスメント、地球温暖化、環境モニタリングフォーム、情報公開、代替案の比較に関する詳細な規定はない。JICA ガイドラインとカ国法規制の比較を**表 2-2.6** に示す。

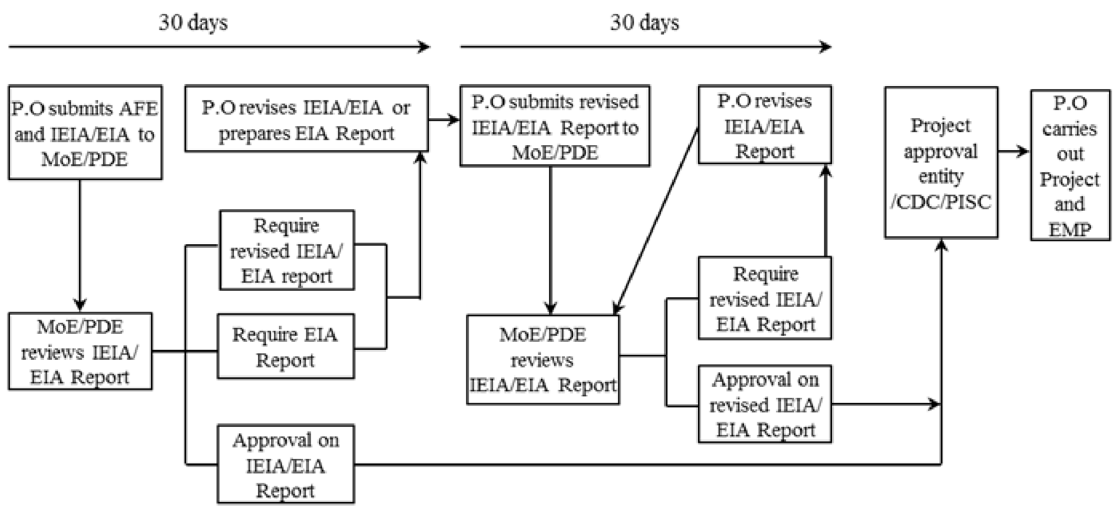
表 2-2.6　JICA ガイドラインとカンボジア法規制の比較

Item	JICA Guidelines	Cambodian Guidelines	Gaps of JICA and Cambodian GLs, Measures
Underlying principles	Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan.	An IEIA/EIA shall be conducted on every project and shall be approved by the MoE. Both positive and negative environmental and socio-economic impacts arising from their project activities shall be assessed.	Basically same as JICA guidelines, but alternatives analysis is not clarified. Alternative analysis was conducted in the Project.
Information disclose	EIA reports must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them. EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted.	Information disclosure is carried out through public participation such as stakeholder meeting.	Information disclosure is not clarified. In the Project, written materials will be provided to local residents in Khmer language, and finally a summary of the IEIA report will be disclosed to public via homepage of PPWSA.
Public consultation	For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of project plans. In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Records of such consultations must be prepared. Consultations with relevant stakeholders, such as local residents, should take place if necessary throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared.	Public participation is one of the important contents in the EIA report in Declaration on General Guideline for conducting IEIA/EIA Reports, 2009 (Annex 1). In IEIA/EIA report, following contents have to included: - Dissemination by the project owner with local authorities and local communities of the development project; - Feedback from relevant ministries/ agencies/ departments and relevant local authorities; - Comments from relevant non-government organizations (NGOs); - Consultation with affected local communities	No significant gaps. However, no specific requirements for records and timing of stakeholder meeting area provided. In the Project, records of public consultation were prepared and stakeholder meeting was held during the preparatory survey.

Item	JICA Guidelines	Cambodian Guidelines	Gaps of JICA and Cambodian GLs, Measures
Impacts assessment items	The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle should be considered throughout the life cycle of the project.	Detailed assessment of physical, biological and socio-economic environment and resources are required, based mainly on primary data on the area within or in the surrounding the project site. This will form the basis for identification, prediction and analysis of potential adverse environmental and social impacts by project activities, aiming to identify actions to minimize negative impacts and maximize positive impacts. Following items have to be included in IEIA/EIA report: Physical resources: soil, climate, air quality, hydrology. Biological resources: forest, wildlife species, habitats, biodiversity and ecology system, wet land system. Socio-economic aspects: demography and settlement, economic status, land use, water use, energy use, infrastructure, education, public health and well-being, cultural heritages, tourism area	Basically same as JICA guidelines, but no detailed items are clarified. JICA Guidelines has been applied.
Monitoring	Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems.	Environmental monitoring is required under EMP. However, no monitoring forms are clarified.	It is proposed to apply monitoring forms based on JICA guidelines.
Ecosystem and biota	Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests.	Description and impacts analysis of biological resources (including forest, wildlife species, habitats, biodiversity and ecology system, wet land system) are required in the Declaration on General Guideline for conducting IEIA1/EIA Reports, 2009 (Annex 1).	Basically same as JICA guidelines.
Indigenous peoples	Any adverse impacts that a project may have on indigenous peoples are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures must be taken to minimize impacts and to compensate indigenous peoples for their losses.	Description and impacts analysis of ethnic minority or indigenous people are required.	Basically same as JICA guidelines.

(3)　　EIA/IEIA 手続き

カ国関連法（Sub-Decree on Environmental Impact Assessment Process）によると、初期環境影響評価（IEIA）/環境影響評価（EIA）は、1 万人以上を給水対象とする案件において必要となる。本プロジェクトは、将来の給水人口が 12 万人程度であるため、IEIA/EIA が必要である。カ国における IEIA/EIA の手続きを**図 2-2.9** に示す。



Note:

P.O:	Project Owner	**PDE:**	Provincial Department of Environment
AFE:	Application Form of Environment	**CDC:**	Council for Development of Cambodia
IEIA:	Initial Environmental Impact Assessment	**PISC:**	Provincial Investment Sub-committee
EIA:	Full Environmental Impact Assessment	**EMP:**	Environmental Management Plan
MoE:	Ministry of Environment		

図 2-2.9　カンボジアにおける IEIA/EIA の手続き

出典：Declaration on General Guidelines for Developing IEIA/EIA Reports (2009)

関連機関の役割と責任は**表 2-2.7** の通りである。

表 2-2.7　関連機関の役割と責任

No.	Organization	Roles and Responsibilities
1	MoE	MoE is responsible for project screening and scoping (approval of TOR), review and evaluation of IEIA/EIA report, monitoring and follow-up on EMP etc. (projects with more than 2 million USD investment) MoE is also responsible for monitoring illegal disposal of construction solid wastes.
2	PDE	PDE is responsible for project screening and scoping (approval of TOR), review and evaluation of IEIA/EIA report, monitoring and follow-up on EMP etc. (projects with less than 2 million USD investment)
3	CDC	CDC is responsible for approving the IEIA/EIA report and supporting FDI (Foreign Direct Investment) for IEIA/EIA study. Facilitates and coordinates government-donor relations.
4	PISC	Supports provincial governor for approving the IEIA/EIA report (small project).
5	MIH	As regular member for concerned ministry for industrial compliance and monitoring.
6	MoWRAM	Approval for intake water
7	MLMUPC	Responsible for construction permit and compliance based on Sub-Decree No.86

No.	Organization	Roles and Responsibilities
8	CNMC	Approval for intake water
9	ISC	Responsible for establishing national standards

MIH: Ministry of Industry and Handicraft
MoWRAM: Minister of Water Resources and Meteorology
MLMUPC: Ministry of Land Management, Urbanization and Construction
CNMC: Cambodia National Mekong Committee
ISC: Institute of Standards of Cambodia

尚、MoE は本プロジェクトの特性を考慮し、IEIA 報告書のみの提出を承認した。本プロジェクトに関する IEIA 調査は、JICA 調査団及び MoE に登録された現地コンサルタント SUSTINAT Green Co., Ltd.の支援のもと、PPWSA が実施し、IEIA 報告書は 2019 年 8 月に MoE へ提出した。

2-2-3-2-4　代替案（ゼロオプションを含む）の比較検討

環環境へのマイナス影響を回避・最小化するために、事業を実施しない案を含む代替案の検討実施結果を**表 2-2.8** に示す。必要性、住民移転や費用効果等を勘案した。

表 2-2.8　代替案の検討

Item		Alternative 1 Without Project	Alternative 2 With Project
WTP	Capacity	0	30,000 m^3/day
	Area	0	App. 0.45 ha
	Location	-	Within the existing facility site owned by PPWSA
	Shortage of drinking water supplied	Negative impacts	Positive impacts
Technical aspect	Dealing with raw water pollution	-	Partly yes
	Transmission water from other WTPs	Needed	Not needed
	Construction cost	0	High
	O&M cost	High (long distance transmission)	Mid (short distance transmission)
	O&M level	-	Mid-level
Environmental and social considerations	1) Land acquisition	Not needed	Not needed
	2) Public health	Negative impacts (no water supply during water stop period due to limited treated water volume from other WTPs)	Positive impacts (stable water supply)
	3) Waste (sludge etc.)	-	Light impacts
	4) Low income households	Light impacts (current tariff)	Positive impacts (tariff may be reduced)
Preferred option		Not recommended (unstable water supply and negative impacts on public health)	Recommended (stable water supply and positive impacts on public health)

2-2-3-2-5　　スコーピング

本プロジェクトは JICA「環境社会配慮ガイドライン」（2010 年 4 月）が掲げる、既存浄水場敷地内での浄水場建設のため、”影響を及ぼしやすい特性及び影響を受けやすい地域”には該当せず)、環境カテゴリーB に分類される。よって、当該ガイドラインに基づき、IEE（初期環境調査 : Initial Environmental Examination） レベル調査を行った。

IEE レベル調査は、JICA 環境社会配慮ガイドラインにおいて“既存データ等比較的容易に入手可能な情報、必要に応じた簡易な現地調査に基づき、代替案、環境影響の予測･評価、緩和策、モニタリング計画の検討等を実施するレベル”と定義される。本プロジェクトに関するスコーピング結果を**表 2-2.9** に示す。

表 2-2.9　スコーピングチェックリスト

No.	Impact Item	Evaluation		Comments
		P & C	Operation	
Social Environment				
1	Resettlement	D	D	Since the WTP will be constructed on the land owned by PPWSA, there will be no land acquisition or involuntary resettlement for the Project.
2	Local economy (employment and livelihood etc.)	D	B+	Water supply project will create positive impacts on the local economy due to increase of service level.
3	Land use and utilization of local resources (fishing)	C	D	There are some non-licensed fishing activities. Some impacts on the fishing activities may occur. Some countermeasures will be necessary to reduce the impacts.
4	Water usage/water right	C	B-	Intake amount (33,000 m^3/d) will have impacts on water usage. Intake approval will be necessary.
5	Social institutions	D	D	Water supply system construction normally has limited negative impact on social institutions.
6	Existing social infrastructures and services (such as traffic etc.)	B-	C	Traffic disruption (especially on National Road No. 2) may occur during construction. The impacts of traffic congestion should be examined. No pipeline installation is planned.
7	Poor households	C	C	Appropriate water tariff with consideration for low income users will be studied.
8	Indigenous, or ethnic people	D	D	According to the results of socio-economic survey at Daeum Mean and Ta Khmau communes, no group of ethnic minorities were identified. Thus, the impacts on ethnic people will be not expected.
9	Misdistribution of benefit and damage	D	D	This is unlikely since the project will provide 100% service coverage to the area.
10	Local conflict of interests	D	D	This is unlikely since the project will provide 100% service coverage to the area.
11	Gender	D	B+	During construction stage, female workers may be employed for construction works. However, the number of female workers will be very few based on past experience of grant aid project in Cambodia. The impact will be limited. Workload of women and children in collecting water from wells and public water taps will be reduced after operation.
12	Children’s rights	D	B+	Health of children will be improved.
13	Cultural heritage	D	D	There will be no negative impact since no pipeline installation is planned and the WTP will be built at an existing site. In addition, there are no cultural heritages around the construction site.
14	Infectious diseases such as HIV/AIDS	C	D	Some local workers will be employed for the construction and there may be a potential of infectious diseases such as HIV/AIDS.

No.	Impact Item	Evaluation		Comments
		P & C	Operation	
				Some measures will be taken.
15	Accidents (risk etc.) and working environment	C	D	During construction, some accidents (collapse etc.) and poor working environment (such as forced overtime work etc.) can be considered. However, some safety measures will be taken to prevent accidents. SPC will transfer Japanese O/M know-how to PPWSA staff to ensure safe operation of the facilities. PPWSA will also conduct monitoring on working environment.
Natural Environment				
16	Geographical features	D	D	The change of topography and geology due to excavation (the depth of excavation at intake tower is estimated about 3-4 meters) will be limited.
17	Ground subsidence	D	D	No ground subsidence is expected due to application of piles for supporting the structures.
18	Bottom sediment	D	D	During construction of the intake, bottom sediment may be disturbed for only a very short-period.
19	Biota and ecosystem	D	D	According to the results of IEIA survey, the project site does not encompass primeval forests, tropical rain forests, or ecologically valuable habitats. Survey results show that of 13 species of birds, all of them are common species. Because the construction site is very limited, impacts are not expected.
20	Meteorology (global warming)	D	B+	Power consumption at distribution pumping station is expected to be reduced because the WTP is closed to the service area.
21	Landscape	D	D	The scale of the proposed facilities is small (app. 0.2ha, 55m×35m). The impact is considered to be negligible.
22	Protected areas	D	D	There is no protected area near Phnom Penh and Ta Khmau.
Pollution				
23	Air pollution	B-	D	During construction, dust and exhaust gas may be generated by construction equipment, vehicles, and excavation activities. During WTP operation, no negative impact on air pollution is expected because no SO_2, NO_2, CO, or dust will be discharged.
24	Water pollution	B-	B-	During construction, water pollution may occur due to construction of intake facility and discharge of wastewater from construction sites. During WTP operation, backwash water will be recycled and wastewater from the administration building will be treated by wastewater treatment facility.
25	Soil pollution	D	D	Impacts of sludge on soil are expected to be limited since no toxic materials will be applied during operation phase.
26	Waste	C	B-	During construction, construction wastes will be transported and disposed to Boeng Tompun (lagoon) for landfill reuse. However, sludge will be transported outside of the WTP.
27	Noise and vibration	C	D	There are no hospitals, schools and residence around the construction site. Pumps will be housed in the pumping station.
28	Offensive odor	D	D	No odor will be produced.

注; P & C: Pre-construction and construction phase
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Impacts are unknown and necessary to be studied.
D: Negative impact is negligible.

2-2-3-2-6　環境社会配慮調査の TOR

スコーピング結果に基づき、自然環境及び社会環境に対する潜在的なマイナス影響の調査方法を提案した（**表 2-2.10**）。

表 2-2.10　IEE（IEIA）の TOR

No.	Impact Item	Study Item	Proposed Study Method and Alternatives
1	Utilization of local resources (fishing)	Number of fishing activity around the WTP	1) Collection information from local authorities. 2) Collection information by IEIA study team at site.
2	Water usage/water right	Low flowrate of Bassac River	1) Collection information from PPWSA and MOWRAM. 2) Obtain approval from related authorities.
3	Traffic	Current traffic situation	1) Confirm residential situations and current traffic flow around the WTP during IEIA study. 2) Confirm construction methods and equipment. 3) Propose traffic control methods.
4	Poor households	1) Poverty rate 2) Current tariff system	1) Interview survey during IEIA study. 2) Collection information from PPWSA and local authority.
5	Infectious diseases such as HIV/AIDS	Number of local workers	1) Confirm construction method and period etc. 2) Collection information from existing projects through PPWSA.
6	Accidents (risk etc.)	Safety regulations and historical records	1) Collection information from related authorities. 2) Collection information from PPWSA and other WTPs for historical accident records.
7	Air pollution	1) Air quality standards 2) Current air quality	1) Collection environmental standards and existing air quality data. 2) Measuring current air quality during IEIA study.
8	Water pollution	1) Surface water quality standards 2) Current water quality	1) Collection surface water quality standards and existing information of water quality in Bassac River. 2) Water quality survey in Bassac River
9	Waste	Reuse methods and regulations etc.	1) Confirm with MoE for sludge disposal and reuse. 2) Confirm with PPWSA for reuse methods.
10	Noise and vibration	1) Noise standards 2) Current noise level	1) Collection environmental standards for noise and existing noise data. 2) Measuring current noise level. 3) Propose noise control measures.

2-2-3-2-7　環境社会配慮調査結果（予測結果を含む）

前節で作成した TOR に従い作成した調査結果について、**表 2-2.11** で整理する。

表 2-2.11　環境社会配慮調査結果

<table>
<tr><th>No.</th><th>Impact Item</th><th>Results of Assessment</th></tr>
<tr><td>1</td><td>Alternatives examination</td><td>To avoid or minimize significant environmental and social impacts as well as to reduce construction and O/M costs, alternatives studies on water treatment have been examined.</td></tr>
<tr><td>2</td><td>Utilization of local resources (fishing)</td><td>According to the information from Chief of Ta Khmau Commune, there are some non-licensed fishing activities (app. 10 Vietnamese and Cham families who are not residents of Ta Khmau City). During the construction phase, the turbidity of river water downstream (0 to 500 m) may increas. There will be no toxic materials to be discharged into the river. Thus, water pollution downstream of the river is considered to be limited.
In addition, fishing activity is prohibited from July 1 to November 30 each year because this is the breeding season for all kinds of fish. Therefore, the impacts of the construction on fishing activity are not expected during this period. During fishing season, the construction of the WTP may create impacts on fishing activity. However, fishing activity can be conducted at upstream or downstream (500m or more) of intake construction site. Therefore, the impacts on fishing activity are low and mitigable.</td></tr>
<tr><td>3</td><td>Water usage/water right</td><td>Raw water of 0.38 m^3/s (33,000 m^3/d) will be intaken from Bassac River, which is 0.95% of monthly minimum flowrate (40 m^3/s) of the River. In addition, an approval letter has been issued unconditionally from Cambodia National Mekong Committee (CNMC) and Minister of Water Resources and Meteorology (MoWRAM). Therefore, the impacts on water usage are low.
However, in case of extreme low flowrate (For example, on May 4th 1960 the lowest water level was 0.2 m MSL), intake stop may occur. Countermeasures should be considered.</td></tr>
<tr><td>4</td><td>Traffic</td><td>1) The field observation shows that traffic flow along the road around the WTP after 8 am is light (<1,000 veh/hr).
2) There are no residents around the WTP, but there is some infrastructure such as factories. In addition, before 7 am, most people already start for work, while the construction will start from 8 am.
3) Trucks and other construction vehicles (total number is estimated to be about 17 per day) may create negative impacts on National Road No. 2 and some countermeasures should be considered.
4) If some traffic control measures are applied, the impacts on traffic are low.</td></tr>
<tr><td>5</td><td>Poor households</td><td>Poverty rate in Ta Khmau City is presented in the following table.
<table>
<tr><th>No.</th><th>Sangkat (Commune)</th><th>ID Poor 1
(the poorest)</th><th>ID Poor 2
(poor)</th></tr>
<tr><td>1</td><td>Daeum Mean</td><td>30</td><td>25</td></tr>
<tr><td>2</td><td>Ta Khmau</td><td>147</td><td>120</td></tr>
<tr><td>3</td><td>Prek Russei</td><td>79</td><td>93</td></tr>
<tr><td>4</td><td>Kompong Samnanh</td><td>56</td><td>73</td></tr>
<tr><td>5</td><td>Ta Kdol</td><td>25</td><td>51</td></tr>
<tr><td>6</td><td>Prek Hour</td><td>80</td><td>149</td></tr>
<tr><td>Total</td><td>-</td><td>417</td><td>511</td></tr>
</table>
Source: Interview data with village/commune authorities.

PPWSA has set appropriate water tariff system and house connection fee for low income households based on its water supply for poor program. Comparing the water tariff system of 2001 to 2017, current unit tariff has been reduced by 9% to 27% for low water consumption (0 to 7 m^3/month, for details see Section 2-1-2-3 Water Tariff System). PPWSA has also applied subsidy policy for the poorest since May, 2005: 30%, 50%, 70% and 100% of the total connections fee based on the real poverty. In addition, the WTP will be constructed using Japanese Grant Aid, which will reduce the financial pressure of PPWSA, allowing it to set lower tariff to the public.
Therefore, the impacts on poor households are low or even positive.</td></tr>
<tr><td>6</td><td>Infectious diseases such as HIV/AIDS</td><td>1) The maximum number of local workers is estimated to be less than 100 persons.
2) Law on the prevention and control of HIV/AIDS in Cambodia (2002) stipulates the importance of information, education and communication.
3) If some education and control measures are applied, the impacts are considered to be low.</td></tr>
<tr><td>7</td><td>Accidents (risk etc.)</td><td>Cambodian construction workers are facing many health and safety issues at work, with some losing their lives while others are often disabled. The International Labour Organization (ILO) cited several reasons, including the absence of an Occupational Safety and Health (OSH) law and regulation for labour inspection in construction sites, lack of resources to enforce standards and unsatisfactory data on work-related accidents.
and unsatisfactory data on work-related accidents.</td></tr>
</table>

<table>
<tr><th>No.</th><th>Impact Item</th><th>Results of Assessment</th></tr>
<tr><td></td><td></td><td>During the construction phase of the Project, some countermeasures have to be applied to avoid accidents.</td></tr>
<tr><td>8</td><td>Air pollution</td><td>Air quality standard of Cambodia, Japan and current air quality at Daeum Mean commune are shown in the following table.
<table>
<tr><th>No.</th><th>Parameters</th><th>Unit</th><th>Daeum Mean</th><th>Cambodia Standard</th><th>Japan Standard</th></tr>
<tr><td>1</td><td>Carbon monoxide (CO)</td><td>mg/m^3</td><td>0.87</td><td>20</td><td>20</td></tr>
<tr><td>2</td><td>Nitrogen dioxide (NO_2)</td><td>mg/m^3</td><td>0.026</td><td>0.1</td><td>0.04</td></tr>
<tr><td>3</td><td>Sulfur dioxide (SO_2)</td><td>mg/m^3</td><td>0.024</td><td>0.3</td><td>0.04</td></tr>
<tr><td>4</td><td>Ozone (O_3)</td><td>mg/m^3</td><td>0.47</td><td>0.2</td><td>0.06</td></tr>
<tr><td>5</td><td>Lead (Pb)</td><td>mg/m^3</td><td>ND</td><td>0.005</td><td>-</td></tr>
<tr><td>6</td><td>Total suspended particles (TSP)</td><td>mg/m^3</td><td>0.231</td><td>0.33</td><td>0.1</td></tr>
<tr><td>7</td><td>Particulate matter 10 (PM10)</td><td>mg/m^3</td><td>0.112</td><td>0.005</td><td>-</td></tr>
<tr><td>8</td><td>Particulate matter 2.5 (PM2.5)</td><td>mg/m^3</td><td>0.081</td><td>0.025</td><td>0.015</td></tr>
</table>
Source: MoE Yearbook 2019

In the project area, the level of O_3, PM10 and PM2.5 are slightly above standard which requires to do dust pollution control during construction.</td></tr>
<tr><td>9</td><td>Water pollution</td><td>Drinking water quality standard of Cambodia, Japan and current water quality in Bassac River are shown in the following table.
<table>
<tr><th>Parameter</th><th>Unit</th><th>2016</th><th>2019</th><th>CNDWS</th><th>Japan 1)</th></tr>
<tr><td>1. Temp.</td><td>^0C</td><td>25.0 - 31.5
28.5</td><td>25.3 – 33.0
30.3</td><td>-</td><td>-</td></tr>
<tr><td>2. pH</td><td>-</td><td>7.0 - 8.3
7.7</td><td>6.75 - 7.90
7.39</td><td>6.5-8.5</td><td>5.8-8.6</td></tr>
<tr><td>3. Turbidity</td><td>NTU</td><td>7 - 972
105</td><td>6 - 300
88</td><td>5</td><td>2</td></tr>
<tr><td>4. DO</td><td>mg/L</td><td>6.1 - 8.4
7.5</td><td>-</td><td>-</td><td>>5 2)</td></tr>
<tr><td>5. Color</td><td>TCU</td><td>5.3 - 80
25</td><td>35 - 110
63</td><td>5</td><td>5</td></tr>
<tr><td>6. COD_{Mn}</td><td>mg/L</td><td>1.78 – 5.5
3.25</td><td>0.86 – 5.88
3.92</td><td>-</td><td>3 (TOC)</td></tr>
<tr><td>7. Ammonia nitrogen</td><td>mg/L</td><td>0.10 - 1.81
0.59</td><td>0.02 - 3.35
0.86</td><td>1.5</td><td>-</td></tr>
<tr><td>8. E. Coli</td><td>cfu/100mL</td><td>$0 - 3*10^3$
$7*10^2$</td><td>$1.5 - 7.5*10^3$
$3.3*10^2$</td><td>0</td><td>0</td></tr>
</table>
Source: JICA Survey Team.

1) Japanese drinking water quality.
2) Japanese environmental standards for rivers (Class B, the lowest level of the water source for water supply)
CNDWS: Cambodia National Drinking Water Standard

The average concentrations of COD_{Mn} and ammonia Bassac River in 2019 are slightly increased comparing with that of 2016. In addition, during construction phase, it is estimated that wastewater from the daily use of staff-workers approximately 2.4 m^3/d which will discharged into existing sewer located along National Road No.2 with other wastewaters generated from construction site.
During operation phase, backwash water (app. 480 m^3/d) will be recycled within the WTP after treatment. Domestic wastewater will be treated by septic tank and then discharged into existing sewer.</td></tr>
<tr><td>10</td><td>Waste</td><td>During construction phase, part of construction waste soil (app. 1,000 m^3) will be reused for backfilling at construction site. The remaining waste soil (app. 1,000 m^3) will be reused for backfilling of Boeng Tompun (lagoon, 3 km far from the WTP). Other construction wastes will be disposed at existing solid waste landfill site by a licensed contractor. The amount of domestic solid wastes is estimated to be only around 5 kg/d from construction site. In addition, temporary toilet at the construction site for workers should be installed during construction considering limited capacity of existing toilet located at the site.
During operation phase, PPWSA will collect and transport sludge (app. 3 tDS/d) to the new landfill site because the existing Dangkor landfill site (10 km far from the WTP, with leachate treatment) will be full by the end of 2020 or early 2021 and Phnom Penh authorities are looking for sites that can replace the Dangkor landfill site in Kandal Provincial. In addition, now PPWSA is preparing a plan to sell sludge to local construction company who intends to reuse sludge as backfilling materials.</td></tr>
<tr><td>11</td><td>Noise and</td><td>Noise standard of Cambodia and Japan is shown in the following table. In addition, there is no</td></tr>
</table>

No.	Impact Item	Results of Assessment
	vibration	standard for vibration in Cambodia.

No.	Location	Duration		
		6:00-18:00	18:00-22:00	22:00-6:00
1	Silent areas (hospitals, schools, libraries and kindergartens)	≤ 45 (50)1)	≤ 40 (50)	≤ 35 (40)
2	Residential area (hotel, administration offices, villa, apartment)	≤ 60 (55)	≤ 60 (55)	≤ 45 (45)
3	Mixed commercial, business and service areas	≤ 70 (65)	≤ 65 (65)	≤ 50 (60)
4	Heavy industries mixed with residential areas	≤ 75 (70)	≤ 70 (70)	≤ 50 (65)

Source: MoE
1): Japanese noise standard.

In this project, a noise survey was conducted within the existing WTP site and the results are summarized in the following table.

Time	Noise [dB(A)]	Cambodian Standard1) [dB(A)]
Day (6:00-18:00)	57-69	75
Evening (18:00-22:00)	52-63	70
Night (22:00-6:00)	45-57	50

Source: JICA Survey Team
1) Standard for heavy industries mixed with residential areas.

The noise levels at the project area are lower than that of Cambodian standards, while the noise levels in night time exceeded the standard occasionally. In addition, no sensitive facilities such as (hospital or school etc.) around the WTP site have been identified. However, it is estimated that noise levels at the boundary of the WTP in day time would be 78 to 87 dB due to operation of construction equipment and vehicles, which has exceeded the standard (75 dB) slightly.

The results of vibration survey within the existing WTP site and Japanese standards are presented in the following table.

Time	Vibration (dB)	Japanese Standard1) (dB)
Day (8:00-19:00)	Leg: 13-26 (Lmax: 17-52)	65
Night (19:00-8:00)	Leg: 13-40 (Lmax: 16-75)	60

Source: JICA Survey Team
1) Environmental Quality Standard of Japan.

The vibration levels (equivalent levels) at the project area are lower than that of Japanese standards.

2-2-3-2-8　　影響評価

「**2-2-3-2-7　環境社会配慮調査結果（予測結果を含む）**」の調査結果に基づき、本案件による環境社会影響を評価した。その結果を**表 2-2.12** に示した。また、スコーピング時の影響評価も併記した。

表 2-2.12　影響評価の結果

No.	Item	Assessment in Scoping Phase		Assessment by Survey Results		Contents
		P&C	O	P&C	O	
Social Environment						
1	Resettlement	D	D	N/A	N/A	-
2	Local economy (employment and livelihood etc.)	D	B+	N/A	B+	-
3	Land use and utilization of local resources (fishing)	C	D	B-	N/A	There are some non-licensed fishing activities. Some impacts on the fishing activities may occur. Before construction starts, information will be delivered to fisherman via commune and village chiefs in advance. During fishing season, fishing activity can be conducted at upstream or downstream (500m or more) of intake construction site
4	Water usage/water right	C	B-	D	B-	Compared with low flow (40 m^3/s) of Bassac river, intake volume (0.38 m^3/s) will not have significant impacts on water usage. An approval letter has been obtained from Cambodia National Mekong Committee on Sep. 12, 2019. However, in case of extreme low flowrate of Bassac River, intake stop may occur.
5	Social institutions	D	D	N/A	N/A	-
6	Existing social infrastructures and services (such as traffic etc.)	B-	C	B-	D	Traffic flow along the road around the WTP after 8 am is light. Trucks and other construction vehicles (17vehicles/day) may create negative impacts on public traffic. Therefore, some measures should be taken. During operation, the impacts on traffic are expected to be very limited because there are very few vehicles in the WTP.
7	Poor households	C	C	D	B+	Total number of Poor 1 and Poor 2 householders in Ta Khmau City is 928. The WTP will be constructed by using Japanese Grant Aid, which will reduce the financial pressure of PPWSA, allowing it to set lower tariff to the public. PPWSA has also set appropriate water tariff system and house connection fee for low income households. Therefore, the impacts are expected to be positive.
8	Indigenous, or ethnic people	D	D	N/A	N/A	-
9	Misdistribution of benefit and damage	D	D	N/A	N/A	-
10	Local conflict of interests	D	D	N/A	N/A	-
11	Gender	D	B+	N/A	B+	-
12	Children’s rights	D	B+	N/A	B+	-
13	Cultural heritage	D	D	N/A	N/A	-
14	Infectious diseases such as HIV/AIDS	C	D	D	N/A	The maximum number of local workers is estimated to be less than 100 persons. During construction, contractor will follow relevant regulations. Thus, the impacts are considered to be mitigable and limited.
15	Accidents (risk etc.)	C	D	B-	N/A	There were some cases of disability accident in construction phase of other projects. Therefore, some

No.	Item	Assessment in Scoping Phase		Assessment by Survey Results		Contents
		P&C	O	P&C	O	
						countermeasures must be considered during construction of the WTP.
Natural Environment						
16	Geographical features	D	D	N/A	N/A	-
17	Ground subsidence	D	D	N/A	N/A	-
18	Bottom sediment	D	D	N/A	N/A	-
19	Biota and ecosystem	D	D	N/A	N/A	-
20	Meteorology (global warming)	D	B+	N/A	B+	-
21	Landscape	D	D	N/A	N/A	-
22	Protected areas	D	D	N/A	N/A	-
Pollution						
23	Air pollution	B-	D	B-	N/A	During construction phase, equipment, vehicles, and excavation activities will generate limited amounts of dust and exhaust.
24	Water pollution	B-	B-	B-	B-	During construction phase, the amount of wastewater generated from the construction site is estimated to be very limited. While during operation phase, backwash water will be recycled within the WTP after treatment. Therefore, the impacts of the Project are expected to be light.
25	Soil pollution	D	D	N/A	N/A	-
26	Waste	C	B-	B-	B-	During construction surplus waste soil will reused for backfilling at construction site and Boeng Tompun (lagoon). When the plant is in operation, PPWSA will collect and transport sludge to new landfill site. In addition, now PPWSA is preparing a plan to sell sludge to local construction company who intends to reuse sludge as backfilling materials. Thus, the impact is considered to be not significant.
27	Noise and vibration	C	D	B-	N/A	There are no sensitive facilities such as (hospital or school etc.) around the WTP site. However, it is estimated that noise levels at the boundary of the WTP in day time would be 78 to 87 dB due to operation of construction equipment and vehicles. This exceeds the standard (75 dB) slightly During operation, the noise levels are estimated to be less than standards because all pumps will be installed within buildings. Thus, the impact is considered to be light.
28	Offensive odor	D	D	N/A	N/A	

注: P & C: Pre-construction and construction phase
O : Operation phase
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of impact is unexpected, further study is needed
D : Limited/ negligible impact, further study is not needed.
N/A : Impact assessment is not conducted because the item was categorized as D in scoping phase.

2-2-3-2-9　緩和策（環境管理計画）および実施のための費用

本プロジェクトの環境へのマイナス影響を回避・最小化するための緩和策を以下に提案する（**表 2-2.13**）。詳細な環境管理計画（EMP）を**資料 6** に記載する。

表 2-2.13　本プロジェクトにおける環境社会影響に対する緩和策（工事中）

No.	Item	Proposed Mitigation Measures	Implementing & (Inspection) Organization	Estimated Cost (USD/year)
Social Environment				
1	Land use and utilization of local resources (fishing)	Before construction starts, information will be delivered to fisherman via commune and village chiefs as well as post at Ta Khmau port in advance.	Contractor (PPWSA & communes)	Included in construction costs
2	Existing social infrastructures and services (such as traffic etc.)	The construction of the WTP may create traffic disruption (especially on National Road No. 2). 1) Prepare a detailed traffic control plan and to coordinate with local government. 2) Prepare proper construction schedule and methods to reduce traffic disruption and traffic accident. 3) Assign traffic control person at the entrance of the WTP while construction is taking place. 4) Cooperated with the Traffic Police to facilitate traffic. 5) Install traffic lights at the crossroad to avoid possible accidents.	Contractor (PPWSA, Traffic Police Office, communes)	Included in construction costs
3	Accidents (risk etc.)	1) Prepare appropriate construction plan. 2) Educate staff/workers on the safety and fire. 3) Set up regularly inspection etc.	Contractor (MIH/PPWSA)	Included in construction costs
Pollution				
1	Air pollution	1) Cover stored materials with plastic or other materials. 2) Cover trucks, and to spray exposed areas with water. 3) Wash vehicles before going out the construction site. 4) Minimize traffic over freshly exposed surfaces. 5) Install barrier walls for limiting wind dispersing if necessary. 6) Prepare air quality monitoring plan and carry out it during construction. (for details, see Environmental Monitoring Plan)	Contractor (MoE/PDE, PPWSA)	Included in construction costs
2	Water pollution	1) The embankment will be constructed to prevent land erosion during the rainfall. 2) Carry out water quality monitoring. 3) Install wastewater treatment system within the WTP to treat domestic wastewater during construction.	Contractor (MoE/PDE, PPWSA)	Included in construction costs
3	Waste	1) Prepare reasonable plan for solid waste disposal, especially for excavated soil. 2) Install temporary toilet at the construction site for workers, and set sanitary bins for domestic wastes. 3) Dispose solid wastes appropriately (The amount of solid waste is estimated to be only around 5 kg/day).	Contractor (MoE/PDE, PPWSA)	PPWSA may benefit from it (selling the wastes to buyer)
4	Noise and vibration	1) Prepare a detailed plan for noise control and coordinate with local government. 2) Prepare proper construction schedule and methods. 3) Set speed limits for vehicles and train workers on mitigation measures for environmental impacts. 4) Use low noise level equipment, if necessary. 5) Prepare noise monitoring plan and carrying out monitoring during construction.	Contractor (MoE/PDE, PPWSA)	Included in construction costs

表 2-2.14　本プロジェクトにおける環境社会影響に対する緩和策（供与時）

No.	Item	Proposed Mitigation Measures	Implementing & (Inspection) Organization	Estimated Cost (USD/year)
Social Environment				
1	Water usage/water right	1) Monitor the water level (flowrate) of Bassac River. 2) Prepare a detailed water supply plan to deal with intake stop during extreme low flowrate of Bassac River. (such as transmit water from other WTPs to Ta Khmau City)	Operator (MIH/PPWSA)	Included in OM costs of other WTPs
Pollution				
1	Water pollution	1) Keep the facilities and equipment in good condition. 2) Carry out water quality monitoring on recycled water, effluent of septic tank and Bassac River.	Operator (MoE/PDE, PPWSA)	Included in OM costs of the WTP
2	Waste	1) Prepare reasonable plan for solid waste disposal, especially for sludge. 2) Thickened sludge will be transported to new landfill site by PPWSA or sold to local construction company as backfilling materials. Thus, check the volume of sludge transported. 3) Dispose solid wastes appropriately and cooperate with CINTRI Co. Ltd.).	Operator (MoE/PDE, PPWSA)	PPWSA may benefit from it (selling the wastes to buyer)

2-2-3-2-10　モニタリング計画および実施のための費用

前項に環境管理計画として示した項目を実施するに当たり、必要となるモニタリング計画を**表 2-2.15** に示した。内容に関しては、今後の詳細設計等の段階で変更や追加が必要となることが予想され、適宜変更するものとする。

表 2-2.15　モニタリング計画（案）

Monitoring Parameter	Monitoring Location	Monitoring Parameter	Compliance Standards	Monitoring Frequency	Implementing & (Inspection) Organization	Estimated Cost (USD/year)
During Construction Phase						
Traffic	(1) at entrance of the WTP	Visual observation	-	During working hours of every day	Contractor ((PPWSA, Traffic Police Office, communes)	Included in construction costs
Air quality	(1) at the WTP boundary	CO, NO_2, SO_2, O_3, Pb, TSP, PM10 and PM2.5	Sub-Decree No. 42 on Air Pollution Control and Noise Disturbance	Once, preconstruction: Once/6 months during construction	Contractor (MoE/PDE, PPWSA)	2,000
Waste	(1) at the gate of the WTP (2) at Boeng Tompun (lagoon)	Volume of wastes	-	Once/week	Contractor (MoE/PDE, PPWSA)	Included in construction costs
Noise	(1) at construction site; (2) at western boundary of the WTP	Equivalent continuous A sound level ($L_{aeq, 10}$)	Sub-Decree No. 42 on Air Pollution Control and Noise Disturbance	Once, preconstruction: Once/6 months during construction	Contractor (MoE/PDE, PPWSA)	1,000
Water pollution	(1) at upstream of the WTP: (1) at	pH, DO, SS, turbidity, COD, NH_4-N,	Sub-Decree No. 42 on Water	Once, preconstruction:	Contractor (MoE/PDE, PPWSA)	1,000

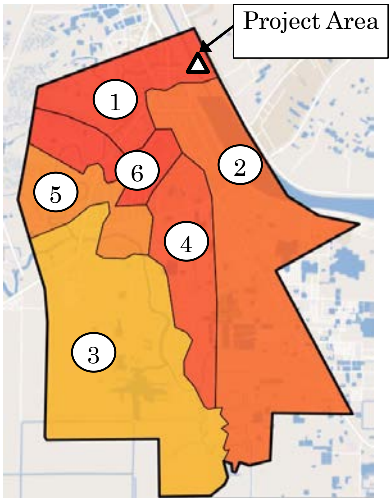
Monitoring Parameter	Monitoring Location	Monitoring Parameter	Compliance Standards	Monitoring Frequency	Implementing & (Inspection) Organization	Estimated Cost (USD/year)
	downstream of the WTP	Coliform	Pollution Control	Once/6 months during construction		
During Operation Phase						
Air quality	(1) at the WTP boundary	CO, NO_2, SO_2, O_3, Pb, TSP, PM10 and PM2.5	Sub-Decree No. 42 on Air Pollution Control and Noise Disturbance	Once/year during construction	Operator (MoE/PDE, PPWSA)	1,000
Waste	(1) at the gate of the WTP (2) at new landfill site	Volume of wastes and disposal method	-	Once/month	Operator (MoE/PDE, PPWSA)	Included in OM costs of the WTP
Water pollution	(1) at upstream of the WTP: (1) at downstream of the WTP	pH, DO, SS, turbidity, COD, NH_4-N, Coliform	Sub-Decree No. 42 on Water Pollution Control	Once/3 months	Operator (MoE/PDE, PPWSA)	2,000

2-2-3-2-11　ステークホルダー協議

事業内容説明・情報公開、また社会的合意を目的とし、公聴会を 2 回開催した。事業内容に対するステークホルダーの理解を促進し、より多くのフィードバックを得るため、環境社会配慮を含む調査結果を説明した。質疑応答が活発になされたが、プロジェクト実施に対して否定的な発言は出なかった。ステークホルダー協議の概要を**表 2-2.16** に示す。

表 2-2.16　ステークホルダー協議の概要

Item	1st Stakeholder Meeting	2nd Stakeholder Meeting
Purpose	1) Introduction of the project 2) Collection of the stakeholder comments and opinions on the project	1) Explanation for the Results of IEIA Study (Draft) 2) Collection of the stakeholder comments and opinions on the draft IEIA report
Organizer	PPWSA, SUSTINAT Green	PPWSA, Kandal Provincial Department of Environment (DoE)
Time	June 22, 2019	July 18, 2019
Place	Daeum Mean Commune (vicinity of WTP, see location map of each commune)	Meeting Hall of Kandal Provincial DoE
Participant	10 residents (5 men and 5 women, number of participants is appointed by MoE considering no land acquisition and resettlement)	23 Participants (PPWSA, DoE, Ta Khmau City, Departments of Water Resource & Meteorology, Health, Agriculture, Land Management etc.)
Notification method	2 weeks before the stakeholder meeting, the stakeholders are notified by poster at the commune, telephone, direct visit etc.	Invited by MoE based on “Sub-decree on EIA Process”
Main Consultation Contents	1) Improvement of house connection and regular water supply Answer: The project will provide 100% service coverage to Ta Khmau City. 2) Appropriate water tariff Answer: Appropriate water tariff will be set by PPWSA. 3) Lower price (than the standard price) of	1) Noise and vibration impacts on people and worker Answer: Noise control plan will be prepared by contractor and PPWSA will conduct regular inspection. 2) Service areas of water supply Answer: The project will provide 100% service coverage to Ta Khmau City. 3) Countermeasures on raw water quality deterioration Answer: Pre-chlorination will be applied to remove

<table>
<tr><th>Item</th><th>1st Stakeholder Meeting</th><th>2nd Stakeholder Meeting</th></tr>
<tr><td></td><td>house connection
Answer: Subsidy will be applied to low income households.</td><td>ammonia in the water. In addition, cascade type aeration will also be introduced.
4) Possibility of paused water supply during construction
Answer: During construction, no paused water supply will be occurred.</td></tr>
<tr><td>Photos of Stakeholder Meeting</td><td></td><td></td></tr>
<tr><td>Location Map of Commune</td><td></td><td><table>
<tr><th>No.</th><th>Sangkat (Commune)</th></tr>
<tr><td>1</td><td>Daeum Mean</td></tr>
<tr><td>2</td><td>Ta Khmau</td></tr>
<tr><td>3</td><td>Prek Russei</td></tr>
<tr><td>4</td><td>Kompong Samnanh</td></tr>
<tr><td>5</td><td>Ta Kdol</td></tr>
<tr><td>6</td><td>Prek Hour</td></tr>
</table></td></tr>
</table>

2-2-3-3　用地取得・住民移転

本プロジェクト予定地は、PPWSA が所有する既存浄水場の敷地内であり、用地取得や住民移転は発生しない。

2-2-3-4　その他

2-2-3-4-1　地雷・不発弾（UXO）

カンボジア地雷対策センター (以下、「CMAC」)が、本プロジェクト予定地における地雷・不発弾（UXO）がないことを工事開始前までに確認する。工事中、万が一地雷・不発弾（UXO）が発見された場合は、すべての工事を中止し、コントラクターから PPWSA を通じて CMAC へ連絡し、CMAC が調査及び処理を実施する。

2-2-3-4-2　モニタリングフォーム（案）

モニタリングフォーム（案）を**資料 6** に記載する。

2-2-3-4-3　環境チェックリスト

環境チェックリストを**資料 6** に記載する。

2-2-4　その他

プロジェクトの実施とグローバルイシューとの直接的な関連性は特にないが、本プロジェクト実施により貧困世帯に供給する配水量が増量されることになり、また、これまで安全な水へのアクセスが行われていなかった貧困世帯にも新規に配水が行われることになるため、水の使用に関連した経済効果が期待されるため、間接的に貧困削減に貢献するものと考える。

2-2-4-1　気候変動の適応策について

2-2-4-1-1　気候変動の適応策

JICA の気候変動対策支援ツール／適応策「気候リスク評価・適応策検討のガイダンス」（2019 年）に基づく気候リスク評価、適応策の検討結果は次のとおりである。

(1)　当該プロジェクトの概要

(a)　事業の目的、期待する事業効果
事業の目的を **3-1-1-2** に、期待する事業効果を **4-4** に示す。

(b)　事業期間
事業期間を **3-1-1-2** に示す。

(c)　事業計画のうち、施設、設備等のハード面のコンポーネント
施設、設備等のハード面のコンポーネントを **3-1-2** に示す。

(d)　事業計画のうち、人材育成等、技術支援活動などのソフトコンポーネント
本件にはソフトコンポーネントは含まれない。

(e)　当該プロジェクトの立地場所
当該プロジェクトの立地場所 **2-2-3-2** に示す。

(f)　当該プロジェクトの実施体制、運営機関
実施機関は PPWSA であるが、施設完成後から 10 年間は特別目的会社（以下、「SPC」）が事業運営を実施する。また気候関連のリスクは MoE が管轄する。

(2)　当該プロジェクトにおける「曝露」

気候関連のハザードにさらされうると考えられるプロジェクトのコンポーネントは、取水場、

浄水場である。

(3) 当該プロジェクトに関わる「ハザード」

気候ハザードは、気温の変化と降雨量の変化を想定する。カ国における過去の平均降雨量及び平均気温を図 **2-2.10** に示す。

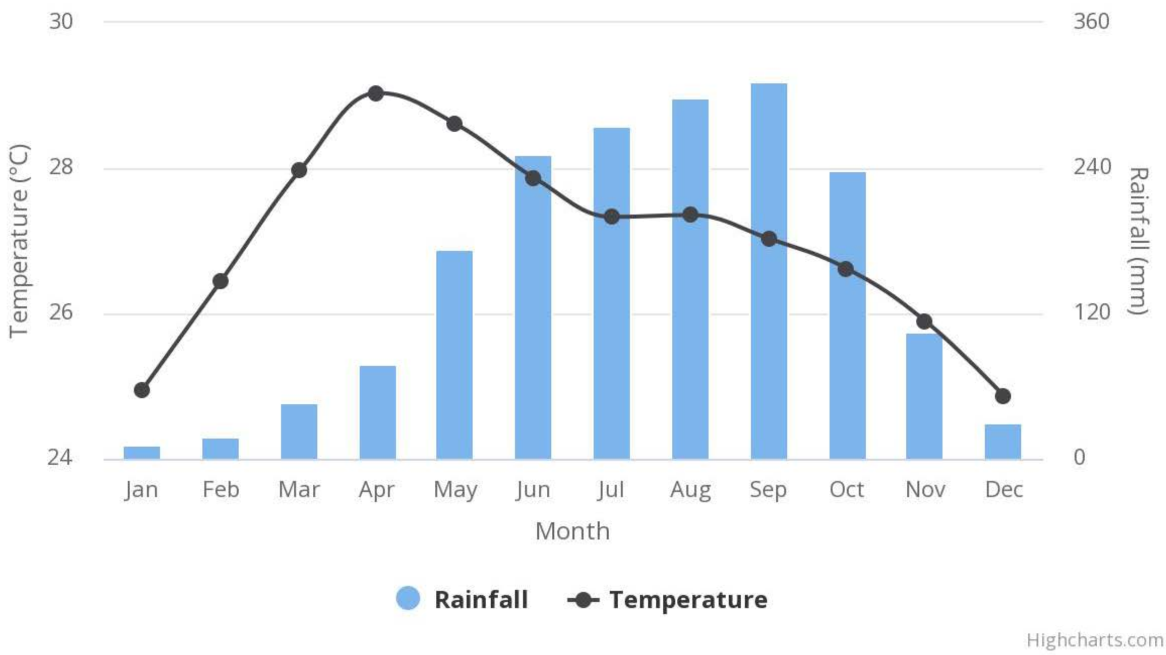


図 2-2.10 カ国の平均降雨量と平均気温(1901~2016)

出典：World Bank, Climate Change Knowledge Portal

Climate Change Knowledge Portal では、カンボジアの平均気温は 2060 年までに 0.7 から 2.7°C、2090 年までに 1.4 から 4.3°C 上昇すること、月平均降雨量の変化量は 2049 年から 2059 年に-47mm から+80mm（図 **2-2.11**）、2080 年から 2099 年に-65mm から+130mm（図 **2-2.12**）と予測している。

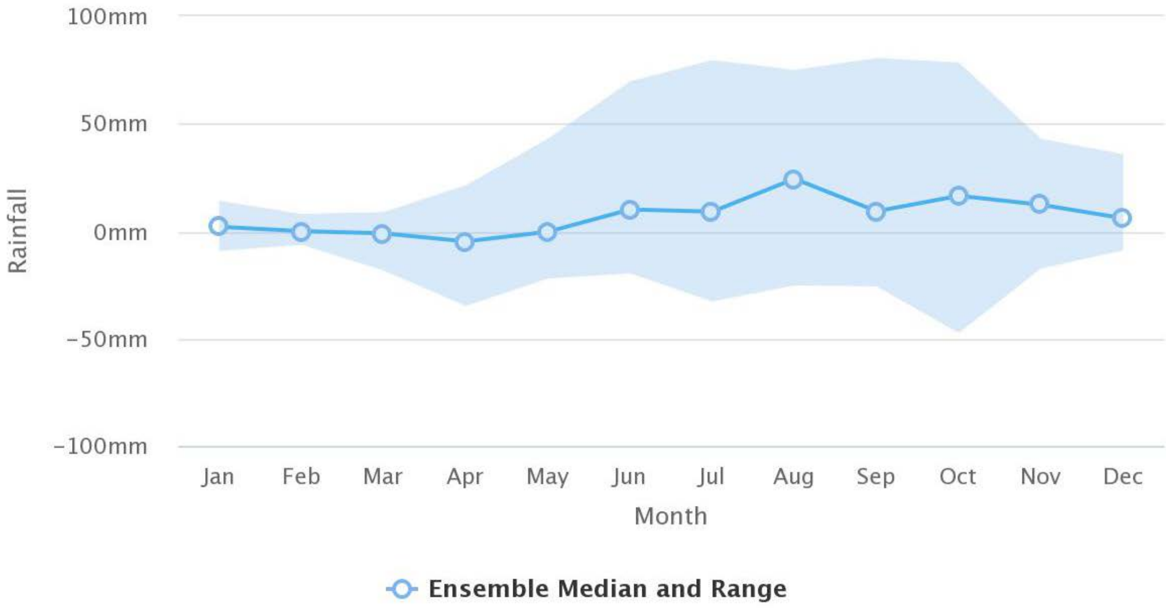


図 2-2.11　カ国における平均月降水量の変化量予測（2049 年から 2059 年）

出典：World Bank, Climate Change Knowledge Portal　（RCP8.5 シナリオ、ensemble モデル）

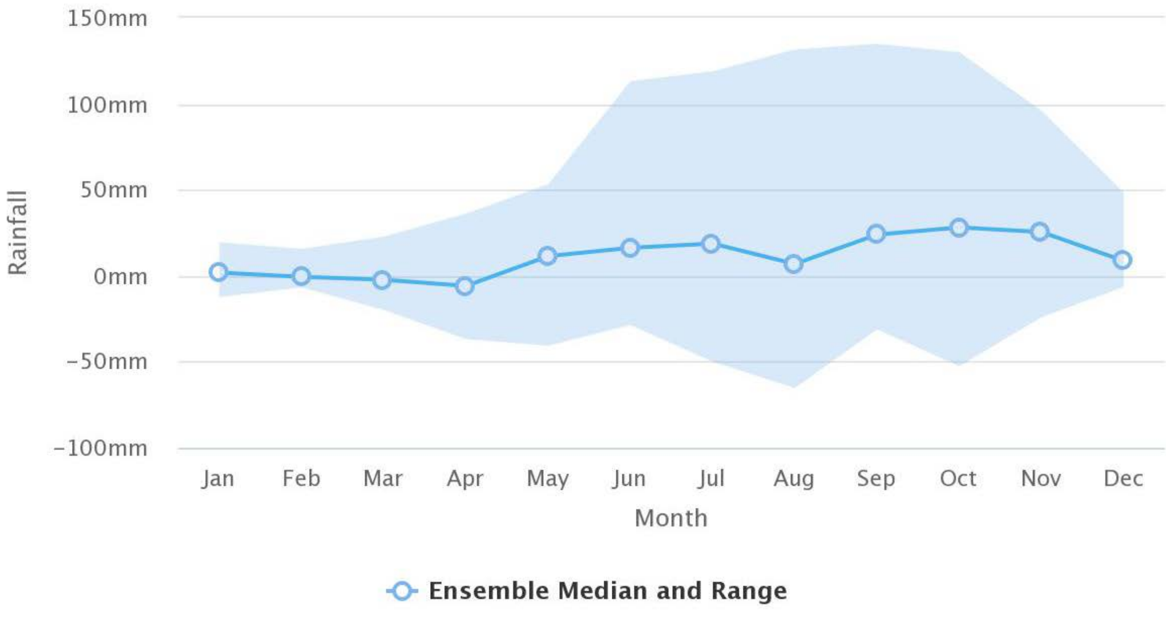


図 2-2.12　カ国における平均月降水量の変化量予測（2080 年から 2099 年）

出典：World Bank, Climate Change Knowledge Portal　（RCP8.5 シナリオ、ensemble モデル）

(4)　気候リスク評価のマトリクスを用いた「気候リスク評価」

気候リスク評価マトリクスを**図 2-2.13** に示す。

		気候ハザード（Hazard）					
		H1 気温の変化	H2 降雨量、降雨パターンの変化、洪水の発生				
	現状での発生状況（頻度等）	+	+	脆弱性（Vulneralibility）		今後重要（顕著）となりうる気候リスク（Climinate Risk）	適用オプション候補（Potential Adaption Option）
	将来の見込み	→	↗	・過去・現在の取り組み、対処状況 ・計画している取り組み	カウント		
暴露（Exposure）	E1 取水塔	0	2	雨期の水位変動の把握のための水位計の設置 スペアパーツの整備と適切な維持管理 SOPとERPの整備と実践及び訓練 水質モニタリング	0	高濁度期間の継続	モニタリング設備の導入 濁水時のリスク対応や運転管理計画の作成
	E2 浄水場	0	2	スペアパーツの整備や適正な維持管理 SOPとERPの整備と実践及び訓練 水質モニタリング	0	高濁度期間の継続	送水連絡管による各浄水場から相互融通による配水できるようにする
	カウント	0	0				

図 2-2.13　気候リスク評価のマトリクス

(5)　　気候リスク評価結果をもとに検討した、考えられる「適応オプション」

考えられる「適応オプション」は次のとおりである。

- 雨期の水位変動の把握のための水位計の設置：予想外の高水位に対応するため。
- スペアパーツの整備と適正な維持管理：事故時に速やかに対応するため。
- 業務標準手順書（以下、「SOP」）と緊急時対応手順書（ERP）の整備と実践及び訓練：緊急時に速やかに対応するため。
- 水質モニタリング：予想外の高濁度等の原水水質の悪化や浄水水質の異常を速やかに対応するため。

(6)　　考えられる「適応オプション」候補群について、プロジェクト計画での最終的な考慮結果

考えられる「適応オプション」候補群について、プロジェクト計画での最終的な考慮結果は次のとおりである。

- 雨期の水位変動の把握のための水位計の設置：予想外の高水位に対応するため。
- 水質モニタリング：予想外の高濁度等の原水水質の悪化や浄水水質の異常を速やかに対応するため。

尚、施設完成後から 10 年間は SPC が事業運営を行うため、上記に関しては、維持管理マニュアルに明記することを入札図書の要求水準書に含める。その後は、PPWSA が施設を管理することとなる。PPWSA は、上記マニュアルの引き継ぎが実施されるとともに、これまでの技術協力プロジェクト等により、データ管理、計画策定、浄水場運転管理、水質管理、管路の維持管理、財務管理、水資源管理の知識・意識を含め、水道事業に対する能力強化が実施されていることから十分な対応が可能である。

2-2-4-2　貧困世帯に対する支援

貧困層への補助として給水接続の際に補助金を利用した接続戸数の割合を**表 2-2.17** に示す。プノンペン都内に比べて貧困層への接続数は少ないものの、貧困層の割合は、プノンペン都内に比べてタクマウ市が多いため、タクマウ市は低所得者層が多く住む居住地域である。

表 2-2.17　2016 年の貧困層の割合

地域	接続数（戸）	貧困層への接続数	貧困層の割合
プノンペン都	300,244	33,373	11.1%
タクマウ市	10,591	2,511	23.7%

出典：PPWSA

PPWSA では、貧困層向けのプログラムとして、1999 年より「Clean Water for Low-Income Families」を実施している。接続に要する費用は利用者負担となっているが、貧困層向けプログラムとして、①支払い余力に応じた接続費の分割払い（10、15、20 ヶ月）、②郊外に住む貧困者の接続費の割引(2 割)、③貧困度合に応じた接続費の補助金（30、 50、70、100%）を提供している。今後も PPWSA により本プログラムが実施されていく予定であり、本プロジェクト実施により貧困世帯に供給する配水量が増量されることになり、また、これまで安全な水へのアクセスが行われていなかった貧困世帯にも新規に配水が行われることになる。

第3章 プロジェクトの内容

3-1 プロジェクトの概要

3-1-1 上位目標とプロジェクト目標

3-1-1-1 上位目標

カ国政府は、国家戦略開発計画（NSDP）で 2025 年までに都市部人口の 100％が安全な水に持続的にアクセスできることを目指し、全国の都市部における安全な飲料水へのアクセス率の改善を行っている。

3-1-1-2 プロジェクト目標

本プロジェクトは、浄水場（30,000m^3/日）を建設し、タクマウ市及び周辺地域への給水サービスの向上を図り、タクマウ市及びプノンペン都における生活環境を改善に寄与することを目標としている。

3-1-2 プロジェクトの概要

本プロジェクトは、上記目標を達成するためにタクマウ市及び周辺地域への配水を行うための浄水場を建設することとしている。これにより、2030 年におけるタクマウ市の安定的な給水がなされることが期待されている。

協力対象事業の主なコンポーネントは**表 3-1.1** のとおりである。

表 3-1.1　協力内容のコンポーネント

施設	タクマウ浄水場	取水・導水施設	取水能力： 31,500 m^3/日、取水施設（取水塔方式） 導水施設
		浄水施設	浄水能力： 30,000 m^3/日
		配水施設	配水池及び配水ポンプ バルクメーター（１基）
		SCADA	浄水場内の中央監視システム
コンサルティング・サービス			入札補助
			設計確認
			施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務

3-2　協力対象事業の概略設計

3-2-1　設計方針

3-2-1-1　基本方針

本案件の対象地域は、首都圏の中でも特に低所得層が多く居住する地域で、貧困、感染症など個人の生命、生活に対する脅威への対応が必要であり、無償資金協力にて支援する必要性は高い。加えて、本邦企業・地方自治体が、運営・維持管理を行うことで、進んだノウハウや新たな技術の導入が図られ、従来よりも効率的かつ効果的な給水サービスが期待できるため、事業・運営権対応型無償を活用する。本事業権無償は、カ国における法的整合性を考慮し、事業権無償の英語の名称として Japanese Grant Aid with O&M を用いる。無償資金は機材調達・施設整備及び関連するコンサルティング・サービスに活用される。無償資金で調達する事業者及び代表コンサルタントは交換公文で定めるところの日本人（Japanese Nationals）を基本とする。競争入札によって選定された事業者は、施設整備に係る設計・調達・建設（以下、「EPC」）契約、運営維持管理に係る O&M 契約及び事業の実施方針と各契約の関係性を定めた包括契約に基づき、これらの業務を一体的に遂行する。事業者入札においては、事業者の提案を技術的、商業的、財務的及び法務的な観点から総合的に評価する総合評価落札方式を採用する。外務省が公表している一般的な事業権無償のスキーム及び本件の事業スキームを**図 3-2.1** と**図 3-2.2** に示す。

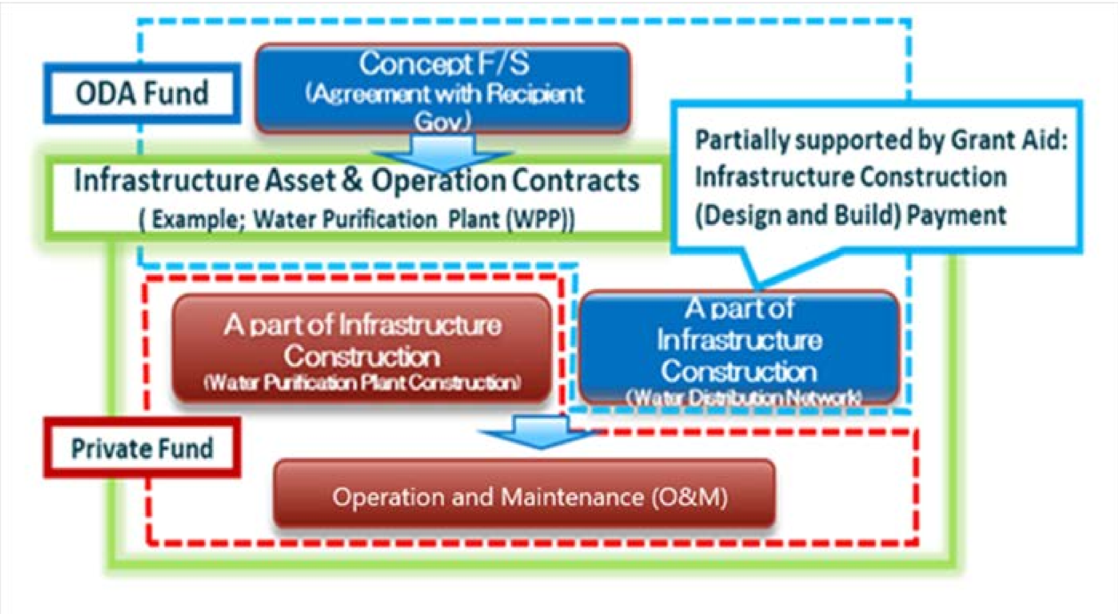


図 3-2.1　一般的な事業権無償のスキーム

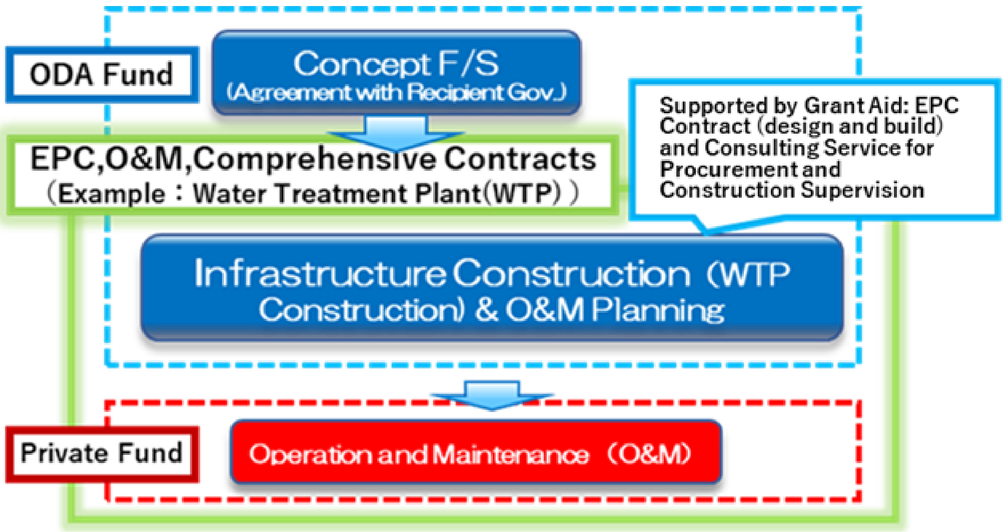


図 3-2.2　本件の事業権無償のスキーム

事業権無償は、住民への給水サービス向上を目標として、カ国政府が取り組んでいる都市部における安全な水へのアクセス率の向上に資するため、タクマウ市において、上水道施設を拡張・改良するものである。

本プロジェクトは、事業権無償を活用し、設計施工一括発注方式による実施を想定しているため、最終的な施設の設計は事業者の提案に基づくこととなる。無償資金協力の事業規模の検討、要求水準書案の作成、運営・維持管理費の試算等のために、本業務において想定標準施設（以下、「コンパラター施設」）を想定した概略設計を行う。

タクマウ市はプノンペンの郊外にあり商業施設の少ないベッドタウンであるため、採算性の取れない居住者レートで水道料金が徴収される世帯が多いことから、PPWSA の「商業レートで採算性の取れる地域は借款で、居住者レートで採算性の取れない地域は無償資金で整備するという戦略」に基づき、施設を無償資金で整備することが要請された。コンパラター施設は、このようなカ国政府の要請と現地調査及び協議の結果を踏まえて、以下の方針に基づき概略設計を実施した。

① 施設の建設完了は 2023 年とし、計画対象水需要は 2030 年とする。
② 浄水能力は、30,000 m^3/日とする。
③ カ国には設計基準が無く、基本的に現在実施中もしくは過去数年以内に実施した無償資金協力事業の設計方針（日本の「水道施設設計指針」（公益社団法人日本水道協会））に準ずるものとし、カ国での過去の案件及び PPWSA で使用している設計基準等も参考にする。
④ 施工体制は、現地建設業者の能力、規模、実績を勘案の上、日本の請負業者の下で現地建設業者を十分活用することとする。
⑤ 運営維持管理は、SPC（現地法人）により 10 年間の維持管理を行う。
⑥ 取水施設は河川内での工事となるため、河川水位が上昇する雨季期間中を避けることとする。
⑦ 浄水場の建設用地面積が限られているといった制約の中での施設配置が必要であり、周辺地

域の建造物を含め既存の施設・建造物に影響のないようにする。

3-2-1-2　自然環境条件に対する方針

3-2-1-2-1　降水量

タクマウ市が属する気候区分は熱帯性モンスーン気候であり、雨季は 5 月から 10 月、乾季は 11 月から 4 月までである。降水量等の自然条件を考慮し、施工計画に反映する。

3-2-1-2-2　地形・地質

取水施設及び浄水施設建設予定地にて、地盤及び土質調査を実施した。その結果、現況地盤高から 20m 付近までは N 値 10 程度、30m 付近で N 値 30 程度、45～50m 付近において N 値 50 以上の粘性土が堆積していることが確認された。この結果より、主要構造物は現況地盤高から 30m 付近の締まった粘土層が支持層となり、杭基礎が想定される。

3-2-1-2-3　水量および水位

取水施設建設予定地はバサック川の西岸である。バサック川は、メコン川の支流の国際河川であり、下流はベトナムに続いている。乾季である 4 月に最小流量（3,456,000 m^3/日）となり（**図 2-2.6**）、河川の水位変動は年間を通じて 10m 程度である。また、2014 年から 2018 年のデータ（MoWRAM）によると、4 月の最低水量及び最低水位は 17 m^3/s と 1.59 m であった。一方、最大流量及び最高水位は 5,229 m^3/s と 9.95m であった。

取水施設の建設は、河川水位によって大きく影響を受けるため、11 月から 4 月の乾季に主要工事を行うこととする。

3-2-1-2-4　原水水質

原水の水源・水質調査の結果（**表 2-2.1**）により、除去が困難な有害物質等は検出されておらず、COD が高い傾向があるものの、水道水源として特に問題はない。濁度は 6NTU から 300NTU 程度である。

アンモニア濃度が高い傾向及び取水地点上流の排水の影響により、原水中の大腸菌の濃度が高くなっているが、浄水施設で塩素処理を計画しているため、除去できるものと考える。

3-2-1-3　社会経済条件に対する方針

タクマウ市はプノンペン都の南部に隣接し、カンダール州の中心地である。タクマウ浄水場はタクマウ市の商業施設の中心地に近いため、工事期間中の車両通行の維持と通行の安全確保につ

いて十分考慮する必要がある。

カ国における電力供給事業は、EDC が行っている。短時間の停電等はあるものの、タクマウ市の電力供給能力は比較的安定している。したがって、新規浄水場および取水施設への通常時の電力供給に問題はなく、新規浄水場および取水施設の建設・運転で使用する電力量がタクマウ市の電力供給に大きな負荷を与える可能性は低いと考えられる。

プノンペン都及びタクマウ市のあるカンダール州では、乾季に電力供給不足が予想され、計画停電が 2019 年の 3 月から 5 月まで実施された。今後も電力供給不足による計画停電が実施されることから、北部及び南部の変電所の 2 系統の配電線より、受電を行う 2 回線受電方式を想定する。

3-2-1-4　建設事情／調達事情に対する方針

建設一般資材のなかで、セメントはカ国で生産している。プノンペン都及びタクマウ市周辺には多くの セメント工場がある。生産されているセメントは、普通ポルトランドであり、市場で調達可能である。また、構造用鋼材、鉄筋は、カ国で生産されていないものの、主にベトナム、タイ等からの輸入品が市中で入手可能である。

浄水施設の機器・設備はカ国では生産しておらず、本邦企業において競争性を確保した上で調達を行い、コストの縮減が図れるように配慮する。浄水処理用の薬品類については、可能な限りカ国国内で調達する想定とする。

3-2-1-5　現地業者の活用に係る方針

カ国で実施された無償資金協力のプロジェクトでは、ほとんどがカ国内の下請けを活用して施工されている。土工事、コンクリート工事などに使用する汎用機械を保有している会社も多く、また揚重機械もプノンペン都の各所で見受けられた。日本の元請業者へのヒアリング結果から、一般的な施工機械はカンボジア業者が保有していることが多いが、整備が十分でない、特殊な工事の機械はカ国内では調達できないということであった。カンボジア業者を下請けとして活用しても、人的あるいは追加機械の補強をしているのが実態である。よって、本邦建設会社の十分な管理指導の下、ローカル建設業者を活用するものと想定する。

3-2-1-6　運営・維持管理に対する対応方針

浄水場の O&M は SPC によって実施される。コンパラター施設における運営・維持管理体制を検討する。

3-2-1-7　施設、機材等のグレードの設定に係る方針

機械・電気設備は維持管理性やスペアパーツの入手性を考慮して選定する。特に、大型機器となる取水ポンプ・配水ポンプについては本邦企業において競争性を確保し、コストの縮減が図れ

るように配慮する。

3-2-1-8 工法／調達方法、工期に係る方針

取水施設の建設は雨期・乾季によって大きく影響されるため、着工時期と工期の設定に注意を払う必要がある。

3-2-1-9 事業権無償にかかる入札、契約に係る方針

本プロジェクトは、無償資金を原資とする施設の設計施工と施設の引き渡しを行う業務について合意する EPC 契約と、当該施設の維持管理運営及び当該施設を活用して浄水した水を PPWSA に売却するバルク水販売（PPWSA による支払いを原資とする）の業務について合意する O&M 契約を事業者と締結し、両契約の関連性を規定するとともに、事業者の瑕疵により施設の不具合が生じるリスク等を事業者に移転するために、これらの二つの契約を統合する包括契約を締結するものである。したがって、これらの 3 つの契約の整合性を取ったうえで、事業のパフォーマンスを民間事業者がコントロールできるように、入札図書を作成し、入札を行う必要がある。

3-2-2　基本計画（施設計画／機材計画）

3-2-2-1　全体計画

本プロジェクトはタクマウ地域及び周辺地域への給水の為の浄水場（30,000m^3/日）を建設し、SPC により 10 年間の運転維持管理が行われるものである。施設整備内容は**表 3-1.1** のとおりである。

本件は設計・施工一括受注方式の為、実際の施設の浄水方法、施設構造、施設サイズ等は SPC の提案する設計をコンサルタントが確認し、施主の承認した上で決定されるため、ここで設計する施設はコンパラター施設として標準的な施設の概略設計を行うものである。

3-2-2-2　施設計画

3-2-2-2-1　水需要

マスタープラン（2017 年改訂版）では、給水栓接続密度（1 ヘクタールあたりの給水栓接続数）に基づいて水需要予測が実施された。給水栓接続密度は、各小エリアにおける都市化の種類に直接的に関係していると考えられ、都市化の進展は、中心部から郊外へと広がっていくため、近年の都市部の発展の経緯に基づいて郊外の発展を想定することが可能である。水需要の予測は、以下の次の 4 つのパラメータの想定値に基づいて実施されている。

① １ヘクタールあたりの給水栓数
② 生活用の給水栓の割合
③ 一給水栓あたりの水使用量（生活用）
④ 一給水栓あたりの水使用量（非生活用）

プノンペン都内及びタクマウ市の給水栓数の予測を**図 3-2.3** に、各地区における給水栓数の予測を**図 3-2.4** に、一給水栓当たりの水使用量を**表 3-2.1** に示す。

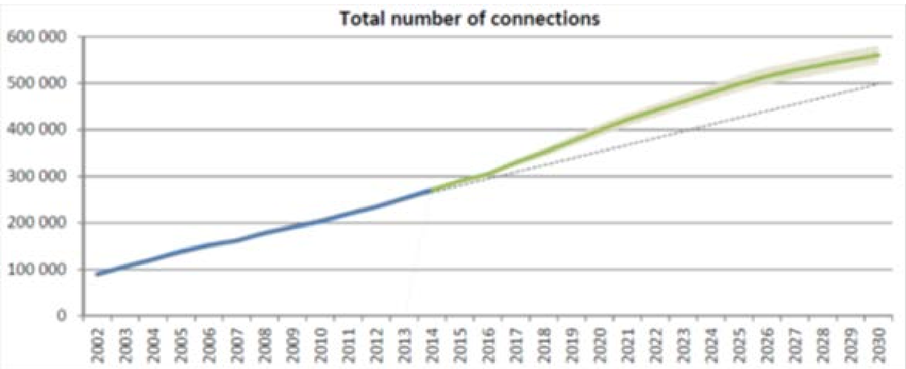


図 3-2.3　給水栓数の予測

出典：マスタープラン（2017 年改訂版）

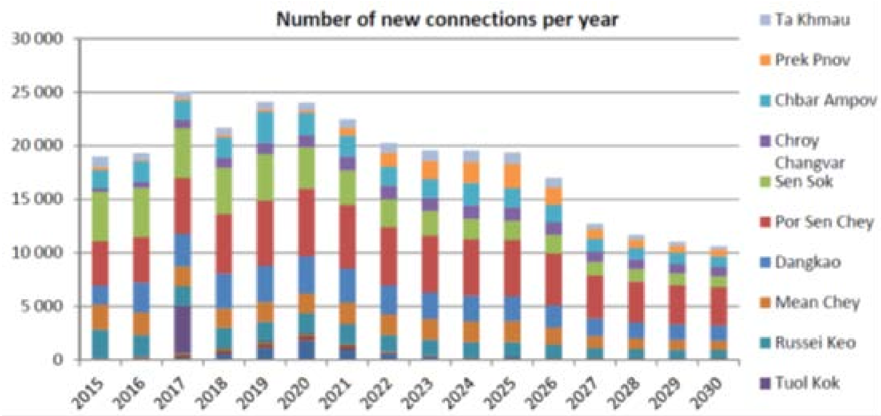


図 3-2.4　各地区おける給水栓数の予測

出典：マスタープラン（2017 年改訂版）

表 3-2.1　一給水栓当たりの水使用量

項目	条件
一給水栓当たりの水使用量（生活用）	0.95 m^3/日（2015 年） 1.03 m^3/日（2030 年）
一給水栓当たりの水使用量（業務・営業・工場等）	3.50 m^3/日（2015 年） 3.65 m^3/日（2030 年）

出典：マスタープラン（2017 年改訂版）より作成

上記検討条件に基づき、2030 年のタクマウ市内の水需要についてマスタープラン（2017 年改訂版）では**表 3-2.2** のように試算している 。

表 3-2.2　タクマウの水需要

		2015	2020	2025	2030
Consumption	m^3/day	11,668	14,854	19,556	21,966
NRW	%	8	10	10	10
Leakage Amount		1,015	1,650	2,173	2,441
Average Demand	m^3/day	12,683	16,504	21,729	24,407
Peak factor		1.15	1.15	1.15	1.15
Maximum Demand	m^3/day	14,585	18,980	24,988	28,068

出典：マスタープラン（2017 年改訂版）

2030 年の水需要は約 28,100m^3/日と予測しており、浄水場の処理能力として 30,000m^3/日は妥当であるといえる。

3-2-2-2-2　取水・導水施設計画

(1)　計画取水量

バサック川を取水河川とし、原水取水量は、31,500 m^3/日を計画取水量とする。

(2)　取水方式

取水方式として、カ国では、取水塔方式での保守運転管理の経験が豊富であり、PPWSA からタ

クマウ浄水場も取水塔方式としたいとの要望があった。

一方で、バサック川の低水位（+0.20m MSL）での安定的な取水を行うためには、河岸から約 50m の地点から取水を行う必要がある。取水管方式の取水だと管の閉塞が懸念され、頻繁な取水管のバックウォッシュや水中での粗目スクリーンの清掃等のメンテナンスが必要となるため、タクマウ浄水場もゴミや堆砂等による不安定な取水や頻繁な清掃等を行う必要が生じない取水塔方式をコンパラター施設の概略設計とする。取水塔方式は、浄水場内に取水施設を建設しないため、タクマウ浄水場の敷地制限を考慮すると敷地を最大限活用するための有効な方法である。

(3)　　取水ポンプ計画

取水ポンプは取水塔内に設置し、カ国で経験のある立型斜流ポンプ、保護管付きポンプ軸、水シール方式をコンパラター施設の概略設計とする。

想定される取水地点の水位を**図 3-2.5** に示す。

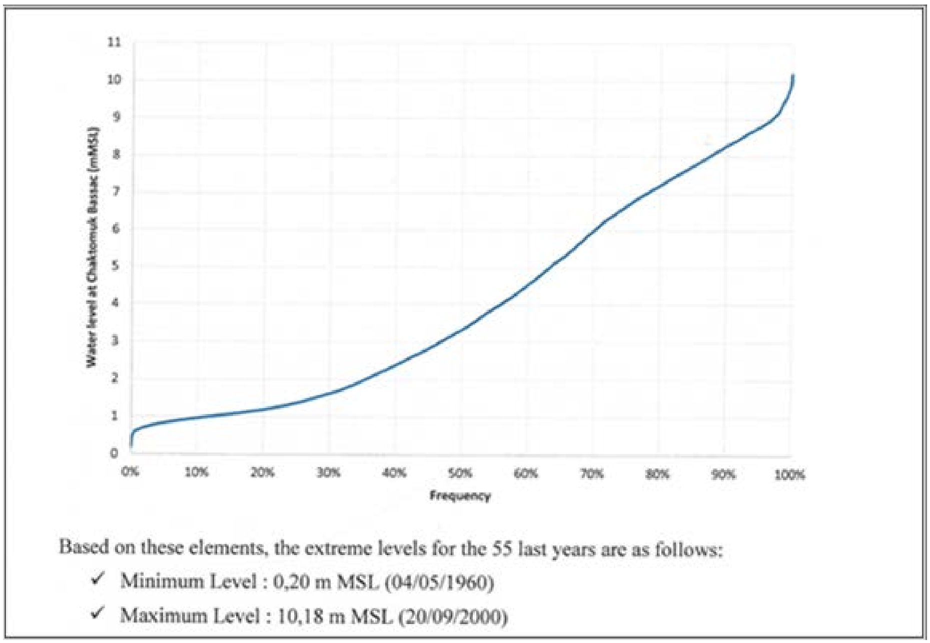


図 3-2.5　Chamcar Mon 浄水場の F/S 調査によるバサック川の水位変動

出典：PPWSA

水位は、最低水位が 0.2m MSL（1960 年 5 月 4 日）、最高水位が 10.18m MSL（2000 年 9 月 20 日）を記録している（Chamcar Mon 浄水場の FS 調査）。

取水水位の変動が約 10m あるため、経済的取水流量制御を考慮し、ポンプは回転数制御付きとする。取水塔に必要となる付帯設備を**表 3-2.3** に示す。

表 3-2.3　取水塔に必要となる付帯設備

設備名	設置目的
取水流入ゲート	取水塔締め切り及び水位による選択取水を行う
粗目及び細目スクリーン	ポンプ羽根車保護の為、塵芥を除去する。
沈砂排出ポンプ	取水塔内に堆積する事が予想される砂及び汚泥の搬出
ポンプ吐出配管	ポンプを他ポンプより隔離し保守管理でき、且つポンプ起動及び停止に必要な配管（弁類含む）
その他設備	取水導水管橋及び保守管理通路 機器搬出入用のクレーン 屋内外照明

(4)　　導水施設計画

取水した原水は取水施設から浄水場までの導水管により送水される。

3-2-2-2-3　　浄水施設計画

(1)　　原水水質及び必要水処理用薬品

原水となるバサック川の原水水質（濁度、pH、アンモニア態窒素）は、2009 年から 2017 年の間の Chamcar Mon 浄水場の取水地点における原水水質の記録によると次のような特徴がある。

- 濁度は乾季雨季で大きく変動し、最低は 7NTU 前後、雨季の平均は約 250 NTU, 最大は 1,088 NTU である。
- pH は雨期には比較的高く、乾季では多少低い。年間平均は約 7.4 であり、最低は 6.7 だが、概ね 7.2 ～7.7 となっている。
- アンモニア態窒素は雨季の平均値は 0.5 mg/L 前後、乾季の平均値は 0.2 mg/L 前後だが、2016 年頃から増加傾向にあり、1.0 mg/L を超える月が 4 回あり、最大値は 1.48 mg/L であった。

コンパラター施設の概略設計として、アンモニア態窒素は塩素により対応する方針とし、概略設計における水処理用薬品としては、以下とする。

- 凝集剤：PAC
- 消毒剤：生成次亜塩素酸ナトリウム

(2)　　浄水施設計画　（概略設計計画）

Chamcar Mon 浄水場の取水地点におけるバサック川の濁度（**図 3-2.6**）より、コンパラター施設の浄水場処理対象濁度を以下の通りとする。

- 設計最大濁度: 1,000 NTU
- 設計平均濁度: 120 NTU
- 設計最小濁度: 10 NTU

なお、2009 年から 2016 年の過去 8 年間の Chamcar Mon 浄水場の原水水質は以下のようであった。

- 乾期平均濁度 40 NTU
- 雨期平均濁度 245 NTU
- 全期平均濁度 115 NTU
- 全期最高濁度 1,088 NTU
- 全期最小濁度 7 NTU

乾季を中心に一年を通して約 2/3 の時期の濁度は概ね 200 NTU 以下となっている。実際には、コントラクターが設計する施設内容に合わせて管理基準や施設の運用方法が確定される。

本コンパラター施設を設計するに当たり、原水最大濁度が 1,000NTU を超えた場合には浄水処理が非常に非経済的になり、また、ろ過システムへの過大な負担により、必要な濾過池洗浄を行うことが出来ない等により、濾過メディアへのダメージ等が懸念されるため、PPWSA と調整の上取水・浄水・配水量の調整を行うこととする。

雨期に濁度が上昇する傾向が見られるが、上流ダムが 2009 年 1 月に稼働を開始してからの 8 年間で濁度が 1,000NTU を超えたことは 2009 年の 2 月(1,026NTU)と 2015 年 8 月（1,088NTU）の 2 度しかない。

なお、これらの時期に 1,000 NTU を超えた日は一日だけであったが、PPWSA は Chamcar Mon 浄水場の取水停止は行わず、取水量を抑えた運転を 2 日間続けたとのことであった。

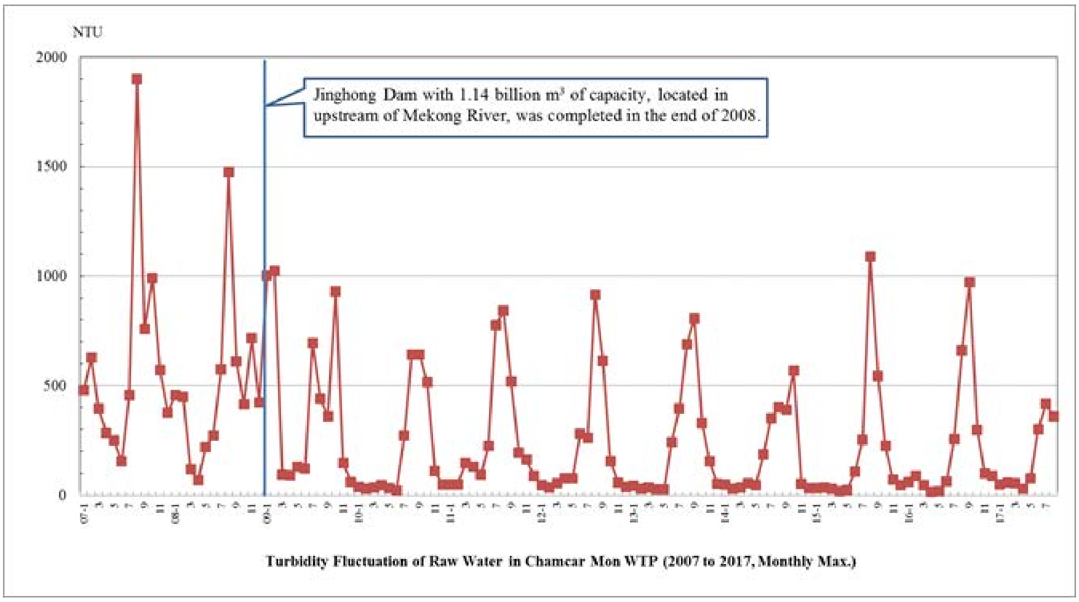


図 3-2.6　Chamcar Mon 取水地点における過去の濁度記録

1)　　浄水施設プロセス

コンパラター施設の概略設計は、経済的建設費及び運転費を考慮して検討した。浄水処理プロセスを**図 3-2.7** に、浄水処理プロセスの概要を**表 3-2.4** に示す。

コンパラター施設の浄水処理プロセスは、カ国で実施された無償資金協力（コンポンチャム、バッタンバン及びカンポット浄水場）と基本的に同様の凝集沈殿・急速ろ過による浄水処理プロセスである。

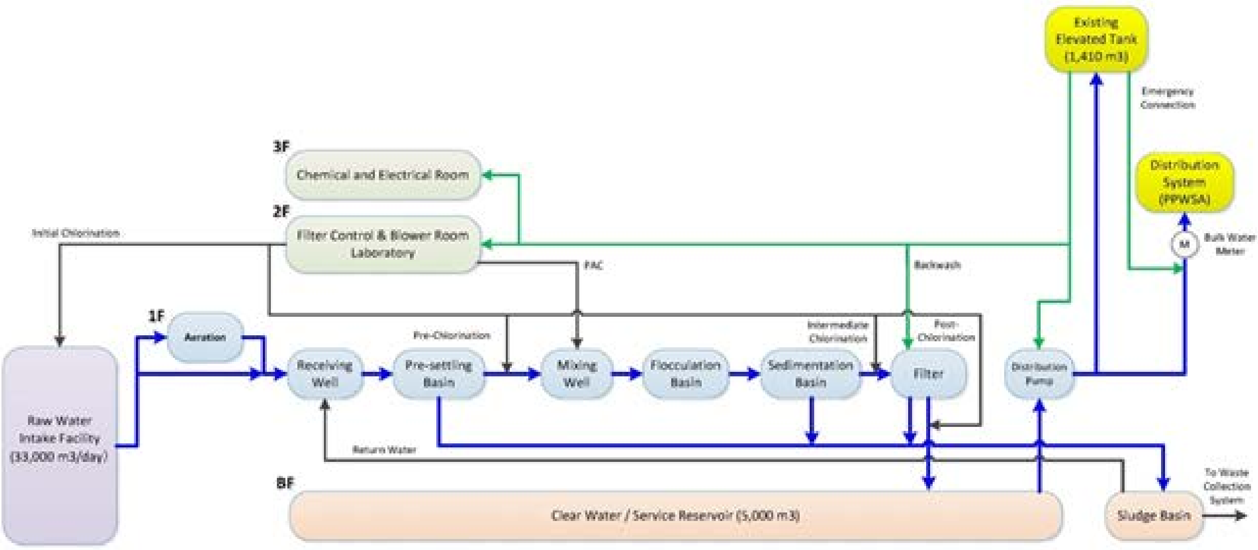


図 3-2.7　コンパラター施設の概略設計における浄水処理プロセス

表 3-2.4　コンパラター施設の浄水処理プロセスの概要

処理プロセス	処理目的
曝気処理	曝気を行い塩素処理の負荷を低減する。
着水井	取水ポンプの吐出圧力変化を抑え、その後の処理プロセスに水理的変動を与えず、最適に運転出来るようする。
沈砂池	原水と共に流入した砂及び比較的大きな懸濁物質を除去し、併せて沈殿プロセスで必要となる凝集剤の注入量低減を図る。
混和プロセス（急速攪拌）	原水に凝集剤を均一に注入し、出来るだけ短い時間に大きい攪拌エネルギーを与え原水と凝集剤を混和し微細なフロックを形成させる。 原水が堰を超えて滝落ちする箇所に凝集剤を注入し原水と混和させる、水理的攪拌方式とする。この方式は他方式（機械式攪拌機等）に比べて次の利点がある。 － 独立した混和池は不要。 － 短い時間で確実な混和が行える。 － 攪拌機等の機器を使用しない為、この機器類の攪拌動力が不要。 － 建設費と O&M コストが他の方式に比べて経済的。 － 保守管理がほとんど不要で、保守管理での長期混和池停止がない。

処理プロセス	処理目的
フロック形成プロセス	混和プロセスで作った微細フロックを大きく成長させる為に緩やかな攪拌エネルギーと滞留時間を与える。 水流自体の持つエネルギーをよる攪拌方式で、下流に行くにしたがって攪拌強度が漸減する、水平迂流（上下迂流付き）方式を採用する。この水流式水平迂流（上下迂流付き）方式は他の方式（機械式攪拌）に比べ、次の利点がある。 － 撹拌機等の機器を使用しない為、この機器類の撹拌動力が不要。 － 建設費と O&M コストが他の方式に比べて経済的。 － 保守管理がほとんど不要。
沈殿プロセス	フロック形成プロセスで大きく成長したフロックを重力沈降作用により除去し､後続のろ過プロセスにかかる負担を軽減させる。 浄水場建設敷地に制限があり､面積負荷を大きくとることができる､傾斜管上向流式沈殿池方式とする。 傾斜管上向流式沈殿池方式は PPWSA の浄水場での運転実績がある。
ろ過プロセス	沈殿プロセスで処理出来なかった微細フロックを持つ沈殿水をろ過プロセスで処理する。 比較的有効径の大きなろ材（砂）を用い、ろ材全体で微細フロックを捕捉し空気と水でろ材の洗浄を行う方式と比較的有効径の小さなろ材（砂）を用い、ろ材表層で微細フロックを捕捉し水のみでろ材の洗浄を行う方式がある。カ国のほとんどの浄水場が前者の方式を採用し、多くの運転実績がある為。比較的有効径の大きなろ材（砂）を用い、ろ材全体で微細フロックを捕捉し空気と水でろ材の洗浄を行う方式とする。
配水池	ろ過水に後塩素を注入し､出来上がった浄水を貯える施設であると同時に､浄水量と配水量の不均等を調節緩和する。
排水処理プロセス	ろ過洗浄水は閉鎖処理とし着水井に返送する。
薬品注入プロセス	凝集剤注入設備 粉末 PAC を使用し､溶解後 PAC 溶液を自然流下で溶液を注入する。注入量は最大濁度: 1000 NTU 時に対応できる施設とする。 塩素剤注入設備 塩素は、塩を電気分解し生成次亜塩素酸ナトリウムとする。 塩素注入設備は、注入量として、通常の注入処理（前塩素、中塩素、後塩素）で用いられる容量に加えアンモニア態窒素を処理する容量を確保できる施設とする。 アルカリ剤注入設備 アルカリ剤として粉末消石灰が入手可能である。原水水質より判断すると、pH が比較的高くかつ PAC を凝集剤として使用するため、アルカリ剤の注入設備を建設する必要はない。

2) 概略設計計画

コンパラター施設の浄水施設の概略設計を**図 3-2.8** 及び**資料 6** に示す。

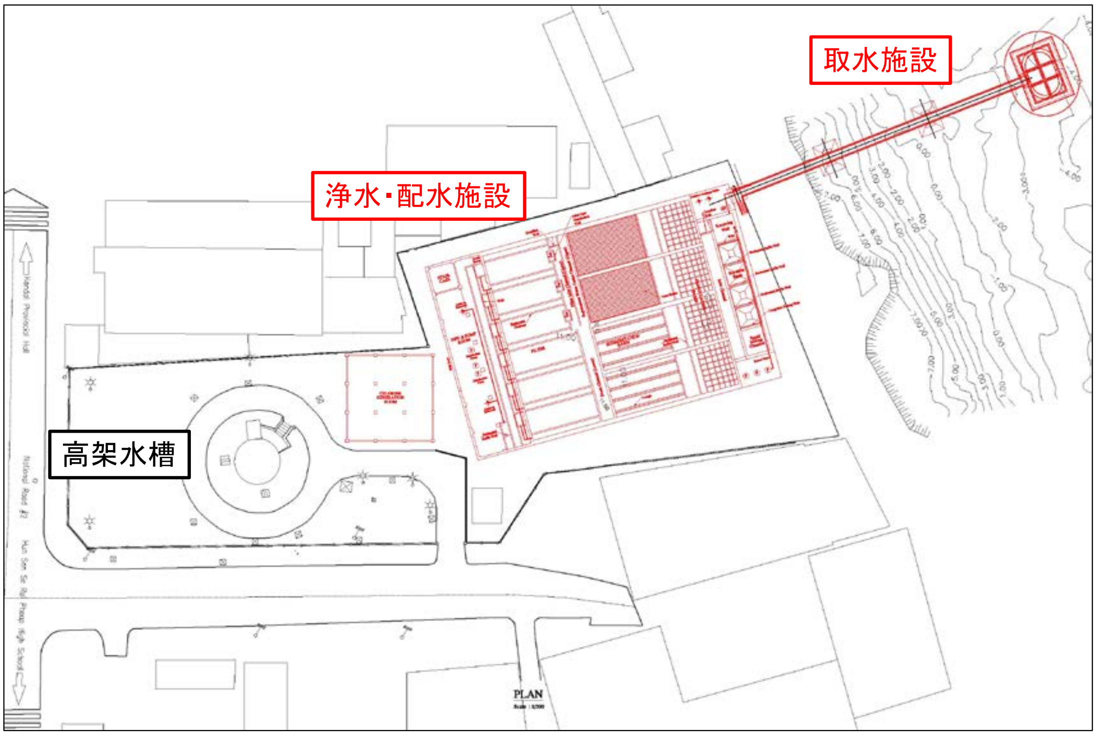


図 3-2.8 コンパラター施設の概略設計における平面配置図（案）

3-2-2-2-4 送配水施設計画

(1) 配水計画

コンパラター施設の概略設計として、給水地域がほぼ平坦であることと配水エネルギーの経済性を考慮して、ポンプ直配水システムを採用する。ポンプ直配水システムは、配水ポンプの吐出圧力を一定に保つこととし、配水圧力はポンプ台数（回転数制御含む）で制御を行う。SPC は引渡地点での要求水圧を満たすように配水ポンプの制御を行う責任がある。

(2) 配水量時間変動及び配水池容量

コンパラター施設の概略設計として、過去一年のタクマウへの配水流量記録を考慮し、配水量時間変動率及び配水池容量を次のとおりとする（**図 3-2.9**）。

- 配水量時間変動率： 1.4
- 配水池容量： 4 時間

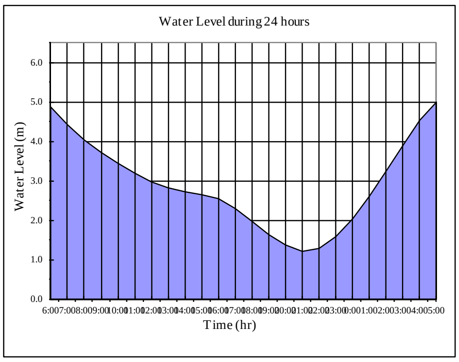
Ta Khmau Reservoir

Day max. =	30000	m3/day	Res. Cap.=	5000	m3
=	1250.00	m3/hr	Effec. Dpt.=	5	m3
Day ave.=	30000.0	m3/day	Effec.Area=	1000	m2
	1250.0	m3/hr		4.0	hours

Time (hr)	Peak Factor	% of Daily Demand (%)	Water Demand (m3/hr)	Fire Demand (m3/hr)	Total Outlet	Inlet (m3/hr)	Volume (m3)	Water Level (m)
0								
6:00	1.10	4.6%	1,375		1,375	1,250	4,875	4.9
7:00	1.36	5.7%	1,700		1,700	1,250	4,425	4.4
8:00	1.31	5.5%	1,638		1,638	1,250	4,038	4.0
9:00	1.25	5.2%	1,563		1,563	1,250	3,725	3.7
10:00	1.22	5.1%	1,525		1,525	1,250	3,450	3.5
11:00	1.20	5.0%	1,500		1,500	1,250	3,200	3.2
12:00	1.18	4.9%	1,475		1,475	1,250	2,975	3.0
13:00	1.12	4.7%	1,400		1,400	1,250	2,825	2.8
14:00	1.08	4.5%	1,350		1,350	1,250	2,725	2.7
15:00	1.06	4.4%	1,325		1,325	1,250	2,650	2.7
16:00	1.08	4.5%	1,350		1,350	1,250	2,550	2.6
17:00	1.20	5.0%	1,500		1,500	1,250	2,300	2.3
18:00	1.26	5.3%	1,575		1,575	1,250	1,975	2.0
19:00	1.27	5.3%	1,588		1,588	1,250	1,638	1.6
20:00	1.21	5.0%	1,513		1,513	1,250	1,375	1.4
21:00	1.13	4.7%	1,413		1,413	1,250	1,213	1.2
22:00	0.94	3.9%	1,175		1,175	1,250	1,288	1.3
23:00	0.76	3.2%	950		950	1,250	1,588	1.6
0:00	0.64	2.7%	800		800	1,250	2,038	2.0
1:00	0.54	2.3%	675		675	1,250	2,613	2.6
2:00	0.49	2.0%	613		613	1,250	3,250	3.3
3:00	0.48	2.0%	600		600	1,250	3,900	3.9
4:00	0.49	2.0%	613		613	1,250	4,538	4.5
5:00	0.63	2.6%	788		788	1,250	5,000	5.0
Total	24	100%	30000	0		Min.	1212.50	1.21
			Total	30000				

Max. 1.36
Min. 0.48

Required Min. Cap. of Res. (hour)
3.03 hr



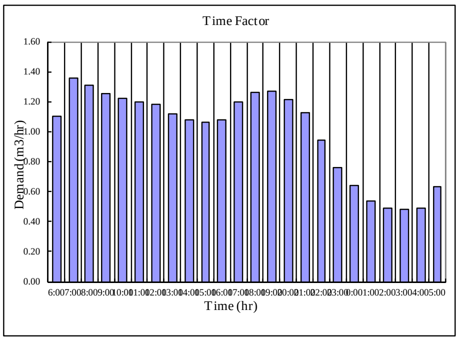


図 3-2.9 配水量時間変動率及び配水池容量

(3) 既存高架水槽の利用

タクマウ浄水場の既存高架水槽は、2009 年に世界銀行の支援により建設され、現在は PPWSA により非常によく維持管理されているため、今後も有効利用することが可能である。しかし、高架水槽の水位は、コンパラター施設の概略設計で計画する配水最適圧力より低いため、高架水槽を配水用として常用することはできない。

そのため、高架水槽の利用方法として、浄水場のろ過池洗浄水及び場内給水、配水ポンプが停電等で緊急停止した場合の緊急時の利用が想定される。

(4) 送配水管整備計画

送配水管の整備は本プロジェクトスコープに含まれておらず、PPWSA により実施される。PPWSA による送配水管整備計画の概要を**図 3-2.10** に示す。

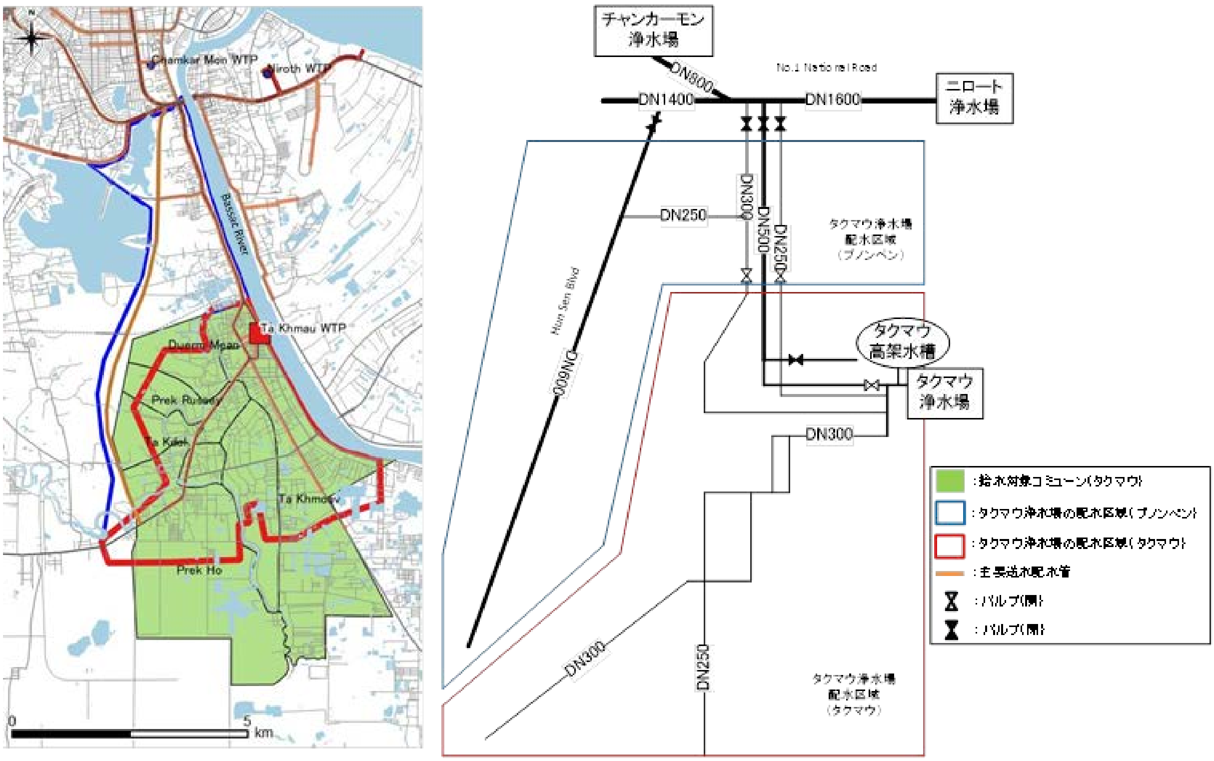


図 3-2.10　PPWSA による送配水計画の概要

タクマウ浄水場の完成後、タクマウ市及びプノンペン都の南部に配水する計画である。プノンペン都の南部の地域については、PPWSA では Hun Sen ロード沿いに新たに口径 600mm の配管の布設を計画しいる。タクマウ浄水場からプノンペン都の南部へ配水する場合は、国道 1 号線の南側及び Hun Sen ロード沿いがタクマウ浄水場からの配水区域となることが想定される。

配水システムは PPWSA が 30,000m^3/日のキャパシティー以上のものを整備し 30,000 m^3/日の浄水を SPC より購入することとなっており、浄水場からの配水量が、最終需要の低迷や配水網のトラブル等の何らかの PPWSA 側の原因でこれを下回った場合、SPC は PPWSA と協議を行う必要がある。

タクマウの配水圧は、PPWSA の配水方針により、他の浄水場からの配水圧と同様に、時間最大時に配水管の末端配水圧 20m 以上が要求されている。

施設完成後のタクマウ及びプノンペンへの配水計画、2030 年におけるタクマウへの配水計画案に基づく管網解析を**資料 6** に示す。

3-2-2-2-5　　機械設備計画

コンパラター施設の概略設計として、機械設備は、基本的に高効率で長寿命、故障の少なく、且つ初期投資額並びに維持管理費が安価なものとする。コンパラター施設の主要機械設備を**表 3-2.5** に示す。

表 3-2.5　主要機械設備

機械設備名	設置個所
1．取水ポンプ設備 － 取水ポンプ － 流入ゲート － 取水ポンプ吐き出し配管（弁類含む） － 沈砂排出ポンプ － 機器搬入用クレーン	取水ポンプ場
2．沈砂池排砂設備（配管及び弁類）	沈砂池
3．凝集剤注入配管	混和池
4．沈殿池汚泥引き抜き配管（自動弁類含む）設備	沈殿池
5．ろ過池設備 － 流入弁及び流出、洗浄配管（自動弁含む）設備 － 空気洗浄用ブロアー	ろ過池
6．配水ポンプ設備 － 配水ポンプ － 配水ポンプ吐き出し配管（弁類含む） － 機器搬入用クレーン － 場内給水分岐配管（弁類含む）	配水ポンプ場
7．薬品注入設備 － 凝集剤（PAC）注入設備 － 塩素剤生成及び注入設備	薬品注入室
8．排水排泥池設備 － 排水返送ポンプ － 汚泥引き抜きポンプ － 排水及び汚泥引き抜きポンプ吐き出し配管（弁類含む） － ポンプ保守用ホイスト類	排水排泥池

3-2-2-2-6　電気設備計画

(1)　受変電計画

受変電設備は、浄水場の規模から、EDC の配電線より 22kV にて受電を行う。受電された 22kV は、浄水場内設置予定の変圧器により降圧して、各盤に配電を行う。EDC 指定仕様の変圧器は、無償資金を活用し設置する。尚、受電点から変圧器までの電柱及び配管配線の工事、受電に関する手続きについてはカ国側の負担とする。

(2)　停電時対策

2019 年の電力事情は、乾季に電力の供給不足が予想されることから、計画停電が 3 月から 5 月まで実施された。計画停電の対象地区は、プノンペン都及びタクマウ市のあるカンダール州であった。EDC に別々の変電所から 2 回線受電が可能かの確認を行った結果、南北別々の変電所から異なる系統の配電線より、受電が可能とのことであった。また、計画停電においても、事前に協議をすれば同時停電を避けることが可能であるとの回答であった。

よって、タクマウ浄水場の停電時対策は、2 回線受電とする。理由としては、自家発電設備と 2 回線受電設備の工事費を比較すると自家発電設備の方が高価となるためである。尚、2017 年に完成したニロート浄水場においても 2 回線受電方式を採用している。

(3) 監視制御装置（SCADA）

コンパラター施設の概略設計として、機器の操作、状態及び計測項目を一括で監視制御するための監視制御装置（SCADA）を導入する。監視制御装置（SCADA）のシステム構成を**図 3-2.11** に示す。

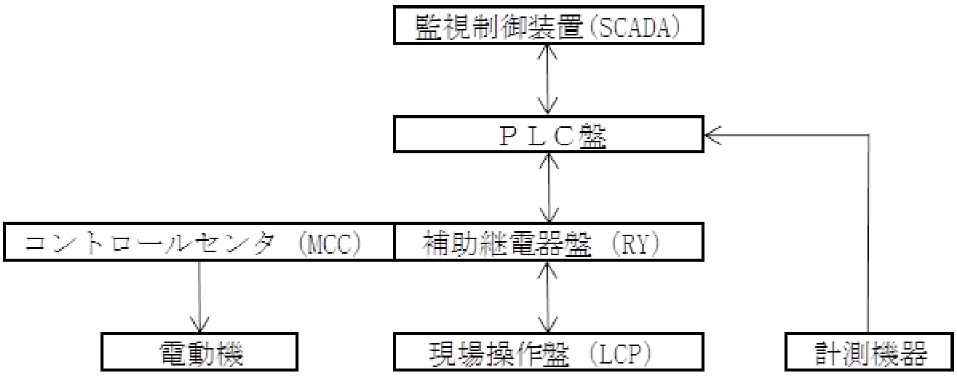


図 3-2.11 監視制御装置（SCADA）のシステム構成

システム構成は、現場からの各デジタル及びアナログ信号を PLC 盤に入力し、監視制御装置（SCADA）に伝送する。また、監視制御装置（SCADA）からの制御信号は PLC 盤を経由して補助継電器盤へ入力する。監視項目は、機器の運転状態及び以下の計装項目とする。

表 3-2.6 監視項目

運転状態	流量	水位	圧力	水質
取水ﾎﾟﾝﾌﾟ 配水ﾎﾟﾝﾌﾟ 空気洗浄ﾌﾞﾛﾜ 電動弁 排泥ﾎﾟﾝﾌﾟ 薬注設備	取水流量 配水流量 逆洗流量 ろ過池流量	ﾊﾞｻｯｸ川河川水位 浄水池水位 薬品貯留ﾀﾝｸ水位	配水圧力	色度 pH(着水井、沈殿池後) TDS 又は導電率 濁度(着水井、沈殿池後、ろ過池後)

(4) 設備計画

電気設備は、基本的に高効率、長寿命で故障が少なく、且つ初期投資額並びに維持管理費が安価なものとする。コンパラター施設の主要電気設備を**表 3-2.7** に示す。

表 3-2.7 主要電気設備

電気設備名	設置個所
1.受変電設備 － 変圧器（常用回線） － 変圧器（予備回線） － 配電盤	 屋外 屋外 屋内
2.運転操作設備 － モーターコントロールセンタ（VFD 盤含む） － 補助継電器盤 － 現場操作盤	 電気室 電気室 各電力駆動機械の現場
3.計測設備	

電気設備名	設置個所
－流量計 －水位計	各計測場所 各計測場所
4.監視制御設備 －監視制御装置（SCADA） －PLC 盤	監視室、ろ過制御室 電気室

3-2-2-2-7　運転維持管理計画

(1)　SPC の運営・維持管理体制

施設の運営・維持管理は SPC により実施される。事業体が先進的で効率的な浄水施設を提案した場合や、本邦で非常に効率的且つ効果的な維持管理の実績を積んだ O&M オペレーターが維持管理を行うことにより、これらについての技術移転が行われることが期待される。特に予防保全、在庫管理、文書管理、人材管理や、能力開発・評価等の技術移転については期待できるところである。なお、協議を通して、PPWSA が SPC に PPWSA の費用負担で職員を出向させて維持管理業務に従事することが PPWSA より提案された。また、PPWSA は、浄水場のモニタリングをしなければならないものの、適切なモニタリングの仕組みが構築できていないことを課題として認識している。本プロジェクトを通して本邦企業の O&M のモニタリング及び、そのモニタリング結果に基づいてとられる対応方法等を、PPWSA 自らのモニタリングの仕組みの構築及び運営に参考にしたいという要望がある。現在、Chruoy Changwar 浄水場では 4 チーム各 4 人体制で、Niroth 浄水場では 4 チーム各 7 人体制で浄水場の維持管理を行っている。なお、4 チームの内 3 チームが 3 シフトで 8 時間勤務を行い、1 チームを予備としているとのことである。

コンパラター施設を想定した場合の運転維持管理は、浄水場の施設規模から必要スタッフ人数を考慮すると、Chruoy Changwar 浄水場（130,000m^3/日）や Niroth 浄水場（260,000m^3/日）に比べて施設規模が小さく二人一組のオペレーターが 3 シフト（8 時間毎）で行うことで可能であると考える。場長やマネージャ等を合わせれば水質検査要員を除き日中には 5 人が常駐しているので、日常的な運転や、定期的な掃除等は 5 人で行うことは十分に可能であると考える。配管や機械電気設備の故障などに対しては、SPC が技師や作業員を派遣し、必要に応じて SPC を通して PPWSA に支援を要請して対応を行う事を想定する。

コンパラター施設の運営及び運転維持管理体制（案）を**表 3-2.8** に示す。

表 3-2.8　コンパラター施設の運営維持管理体制（案）

	Origin	Duty	Number	Shift	Total Number
CEO	Japanese/ Foreign	Control of WTP Works	1	0.5	1
O&M Technical training advisor	Japanese/ Foreign	Instruction of O&M Works	1	0.5	
Chief Manager	Local	Management of Entire WTP Works	1	1	1
Facility Manager	Local	Support of Chief Manager to Control Daily Regular Work	1	1	1
Quality Manager	Local	Water Quality Analysis of Daily Regular Work	1	1	1

	Origin	Duty	Number	Shift	Total Number
Admin/ business Staff	Local	Administration Works	3	1	3
M & E Engineer	Foreign/ Local	Maintenance and Repair of M&E Equipment	1	1	1
Operating Staff	Local	Plant O&M	2	3	6
					14

3-2-2-2-8　調達計画

(1)　一般資材

建設に関連する主要資材のうち、セメントはカ国で生産しており、コンクリートプラントは、タイ資本の大規模のプレミックスコンクリートプラントがプノンペン都に各所に存在している。構造物鋼材及び鉄筋は、ベトナム、タイなどからの輸入品が市場で入手可能である。

(2)　機械電気設備

機械電気設備は、カ国で製作ができないため、本邦調達とするが、近隣国であるタイ及びベトナムで調達可能なものは、第三国調達とする。

(3)　国内輸送

本邦調達及び第三国調達の機材の海上輸送はシアヌークビル港に陸揚げされ、内陸輸送は、国道 4 号を経由して陸路でプノンペン都に運搬される。シアヌークビル港はカ国で最大の商業港であり大規模のコンテナ基地があり、輸送上の問題はなく、シハヌークビル港からプノンペンの輸送経路の道路状況は良好である。

(4)　施工計画

施工計画タクマウ市はプノンペン都の南部に位置している。気候は熱帯モンスーンであり、5 月から 10 月が雨季、11 月から 4 月が乾季である。

取水施設はバサック川の右岸に予定される。取水施設の建設は、河川水位によって大きく影響を受けるので、乾季に主要工事を行うこととする。

3-2-2-3　ソフトコンポーネント計画

本件にはソフトコンポーネントは含まれない。

3-2-2-4　機材計画

本件には機材調達は含まれない。

3-2-3　　コンパラター施設の概略設計図

本業務で作成したコンパラター施設の図面のリストを**表 3-2.9** に示す。コンパラター施設の概略設計図を**資料 6** に示す。

表 3-2.9　概要設計図面リスト

番号	施設区分	図面標題	図番号
1	全体施設	全体施設計画図（１）	G-1
2		全体施設計画図（２）	G-2
3		全体施設計画図（３）	G-3
4		全体施設計画図（４）	G-4
5	取水施設	取水施設計画図（１）	I-1
6		取水施設計画図（２）	I-2
7		取水施設計画図（３）	I-3
8		取水施設計画図（４）	I-4
9		取水施設計画図（５）	I-5
10		取水施設計画図（６）	I-6
11		取水施設計画図（７）	I-7
12	浄水施設	浄水施設計画図（１）	W-1
13		浄水施設計画図（２）	W-2
14		浄水施設計画図（３）	W-3
15		浄水施設計画図（４）	W-4
16		浄水施設計画図（５）	W-5
17		浄水施設計画図（６）	W-6
18		浄水施設計画図（７）	W-7
19		浄水施設計画図（８）	W-8
20		浄水施設計画図（９）	W-9
21		浄水施設計画図（１０）	W-10

3-2-4　契約形態／入札

3-2-4-1　契約形態

本プロジェクトの契約形態は、Design, Build and Operate（DBO）である。主契約者は、日本企業を代表とする単独企業または共同事業体（以下、「事業体」）が施設整備を担当し、現地で設立される SPC が O&M を担当する。

- 入札において、PPWSA は施設整備及び運営・維持管理における要求水準を提示し、応札者はそれぞれの計画と価格を提案する。
- PPWSA は、落札者による事業体と包括契約、EPC 契約（無償対象）及び O&M 契約（契約書案作成等のスキーム構築業務は無償の対象となるが、O&M 自体は無償対象外）を締結する。
- 事業体が EPC コントラクターに設計・施工にて施設を整備させ、試運転ののち、1 年間の瑕疵担保期間付きで PPWSA が施設を所有する。
- 施設整備をした事業体の構成員を中心とした EPC コントラクター又は O&M オペレーターを代表として現地で設立される SPC が O&M 契約に基づき施設完工後 10 年間にわたり施設の維持管理・運営を担う。SPC は、バルク水を PPWSA に供給し、PPWSA は SPC にパフォーマンスに応じたサービス料金を支払う。

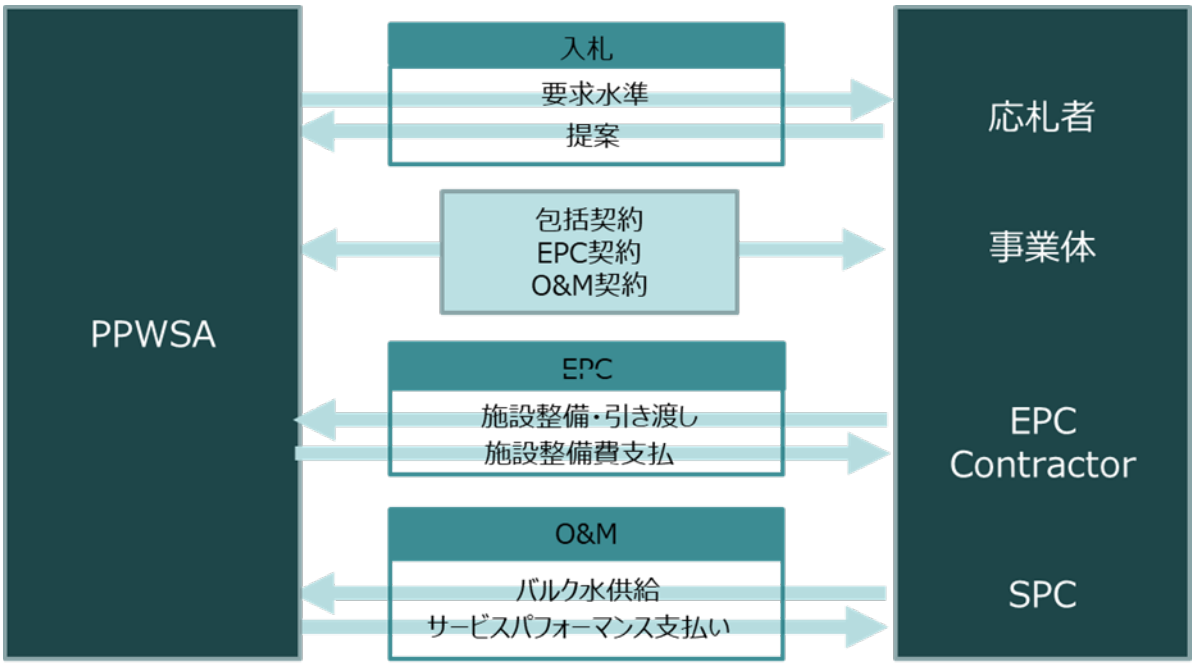


図 3-2.12　入札、契約及び事業の実施形態

本プロジェクトは維持管理運営も含めた無償資金協力でカンボジア公共調達法の例外規定に基

づき､JICAの調達ガイドラインの適用を受けられるとM/Dにおいて PPWSA 及び経済財政省（MEF）と合意している。ただし、公共調達法第 3 条では、ファイナンス合意書で記載された活用原則と手続きに則って履行されるという記載があるだけであり､JICA の調達ガイドラインの適用を確約したものではない。また、上場企業であるため、PPWSA の MEF 以外の株主が公共調達法の例外規定を適用することに反対する可能性もある。このような調達ルールが変動するリスクを軽減するため､本プロジェクトは、カンボジア公共調達法に基づく調達(同法 3 条の例外規定適用)であることを踏まえ、カンボジア政府との合意文書において適用される具体的な活用原則と手続き内容を記載しておくことが望ましい。

3-2-4-2　入札評価

本プロジェクトの入札は、入札参加資格事前審査及び、提案入札評価の 2 段階で実施する。入札評価は総合落札評価方式（Quality and Cost based Selection（QCBS））を採用する。

3-2-4-2-1　　入札参加資格事前審査

入札参加資格事前審査（以下､「P/Q」）においては、入札資格のない者を明確化したうえで、事前資格申請書の提示を求める。入札資格の無いものとは、法律に基づく処分を受けている者や、反社会勢力の疑いや反社会勢力との関わりがある者もしくは、資本関係や組織体制等により応札が認められない者であり、このような者が事前資格申請書を提出した場合には、申請書を無効とする。入札参加資格事前審査は、事業権無償の特性を考慮し、無償資金協力事業で採用される標準的な P/Q 項目を**表 3-2.10** のように変更することを提案する。

表 3-2.10　事業・運営権対応型無償資金協力の P/Q 基準

無償資金協力の標準的な P/Q 基準	事業・運営権対応型無償資金協力の P/Q 基準
ア．企業形態：適格性	ア．企業形態：適格性
イ．財務状況	イ．財務状況
ウ．海外での工事実績	ウ．海外での工事実績及び運営実績
エ．類似工事実績	エ．類似工事実績及び類似事業運営実績
オ．技術者数	オ．技術者数および事業運営経験者

3-2-4-2-2　　提案入札評価

入札において PPWSA は事業の実施方針、要求水準及び契約条件を提示し、応札者は施設の基本設計、建設計画及び運営・維持管理計画と以下に示す価格を提案する。各提案の総合得点は以下の数式に基づいて決定する。

総合得点= 技術点×X + 価格点× (1-X)

X：技術評価と価格評価の比重：50%を想定

3-2-4-2-3　　技術点の評価内容

表 3-2.11　技術点の評価内容

	評価項目	サブ評価項目	配点
1	事業実施指針及び過去の実績の反映	技術、機能、社会環境配慮等	TBA（To be agreed）
2	組織の事業支援体制	事業管理、リスク管理、品質管理	TBA
3	業務従事者	資格及び経験	TBA
4	概略設計	取水塔、浄水場	TBA
5	施設整備に関する計画と体制	工期短縮提案、新技術導入等	TBA
6	運営維持管理に係る計画と体制	自動化、セミオート維持管理等	TBA
		合計	100

3-2-4-2-4　　価格点の評価内容

価格評価方法は別途入札図書で規定するが、10 年間総調達コストを対象とし、価格点は以下の式で算定する。

価格点 ＝ 最低入札価格 / 入札者の価格 * 100

価格提案においては、PPWSA から試算前提条件（割引率 4.5%：PPWSA が事業計画立案において活用している割引率と同一のもの）と、バルク水 m^3 当たりの電気代を除く生産コスト単価の 10 年平均（α）、バルク水 m^3 当たりの電力消費量の 10 年平均（β）、SPC の利益率の上限を提示し、応札者はそれぞれの制約条件の下で以下の図の緑セル部分（EPC 価格、運営期間 10 年分の電気使用量、その他運営費、SPC が求める利益率）を価格の決定要素として提案する。

表 3-2.12　価格評価における 10 年総調達コスト算出表（例）

前提条件		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
生産量	000m3		10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	…(1)
電力価格	KHR/kWh		584	584	584	584	584	584	584	584	584	584	
その他インフレ率、為替、割引率等													
EPCコスト		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
EPC価格	000JPY	X											
O&Mコスト		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
電力費	000,000KHR		1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	…(2)
電気使用量	000kWh		3,309	3,309	3,309	3,309	3,309	3,309	3,309	3,309	3,309	3,309	…(2')
その他運営費	000,000KHR		1,789	1,988	1,988	1,988	1,988	1,988	1,988	1,988	1,988	2,187	…(3)

α	電気代を除くバルク水m3あたりの生産コスト(10年平均)	KHR/m3	302	=sum((3))/sum((1))
β	バルク水m3あたりの電力使用量(10年平均)	Wh/m3	182	=sum((2'))/sum((1))

バルク水価格		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
SPC利益率	%		15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	
バルク水価格	KHR/m3		432	432	432	453	453	453	476	476	476	501	
調達総コスト		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
EPCコスト	000KHR	X'											
バルク水支払額	000KHR		4,725	4,725	4,725	4,957	4,957	4,957	5,211	5,211	5,211	5,489	
合計	000KHR	X'	4,725	4,725	4,725	4,957	4,957	4,957	5,211	5,211	5,211	5,489	…(4)

10年間総調達コスト（現在価値）	**KHR000**	**(4)の現在価値**

また、以下の考え方で入札を実施することを想定している。

① 入札時点では、設計、施工及び維持管理運営のすべての実績・ノウハウを有する事業体として入札する。
② 入札時点では、応募者が単独企業の場合には、すべての業務を 1 社で実施するため、役割分担を提示する必要はないが、応募者が JV の場合は、被選定後に施設整備を行う際の企業体メンバーのそれぞれの役割及び、運営開始前に構築する SPC における出資企業の役割分担及び出資比率を記載した JV 合意書を提示する。なお、SPC の最低出資要件については、今後 PPWSA と協議し決定するものとするが、最低出資要求額を上回る出資額であり、かつ EPC コントラクターの出資比率は当該出資額の EPC コントラクター最低出資比率を上回る出資でなければならないものとする。
③ 本プロジェクトの主契約者は施設整備段階においては、邦人である事業体であり、運営段階においては、事業体の構成員を中心とした EPC コントラクター又は O&M オペレーターを代表として現地で設立される SPC とする。
④ なお、EPC 契約、O&M 契約及び、これら 2 契約を統合して施設不具合リスクを SPC に移転するための包括契約の 3 契約は、落札者被選定後に事業体と同時締結したうえで、SPC が設立された時点で O&M 契約の地位の移転を行うことを想定している。

SPC の最低出資要件において決める必要がある項目：

- 最低出資要求額：SPC の設立における出資額の最低額を規定するもの
- EPC コントラクター最低出資比率：SPC の出資額の内、EPC コントラクターによる出資額が出資額全体に占める割合を示すものであり、EPC コントラクターは、当該最低出資比率を上回る出資をしなければならないものとする。

共同事業体に求められる実績については、事業・運営権対応型無償資金協力のスキームの意義を踏まえつつ、競争性が担保される条件設定とする。

3-2-4-3　リスク分担

本プロジェクトにおけるリスク分担は、最もリスクを適切に管理できる主体が当該リスクを負担することで事業価値を最大化することを基本的な考え方とする。主なリスクと分担は以下の通りである。

表 3-2.13　リスク分担表

リスク	PPWSA	SPC	内容
EPC 契約に係るリスク			
EPC リスク	O	O	− 要求水準の変更や残留 UXO 等、PPWSA の責任に起因する追加費用は PPWSA が負担する。 − 自然条件等の外部要因による追加費用は原則として PPWSA が負担するが、JICA ガイドラインに基づく予備的経費の適用を想定している。 − 設計の不備等 SPC の責任及び規定範囲内のインフレに起因する追

リスク	PPWSA	SPC	内容
			加費用は SPC が負担する。
施設整備段階における不可抗力リスク	O		− 予測不可能かつ対応不可能な外部要因であり、プロジェクトに重大な悪影響を及ぼす事象を不可抗力とし、施設整備段階において不可抗力が発生し施設整備の遂行が困難となった場合は、PPWSA のリスクとして認識し、費用負担が行われるものとする。（但し、JICA の予備費の範囲内においてリスク負担されるものとする。）
O&M 契約に係るリスク			
需要リスク	O		− PPWSA は最終需要の低迷や配水網のトラブル等により、月平均 30,000 m^3/日を受け入れることができなかった場合においても、SPC が月平均 30,000 m^3/日の浄水能力を維持し続ける場合は、SPC に対して、月平均 30,000 m^3/日の支払いを保証する。
運営リスク		O	− SPC の運営の瑕疵によって水質基準を満たさない水が供給された場合（機械の故障や薬品の扱いの不備等）、PPWSA は、当該水に対する支払い義務は生じない。さらに、PPWSA の定める飲料水質基準を満たさない浄水を給水して PPWSA に損害が生じた場合には､SPC には当該損失の補償義務が生じる。
電力価格リスク	△		− 電力価格の変動リスクの一部を PPWSA が取るものであり、3 年毎に支払メカニズム（価格算定式）を適用してバルク水価格を調整することで適用される。価格算定式は、電力価格と物価に連動しており、算定結果が、見直しの時点までに適用されてきたバルク水価格（現行バルク水価格）を上回った場合は新たなバルク水価格が適用される。ただし、算定結果が現行バルク水価格を下回る場合には、現行バルク水価格を継続できるものとする。
電力供給リスク		O	− 停電等により電力が供給されなかった場合、PPWSA は SPC の営業補償や固定費の負担を含め、当該期間中 SPC に対する支払い責任はない。一方、SPC も浄水の供給責任を免除される。
物価上昇リスク	△	△	− 物価変動リスクの一部を PPWSA がとるものであり、3 年毎に価格算定式を適用してバルク水価格を調整することで適用される。価格算定式は、電力価格と物価に連動しており、算定結果が、現行バルク水価格を上回った場合は新たなバルク水価格が適用される。ただし、算定結果が現行バルク水価格を下回る場合には、現行バルク水価格を継続できるものとする。なお物価変動は、カンボジア国家統計局が毎月公表する All Items (CPI TOTAL）もしくは、合理的に適用可能な指標を適用する。
為替リスク		O	− SPC への出資金及び収益･配当に係る為替リスクは SPC の負担とする。
原水質悪化リスク	O		− 長期的かつ恒常的な原水の水質悪化によって生産コストが増加した場合、支払メカニズム（価格算定式）の追加生産コストが該当する。SPC は PPWSA と協議を行い、生産コストの上昇分を PPWSA が SPC に補償する。原水水質の季節的な変動については対象外とする。
許認可リスク	O		− IEIA 及びその他運営に必要な許認可は PPWSA が取得する。
法令変更リスク (水道セクター)	O		− 水道セクター特有の法令変更（飲料水の水質基準強化等）によって追加コストが生じた場合、SPC は PPWSA に対して当該コストを請求できる。
法令変更リスク (経済全般)		O	− 国或いは経済全体に影響する法令変更による追加コストについて SPC は PPWSA に対して当該コストを請求できない。（VAT 率の変更、法人税率の変更等）。
不可抗力リスク	O	O	− 予測不可能かつ対応不可能な外部要因であり、プロジェクトに重大な悪影響を及ぼす事象を不可抗力とし、不可抗力が発生し契約の遂行が困難となった場合、その対応に伴う費用は双方の負担とする。またその状況が 180 日以上継続した場合、双方は契約を解除することができる。民間資産がある場合は、PPWSA は SPC に対して、正味簿価にて民間資産の受け渡しを要求できる。

尚、SPC にとって契約カウンターパートとなる PPWSA の財務リスク・信用リスクは極めて限定的である。

3-2-4-4　オフテイク価格と支払メカニズム

3-2-4-4-1　　オフテイク価格

O&M 契約に基づいて、SPC はバルク水を PPWSA に供給し、PPWSA は SPC にパフォーマンスに応じたサービス料金を支払う。支払額については、入札において SPC が提示した価格決定要素（α、β、期待収益率）とリスク分担を参照し、以下の通り算定する。

PPWSA の支払＝SPC の収入＝バルク水販売売上 ＋ 追加サービス料 － 損害賠償

バルク水販売売上 ＝ バルク水供給量 × バルク水販売単価

バルク水販売単価 ＝（α*インフレ指数+β*電力価格+ 追加生産コスト）×（1+ SPC の期待収益率 ）

α　（アルファ）	契約書で定めた電気代を除くバルク水 m^3 あたりの生産コスト（定額）
β　（ベータ）	契約書で定めたバルク水 m^3 あたりの電力使用量（定量）
SPC の期待収益率	契約書で定めた浄水供給原価（α*インフレ指数 ＋ β*電力価格＋追加生産コスト）に対する%
追加生産コスト	原水の水質悪化或いは水道セクター特有の法令変更（水質基準の強化等）によって追加的に発生するコスト
追加サービス料	水質の詳細分析やワークショップ・サイト見学の実施等、SPC の基本業務以外の要請に対する支払い
損害賠償	SPC が水質・水圧基準を満たさない浄水を供給した場合に PPWSA が受けた損害について、SPC が補償する

価格算定式の要素

αに含まれるもの	労務費（施設運営、SPC 管理、、日本人 CEO)、材料費、修繕費、事務所経費、財務/法務サービス、輸送、社会保険、材料費に関わる VAT/輸入税、施設損害保険及び第三者賠償保険が必要な場合は含めて構わない。
αに含まれていないもの	投資会社のオーバーヘッド、
αと PPWSA のコストの違い	PPWSA のコストは、減価償却費を含むが、SPC のαは含まない。これは施設を PPWSA が所有している為。また、SPC のαにはバックオフィス経費が含まれているが、PPWSA のコストにはこれらは含まれていない。

前提条件：インフレ率　3%、電力料金　KHR584/kWh
2017 年の PPWSA による運営結果:

内訳	（KHR/ m^3）
電力	172.11（275Wh/ m^3）
減価償却	82.86
修繕費	38.85
材料費	33.45
労務費	18.68
合計	345.95

なお、インフレ指数及び電力価格の詳細な適用方法については、入札図書案策定段階において具体的に活用可能な方法で合意するものとする。PPWSA は、入札時に提案し合意されたバルク水価格を 3 年毎に改定することに合意した。改定額は、上記の「バルク水販売単価」算定式を活用

して算定されるものとし、算定結果が現行バルク水価格を上回った場合は、算定結果を新たなバルク水価格として適用する。ただし、算定結果が現行バルク水価格を下回る場合には、現行バルク水価格が次の 3 年間継続されるものとする。

3-2-4-4-2　電力価格

電力価格の顧客別単価を**表 3-2.14** に示す。浄水場は、産業用の顧客カテゴリーとなることから、No.4 の 0.1470USD/kWh となる。

表 3-2.14　電気料金の顧客別単価

No.	Type of customers and Condition of Purchase	Tariff	Note
1	Connection from HV of sub-station	0.1170 USD/kWh	Customers can pay the consumption in Riels with the official exchange rate of EDC.
2	Connection from MV of sub-station in Phnom Penh and Ta Khmau	0.1350 USD/kWh	
3	Connection from MV of sub-station in other provinces	0.1220 USD/kWh	
4	Connection from distribution line and sub-transmission line by MV meter for industrial customers	0.1470 USD/kWh	
5	Connection from distribution line and sub-transmission line by MV meter for commercial and institution customers	0.1590 USD/kWh	

出典：EDC

尚、電気の購入は PPWSA で行うものとする。SPC は電力メーターによって測定した浄水場における電気の消費量に基づいた電気料金を PPWSA に支払い、バルク水販売による料金を PPWSA から受取る。従って、PPWSA と SPC の契約締結時に合意した量よりも実際の使用電力量を抑えることができれば、少ない電力支払い金額で済むことになる。よって、SPC が維持管理を適正に行い、電力使用量を少なく運転できれば、SPC の利益向上と PPWSA のコスト削減の同時達成が可能となる。

3-2-4-4-3　薬品価格

SPC が浄水処理に必要とする薬品が PPWSA が購入している薬品と同じ場合、PPWSA を通じて PPWSA が現在購入している価格で調達することが可能である。

3-2-4-5　契約条件

その他の契約条件については、契約書案で以下のように定めることを想定している。

表 3-2.15　その他の契約条件

項目	内容
O&M 期間	− WTP 施設整備完了後、PPWSA が WTP の所有権を有し、PPWSA は SPC と引き渡し（引き渡しの定義は別途合意する）から 10 年間の O&M 契約を締結する。
バルク水の生産	− バルク水の生産は基本的に SPC の責任とする。
施設維持及び修繕	− O&M 契約期間における修繕及び必要な部品交換等に要する費用は契約額（α）に織り込み、SPC のコストと責任で実施する。SPC は PPWSA の SOP に従って運営し、施設を適切に管理する義務を有する。
施設条件	− 取水施設は取水塔形式とする − 塩素注入は生成次亜塩素酸ナトリウムを使用する

項目	内容
	－ 配水池容量は 5,000 m3 以上とする － 浄水水質はカ国の National Drinking Water Quality Standard に準じる。但し濾過池出側の濁度のみ 1NTU 以下とする。 － バルク水量は 30,000 m^3/day とする － バルク水は 24 時間供給とする － バルク水圧は引渡地点で 4 bar 以上とする
施設の引き渡し条件	－ 主要設備については、契約時に引き渡し時のパフォーマンス要求基準を設定し、基準を満足していない設備については SPC のコストと責任で修繕・交換する。また、SPC の運営のために変更した箇所（例：追加の手すりの設置等）については、PPWSA の要望がある場合には原状回復義務を有する。
民間投資	－ SPC は付随施設、ソフトウェア、または、その他運営に必要な機材等に民間投資することができる。PPWSA は O&M 期間の終了時において、SPC より民間投資部分を正味簿価によって買い取る権利を有する。
セルフモニタリング	－ SPC は運営についてのモニタリングを行い、結果を PPWSA に報告しなければならない。モニタリングについての要求項目については今後検討の上決定する。
運営関連データと財務情報	－ SPC は全ての運営に関するデータ及び財務情報を要求されたフォーマットで記録・報告し、データを共有する。PPWSA は施設の返還後に当該データを活用して運営を継続する（民間のシステムの使用権や譲渡については別途協議）。
早期契約解除・清算事象	－ 任意終了（PPWSA からの一方的な終了） PPWSA は公益のために契約を早期に終了する権利を有する。ただし、PPWSA はすべての民間投資、契約の終了によって発生した追加費用、および契約の機会費用について全額補償する。契約の機会費用は、当初事業計画で合意した利益の残存期間分とする。 － PPWSA のデフォルトによる終了 終了条件は前述した任意終了の場合と同等とする。 － SPC のデフォルトによる終了 PPWSA は、SPC の資産等の権利および利益の全てを PPWSA へ譲渡することを要求できるものとする。資産の価値は、資産の正味簿価から、契約の終了により PPWSA が被った損害および損失の費用を差し引いたものとする。 － 不可抗力による解除 予測不可能かつ対応不可能な外部要因であり、プロジェクトに重大な悪影響を及ぼす事象を不可抗力とし、不可抗力が発生し契約の遂行が困難となった場合、その対応に伴う費用は双方の負担とする。またその状況が 180 日以上継続した場合、双方は契約を解除することができる。その場合 PPWSA は SPC に対して民間資産を正味簿価で譲渡することを要求できる。
支払条件	－ SPC は、当月に供給した水量に基づき翌月の 10 日までに請求書を提出する。 PPWSA は請求書を受領日から 30 日以内に支払いを行う。支払通貨はカンボジアリエルとする。
従業員の雇用	－ SPC は現地従業員の雇用について、原則として PPWSA の雇用と同等の条件とする。 － PPWSA は SPC の雇用契約を O&M 期間が終了した時点で引き継ぐ。 － PPWSA は 5 名程度の従業員を PPWSA の費用負担にて出向させる。その場合、当該費用をバルク水価格から控除する。 － 出向者に関する指揮命令権は SPC に属する。 － 2014 年 8 月 20 日付労働省令は、使用者はカンボジア人労働者数の 10%以下の人数の外国人を雇用することができるとしているが、外国人労働者数が 10%を超える場合であっても、従業員割当申請の際に、労働省に対して特例許可に関する手続きを取ることが可能である。
政府保証	－ 本件においては、上場企業である PPWSA との契約であるため、政府保証はない。
免税	－ 通常の無償資金事業と同様に EPC 契約が免税となる。 － PPWSA から利用者への水道料金だけでなく、SPC から PPWSA へのバルク水販売においても、VAT は課せられない。
その他手続き	－ 外国企業がカンボジア現地法人を設立する場合、商業省への商業登記に加え、経済財政省租税総局への税務登録、労働職業訓練省への事業所開設申告、国家社会保障基金（NSSF）への登録が必要となる。カ国政府は、これらの手続きに関し、オンライン化を進めつつあるので、最新情報について確認すること。

3-2-4-6　コンパラター施設の運営・維持管理費

入札における価格決定要素の上限（α、β）を定めるにあたり、以下の通りコンパラター施設を基準に運営・維持管理費（**表 3-5.6**）を試算した。

3-2-4-6-1　　PPWSA の既存施設との比較

PPWSA は既存の浄水場において、高い生産効率を実現しており、本プロジェクトにおいて SPC に対しても同等以上の運営効率を要求している。以下は PPWSA の既存の浄水場における生産要素投入量である。

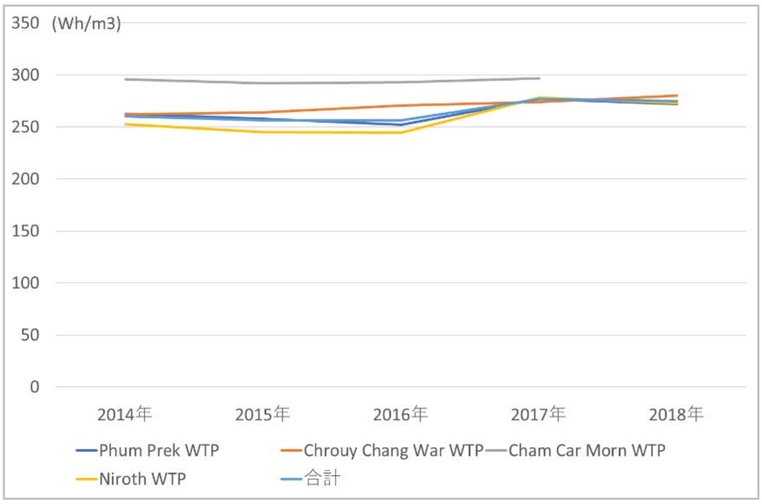


図 3-2.13　PPWSA 既存浄水場の電力使用量

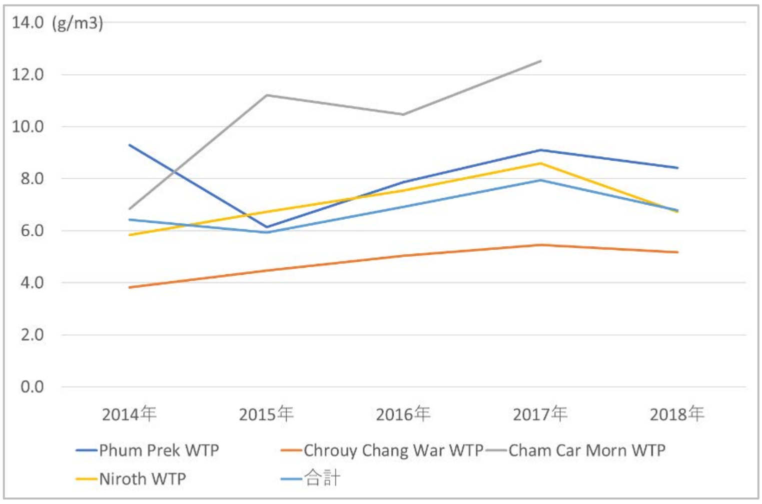


図 3-2.14　PPWSA 既存浄水場の PAC 使用量

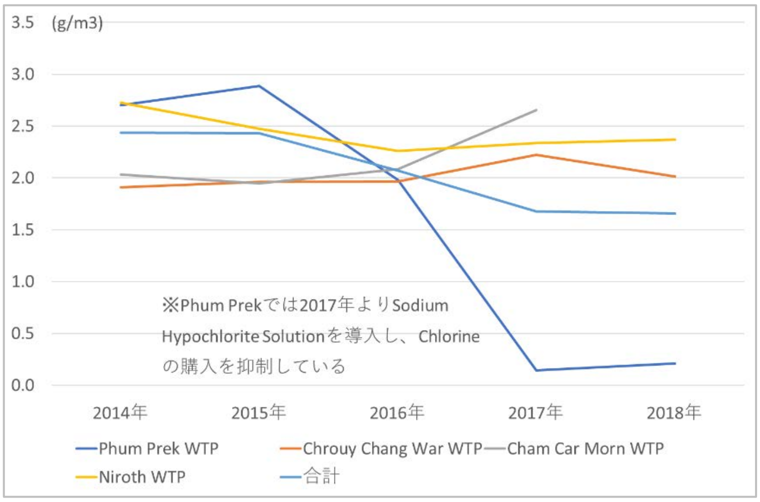


図 3-2.15　PPWSA 既存浄水場の Chlorine 使用量

以下は、コンパラター施設における運営・維持管理と、PPWSA の既存のコスト構造の比較である。ほぼ同等の生産コスト水準であるが、以下の点に留意が必要である。

- 火災保険・損害保険等の適用を PPWSA は検討中であるが、これまでのところ、既存の浄水場には付保していない。
- PPWSA の生産コストには施設の減価償却が含まれている一方で、SPC の O&M コストには（本プロジェクトの浄水施設は PPWSA の所有となるため）減価償却は含まれていない。
- SPC は本プロジェクトのみが対象であるため SPC のバックオフィス費用が含まれる一方で、複数の浄水場を監理している PPWSA の生産コストには PPWSA のバックオフィス費用は含まれていない。

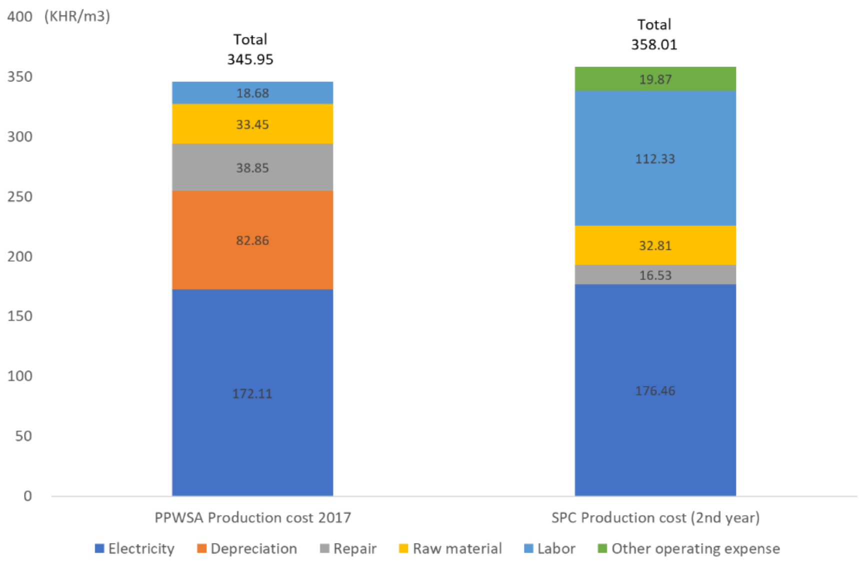


図 3-2.16　コンパラター施設と PPWSA 既存浄水場のコスト構造比較

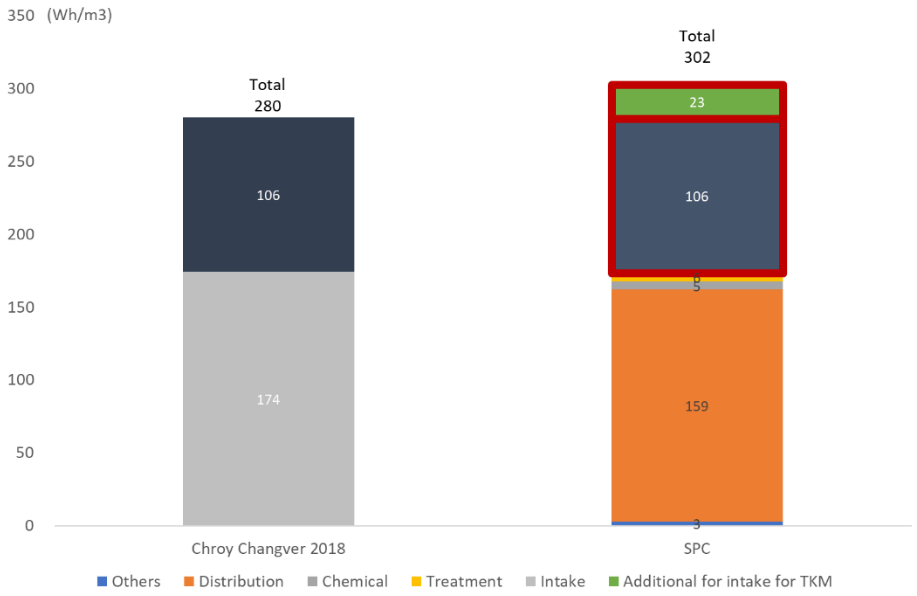


図 **3-2.17**　コンパラター施設と **PPWSA** 既存浄水場の電力使用量比較

3-2-4-6-2　コンパラター施設に基づく SPC の財務計画

コンパラター施設に基づく SPC の財務計画は以下の通りである。

インフレーションは年率 3%として、契約年度を基準として運営開始の 1 年目までで 3 年分の累積上昇を織り込んでいる。10 年間平均の純利益率は 9.4%と、事業リスクを勘案して妥当な水準となっている。

表 3-2.16　コンパラター施設に基づく SPC の財務計画

Operating year (Unit: KHR 000)	2021	2022	2023	1 2024	2 2025	3 2026	4 2027	5 2028	6 2029	7 2030	8 2031	9 2032	10 2033
FX rates													
JPY/USD	111.45	111.45	111.45	111.45	111.45	111.45	111.45	111.45	111.45	111.45	111.45	111.45	111.45
KHR/USD	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00	4,035.00
KHR/JPY	36.20	36.20	36.20	36.20	36.20	36.20	36.20	36.20	36.20	36.20	36.20	36.20	36.20
Inflation rate	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Electricity price	584	584	584	584	584	584	584	584	584	584	584	584	584
1. Profit and Loss Statement													
Operating Revenue													
EPC revenue				0	0	0	0	0	0	0	0	0	0
O&M revenue				4,725,264	4,725,264	4,725,264	4,957,485	4,957,485	4,957,485	5,211,239	5,211,239	5,211,239	5,488,523
Amount of Water Production (000m3)				10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950
Price of bulk Water Sale (KHR/m3)				432	432	432	453	453	453	476	476	476	501
Total Operating Revenue	**0**	**0**	**0**	**4,725,264**	**4,725,264**	**4,725,264**	**4,957,485**	**4,957,485**	**4,957,485**	**5,211,239**	**5,211,239**	**5,211,239**	**5,488,523**
Operating Cost													
Electricity costs	0	0	0	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210
Salaries, wages and related expenses	0	0	0	1,344,108	1,384,431	1,425,964	1,468,743	1,512,806	1,558,190	1,604,935	1,653,083	1,702,676	1,753,756
Raw materials for water treatment	0	0	0	392,595	404,373	416,504	428,999	441,869	455,125	468,779	482,842	497,328	512,248
Repairs and maintenance	0	0	0	0	203,743	209,855	216,151	222,635	229,314	236,194	243,280	250,578	516,191
Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0
Other operating expense	0	0	0	217,995	244,909	252,257	259,824	267,619	275,648	283,917	292,435	301,208	336,053
Total Operating Cost	0	0	0	3,886,909	4,169,667	4,236,790	4,305,928	4,377,139	4,450,487	4,526,035	4,603,850	4,683,999	5,050,458
Gross Operating Profit	**0**	**0**	**0**	**838,355**	**555,597**	**488,474**	**651,557**	**580,346**	**506,998**	**685,203**	**607,389**	**527,239**	**438,065**
Non Operating Cost													
Others	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non Operating Cost	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Profit before Tax	**0**	**0**	**0**	**838,355**	**555,597**	**488,474**	**651,557**	**580,346**	**506,998**	**685,203**	**607,389**	**527,239**	**438,065**
Tax on Profit	0	0	0	167,671	111,119	97,695	130,311	116,069	101,400	137,041	121,478	105,448	87,613
Net Profit after Tax	**0**	**0**	**0**	**670,684**	**444,478**	**390,779**	**521,246**	**464,276**	**405,598**	**548,163**	**485,911**	**421,792**	**350,452**
Operating margin				17.7%	11.8%	10.3%	13.1%	11.7%	10.2%	13.1%	11.7%	10.1%	8.0%
Net margin				14.2%	9.4%	8.3%	10.5%	9.4%	8.2%	10.5%	9.3%	8.1%	6.4%
ROE				40.1%	21.0%	15.6%	17.2%	13.3%	10.4%	12.3%	9.9%	7.9%	6.5%
10 year average operating margin	11.7%												
10 year average net margin	9.4%												
10 year average ROE	15.4%												
2. Cashflow													
Cashflow from Operating Cashflow													
Net Profit after Tax	0	0	0	670,684	444,478	390,779	521,246	464,276	405,598	548,163	485,911	421,792	350,452
Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0
Change in working capital	0	0	0	-69,863	23,563	5,594	-13,590	5,934	6,112	-14,850	6,485	6,679	43,937
Cash Flows from Investment Activity													
Capital Investment	0	0	0	0	0	0	0	0	0	0	0	0	0
Cashflow from Financial Activities													
Equity Injection	0	0	1,000,000	0	0	0	0	0	0	0	0	0	-1,000,000
Dividend	0	0	0	0	0	0	0	0	0	0	0	0	-4,703,379
Net Cashflow	0	0	1,000,000	600,821	468,041	396,373	507,655	470,211	411,710	533,312	492,395	428,471	-5,308,990
Opening Cash	0	0	0	1,000,000	1,600,821	2,068,862	2,465,235	2,972,890	3,443,101	3,854,812	4,388,124	4,880,519	5,308,990
Closing Cash	0	0	1,000,000	1,600,821	2,068,862	2,465,235	2,972,890	3,443,101	3,854,812	4,388,124	4,880,519	5,308,990	0
3. Balance Sheet													
Assets													
Cash	0	0	1,000,000	1,600,821	2,068,862	2,465,235	2,972,890	3,443,101	3,854,812	4,388,124	4,880,519	5,308,990	0
Account receivable	0	0	0	393,772	393,772	393,772	413,124	413,124	413,124	434,270	434,270	434,270	0
Propery, plant and equipment	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Assets	0	0	1,000,000	1,994,593	2,462,634	2,859,007	3,386,014	3,856,225	4,267,935	4,822,394	5,314,789	5,743,260	0
Liabilities													
Account payable	0	0	0	323,909	347,472	353,066	358,827	364,762	370,874	377,170	383,654	390,333	0
Borrowings	0	0	0	0	0	0	0	0	0	0	0	0	0
Others	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Liabilities	0	0	0	323,909	347,472	353,066	358,827	364,762	370,874	377,170	383,654	390,333	0
Equity													
Share capital	0	0	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	0
Retained earnings	0	0	0	670,684	1,115,162	1,505,941	2,027,187	2,491,463	2,897,062	3,445,224	3,931,135	4,352,927	0
Total Equity	0	0	1,000,000	1,670,684	2,115,162	2,505,941	3,027,187	3,491,463	3,897,062	4,445,224	4,931,135	5,352,927	0

3-2-5　施工計画／調達計画

3-2-5-1　設工方針／調達方針

3-2-5-1-1　事業実施体制

本プロジェクトは、事業権無償（**図 3-2.2**）に基づいて実施され、プロジェクトの実施決定後、カ国政府は準備調査を実施したコンサルタントおよび入札で選定された事業体もしくは、事業体の構成員を中心とした EPC コントラクター又は O&M オペレーターを代表として現地で設立される SPC と契約を締結し事業を実施する。

事業実施体制は、次の 2 パターンがある。一つ目は、入札で落札してすぐに包括契約/EPC 契約/O&M 契約を SPC と一括契約し、一つの SPC が施設の設計施工維持管理運営の全てを行うものである。（**図 3-2.18**）。二つ目は、事業体が包括契約、EPC 契約及び O&M 契約を最初に一括して締結し、後に SPC が設立された段階で、O&M 契約の地位の移転を SPC と契約するもの（**図 3-2.19** は、SPC が設立された段階で O&M 契約の地位の移転が行われた後のスキーム）である。

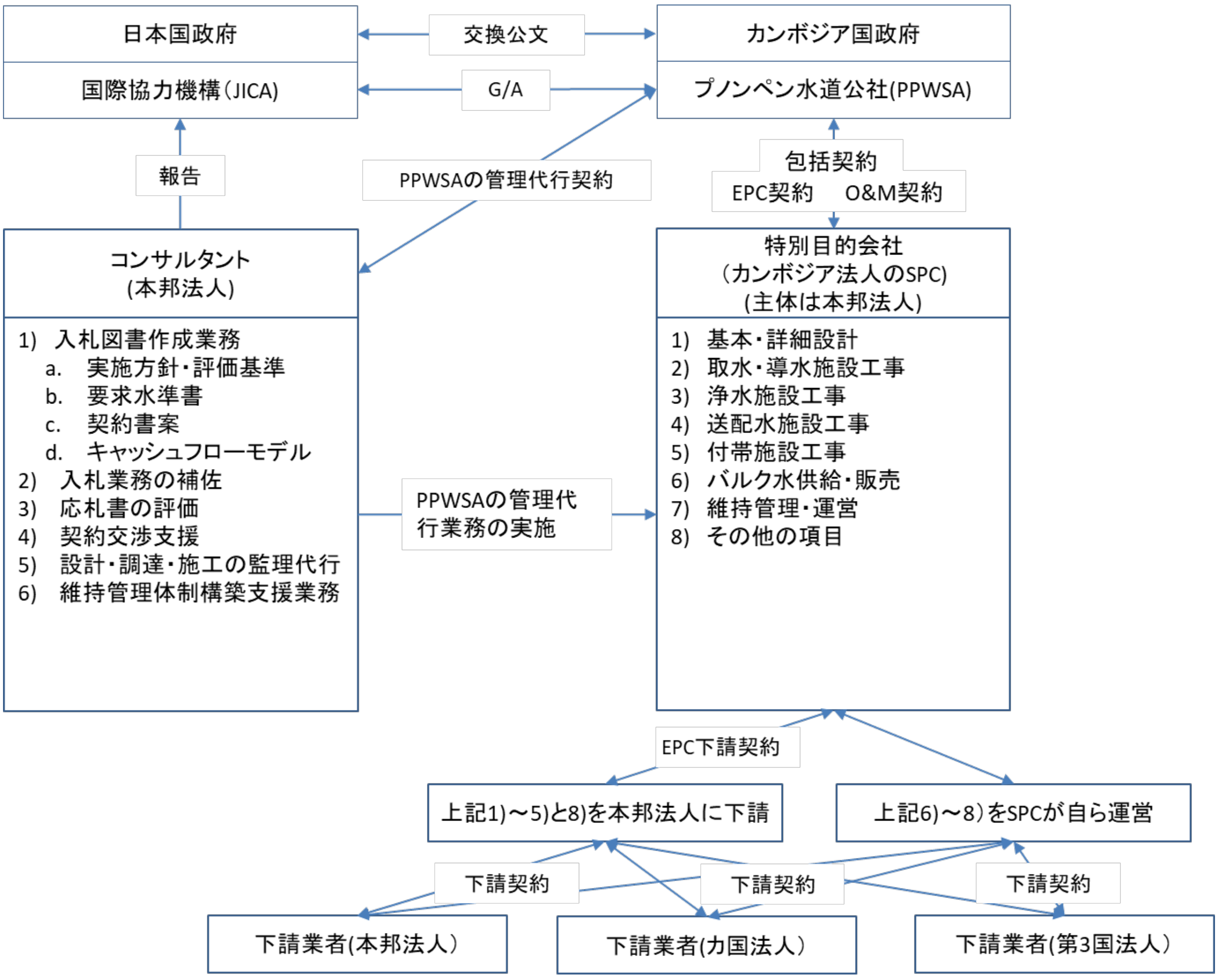


図 3-2.18　事業実施体制の概念図①

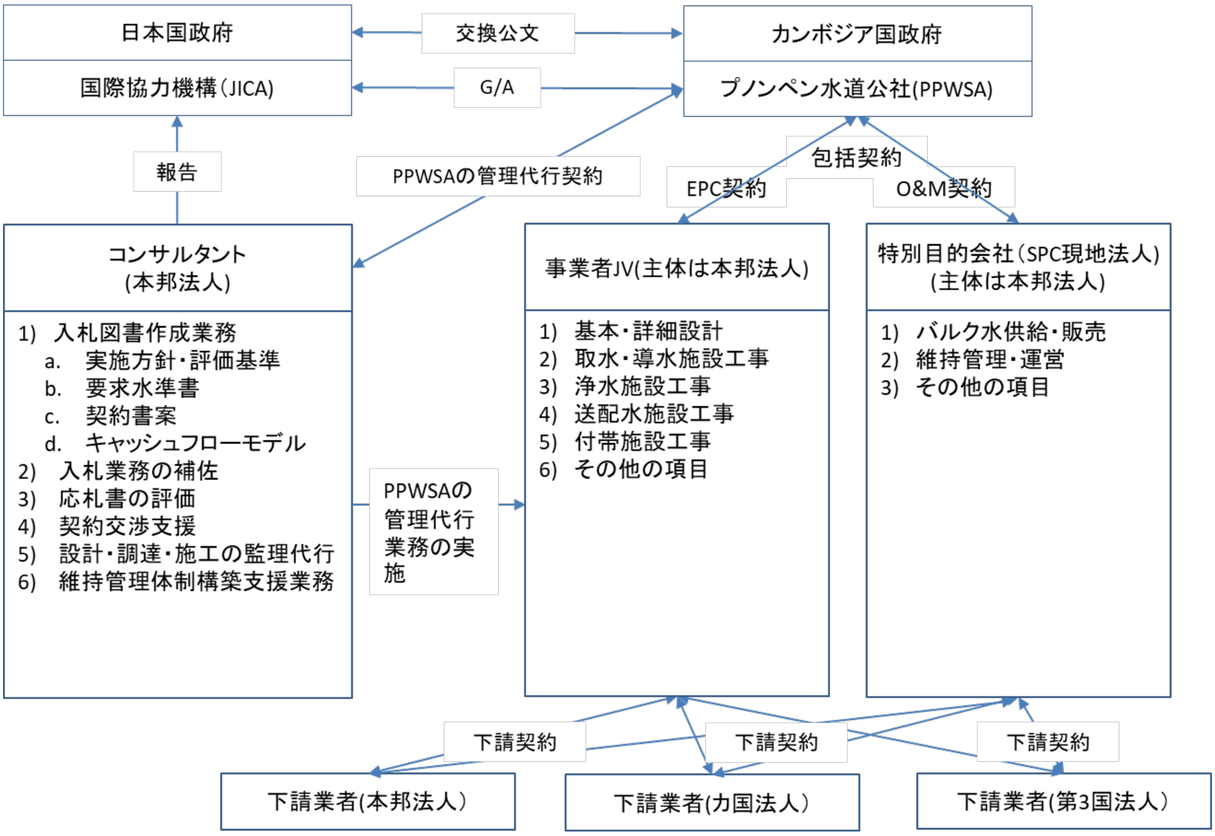


図 3-2.19 事業実施体制の概念図②

3-2-5-1-2 事業実施機関

本プロジェクトの実施機関及び事業実施機関は共に、PPWSA である。

3-2-5-1-3 コンサルタント

日本国側が事業権無償を行う取水・導水施設工事、浄水施設工事、附帯施設工事、送配水施設工事に係る入札補助、設計確認、施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務は、日本国法人で水道施設の設計・施工監理に精通し経験のある建設コンサルタントと、官民連携事業に精通し経験のある PPP コンサルタントによって構成されたコンサルタントの共同企業体（JV）を選定し実施する。

3-2-5-1-4 事業体（一般的に JV）

水道施設整備の実績のある EPC コントラクターと、水道事業運営の実績のある O&M オペレーターが構成員となる本事業の入札のために構築する共同企業体であり、本事業においては、落札後に包括契約、EPC 契約及び O&M 契約を締結する事業主体となる。事業体は施設整備を目的として、EPC 業務を EPC コントラクターに一括下請けする。また、O&M 契約は、事業体の構成員によってカンボジアで設立する SPC に契約の地位を移転する。なお、EPC 契約と O&M 契約を一

つの企業が実施できる場合には、単独企業であることも可能とする。

3-2-5-1-5　EPC コントラクター

事業体の構成員であり、事業体メンバーである O&M オペレーターが合意する場合には、事業体から EPC 契約を一括下請けできるものとする。本施設整備の内訳は取水・導水施設、浄水施設、送配水施設及び付帯施設である。よって本件のような都市部における土木工事かつ水密構造物の品質を確保し、且つ水処理プラントを設計・建設することができる業者であることが求められる。なお、事業の維持管理運営期間にわたり、EPC コントラクターが整備した施設の不具合リスクを担保するために、維持管理・運営を行う SPC に対して EPC コントラクター最低出資比率もしくは、最低出資額以上を出資することが求められる。

3-2-5-1-6　O&M オペレーターとしての特別目的会社（SPC）

事業体の構成員が出資してカンボジアにおいて設立する、事業権無償を活用して整備した施設の維持管理・運営業務を遂行する企業であり、施設整備の段階で設立され、事業体と PPWSA との契約を、SPC と PPWSA の契約に更改する。維持管理・運営業務には、造水したバルク水を PPWSA に売却する権利を有する一方で、施設の適切な維持管理に伴って発生する修繕義務や部品交換義務等を負うものとし、O&M 期間の終了に際しては、合意した通りの引き渡し条件に基づいて、施設を PPWSA に変換する必要がある。

3-2-5-1-7　技術者派遣の必要性

事業体を構成する日本国法人の EPC コントラクターによって構成される。所長は本邦より派遣する必要がある。

3-2-5-2　施工上／調達上の留意事項

各施設の設計及び建設工事における留意事項は下記の通りである。

- カンボジア側、EPC コントラクター、コンサルタント間の連携強化を図り、定期的な工程会議等、組織間の情報共有手段を明確にする。
- コンサルタントは、設計確認時には設計監理技術者と各担当技術者を、施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務時には施工監理技術者と各担当技術者配置し、事業関係者との日々の情報共有を図るとともに、設計確認、施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務に支障がないように留意する。
- EPC コントラクターは、コンサルタントと同様に、現場代理人１名と主任技術者並びに、設計・施工に必要な技術者を配置し、責任を持って事業を実施する体制を整える。
- コンサルタント及び EPC コントラクターの事務所は、事業実施に適切な場所に配置する。
- 取水施設工事は河川水位に大きく依存しており、水位が低下する 11 月から 5 月の間に工事

を実施する事が望ましい。水位が上昇する 6 月から 10 月は、基本的に河川内での作業は行わない。従って、契約締結後の最初の乾季に止水の仮設及び基礎工事を行い、その後土工、コンクリート工を行うものとする。

- 工事期間中も住民は給水を受けているため、工事にあたっては断水にならないように配慮する。もし、どうしても断水して工事をしなければならない場合は、PPWSA と相談の上断水期間や場合によっては給水が濁ることについて、事前に住民への広報を行い、理解協力を得る。
- 建設工事の着工前にプロジェクトサイトの不発弾等の探査について、カ国関係者と協議し、不発弾等確認調査等が未完了で、埋設の可能性のある部分についてはカ国側が責任をもって探査・除去を実施する。また、建設時の安全対策を講じる。

3-2-5-3　施工区分／調達・据付区分

施設建設工事は、日本側が実施する。なお、カ国側の負担事業については、「**3.相手国側分担事業の概要**」にて詳細を述べる。

3-2-5-4　施工監理計画／調達監理計画

3-2-5-4-1　　入札補助

入札補助では、入札図書を作成中に事前審査を行い、入札図書承認後は直ちに入札公示及び入札図書を事前資格審査通過者に対して配布を行う。設計施工一括契約方式で総合評価落札方式の入札関連図書を準備し、すべてカ国側の承認を得る。コンサルタントによる入札補助は、主に次のような業務を実施する。

- 入札手順、入札評価方法・項目・評点設定の検討
- 入札図書作成
- 現地調査
- 入札説明会、P/Q 公示、P/Q 審査、図渡し
- 入札期間中の質問対応取りまとめ及び同意取り付け
- 入札評価
- 入札評価結果協議
- 契約交渉
- JICA・先方関連機関への説明・協議
- 先方政府関係機関からの承認取り付け
- 入札評価結果報告書作成

入札補助のフローを**図 3-2.20** に示す。コンサルタントは、カ国側の代理人として入札関連業務を補佐する。入札公示から業者契約・JICA 認証まで 12.5 か月を見込む。

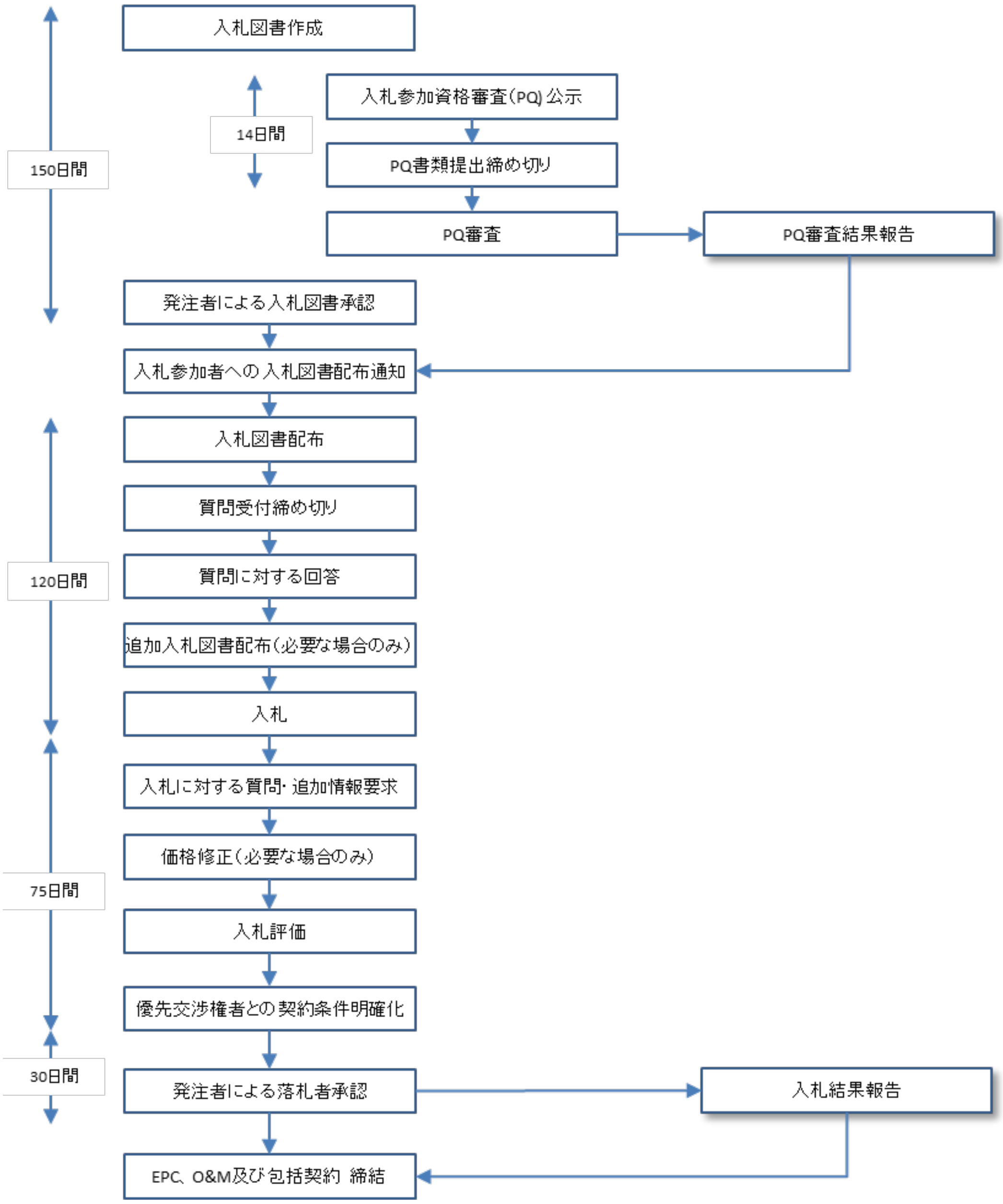


図 3-2.20　入札関連業務の流れ

なお、外国企業がカンボジア現地法人登録するには、商業省への商業登記に加え、経済財政省租税総局への税務登録、労働職業訓練省への事業所開設申告、国家社会保障基金（NSSF）への登録が必要となる。

本プロジェクトは、免税対象の案件であることから、免税での請求書を受け取れる状態になるための商業登記、税務登録及び、免税のマスターリストの承認が必要となる。商業省への登録は、オンラインシステムで申請できるが、定款の原本やカンボジア公認銀行発行の残高証明書等の書類を提出しなければならないことから、不備のない書類を準備し窓口申請によって、商業登記証明書を申請後 2 週間で取得可能である。

商業登記ができれば、事業契約の締結が可能となる。商業登記の承認日から 15 日以内に、租税総局にて税務登録を行う必要があるが、税務登録に合わせて、パテントの登録申請と、付加価値税（VAT）の納税者登録を行う必要があり、契約に基づいて免税対象となる品目のマスターリストを租税総局に提出し承認が得られれば、免税での取引が可能となる。

このような手続きを通して、免税での請求書の受け取りが可能となる状態になるまでには、商業登記申請から約 2 か月～3 か月程度の期間が必要であることから、事業者は、発注者による落札者承認の期間を有効に活用し、手続きを進めることが可能である。（尚、これらはあくまで本業務において確認した参照情報であり、実施段階で最新の情報を確認する必要がある。）

3-2-5-4-2　設計確認

コンサルタントによる設計確認では、主に次のような業務を実施する。

- 基本・詳細設計の設計確認及び PPWSA への説明・協議
- 基本・詳細設計の提案内容・確認結果に関する協議・承認・PPWSA からの同意書（No Objection Letter）の取付け

3-2-5-4-3　施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務

コンサルタントによる施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務では、主に次のような業務を実施する。

- 建設工事に係る書類・材料・機材・図面・施工スケジュール、施工方法、施工手順、安全対策、品質確保、環境社会影響対策等の確認
- 工事品質管理会議事務局
- 検査記録、工事記録等確認
- 試運転の立会い、助言・指導
- JICA への報告
- 瑕疵検査の実施
- 運営維持管理契約の締結及び受注者による当該業務への円滑な移行の支援
- 維持管理における O&M モニタリング体制構築支援
- 詳細設計前のモニタリング方法の具体的な確認
- 詳細設計内容に基づいたモニタリング指標の検討及び、PPWSA との協議
- モニタリングの指標及びその確認の方法・頻度の決定についての作業進捗確認と報告
- O&M 期間中の配員計画、SPC 事業計画、および収益目標の確認
- モニタリングフロー、業務報告フロー、不具合発生時の対応方法の確認等
- EPC コントラクターに求める EPC における最低資本金比率の検討と、PPWSA との協議による決定

- 業務運営マニュアルの内容確認および策定支援等
- その他の項目についての PPWSA との協議
- O&M 契約の詳細条件等に係る契約変更（O&M 期間の開始までに合意）
- O&M 完了後引き渡し条件検討・修正・変更（O&M 期間の開始までに合意）
- O&M 契約変更・修正等に係る法的妥当性確認（O&M 期間の開始までに確認）

本プロジェクトには､取水・導水施設工事、浄水施設工事、送配水施設工事及び附帯施設工事が含まれており、土木・機械・電気の各種工事を伴う一連の浄水施設の工事となっている。施工期間中、相互に関連したこれらの工事について、施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務を行うため、工事着工から試運転・竣工まで各種分野の工事内容に対応するための技術者を短期的に派遣する。

モニタリングシステムは EPC コントラクターの施設設計の内容とマッチしたものでなければならない。コンサルタントは入札に先立ち O&M の契約内容を策定の上、落札者の提案に基づいた事前交渉の内容に応じて O&M 契約の詳細について、作成、修正・変更を実施する。また、維持管理をモニタリングするための体制構築を PPWSA に対して支援する必要がある。

3-2-5-5　品質管理計画

維持管理運営業務を担う SPC は、品質管理計画を作成する。品質管理計画は、提案された管理方針、管理項目、内容、方法、適用規格等と整合性が取れたものでなければならず、コンサルタントが設計内容や要求水準書と照らし合わせ、確認した上で実施することなる。原則として、品質規格は ISO もしくは同等の国際規格を適用することを前提とする。

3-2-5-6　資機材等調達計画

3-2-5-6-1　資機材等調達計画

本プロジェクトに必要な資機材の調達は、原則として現地調達もしくは本邦調達とするが、第三国調達の可能性についても検討を行い、資機材調達先に関しては、以下の事項を考慮して決定する。

- 資機材の品質が要求事項を満たすものであること
- 品質や供給量に関してカンボジア市場での可能性があること
- スペアパーツ供給を考慮した修理・保守の容易性をもつこと
- 価格の妥当性
- アフターケアの確約

工事用資機材の調達については、原則、現地調達または本邦調達とするが、現地調達または本邦調達が困難な場合は、第三国調達も可能とする。

主要資機材調達先区分表を**表 3-2.17** に示す。

表 3-2.17 主要資機材調達先区分表

資　機　材　名	調　達　先			備考
	現地	日本	第三国	
1. 工事材料				
生コン、砂、砂利、セメント、鉄筋	○			
型枠合板、木材	○			
H 形鋼等鋼材	○			
塗料類、潤滑油、燃料	○			
足場材、支保工材等	○			
2. 機械設備				
取水ポンプ・配水ポンプ		○	○	第三国調達先はタイまたはベトナム
その他ポンプ		○	○	
天井クレーン		○	○	
水処理機器		○	○	
薬品注入設備		○	○	
換気ファン		○	○	
配管材料、バルブ類		○	○	
3.電気設備				
変圧器		○	○	第三国調達先はタイまたはベトナム
受電盤		○	○	
配電盤		○	○	
コントロールセンタ（VFD を含む）		○	○	
補助継電器盤		○	○	
現場操作盤		○	○	
流量計		○	○	
水位計		○	○	
監視制御設備		○	○	
ＰＬＣ盤		○	○	
分電盤		○	○	
照明器具、配線器具		○	○	
電線管、ケーブル、その他配線材料		○	○	

3-2-5-6-2　建設機械調達先の選定

カ国内の建設業者等が多数保有しており、リースが可能であり、現地調達とする。

3-2-5-7　輸送・梱包計画

3-2-5-7-1　輸送計画

建設資機材は、基本的に現地調達となるが、本邦調達または第三国調達のものについては輸送が必要になる。

3-2-5-7-2　輸送経路

建設資機材は現地調達である。機械・電気設備は本邦調達となる。本邦調達による資材の輸送経路を**図 3-2.21** に示す。

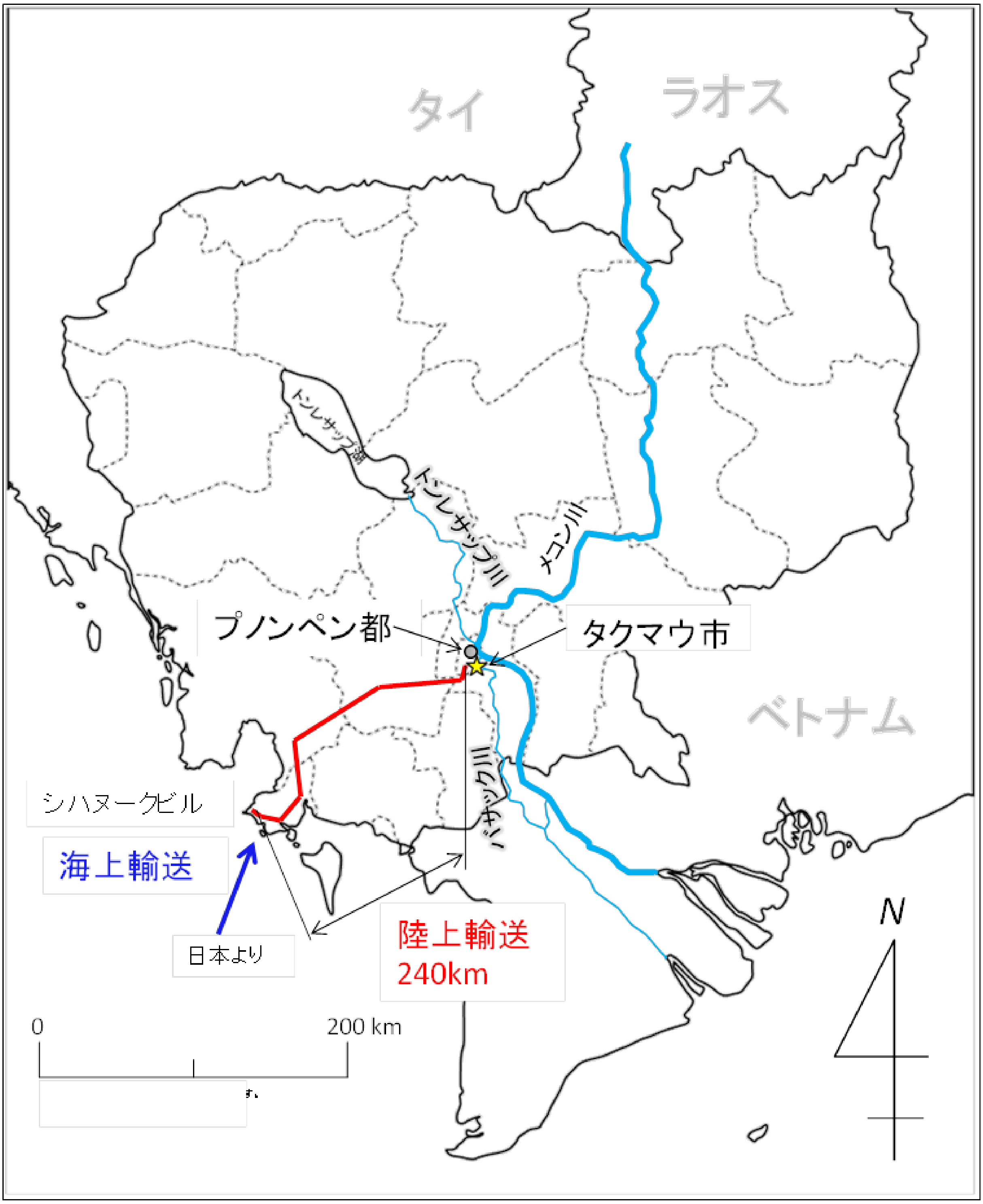


図 3-2.21　調達資材の輸送経路

3-2-5-8　初期操作指導・運用指導等計画

本プロジェクトにて新設される浄水場は、建設後 PPWSA に引き渡しが行われ、SPC が雇用する人員により維持管理が行われる。EPC コントラクターが設計・施工する施設であるものの、EPC コントラクターが出資する SPC が維持管理指標や維持管理方法等をまとめた維持管理マニュアルを整備し、職員の技術指導並びに能力開発も自らが行うことになる。一方、コンサルタントは、事業者が作成する維持管理マニュアルの整備や試運転並びにトレーニングに係る助言を行う。

3-2-5-9　ソフトコンポーネント計画

本プロジェクトにおいてソフトコンポーネントは含まれない。

3-2-5-10　実施工程

本プロジェクトの実施工程は、工事内容・工期の関係から、複数年度案件として実施計画を策定した。初年度に入札を行い、翌年度から工事（設計・調達・施工・維持管理準備）を実施するものとする。工期は、入札期間が 12.5 ヶ月（図 **3-2.22**）、設計・調達・施工が 33 ヶ月（図 **3-2.23**）である。

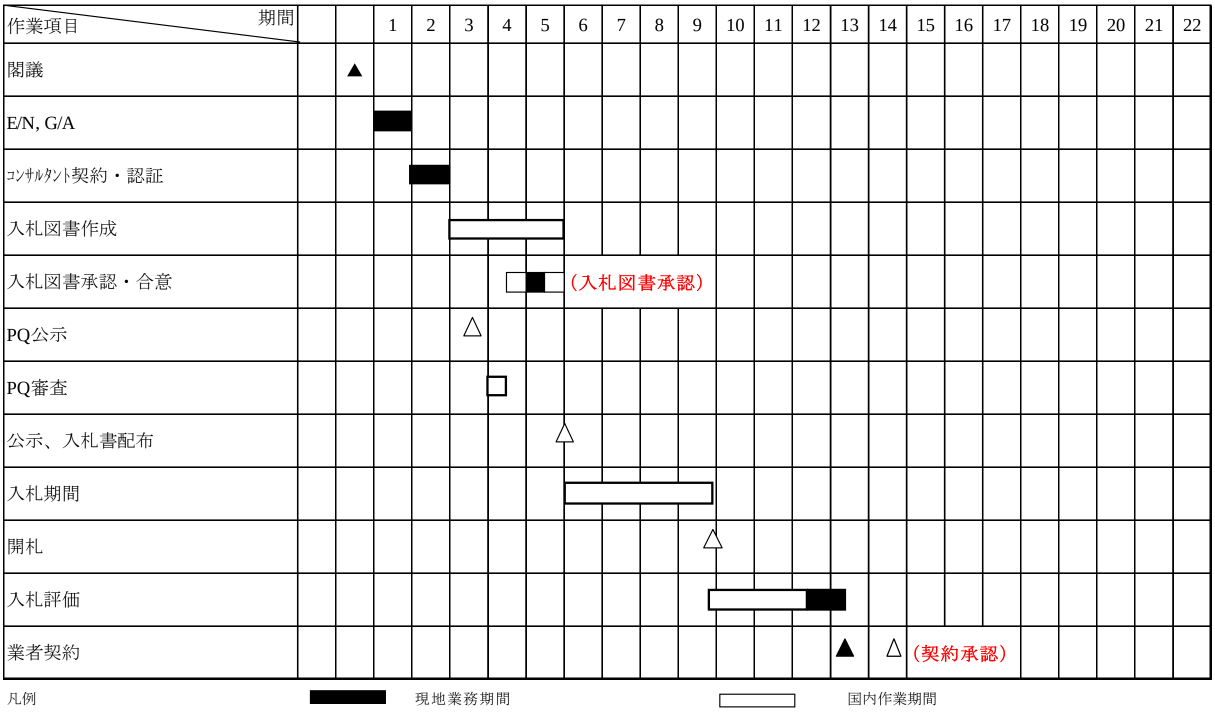


図 **3-2.22**　入札関連業務のスケジュール

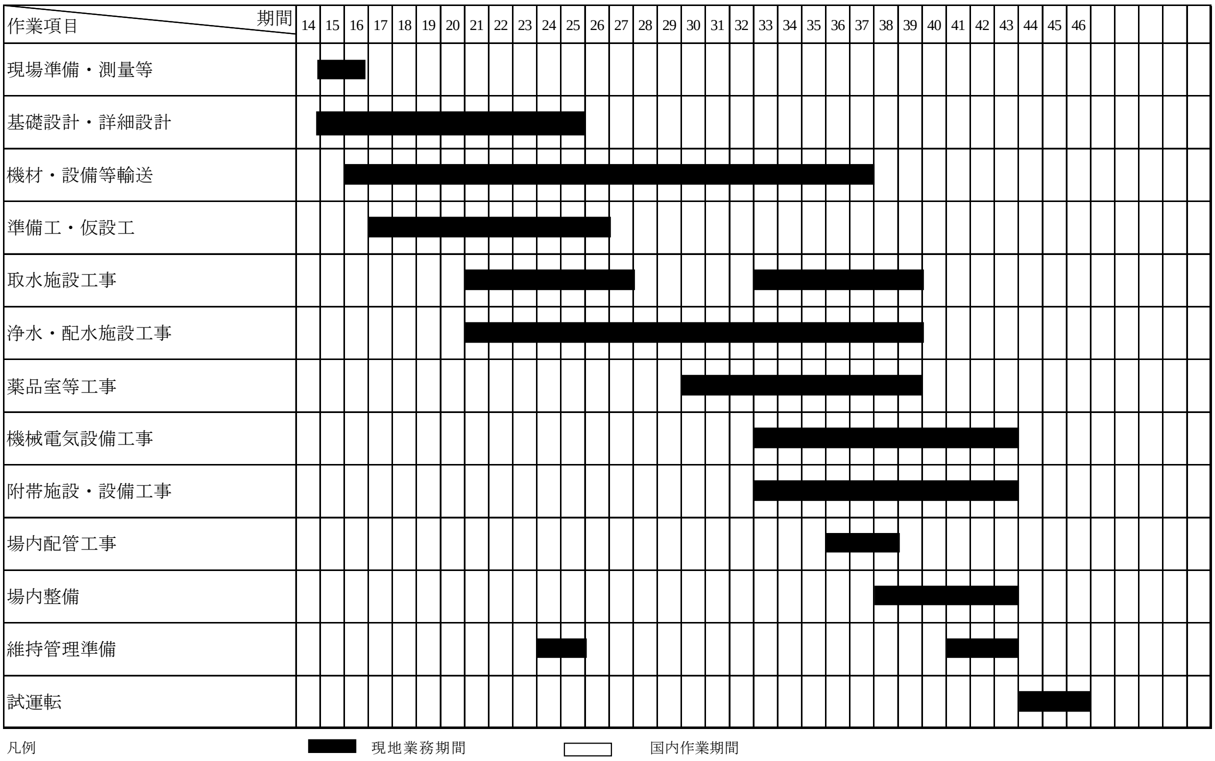


図 3-2.23 実施工程計画（設計・調達・施工）

特記：実施工程計画（設計・調達・施工）は、コンパラター施設の想定であり、入札時において、事業者により提案された実施工程計画を評価する。

3-3　相手国側分担事業の概要

3-3-1　浄水場用地の整備

浄水場の建設は、タクマウ市の PPWSA の敷地内を計画しているため、あらたに用地取得を行う必要はない。この敷地には、既存の高架水槽及び料金徴収所があるが、敷地内の国道側に PPWSA による移設を実施し、建設用地を確保する予定である。建設用地を**図 3-3.1** に示す。

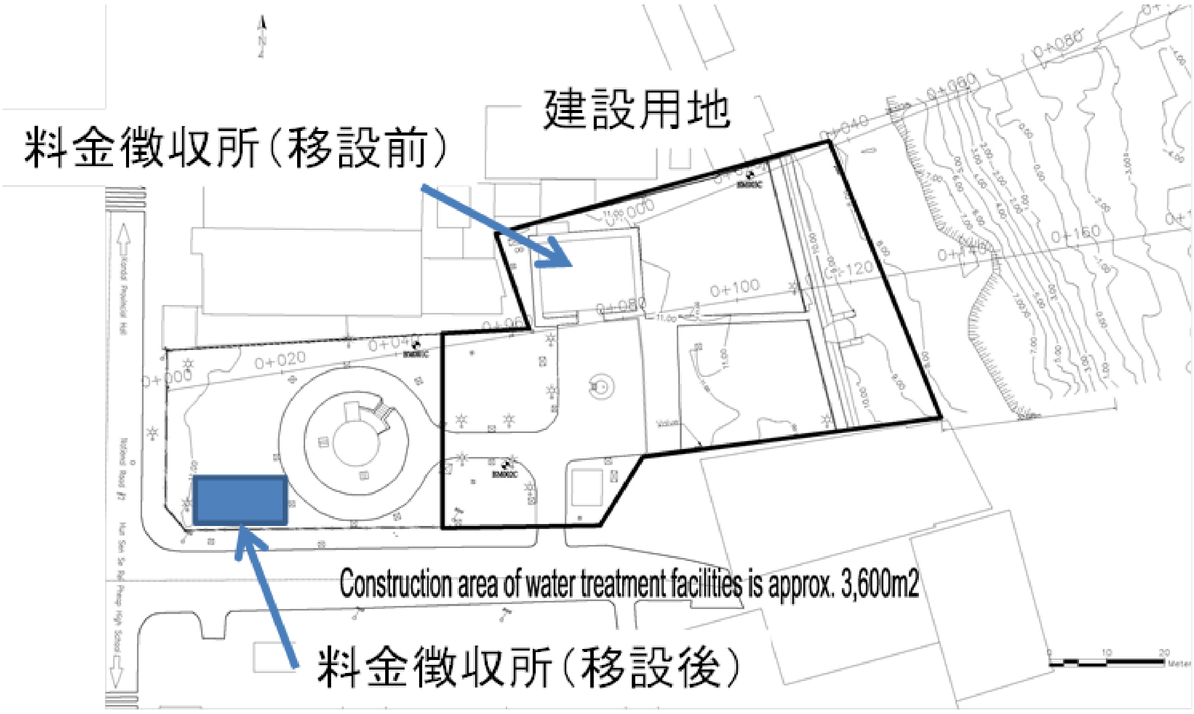


図 3-3.1　料金徴収所の移設と建設用地

また、河川側の敷地はバナナ畑となっているが、建設が開始されるまでには、PPWSA により伐木、伐採、伐根が施される予定である。

3-3-2　河川からの取水許可等

現行法制度上、カ国には水利権が設定されてはいないが、MoWRAM 及びカンボジアメコン川委員会（以下、「CNMC」）が責任機関となり、表流水および地下水の水量管理を実施していく予定である。取水許可に関し PPWSA より MoWRAM 及び CNMC にバサック川からの取水について申請レターを提出しており、MoWRAM 及び CNMC からの了解に関するレターを受領した。

PPWSA によると、河川航行に対する取水施設の建設の許認可は、ステークホルダーミーティングを通して関連部局に共有した為、不要とのことである。

3-3-3　電気工事

新規の取水施設および浄水場用地内に設置する変電設備までは、事業権無償に含まれ、受電点から変圧器までの電柱及び配管配線の工事、受電に関する手続き及び 2 回線受電の申請手続きは、カ国側負担である。

3-3-4　地雷・不発弾の探査・処理

カ国で地雷及び不発弾の探査及び処理、教育活動を行っている政府組織である CMAC の地雷・不発弾（UXO）マップ（**図 3-3.2**）において、タクマウ市とその周辺は、その存在の可能性は少ないものの、プロジェクトの実施においては事前の対策が必要となる。

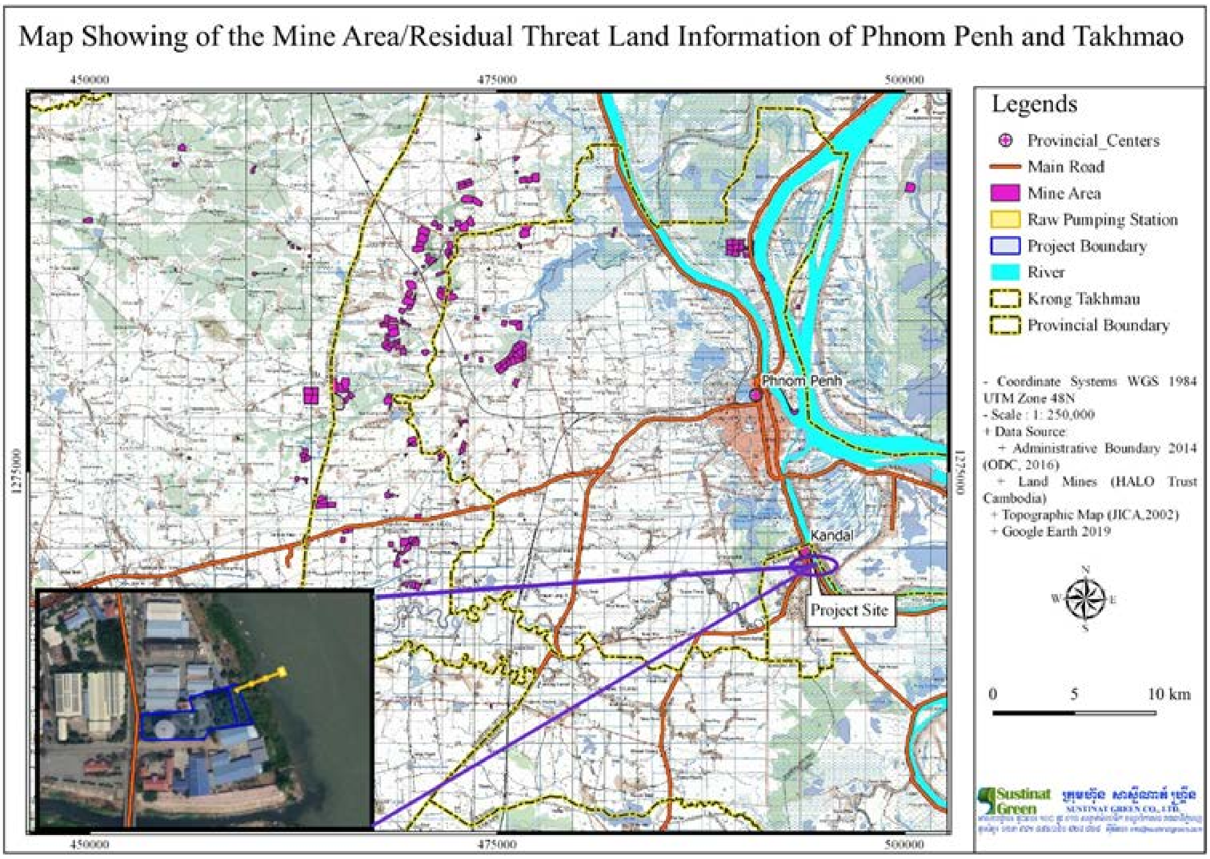


図 3-3.2　タクマウ市とその周辺の地雷・不発弾汚染地域

出典：CMAC

地雷・不発弾（UXO）の事前の探査の実施及び建設中に地雷・不発弾（UXO）に遭遇した場合の処理はカ国側の負担となる。

3-3-5　環境社会配慮への対応

カンボジア環境影響評価法においては、初期環境調査（Initial Environmental Examination, IEE、

カンボジアにおける初期環境影響評価（Initial Environmental Impact Assessment, IEIA））は事業主体である PPWSA が準備し、IEIA 報告書と Pre-feasibility study 報告書を 2019 年 8 月環境省に提出した。IEIA 報告書作成は本業務で支援を行い、2020 年 2 月に環境省の承認を得た。

3-3-6　その他

上記以外に本プロジェクト実施に当たり、カ国側負担事項と想定されるものは下記の通りである。

- カンボジア負担事項に係る予算措置
- 銀行取決め手続き
- 免税措置の支援

3-4　　　プロジェクトの運営・維持管理計画

3-4-1　　運営・維持管理計画

3-4-1-1　運営・維持管理体制

前述「**3-2-2-2-7　運転維持管理計画**」の表 **3-2.8** で示した通り 。

3-4-1-2　施設の維持管理項目

施設の維持管理項目は SPC により提案される。

3-4-1-3　SPC の財務計画

SPC の財務計画は、「**3-2-4-6-2　コンパラター施設に基づく SPC の財務計画**」に示す。

3-4-2　　PPWSA の財務分析及び損益収支の将来予測

3-4-2-1　PPWSA の財務分析

PPWSA の財務状況及び水道料金については「**2-1-2-2　PPWSA の財政状況**」及び「**2-1-2-3　水道料金体系及び改定履歴**」に示す。

3-4-2-2　PPWSA の損益収支への将来予測

PPWSA は国際会計基準（IAS20）に則って、無償資金で取得した資産を貸借対照表上の資産と負債に両建てで計上している。期間損益の計算においては、当該資産の減価償却費と同額の繰延収益を償却することで損益への影響は相殺されている。運営期間における事業収益については、SPC から購入したバルク水を利用者に販売することを想定して以下の通り試算した。

平均水道価格は、タクマウ市は相対的に商業レートが適用される顧客が少ない点を考慮し、2020 年に予定されている価格改定の影響を現状の約 1,000KHR から+10%と仮定した。バルク水購入価格以外の運営コストについては、インフレーション影響（3%を想定）とコスト削減が相殺する想定で、2018 年の上半期の実績をそのまま据え置いた。

表 3-4.1　PPWSA の損益収支への将来予測

(1,000,000KHR)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Purchase volume (1,000m3)	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950
Average tariff (KHR)	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100
Revenue	12,045	12,045	12,045	12,045	12,045	12,045	12,045	12,045	12,045	12,045
Unit cost of bulk water (KHR)	432	432	432	453	453	453	476	476	476	501
Production cost	4,725	4,725	4,725	4,957	4,957	4,957	5,211	5,211	5,211	5,489
Other operating costs	5,895	5,895	5,895	5,895	5,895	5,895	5,895	5,895	5,895	5,895
Total operating cost	10,620	10,620	10,620	10,852	10,852	10,852	11,106	11,106	11,106	11,383
Operating margin	1,425	1,425	1,425	1,193	1,193	1,193	939	939	939	662

前述した前提に基づいて、PPWSA のオペレーションマージンを算定すると、契約初年度においては、オペレーティングマージンが 11.8%（1,425/12,045＝11.8%）となる。前述した前提では、SPC への支払いが増加する分だけオペレーティングマージンは下がっていくが、それでも 10 年後のオペレーティングマージン約 5.5%（662/12,0455＝5.49%）を確保できることになる。タクマウ浄水場だけを見た場合に、10 年間にわたり上昇する SPC への支払額を支払ったとしても、料金収入で収益を生み続けることができる状態であることがわかる。このような試算から、PPWSA の収益に一定の貢献が期待できることがわかる。

また、前述したように、PPWSA の料金体系は居住者（Domestic）レートと、商業（Commercial）レートの幅が大きく開いているため、商業レートの適用が少ないエリアでは、浄水場の施設投資を回収するだけの採算が取れないという。しかしながら、タクマウエリアを含めて商業レートの適用が多いエリアのための浄水場は無償資金でカバーし、商業レートの適用が多いエリアのための浄水場は採算が取れるため借款を活用しているようであり、PPWSA としての事業採算に悪い影響を生じさせないような投資戦略を持っている。

3-5　プロジェクトの概略事業費

3-5-1　協力対象事業の概略事業費

3-5-1-1　日本側負担費用

日本側負担費用内訳を示す。

表 3-5.1　日本側負担費用内訳

費　　目	概算事業費（百万円）
取水施設の新設（取水塔方式）、導水施設の新設、浄水施設の新設、配水施設の新設、SCADA、バルクメーター、詳細設計	2,926
入札補助、設計確認、施工段階における工程管理・品質管理・コスト管理・支払い支援等の各種マネジメント業務	365
合計	3,291

注）　上記概算事業費は即交換公文上の供与限度額を示すものではない。US$1=111.21 円（平成 31 年 1 月から 3 月までの 3 か月平均）、KHR1= 0.026 円（平成 31 年 4 月 JICA 精算レート）

3-5-1-2　カンボジア側負担費用

カ国側負担費用は約 1.7 千万円（施設建設完了の 2024 年までにかかる経費合計）で、**表 3-5.2** にその内訳を示す。

表 3-5.2　カンボジア側負担費用内訳

	負担事項	内容	USD	百万円
1	浄水場建設用地整備	浄水場予定地の整地	-	-
2	料金徴収所の移設	料金徴収所の移設	61,000	-
3	電気工事	2 回線受電の手続き、工事等の負担費用 取水・浄水施設への一次側受電設備の工事負担費用	5,000	-
4	不発弾・地雷調査	プロジェクト対象用地に不発弾及び地雷等がないか事前に調査を行う費用	25,000	-
5	環境社会配慮	環境影響項目のモニタリング費用（2021-2024 年）	31,250	-
6	銀行手数料	銀行取決めに係る手数料	-	3.6
合　計			122,250	3.6

3-5-1-3　積算条件

① 積算時点：　平成 31 年 4 月
② 為替交換レート：　1 US$＝111.21 円
　1 KHR＝0.026 円
③ 施工期間：　全体：45.5 ヶ月
　入札図書作成期間：5 ヶ月
　入札契約期間：7.5 ヶ月
　設計施工調達期間：33 ヶ月
④ その他：　本計画は、日本国政府の無償資金協力の制度に従い、実施されるものとする。

3-5-2　コンパラター施設の運営・維持管理費

3-5-2-1　コンパラター施設の維持管理費算出条件

3-5-2-1-1　コンパラター施設の人件費

運営維持管理体制（**表 3-2.8**）に基づき、コンパラター施設の維持管理費を試算した。日本人を想定する CEO 及び O&M の責任者を合計で一名配置し、諸手当等を含めた人件費を 2 千万円とする。日本人以外の現地スタッフについては、現在の PPWSA の単価を採用している。

表 3-5.3　コンパラター施設の人件費

役職	延べ人数	年間給与単価（千リエル）	合計（百万リエル）
CEO	0.5	724,092	362
O&M & technical training advisor	0.5	724,092	362
Chief manager	1	60,221	60
Facility manager	1	47,634	48
Quality manager	1	47,634	48
Admin/business staff	3	35,047	105
M&E Engineer	1	35,047	35
Operating staff	6	35,047	210
合計	14	--	1,230

3-5-2-1-2　コンパラター施設の電力費

電力使用量については、コンパラター施設を基本として以下の通り設定した。電力価格は現状と同水準の 584KHR/kWh とする。

表 3-5.4　コンパラター施設の電力費

	容量（kW）	稼働量（時間/日）	年間消費量（MWh）	年間電力費（百万リエル）
Intake	161.2	24	1,412	825
Treatment	88.3	2	64	38
Chemical	40.8	4	60	35
Distribution	199	24	1,743	1,018
Others	10	8	29	17
Total	499.3	--	3,309	1,932

3-5-2-1-3　コンパラター施設の薬品費

PAC と塩素について、PPWSA の既存のオペレーションの参考に以下の使用量を前提とした。単価については現在の PPWSA の購入価格と同水準とした。

表 3-5.5　コンパラター施設の薬品費

	使用量（g/m3）	年間使用量（kg）	単価（千リエル/kg）	合計（百万リエル）
PAC	10	109,500	2,137	234
Chlorine	5	54,750	2,288	125
合計	--	--	--	359

3-5-2-1-4　コンパラター施設の修繕費

施設整備費の内、1/3 を修繕が必要な機械設備・電気設備と想定し、それらの総額に対して年間 0.5%の修繕費を織り込んだ。ただし、初年度は EPC 契約における瑕疵担保期間で O&M 費用としては修繕費が発生しないこととし、最終年度は O&M 契約で要求される引き渡し条件を満たすための整備が発生するため 1.0%を計上している。

3-5-2-1-5　その他運営費

その他の運営費用として、雇用に係る社会保険を 4 万 KHR/月/人、交通費を 5 万円/月、オフィス関連費を 10 万円/月、会計監査・顧問弁護士の費用を 5 万円/月とする。また、上記の総額の 10%を予備費として計上し、原材料に対する 24%の関税と、上記運営費に係る 10%の VAT を計上した。

3-5-2-2　コンパラター施設の運営・維持管理費

コンパラター施設の運営・維持管理費を**表 3-5.6** に示す。

表 3-5.6　コンパラター施設の運営・維持管理費

前提条件		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
生産量	000m3		10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950	10,950
電力価格	KHR/kWh		584	584	584	584	584	584	584	584	584	584

O&Mコスト		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
電力費	000,000KHR		1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932	1,932
電気使用量	000kWh		3,309	3,309	3,309	3,309	3,309	3,309	3,309	3,309	3,309	3,309
人件費	000,000KHR		1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230
従業員数	人		14	14	14	14	14	14	14	14	14	14
原材料費	000,000KHR		359	359	359	359	359	359	359	359	359	359
PAC	000,000KHR		234	234	234	234	234	234	234	234	234	234
Chlorine	000,000KHR		125	125	125	125	125	125	125	125	125	125
修繕費	000,000KHR		0	181	181	181	181	181	181	181	181	362
その他運営費	000,000KHR		199	218	218	218	218	218	218	218	218	236
合計	000,000KHR		3,721	3,920	3,920	3,920	3,920	3,920	3,920	3,920	3,920	4,119

第4章 プロジェクトの評価

4-1 事業実施のための前提条件

事業実施のための前提条件、相手国側による負担項目等については、「**3.3 相手国側分担事業の概要**」に詳述した通りであるが、主な項目としては以下が挙げられる。

4-1-1 用地取得

浄水施設は PPWSA の敷地内での建設のため、用地取得は不要である。

4-1-2 河川からの取水許可

取水許可に関し PPWSA より MoWRAM 及び CNMC にバサック川からの取水について申請レターを提出しており、MoWRAM 及び CNMC からの了解に関するレターを受領している。

4-1-3 地雷・不発弾探査・処理

カ国においては、全土において不発弾が発見される可能性があるので、本プロジェクトの実施にあたり、カ国側の責任で、施設建設場所（取水予定地、浄水場予定地）での地雷・不発弾の探査を工事開始までに終えること、また、地雷等が発見された場合には、その処理を速やかに行うことについて合意している。

4-1-4 初期環境影響評価（IEIA）の承認

カンボジア環境影響評価法においては、初期環境調査（Initial Envirnmental Examination, IEE、カンボジアにおける初期環境影響評価（Initial Environmental Impact Assessment, IEIA））は事業主体である PPWSA が準備し、IEIA 報告書を環境省に提出し、承認を得る。IEIA 報告書作成は本業務で支援を行い、2020 年 2 月末に環境省の承認を得た。

4-1-5 新規取水施設及び浄水施設への電力引込み

新規の取水施設および浄水場用地内に設置する変電設備までは、事業権無償に含まれ、受電点から変圧器までの電柱及び配管配線の工事、受電に関する手続き及び 2 回線受電の申請手続きは、カ国側負担である。

4-1-6 免税措置

免税措置については、2019 年 6 月に CDC から建設部分の免税についての基本的な了解を得ている。

4-2　プロジェクト全体計画達成のための必要な相手方投入（負担）事項

事業権無償により浄水場が整備されるが、PPWSA にバルク売りされる水量（30,000 m^3/日）は、PPWSA によって確保さなければばならない。

4-3　外部条件

プロジェクト効果を発現、持続するための外部条件として以下が挙げられる。

- 大規模な天候不順や自然災害が発生しないこと
- 社会・経済状況が著しく悪化しないこと
- 対象地域の人口動態が予測外の動きを示さないこと
- 原水水質が極端に悪化しないこと

4-4　プロジェクトの評価

4-4-1　妥当性

4-4-1-1　プロジェクトの裨益対象

本プロジェクトによりタクマウ市住民への給水能力が改善され、タクマウ市の裨益人口が増加する。新規浄水場の建設に加え、現状の給水サービスの向上が図られるため、増加する給水人口に対する裨益のみならず、現在給水を受けている住民に対しても給水サービスが改善することとなる。また、現在プノンペンからタクマウ市に配水している水量は、浄水場建設後からはプノンペン都に配水できるようになるため、プノンペン都の給水サービスも改善することとなる。よって、本プロジェクトの裨益を受ける人口はタクマウ市及びプノンペン都におよぶこととなる。

4-4-1-2　プロジェクトの緊急性

PPWSA は既存の水道システムを有してはいるが、現在の浄水能力では 2030 年時点でのタクマウ市における水需要の 6 割程度しかない。上水道施設の拡張による給水量の増加なしでは水不足が予測され、上水道施設の拡張が急務となっている。

4-4-1-3　プロジェクトの上位計画との整合性

カ国政府は、国家戦略開発計画（NSDP）により、2025 年までに都市部人口の 100%に対して安全な水へのアクセスを確保するという目標を掲げており、本プロジェクトはタクマウ市において、その実現に寄与するものである。

4-4-1-4　我が国の援助政策との整合性

カンボジアに対する我が国の援助方針の事業展開計画（2016 年 9 月）では、カンボジアの開発目標達成を支援し、「社会開発の促進」を援助の重点分野の一つとし、「上下水道インフラの整備」を開発課題としており、本プロジェクトの実施は、我が国の援助政策と整合している。

4-4-2　有効性

本プロジェクトの有効性に関しては、以下の定量的効果及び定性的効果が見込まれる。

4-4-2-1　定量的効果

タクマウ浄水場の新設をすることにより、**表 4-4.1** に示すような効果が期待できる。

表 4-4.1　定量的効果

No.	指標	基準値(2015 年)	目標値(2027 年) （供用開始後 3 年）
1	日平均給水量	11,440 m^3/日	30,000 m^3/日

4-4-2-2　定性的効果

定性的効果は以下の通りである。

① 給水栓からの水量・水圧不足の改善
② 貧困層への接続の促進
③ 貧困層に適用している水道料金の維持
④ 浄水場の運営・維持管理に関する技術移転による運営・維持管理能力の向上
⑤ 公衆衛生の向上

以上の内容により、本プロジェクトの妥当性は高く、また有効性が見込まれると判断される。

4-5　本プロジェクト実施に当たっての留意事項の整理

本プロジェクト実施に当たっての留意事項は次のとおりである。

・ 共調達法の第 3 条の例外規定は、プロジェクト全体に対して適応されるものであり、EPC 契約と O&M 契約は連動したものであることを G/A に規定する

資　料 1　調査団員・氏名

官団員/JICA Officials

氏名	担当	所属
松本　重行 Dr. Shigeyuki MATSUMOTO	団長 Leader	JICA 地球環境部水資源グループ Deputy General Director, Water Resources Group, Global Environment Department, JICA
中井　一孝 Mr. Kazunori NAKAI	協力企画 Cooperation Planning	JICA インフラ技術業務部有償技術審査室兼地球環境部水資源グループ水資源第一チーム Senior Engineering Officer, Water Resources Team, Global Environment Department, JICA

コンサルタント団員/Consultant Team

氏名	担当	所属
岡崎　浩一 Mr. Koichi OKAZAKI	業務主任者／上水道施設計画・設計 Chief Consultant /Water Supply Facility Planning & Design	株式会社日水コン Nihon Suido Consultants Co., Ltd.
中田　貴大 Mr. Takahiro NAKATA	副業務主任者／施工計画／積算 Deputy Chief Consultant /Construction Planning & Cost Estimate	株式会社日水コン Nihon Suido Consultants Co., Ltd.
熊谷　弘志 Mr. Hiroshi KUMAGAE	PPP ビジネスモデル PPP Project Development	クラウンエイジェンツ・ジャパン株式会社 Crown Agents Japan Limited
金田　誠 Mr. Makoto KANEDA	電気設備計画・設計 Electrical Planning & Design	株式会社日水コン Nihon Suido Consultants Co., Ltd.
松江　龍南 Mr. Ryunan MATSUE	環境社会配慮／UXO 確認 Environmental and Social Consideration / UXO Survey	株式会社日水コン Nihon Suido Consultants Co., Ltd.
斗ケ澤　海 Mr. Umi TOGASAWA	入札図書参考資料作成 Business Modeling /Bidding & Contractual Development	クラウンエイジェンツ・ジャパン株式会社 Crown Agents Japan Limited
男鹿　剛彦 Mr. Takehiko OGA	上水道計画アドバイザー Water Supply Planning Advisor	株式会社日水コン Nihon Suido Consultants Co., Ltd.
林　明 Mr. Akira HAYASHI	機械設備計画・設計 Mechanical Planning & Design	株式会社日水コン Nihon Suido Consultants Co., Ltd.

資　料 2　調査行程

調査行程は次のとおり。

第 1 次現地調査：　　　　2019 年 3 月 17 日～同年 4 月 10 日

		官団員		コンサルタント団員							
		松本 重行	中井 一孝	岡崎 浩一	中田 貴大	熊谷 弘志	金田 誠	松江 龍南	斗ケ澤 海	男鹿 剛彦	林 明
		団長	協力企画	業務主任者／上水道施設計画・設計	副業務主任者／施工計画／積算	PPPビジネスモデル	電気設備計画・設計	環境社会配慮／UXO確認	入札図書参考資料作成	上水道計画アドバイザー	機械設備計画・設計
2019/3/17	日			移動(10:50 NRT－15:10 PNH(NH817))							
2019/3/18	月			現地再委託準備 タクマウ現地調査							
2019/3/19	火			浄水場配置計画に関する協議(PPWSA) 現地再委託準備							
2019/3/20	水			現地再委託準備	送配水計画に関する協議(PPWSA) 現地再委託準備						
2019/3/21	木			免税に関するヒアリング IC協議準備	免税に関するヒアリング 現地再委託準備						
2019/3/22	金			現地再委託準備 IC協議準備	現地再委託準備						
2019/3/23	土			資料整理、資料作成							
2019/3/24	日					移動(10:50 NRT－15:10 PNH(NH817))		移動(10:50 NRT－15:10 PNH(NH817))			
2019/3/25	月	移動(10:50 NRT－15:10 PNH(NH817))		団内協議 免税に関するヒアリング IC協議準備	団内協議 免税に関するヒアリング 現地再委託	団内協議 免税に関するﾋｱﾘﾝｸﾞ (KOBELCO)		EIA業者と協議 環境省情報収集	団内協議 免税に関するﾋｱﾘﾝｸﾞ (KOBELCO)	団内協議	
2019/3/26	火	インセプション協議(PPWSA、MEF、MIH) 現地調査(Chamcar mon WTP) 表敬訪問(カンボジア事務所、日本大使館) ミニッツサイン			インセプション協議(PPWSA) 現地再委託確認	インセプション協議 (PPWSA、MEF、MIH) 現地調査(Chamcar mon WTP) 表敬訪問(カンボジア事務所、日本大使館) ミニッツサイン		インセプション協議 (PPWSA) 水質調査現地再委託	インセプション協議 (PPWSA、MEF、MIH) 現地調査(Chamcar mon WTP) 表敬訪問(カンボジア事務所、日本大使館) ミニッツサイン	インセプション協議 (PPWSA、MEF、MIH)	
2019/3/27	水				現地調査(Chamcar mon WTP) 協議資料作成			PPWSA、EIA業者と協議 水質調査現地再委託			
2019/3/28	木				ミニッツ協議、インセプション協議(PPWSA)			ミニッツ協議、インセプション協議(PPWSA)			
2019/3/29	金				ミニッツサイン 現地再委託確認			水質調査同行・採水			
		移動(22:50 PNH－(NH818))		大使館表敬訪問 JICA表敬訪問	現地再委託確認	大使館表敬訪問 JICA表敬訪問		移動(22:50 PNH－ (NH818))	資料整理、資料作成		
2019/3/30	土	移動(－06:45 NRT (NH818))		資料整理、資料作成	資料整理、資料作成	資料整理、資料作成		移動(－06:45 NRT (NH818))	資料整理、資料作成		
2019/3/31	日				現地再委託確認		移動(10:50 NRT－15:10 PNH(NH817))				
2019/4/1	月				団内協議	KPMG Cambodia打合せ 資料作成	カンボジア電力公社(EDC)協議、団内協議		KPMG Cambodia打合せ 資料作成	団内協議	団内協議
2019/4/2	火				現地再委託確認 既存施設現地調査	Bun & Associates TMI	現地調査(Takmau reservoir,Chroy Changvar WTP,Niroth WTP)		Bun & Associates 資料作成		現地調査(Takmau reservoir,Chroy Changvar WTP,Niroth WTP)
2019/4/3	水				資料作成	資料作成	現地調査(Phum Prek WTP)、資料作成		資料作成		現地調査(Phum Prek WTP)、資料作成
2019/4/4	木			テクニカルノート協議(PPWSA)					テクニカルノート協議		資料作成
2019/4/5	金			技術的検討・確認 団内協議	団内協議、資料整理	テクニカルノート見直確認	団内協議、資料整理		テクニカルノート見直確認		団内協議、資料整理
					移動(22:50 PNH－(NH818))				移動(22:50 PNH－ (NH818))		
2019/4/6	土			資料整理、資料作成	移動(－06:45 NRT (NH818))				移動(－06:45 NRT (NH818))		
2019/4/7	日										
2019/4/8	月			CDC＆GDT協議 資料整理、資料作成							
2019/4/9	火			移動(22:50 PNH－ (NH818))							
2019/4/10	水			移動(－06:45 NRT (NH818))							

第 2 次現地調査：　　　　2019 年 6 月 18 日～同年 7 月 2 日

		官団員		コンサルタント団員		
		松本　重行	中井　一孝	岡崎　浩一	熊谷　弘志	斗ケ澤　海
		団長	協力企画	業務主任者／上水道施設計画・設計	PPPビジネスモデル	入札図書参考資料作成
2019/6/18	火			10:50 NRT− 15:10 PNH(NH817)		
2019/6/19	水			PPWSA情報収集 再委託先調整		
2019/6/20	木					
2019/6/21	金					
2019/6/22	土			資料整理、資料作成		
2019/6/23	日					
2019/6/24	月	10:50 NRT− 15:10 PNH(NH817)		PPWSA情報収集	10:50 NRT− 15:10 PNH(NH817)	
2019/6/25	火	中間協議（PPWSA、GDT） 表敬訪問（カンボジア事務所、日本大使館） ミニッツサイン				
2019/6/26	水					
2019/6/27	木					
2019/6/28	金	移動（22:50 PNH −（NH818））		再委託先調整、原水サンプリング	移動（22:50 PNH −（NH818））	
2019/6/29	土	移動（− 06:45 NRT (NH818)）		資料整理、資料作成	移動（− 06:45 NRT (NH818)）	
2019/6/30	日					
2019/7/1	月			移動（22:50 PNH −（NH818））		
2019/7/2	火			移動（− 06:45 NRT（NH818））		

第 3 次現地調査：　　　　2019 年 8 月 25 日～同年 8 月 31 日

		コンサルタント団員
		岡崎　浩一
		業務主任者／上水道施設計画・設計
2019/8/25	日	移動（10:50 NRT− 15:10 PNH(NH817)）
2019/8/26	月	IEIAに関する協議（PPWSA）
2019/8/27	火	
2019/8/28	水	水利権に関する協議（PPWSA）
2019/8/29	木	現地再委託（水質調査）
2019/8/30	金	移動（22:50 PNH −（NH818））
2019/8/31	土	移動（− 06:45 NRT（NH818））

第 4 次現地調査：　　　　2019 年 10 月 15 日～同年 10 月 23 日

		コンサルタント団員	
		岡崎　浩一	中田　貴大
		業務主任者／上水道施設計画・設計	副業務主任者／施工計画／積算
2019/9/29	火	移動(10:50 NRT-15:10 PNH(NH817))	
2019/9/30	水	IEIAに関する、財務状況に関する協議(PPWSA)	
2019/10/1	木	IEIAに関する協議(PPWSA)	
2019/10/15	火		移動(10:50 NRT-15:10 PNH(NH817))
2019/10/16	水	団内協議	
2019/10/17	木	PPWSA協議資料準備	
2019/10/18	金		取水地点現場確認
2019/10/19	土	資料整理、資料作成	
2019/10/20	日		
2019/10/21	月	DOD事前協議(PPWSA)	
2019/10/22	火	移動(22:50 PNH -(NH818))	現地再委託(水質調査)
2019/10/23	水	移動(- 06:45 NRT(NH818))	移動(13:20 PNH -RGN(PG093))

第 5 次現地調査：　　　　2019 年 11 月 17 日～同年 11 月 23 日

		官団員		コンサルタント団員			
		松本　重行	中井　一孝	岡崎　浩一	中田　貴大	熊谷　弘志	男鹿　剛彦
		団長	協力企画	業務主任者／上水道施設計画・設計	副業務主任者／施工計画／積算	PPPビジネスモデル	上水道計画アドバイザー
2019/11/17	日	移動(10:50 NRT-15:10 PNH(NH817))	移動(10:50 NRT-15:10 PNH(NH817))	移動(10:50 NRT- 15:10 PNH(NH817))	移動(11:20 RGN- 19:35 PNH(TG0584))	移動(10:50 NRT-15:10 PNH(NH817))	
2019/11/18	月	DOD協議(PPWSA, MIH) 表敬訪問(カンボジア事務所、日本大使館) ミニッツサイン					
2019/11/19	火						
2019/11/20	水						
2019/11/21	木	移動(22:50 PNH -(NH818))	移動(22:50 PNH -(NH818))				
2019/11/22	金	移動(- 06:45 NRT(NH818))	移動(- 06:45 NRT(NH818))	移動(22:50 PNH -(NH818))	移動(22:50 PNH -(NH818))	移動(22:50 PNH -(NH818))	
2019/11/23	土			移動(- 06:45 NRT(NH818))	移動(- 06:45 NRT(NH818))	移動(- 06:45 NRT(NH818))	

資　料 3　関係者（面会者）リスト

Phnom Penh Water Supply Authority

-	H.E. Dr. SIM Sitha (PhD)	Director General
-	Dr. CHEA Visoth (PhD)	Deputy Director General, in charge of Corporate Secretary,
-	Mr. SAMRETH Sovithiea	Deputy General Director, in charge of Plan and Investment Project
-	Mr. MA Noravin	Deputy Director General, in charge of Production and Distribution Department
-	Mr. ROS Kimleang	Deputy Director General, in charge of Finance and Securities Exchange Department
-	Mr. CHEA Satephoat	Director of Planning and Project Department

Ministry of Industry & Handicraft (MIH)

-	H.E. Mr. CHAM Prasidh	Senior Minister

The Council for the Development of Cambodia (CDC)

-	Mr. Lim Visat	Assistant to H.E. Sok Chenda Sophea, Minister attached to the Prime Minister, Secretary General of the Council for the Development of Cambodia

資　料 4　討議議事録（M/D）

- MINUTES OF DISCUSSIONS OF THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU IN THE KINGDOM OF CAMBODIA（29th March, 2019）

- TECHNICAL NOTES ON THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU IN THE KINGDOM OF CAMBODIA（5th April, 2019）

- MINUTES OF DISCUSSIONS OF THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU (EXPLANATION ON DRAFT PREPARATORY SURVEY REPORT)　（28th June, 2019）

- MINUTES OF DISCUSSIONS OF THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU (EXPLANATION ON DRAFT PREPARATORY SURVEY REPORT)　（21th November, 2019）

Minutes of Discussions
on the Preparatory Survey for the Project for
Expansion of Water Supply System in Ta Khmau

In response to the request from the Government of the Kingdom of Cambodia (hereinafter referred to as "Cambodia"), Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Survey Team for the Outline Design (hereinafter referred to as "the Team") of the Project for Expansion of Water Supply System in Ta Khmau (hereinafter referred to as "the Project") to the Government of Cambodia. The Team held a series of discussions with the officials of the Government of Cambodia and conducted a field survey. In the course of the discussions, both sides have confirmed the main items described in the attached sheets.

Phnom Penh, 29th March, 2019

Dr. Shigeyuki Matsumoto Leader Preparatory Survey Team Japan International Cooperation Agency Japan	H.E. Dr. Sim Sitha Director General Phnom Penh Water Supply Authority (PPWSA) Kingdom of Cambodia

Witness

PEN Thirong
Ministry of Economy and Finance (MEF)
Kingdom of Cambodia

ATTACHMENT

1. Objective of the Project
   The objective of the Project is to improve the access to safe water in Ta Khmau District through the expansion of water supply system including construction and operation and maintenance (hereinafter referred to as "O&M") of the new water treatment plant (hereinafter referred to as "WTP").

2. Title of the Preparatory Survey
   Both sides confirmed the title of the Preparatory Survey as "the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau".

3. Project site
   Both sides confirmed that the construction site of the new WTP is located in Ta Khmau District, which is shown in Annex 1.
   PPWSA is responsible for distribution plan, and explained that it should be flexible in accordance with change of water demand, future development of the Ta Khmau District and the surrounding area, the possibility of bulk water sale to local private water venders, and other factors. The Team understood it, and pointed out that it would be necessary to clarify planning basis for the project appraisal as an assumption for the initial stage. Both sides agreed to further discuss the planning basis to set and justify the requirements for the SPC, such as production amount and water pressure.

4. Responsible authority for the Project
   Both sides confirmed the authorities responsible for the Project are as follows:
   4-1. PPWSA will be the executing agency and the implementing agency for the Project. The organization chart is shown in Annex 2.
   4-2. PPWSA is autonomously able to agree with the O&M contract and off-take price if such agreement does not affect the current water tariff system.

5. Items requested for Japanese Grant Aid by the Government of Cambodia.
   5-1. As a result of discussion, both sides confirmed that the items requested by the Government of Cambodia are as follows:
   Facility
   - Intake: Capacity of 33,000m^3/day

- Raw Water Intake Pump Station: Quantity $22m^3$/min, Lift 23m
- Raw Water Transmission Pipe: D 600mm L=100m
- Water Treatment Plant: Capacity of $30,000m^3$/day, Solar Power System 146kWh
- Distribution Facility: Distribution Pump (Quantity $20m^3$/min)
- Bulk meters
- SCADA

Equipment

- Water Quality Analysis Equipment
- O&M Tools for Electrical and Mechanical Equipment

Consulting Service

- Tender Assistance, Construction and Procurement Supervision

Soft Component (technical assistance on O&M) was also requested in the Application Form for Grant Aid from Cambodia, but technical instruction will be implemented during O&M period that is not covered by Grant Aid. Both sides confirmed that the Soft Component is excluded from the items requested for Grant Aid.

Material and equipment for service connection was requested in the original request, but PPWSA explained that it would not be necessary and taken care of by PPWSA.

The original request mentioned the water treatment process as rapid sand filtration, but PPWSA explained that other process such as the membrane filtration could be acceptable if it is proposed by the SPC and it has cost advantages.

Regarding the water quality analysis equipment, PPWSA requested only equipment necessary for daily test because it had the central laboratory.

Although the original request mentioned to the lift of distribution pump as 50m, both sides agreed to reconsider it from the technical viewpoint, because PPWSA generally use 35 to 40m to keep the pressure 20m at taps.

PPWSA requested to include a bulk meter to measure the amount of water which

PPWSA received from SPC. The Team suggested two bulk meters, one for SPC and the other for PPWSA, but PPWSA confirmed only one bulk meter is sufficient for the measurement.

PPWSA requested to include SCADA for the operation of WTP and minimize the number of required staff.

6-2. JICA will assess the feasibility of the above requested items through the survey and will report the findings to the Government of Japan. The final scope of the Project will be decided by the Government of Japan.

6. Procedures and Basic Principles of Japanese Grant

6-1. The Cambodian side agreed that the procedures and basic principles of Japanese Grant as described in Annex 3 shall be applied to the Project.
As for the monitoring of the implementation of the Project, JICA requires the Cambodian side to submit the Project Monitoring Report that the form is attached as Annex 4.

6-2. The Cambodian side agreed to take the necessary measures, as described in Annex 5, for smooth implementation of the Project. The contents of the Annex 5 will be elaborated and refined during the Preparatory Survey and be agreed in the mission dispatched for explanation of the Draft Preparatory Survey Report.
The contents of Annex 5 will be updated as the Preparatory Survey progresses, and eventually, will be used as an attachment to the Grant Agreement.

7. Schedule of the Survey

7-1. The Team will proceed with further survey in Cambodia until April 2019.

7-2. JICA will hold a project briefing session for Japanese companies to give information in terms of project outline, draft requirements to be stipulated in the bidding documents, and draft term sheet of the contracts around July, 2019.

7-3. JICA will prepare a draft Preparatory Survey Report in English, and dispatch a mission to Cambodia in order to explain its contents around October, 2019.

7-4. If the contents of the draft Preparatory Survey Report are accepted and the undertakings for the Project are fully agreed by the Cambodian side, JICA will finalize the Preparatory Survey Report and send it to the Cambodian side around March, 2020.

7-5. The above schedule is tentative and subject to change.

8. Environmental and Social Considerations

8-1. The Cambodian side confirmed to give due environmental and social considerations during implementation, and after completion of the Project, in accordance with the JICA Guidelines for Environmental and Social Considerations (April, 2010).

8-2. The Project is categorized as "B" from the following considerations:

PPWSA confirmed to conduct the necessary procedures concerning the environmental assessment (including stakeholder meetings, Environmental Impact Assessment (EIA) / Initial Environmental Examination (IEE) and information disclosure, etc.). Both sides agreed that the team would make EIA/IEE report of the Project and support for approval. The EIA/IEE approval shall be received from the responsible authorities and submitted to JICA by October 2019 before the signing of the G/A.

9. Other Relevant Issues

9-1. Application of the Japanese Grant Aid with O&M

The Team explained that the Project would be implemented by applying the Japanese Grant Aid with O&M, whose outline is explained in Annex 3. The Team also explained important matters as follows and the Cambodian side understood them:

1) The Japanese Grant Aid shall be used for construction of the facilities and procurement of equipment necessary for the Project, and the consulting service for procurement and supervision of the above-mentioned facilities and equipment,
2) The prime contractor(s), namely, special purpose company (hereinafter referred to as "SPC"), and the prime consulting firm, which enter into contracts with the Recipient, are limited to "Japanese nationals", in principle,
3) The SPC shall be responsible for the construction, procurement and O&M consistently,
4) Quality and Cost Based Selection (QCBS) that includes technical, financial and legal evaluation will be applied for the bidding of SPC,
5) Contracts consist (a) comprehensive contract which consolidates both contracts for the purchase of the products and/or services and for the operation and maintenance, (b) contract(s) for the purchase of products and/or

services and (c) contract(s) for the operation and maintenance, and

6) The Government of the Recipient shall ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the Recipient with respect to the purchase of the products and/or the services be exempted or be borne by its designated authority without using the Grant and its accrued interest, since the grant fund comes from the Japanese taxpayers.

9-2. Tax exemption

The Cambodian side confirmed that it gives necessary support to collect the information of tax exemption.

The Team explained the precondition that the tax such as corporate tax, personal income tax, value added tax and customs to be imposed for the construction work and the service which will be covered by the Japanese Grant Aid shall be exempted or reimbursed, and the Cambodian side understood it.

The Team will also study the possibility for tax exemption during the period of O&M and Cambodian side agreed to offer necessary cooperation to the Team. The Cambodian side explained that the tax exemption for the O&M phase should be discussed with General Department of Taxation (GDT) and the Council for the Development of Cambodia (CDC).

PPWSA recommended the Team to pay attention to subcontractors to be exempted from tax, because this point had been a cause of dispute in some previous Grant Aid projects.

9-3. Necessity of reclamation of the banana plant area

The Team explained that considering the limitation of the area of the site, multi-level WTP would be one option to be considered. However, the Team also explained that the multi-level WTP has some negative aspects such as higher electricity cost, additional waterproofing work and space limitation for rehabilitation work. Both sides agreed that the banana plant area could be used to create extra space, and the necessity of reclamation work would be further discussed technically between PPWSA and the Team.

9-4. Issue of raw water quality

The Team explained concern about worsening raw water quality of the Bassac River, and its survey policy to check odor-causing substances and Ammonium in the raw water. PPWSA explained that it considered chlorine dosing to treat Ammonium, and the pretreatment process would not be necessary, because the problem of odor was limited to the dry season.

9-5. Relocation of the tariff collection office

Both sides agreed that the existing office in the Ta Khmau site should be transferred to clear the space for the new WTP before the expected start of the construction work by PPWSA.

9-6. Unexploded ordnance (UXO)

PPWSA explained that the site had been already cleared from UXO, and nothing had been found when the existing water tower was constructed. Both sides agreed that in case that UXO was found during the survey and the Project, the Cambodian side should take necessary measures to secure the safety of the site.

9-7. Conditions for handover of bulk water

The Team proposed the basic concepts of conditions for handover of bulk water in terms of handover point, water quality, water pressure and off-take price.

Both sides agreed that PPWSA would purchase the bulk water of at least 30,000m^3/day throughout the O&M phase.

Both sides agreed that off-take price should be affordable for PPWSA and acceptable for the operations by SPC, and be decided based on the formula, which is taken safe water production O&M costs, extra service cost, administration cost, reasonable expected return for SPC, inflation rate, and so on into consideration. Both sides also agreed that inflation rate can be adopted the rate in the Quarterly Bulletins published by the National Bank of Cambodia.

PPWSA explained their opinion that it is necessary to discuss which cost items should be included into off-take price first, and the off-take price should be equal to or lower than the average production cost of PPWSA. The Team explained that the current PPWSA's average O&M cost and average tariff in Ta Khmau District should not serve as a benchmark to determine the off-take price, because PPWSA could have significant advantage to receive Japanese Grant to construct WTP by paying the off-take price, and there would be some project-specific factors to make the off-take price higher than the current PPWSA's average O&M cost such as the involvement of Japanese companies for quality assurance and technical transfer, and space limitation of the site which could result in higher electricity cost.

Both sides agreed that the conditions for handback should be discussed further on a priority basis to reach consensus by the middle of June, 2019, before the project briefing session for Japanese companies.

PPWSA explained that the off-take price should be approved by the Board of Directors of PPWSA and no other approval would be necessary, if such approval does not affect the current water tariff system. Both sides agreed that PPWSA would further study whether other ministries and authorities need to be informed or involved for the approval process.

9-8. Conditions for hand-back after the termination of O&M contract

The Team proposed the basic concepts of conditions for hand-back after the termination of O&M contract as follows.

- PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the Assets. The Value of the Asset shall be net book value of the assets.

PPWSA requested that SPC should keep good conditions of the facility and equipment, and SOP for operation to reduce the risk of breakdown soon after the hand-back.

Both sides agreed that this topic should be discussed further on a priority basis to reach consensus by the middle of June, 2019, before the project briefing session for Japanese companies.

9-9. Conditions for hand-back in case of the early termination of O&M contract

The Team proposed the basic concepts of conditions for hand-back in case of the early termination of O&M contract as follows.

1) Termination for convenience (Unilateral termination):

PPWSA has the right to terminate the contract early for public interest. In this case the SPC shall be compensated in full, for all the private investments, additional costs incurred by the termination of the contract, and opportunity costs for the equity.

2) Termination for default by PPWSA:
The termination condition shall be in line with the case of the termination for convenience.

3) Termination for default by SPC.
PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the Assets. The Value of the Asset shall be net book value of the assets minus cost of damages and losses suffered by PPWSA, which is equivalent to 30% of the net book value.

4) Termination for Force Majeure:
A Force Majeure is an event that is external, unpredictable, and irresistible and has a significant impact on the project. Both parties may terminate the contract if the impact of a Force Majeure lasts for a certain period. Neither party has any obligation to each other for the cost of mitigation measures to prevent increasing loss caused by Force Majeure. PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the Assets. The Value of the Asset shall be net book value of the assets.

Both sides agreed that this topic should be discussed further on a priority basis to reach consensus by the middle of June, 2019, before the project briefing session for Japanese companies.

9-10. Risk allocation during the O&M period

The Team proposed the basic concept of risk allocation as follows.

1) Facilities Design and Construction Risks: Facilities Design and Construction Risks are taken by SPC under conditions to be defined in the contracts.

2) Safe water production quality and quantity variation risk: Maintaining the quality and quantity of safe water production is under control of SPC, therefore

such variation risks are taken by SPC under conditions to be defined in the contracts.

3) Demand variation risk: Water demand variation risk is not under control of SPC, therefore such risk is taken by PPWSA.

4) Inflation variation risk: Inflation variation risk is not under control of SPC, therefore such risk is taken by PPWSA

5) Intake water quality variation risk: Intake water quality variation risk is not under control of SPC, therefore such risk is taken by PPWSA.

6) Electricity price variation risk: Electricity price variation risk is not under control of SPC therefore such risk is taken by PPWSA.

7) Law change risk especially related with water requirement is not under control of SPC, therefore such risk is taken by PPWSA.

Both sides agreed that risk allocation should be discussed further on a priority basis to reach consensus by the middle of June, 2019, before the project briefing session for Japanese companies.

9-11. Reconfirmation of the Minutes of Meetings (M/M) concluded between PPWSA and JICA Cambodia Office.

Both sides reconfirmed the M/M which had been signed on March 22, 2019 attached as Annex 6.

9-12. Applicable procurement rule and the domestic law in Cambodia

The Team explained that the bidding for Japanese Grant Aid with O&M should be Japan-tied in accordance with JICA's procurement rule based on the Article 3 of the Public Procurement Law in Cambodia. MEF and PPWSA agreed with it.

9-13. Duration of O&M phase

PPWSA explained that the duration of O&M should be 10 years at the longest after the commencement of the O&M.

9-14. Dispatch of PPWSA staff to SPC

PPWSA expressed its interest to dispatch its staff to SPC for technical transfer.

9-15. The schedule of the Project

The Cambodian side requested to accelerate the schedule to complete the construction before July 2023. The Team replied that possibility to shorten the schedule would be studied.

9-16. Water quality

The Cambodian side requested that SPC should comply with the water quality standards of PPWSA, because PPWSA is highly evaluated by its good quality of supplied water.

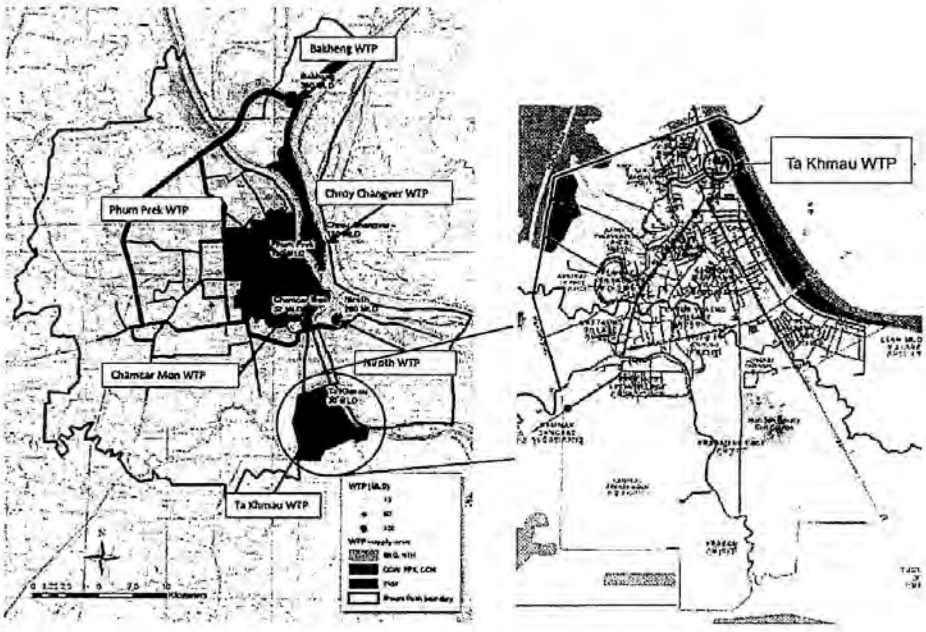
9-17. Ownership of the WTP

MEF and PPWSA confirmed that PPWSA would own the WTP to be constructed in the Project.

Annex 1 Project Site
Annex 2 Organization Chart
Annex 3 Japanese Grant Aid Scheme
Annex 4 Project Monitoring Report (template)
Annex 5 Major Undertakings to be taken by the Government of Cambodia
Annex 6 M/M between PPWSA and JICA Cambodia

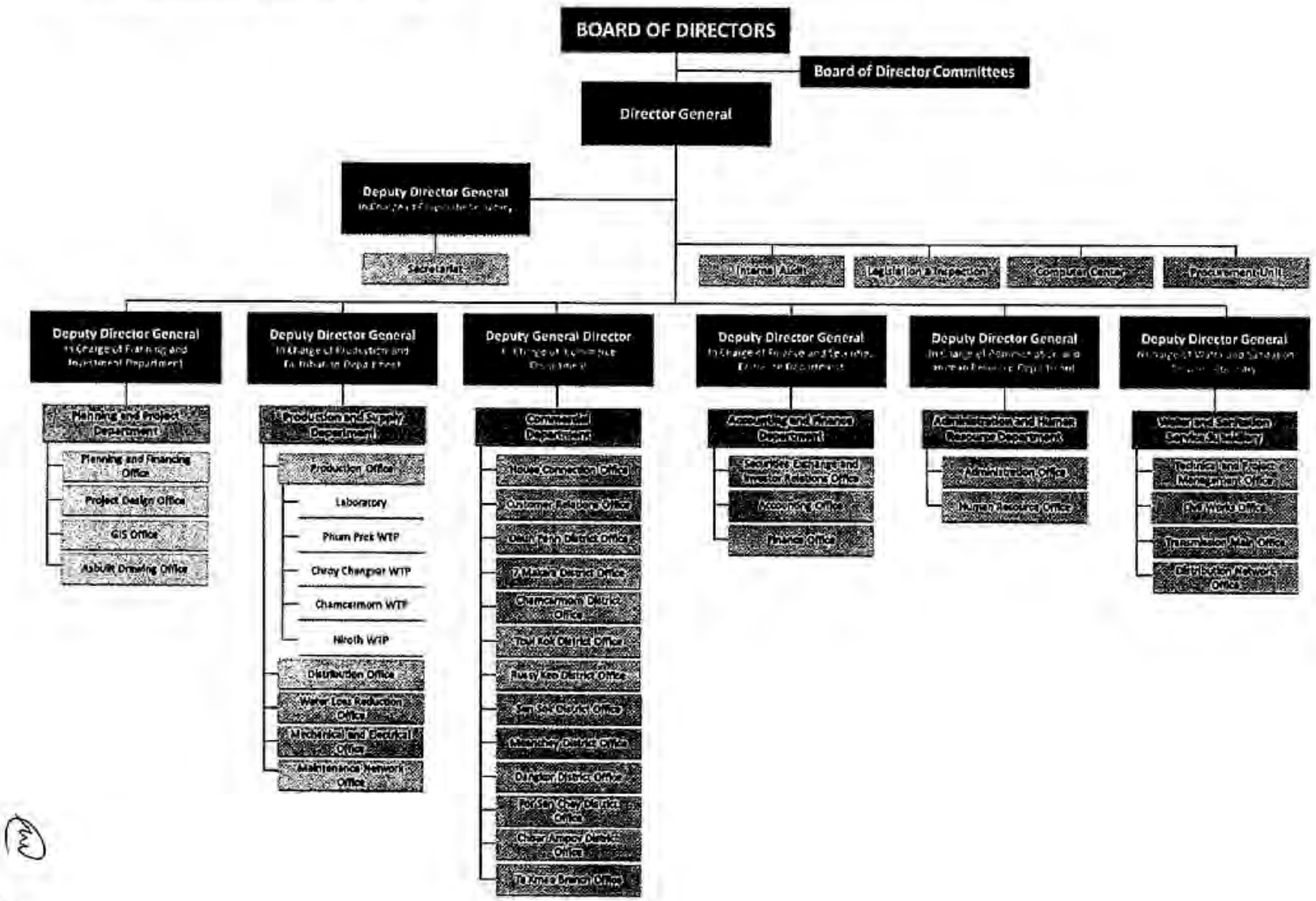
Annex1 Project Site Map

Cambodian Map



Site location Map

Annex2 Organization Chart of PPWSA



JAPANESE GRANT

The Japanese Grant is non-reimbursable fund provided to a recipient country (hereinafter referred to as "the Recipient") to purchase the products and/or services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. Followings are the basic features of this project grants operated by JICA (hereinafter referred to as "the Project Grant"). The Project Grant means a public project which is implemented by (a) private company (ies) with the technologies and experience of Japanese nationals. The private company(ies) will be comprehensively engaged in construction of facilities, procurement of equipment, and operation and management as well.

1. Procedures of the Project Grant

The Project Grant is conducted through following procedures. (See "PROCEDURES OF JAPANESE GRANT" for details):

(1) Preparation

- The Preparatory Survey (hereinafter referred to as "the Survey") conducted by JICA

(2) Appraisal

-Appraisal by the government of Japan (hereinafter referred to as "GOJ") and JICA, and Approval by the Japanese Cabinet

(3) Implementation

Exchange of Notes

-The Notes exchanged between the GOJ and the government of the Recipient

Grant Agreement (hereinafter referred to as "the G/A")

-Agreement concluded between JICA and the Recipient

Banking Arrangement (hereinafter referred to as "the B/A")

-Opening of bank account by the Recipient in a bank in Japan (hereinafter referred to as "the Bank") to receive the Japanese Grant

Construction works/procurement

-Implementation of the project (hereinafter referred to as "the Project", the term "the Project" means that the Recipient concludes contract(s) to construct facilities and/or procure equipment by using the Japanese Grant.) on the basis of the G/A

(4) Operation and Management (without using the Japanese Grant)

-Operation and management of the facilities and equipment

(5) Ex-post Monitoring and Evaluation

-Monitoring and evaluation of the Project at post-implementation stage

2. Preparatory Survey

(1) Contents of the Survey

The aim of the Survey is to provide basic documents necessary for the appraisal of the Project Grant made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project Grant and also institutional capacity of relevant agencies of the Recipient necessary for the implementation of the Project.
- Evaluation of the feasibility of the Project Grant to be implemented under the Japanese Grant from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project Grant.
- Preparation of an outline design of the Project.
- Estimation of costs of the Project Grant.
- Confirmation of Environmental and Social Considerations

The contents of the original request by the Recipient are not necessarily approved in their initial form. The Outline Design of the Project is confirmed based on the guidelines of the Japanese Grant.

JICA requests the Recipient to take measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the executing agency of the Project. Therefore, the contents of the Project Grant are confirmed by all relevant organizations of the Recipient based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA contracts with (a) consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the feasibility of the Project Grant.

3. Basic Principles of the Project Grant

(1) Implementation Stage

1) The E/N and the G/A

After the Project Grant is approved by the Cabinet of Japan, the Exchange of Notes (hereinafter referred to as "the E/N") will be singed between the GOJ and the Government of the Recipient to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Recipient to define the necessary articles, in accordance with the E/N, to implement the Project, such as conditions of disbursement, responsibilities of the Recipient, and procurement conditions. The terms and conditions generally applicable to the Japanese Grant are stipulated in the "General Terms and Conditions for Japanese Grant (January 2016)."

2) Banking Arrangements (B/A) (See "Financial Flow of Japanese Grant (A/P Type)" for details)

a) The Recipient shall open an account or shall cause its designated authority to open an account in the Bank. JICA will disburse the Japanese Grant in Japanese yen for the Recipient to cover the obligations incurred by the Recipient under the verified contracts.

b) The Japanese Grant will be disbursed when payment requests are submitted by the Bank to JICA under an Authorization to Pay (A/P) issued by the Recipient.

3) Procurement Procedure

The products and/or services necessary for the implementation of the Project shall be procured in accordance with JICA's procurement guidelines as stipulated in the G/A.

4) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the Recipient to continue to work on the Project's implementation after the E/N and G/A.

5) Eligible source country

In using the Japanese Grant disbursed by JICA for the purchase of products and/or services, the eligible source countries of such products and/or services shall be Japan and/or the Recipient. The Japanese Grant may be provided for the purchase of the products and/or services of a third country as eligible, if necessary, taking into account the quality, competitiveness and economic rationality of products and/or services necessary for achieving the objective of the Project. However, the prime contractor(s), namely, constructing and procurement firms, and the prime consulting firm, which enter into contracts with the Recipient, are limited to "Japanese nationals".

6) Contracts and Concurrence by JICA

1) Contracts consist of (a) a comprehensive contract which consolidates both contracts for the purchase of the products and/or services and for the operation and maintenance, (b) contract(s) for the purchase of products and/or services and (c) contract(s) for the operation and maintenance.

2) The Recipient will conclude (b) contract(s) for the purchase of products and/or services denominated in Japanese yen with Japanese nationals. Those contracts shall be concurred by JICA in order to be verified as eligible for using the Japanese Grant.

7) Monitoring

The Recipient is required to take their initiative to carefully monitor the progress of the Project in order to ensure its smooth implementation as part of their responsibility in the G/A, and to regularly report to JICA about its status by using the Project Monitoring Report (PMR).

8) Safety Measures

The Recipient must ensure that the safety is highly observed during the implementation of the Project.

9) Construction Quality Control Meeting

Construction Quality Control Meeting (hereinafter referred to as the "Meeting") will be held for quality assurance and smooth implementation of the Works at each stage of the Works. The member of the Meeting will be composed by the Recipient (or executing agency), the Consultant, the Contractor and JICA. The functions of the Meeting are as followings:

a) Sharing information on the objective, concept and conditions of design from the Contractor, before start of construction.

b) Discussing the issues affecting the Works such as modification of the design, test, inspection, safety control and the Client's obligation, during of construction.

(2) Operation and Management Stage

The Contractor operates and manages the facilities and equipment based on the contract(s) for operation and maintenance with the Recipient.

(3) Ex-post Monitoring and Evaluation Stage

1) After the project completion of all construction and procurement works by using the Japanese Grant, JICA will continue to keep in close contact with the Recipient in order to monitor that the outputs of the Project is used and maintained properly to attain its expected outcomes.

2) In principle, JICA will conduct ex-post evaluation of the Project after three years from the completion of all construction and procurement works by using the Japanese Grant. It is required for the Recipient to furnish any necessary information as JICA may reasonably request.

(4) Others

1) Environmental and Social Considerations

The Recipient shall carefully consider environmental and social impacts by the Project and must comply with the environmental regulations of the Recipient and JICA Guidelines for Environmental and Social Considerations (April, 2010).

2) Major undertakings to be taken by the Government of the Recipient

For the smooth and proper implementation of the Project, the Recipient is required to undertake necessary measures including land acquisition, and bear an advising commission of the A/P and payment commissions paid to the Bank as agreed with the GOJ and/or JICA. The Government of the Recipient shall ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the Recipient with respect to the purchase of the products and/or the services be exempted or be borne by its designated authority without using the Japanese Grant and its accrued interest.

3) Proper Use

The Recipient is required to maintain and use properly and effectively the products and/or services under the Project (including the facilities constructed and the equipment purchased), to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Japanese Grant.

4) Export and Re-export

The products purchased under the Japanese Grant should not be exported or re-exported from the Recipient country.

PROCEDURES OF JAPANESE GRANT

Stage	Procedures	Remarks	Recipient Government	Japanese Government	JICA	Consultants	Contractors	Agent Bank
Official Request	Request for grants through diplomatic channel	Request shall be submitted before appraisal stage.	x	x				
1. Preparation	(1) Preparatory Survey Preparation of outline design and cost estimate		x		x	x		
2. Appraisal	(2)Preparatory Survey Explanation of draft outline design, including cost estimate, undertakings, etc.		x		x	x		
	(3)Agreement on conditions for implementation	Conditions will be explained with the draft notes (E/N) and Grant Agreement (G/A) which will be signed before approval by Japanese government.	x	x (E/N)	x (G/A)			
	(4) Approval by the Japanese cabinet			x				
3. Implementation	(5) Exchange of Notes (E/N)		x	x				
	(6) Signing of Grant Agreement (G/A)		x		x			
	(7) Banking Arrangement (B/A)	Need to be informed to JICA	x					x
	(8) Contracting with consultant and issuance of Authorization to Pay (A/P)	Concurrence by JICA is required	x			x		x
	(9) Preparation of bidding documents	Concurrence by JICA is required	x			x		
	(10) Bidding	Concurrence by JICA is required	x			x	x	
	(11) Contracting with contractor/supplier and issuance of A/P	Concurrence by JICA is required	x				x	x
	(12) Design/Construction works/procurement	Concurrence by JICA is required for amendment of contracts.	x			x	x	
	(13) Completion certificate		x			x	x	
4. Operation & Management	(14) Operation and management of the facilities and equipment		x			x	x	
5. Ex-post monitoring & evaluation	(15) Ex-post monitoring	To be implemented generally after 1, 3, 10 years of completion, subject to change	x		x			
	(16) Ex-post evaluation	To be implemented basically after 3 years of completion	x		x			

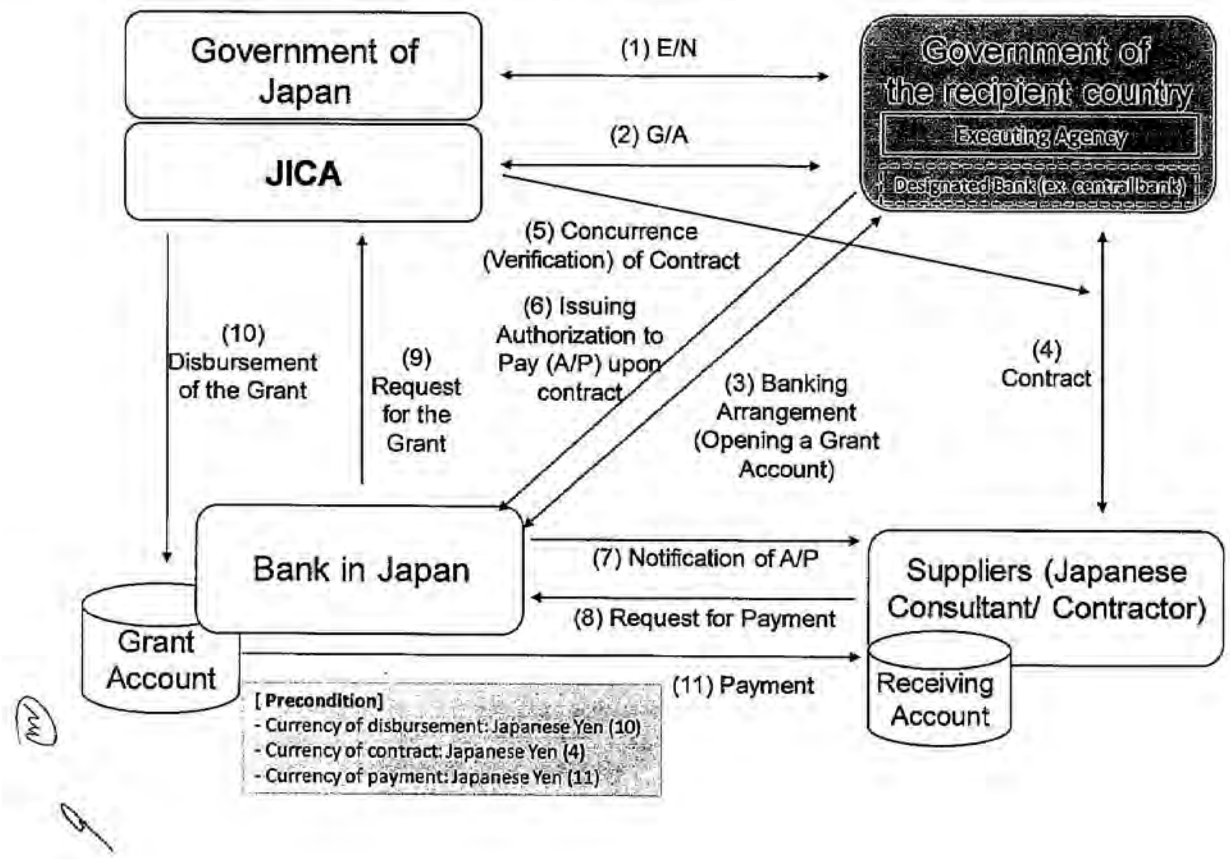
notes:

1. Project Monitoring Report and Report for Project Completion shall be submitted to JICA as agreed in the G/A.

2. Concurrence by JICA is required for allocation of grant for remaining amount and/or contingencies as agreed in the G/A.

Attachment 2 of Annex3

Financial Flow of Japanese Grant (A/P Type)



Project Monitoring Report
on
Project Name
Grant Agreement No. XXXXXXX
20XX, Month

Organizational Information

Signer of the G/A (Recipient)	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:
Executing Agency	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:
Line Ministry	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:

General Information:

Project Title	
E/N	Signed date: Duration:
G/A	Signed date: Duration:
Source of Finance	Government of Japan: Not exceeding JPY ______ mil. Government of (________): ____________

G/A NO. XXXXXXX
PMR prepared on DD/MM/YY

1: **Project Description**	

1-1 Project Objective

1-2 Project Rationale
- Higher-level objectives to which the project contributes (national/regional/sectoral policies and strategies)
- Situation of the target groups to which the project addresses

1-3 Indicators for measurement of "Effectiveness"

Quantitative indicators to measure the attainment of project objectives		
Indicators	Original (Yr)	Target (Yr)
Qualitative indicators to measure the attainment of project objectives		

2: **Details of the Project**

2-1 Location

Components	Original *(proposed in the outline design)*	Actual
1.		

2-2 Scope of the work

Components	Original* *(proposed in the outline design)*	Actual*
1.		

Reasons for modification of scope (if any).

(PMR)

2

2-3 Implementation Schedule

Items	Original (proposed in the outline design)	Original (at the time of signing the Grant Agreement)	Actual

Reasons for any changes of the schedule, and their effects on the project (if any)

2-4 Obligations by the Recipient

2-4-1 Progress of Specific Obligations
See Attachment 2.

2-4-2 Activities
See Attachment 3.

2-4-3 Report on RD
See Attachment 11.

2-5 Project Cost

2-5-1 Cost borne by the Grant(Confidential until the Bidding)

Components			Cost (Million Yen)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			
Total				

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar = Yen

2-5-2 Cost borne by the Recipient

Components			Cost (1,000 Taka)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar =

Reasons for the remarkable gaps between the original and actual cost, and the countermeasures (if any)

(PMR)

2-6 Executing Agency

- Organization's role, financial position, capacity, cost recovery etc,
- Organization Chart including the unit in charge of the implementation and number of employees.

Original *(at the time of outline design)* name: role: financial situation: institutional and organizational arrangement (organogram): human resources (number and ability of staff):
Actual *(PMR)*

2-7 Environmental and Social Impacts

- The results of environmental monitoring based on Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- The results of social monitoring based on in Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- Disclosed information related to results of environmental and social monitoring to local stakeholders (whenever applicable).

3: Operation and Maintenance (O&M)

3-1 Physical Arrangement

- Plan for O&M (number and skills of the staff in the responsible division or section, availability of manuals and guidelines, availability of spareparts, etc.)

Original *(at the time of outline design)*
Actual *(PMR)*

3-2 Budgetary Arrangement

- Required O&M cost and actual budget allocation for O&M

Original *(at the time of outline design)*

Actual *(PMR)*

4: Potential Risks and Mitigation Measures

- Potential risks which may affect the project implementation, attainment of objectives, sustainability
- Mitigation measures corresponding to the potential risks

Assessment of Potential Risks *(at the time of outline design)*

Potential Risks	Assessment
1. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
2. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
3. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:

	Contingency Plan (if applicable):
Actual Situation and Countermeasures	
(PMR)	

5: Evaluation and Monitoring Plan (after the work completion)

5-1 Overall evaluation

Please describe your overall evaluation on the project.

5-2 Lessons Learnt and Recommendations

Please raise any lessons learned from the project experience, which might be valuable for the future assistance or similar type of projects, as well as any recommendations, which might be beneficial for better realization of the project effect, impact and assurance of sustainability.

5-3 Monitoring Plan of the Indicators for Post-Evaluation

Please describe monitoring methods, section(s)/department(s) in charge of monitoring, frequency, the term to monitor the indicators stipulated in 1-3.

Attachment

1. Project Location Map
2. Specific obligations of the Recipient which will not be funded with the Grant
3. Monthly Report submitted by the Consultant

Appendix - Photocopy of Contractor's Progress Report (if any)
- Consultant Member List
- Contractor's Main Staff List

4. Check list for the Contract (including Record of Amendment of the Contract/ Agreement and Schedule of Payment)
5. Environmental Monitoring Form / Social Monitoring Form
6. Monitoring sheet on price of specified materials (Quarterly)
7. Report on Proportion of Procurement (Recipient Country, Japan and Third Countries) (PMR (final)only)
8. Pictures (by JPEG style by CD-R) (PMR (final)only)
9. Equipment List (PMR (final)only)
10. Drawing (PMR (final)only)
11. Report on RD (After project)

Attachment 6

Monitoring sheet on price of specified materials

1. Initial Conditions (Confirmed)

	Items of Specified Materials	Initial Volume A	Initial Unit Price (¥) B	Initial total Price C=A×B	1% of Contract Price D	Condition of payment	
						Price (Decreased) E=C−D	Price (Increased) F=C+D
1	Item 1	●●t	●	●	●	●	●
2	Item 2	●●t	●	●	●		
3	Item 3						
4	Item 4						
5	Item 5						

2. Monitoring of the Unit Price of Specified Materials

(1) Method of Monitoring : ●●

(2) Result of the Monitoring Survey on Unit Price for each specified materials

	Items of Specified Materials	1st ○month, 2015	2nd ○month, 2015	3rd ○month, 2015	4th	5th	6th
1	Item 1						
2	Item 2						
3	Item 3						
4	Item 4						
5	Item 5						

(3) Summary of Discussion with Contractor (if necessary)

-
-
-

Attachment 7

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
(Actual Expenditure by Construction and Equipment each)

	Domestic Procurement (Recipient Country) A	Foreign Procurement (Japan) B	Foreign Procurement (Third Countries) C	Total D
Construction Cost	(A/D%)	(B/D%)	(C/D%)	
Direct Construction Cost	(A/D%)	(B/D%)	(C/D%)	
others	(A/D%)	(B/D%)	(C/D%)	
Equipment Cost	(A/D%)	(B/D%)	(C/D%)	
Design and Supervision Cost	(A/D%)	(B/D%)	(C/D%)	
Total	(A/D%)	(B/D%)	(C/D%)	

Annex 5

Major Undertakings to be taken by the Royal Government of Cambodia

1. Specific obligations of the Royal Government of Cambodia which will not be funded with the Grant

(1) Before the Bidding

No	Items	Deadline	In charge	Estimated Cost	Ref.
1	To open bank account (B/A)	within 1 month after the signing of the G/A	PPWSA		
2	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the consultant	within 1 month after the signing of the contract(s)	PPWSA		
3	To approve IEIA/EIA(Conditions of approval should be fulfilled, if any) and secure the necessary budget for implementation	within 1 month after the signing of the G/A	PPWSA		
4	To notice the construction of the intake facility in the Bassac River to local authorities	before notice of the bidding document(s)	PPWSA		
5	To secure, clear, level and reclaim the following lands/sites * 1) Site for Ta Khmau WTP *The details will be confirmed by the Preparatory Survey	before notice of the bidding document(s)	PPWSA		
6	To explore landmines and UXO at construction site	before notice of the bidding document(s)	PPWSA		
7	To obtain water right from the Bassac River from MOWRAM	before notice of the bidding document(s)	PPWSA		
8	To demolish and transfer the existing tariff collection office	before notice of the bidding document(s)	PPWSA		
9	To submit Project Monitoring Report	before preparation of bidding document(s)	PPWSA		

(B/A: Banking Arrangement, A/P: Authorization to pay, N/A: Not Applicable)

(2) During the Project Implementation (during construction)

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Supplier(s)	within 1 month after the signing of the contract(s)	PPWSA		
2	To bear the following commissions to a bank in Japan for the banking services based upon the B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	PPWSA/ NBC		
	2) Payment commission for A/P	every payment	PPWSA/ NBC		
3	To ensure prompt customs clearance and to assist the Supplier(s) with internal transportation in the country of the Recipient	during the Project	PPWSA		
4	To accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into Cambodia and stay therein for the performance of their work	during the Project	PPWSA		
5	To ensure that customs duties, VAT, internal taxes and other fiscal levies which may be imposed in Cambodia with respect to the purchase of the products and/or the services be exempted by its designated authority without using the Grant;	during the Project	MEF		
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	during the Project	PPWSA		
7	1) To submit Project Monitoring Report	every month	PPWSA		
	2) To submit Project Monitoring Report (final)	within one month after signing of Certificate of Completion for the works under the contract(s)	PPWSA		
8	To submit a report concerning completion of the Project	within six months after completion of the Project	PPWSA		
9	To provide facilities for distribution of electricity, water supply and drainage and other incidental facilities necessary for the implementation of the Project outside the site(s)		PPWSA		
	1) Electricity The distributing line to the site *To be confirmed by the Preparatory Survey	before start of the construction			
	2) Drainage The city drainage main (for storm, sewer and others) to the site *To be confirmed by the Preparatory Survey	before start of the construction			
10	To take necessary measure for safety of construction - Coordination with the police for traffic control - Coordination with relevant authority to ensure the safety of boats and ships in relation to the construction of intake facility *To be confirmed by the Preparatory Survey	during the construction	PPWSA		
11	To implement EMP and EMoP	during the construction	PPWSA		
12	To submit results of environmental monitoring to JICA, by using the monitoring form, on a quarterly basis as a part of Project Monitoring Report	during the construction	PPWSA		

NBC: National Bank of Cambodia

(3) During the Project Implementation (during O&M)

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To implement EMP and EMoP	for a period based on EMP and EMoP	PPWSA		
2	To submit results of environmental monitoring to JICA, by using the monitoring form, semiannually - The period of environmental monitoring may be extended if any significant negative impacts on the environment are found. The extension of environmental monitoring will be decided based on the agreement between PPWSA and JICA.	for three years after the commissioning	PPWSA		
3	To extend distribution network and facilitate the service connections.	for the O&M period	PPWSA		
4	To submit reports to JICA regarding the situation of O&M* *The details will be confirmed by the Preparatory Survey	for the O&M period	PPWSA		
5	To comply strictly with the O&M contract	for the O&M period	PPWSA		

Annex 6

THE MINUTES OF MEETINGS
ON
THE PROJECT FOR CONSTRUCTION OF WATER TREATEMENT SYSTEM IN TA KHMAU
AGREED UPON BETWEEN
PHNOM PENH WATER SUPPLY AUTHORITY
AND
JAPAN INTERNATIONAL COOPERATION AGENCY CAMBODIA OFFICE

Phnom Penh, March 22, 2019

Based on a series of discussions between Phnom Penh Water Supply Authority (hereinafter referred to as "PPWSA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") Cambodia Office concerning the project formulation for water treatment plant in Ta Khmau, both sides discussed pre-condition to conduct the Preparatory Survey of the Project for Construction of Water Treatment System in Ta Khmau (hereinafter referred to as "the Project).

As a result of the discussions, both sides agreed on the main items described in the attached sheets.

Annex 1: Main Points Discussed

Mr. Kotaro TANAKA Deputy Chief Representative Japan International Cooperation Agency Cambodia Office	Dr. Sim Sitha Director General Phnom Penh Water Supply Authority

MAIN POINTS DISCUSSED

1. Water Source

PPWSA confirmed that raw water source should be the Bassac River for the water treatment plant (WTP) in Ta Khmau, and there was no other reservation and option. PPWSA also provided JICA Cambodia Office with the feasibility study report for rehabilitation and extension of Chamcar Mon WTP which contained flow rate, water level and water quality data of the Bassac River. JICA Cambodia Office requested PPWSA to obtain latest data from 2015 to 2018 from MOWRAM and provide them to JICA, because the feasibility study report contained data up to 2014. JICA provides the list of general and specific data of the Bassac River that would assist PPWSA to obtaining the required data from MOWRAM.

2. Water Rights

PPWSA explained that the project is to replace the existing facilities, which a permit to withdraw raw water from the Bassac River in amount of 33,000m^3/day is not required. PPWSA additionally explained that since the written document did not remain, PPWSA could apply a permit to MOWRAM if JICA requested. The related official documents are required in case of application of the permit,and the approval from MOWRAM may take at least three (3) months. JICA Cambodia Office requested PPWSA to obtain a written permit from MOWRAM in the course of the Preparatory Survey.

With this respect, PPWSA would request JICA to provide some supporting documents such as initial design of WTP, intake facility, river bank protection, the related data and information like volume of raw water intake, location of intake facility and WTP. JICA Cambodia Office took note of it.

3. Population and water demand

PPWSA confirmed that population increase and water demand in Ta Khmau is based on the report of Third Master Plan. PPWSA explained that the area of Ta Khmau had recently added 4 communes to the original 6 communes, but those communes were supplied water by private operators and PPWSA were still not authorized to cover the new area. Considering this situation, both sides agreed to target original 6 communes in the Preparatory Survey as a planning basis.

4. Quality of raw water and intake facility

PPWSA explained that the raw water quality from the Bassac River was not good, but a pre-treatment facility would not be necessary, since the space of the construction was limited. PPWSA explained that ammonium could be treated using chlorine, and the intake tower was recommended to be constructed off the river bank to take raw water of better quality especially during the dry season. JICA Cambodia Office took note of it. Odor substance in raw water will be also examined in the Preparatory Survey since PPWSA explained the number of complaints about odor was increasing. Optimal treatment process would be considered based on the water quality examination in the course of the Preparatory Survey.

5. Capacity of WTP and Distribution Plan

PPWSA explained that it had a plan to distribute surplus water to Phnom Penh when water demand would not reach up to 30,000m^3/day in Ta Khmau. PPWSA also confirmed that it was technically possible to transmit water from the new WTP to Phnom Penh using the existing pipe DN 500mm.

JICA Cambodia Office took note of it, and explained that the JICA Preparatory Survey Team would confirm technical justification during the Preparatory Survey.

PPWSA also explained that handing over point of bulk water (the place of water meter) should be installed inside of the WTP, and the exact location would be determined during the Preparatory Survey.

6. Ownership of the WTP

PPWSA confirmed that PPWSA would own the WTP to be constructed in the Project after the completion of the construction.

7. Off-take price

PPWSA and JICA Cambodia Office discussed and exchanged opinions about off-take price. PPWSA explained that it may be expensive to set up off-take price in the amount of 800 KHR/m^3, which is indicated in the Data Collection Survey on Water Supply Sector in Phnom Penh Capital City (hereinafter referred to as the Survey), considering the pre-conditions shown below.

- The cost calculation for electricity is estimated too high (300 KHR/m^3) comparing the current cost of electricity (200 KHR/m^3).
- The estimated cost for salary is also high, which should be 17-18% from the

total production cost.

- o Operation and maintenance cost should be also estimated around 6%.

In this context, PPWSA roughly estimates off-take price in amounting 400-500 KHR/m^3. PPWSA additionally explained that the production cost and distribution cost are 400 KHR/m^3 and 500 KHR/m^3 respectively. Off-take price can be adjustable based on inflation and possibly either fixed or variable. It is also subject for further discussion and approval by Ministry of Economy and Finance (MEF) as PPWSA is a public listing company, which MEF holds 85% of stock share from PPWSA.

PPWSA also explained that private water operators may receive the right to be exempted from VAT tax, withholding tax, profit tax, and corporate tax for their investment, though it is still on-going discussion in the government. It can be applied during the construction and operation period.

8. Proposed type of contracts

JICA Cambodia Office explained that the facilities should be handed over to PPWSA after the completion of construction due to the rule of Japan's ODA grant aid. In this regard, JICA explained that the following composition of the contract documents were currently considered.

i. EPC Contract

ii. Lease Contract to let SPC to use the constructed facilities (can be integrated into the Bulk Water Supply Contract below if the facility belongs to PPWSA)

iii. Bulk Water Supply Contract

iv. Overarching document to stipulate the relationship of these contract documents

JICA explained that the contents of each contract would be considered further during the Preparatory Survey, and PPWSA took note of it.

9. Multi-level WTP

PPWSA confirmed that there was no other alternative site. JICA Cambodia Office explained that multi-level WTP could be required since the existing site may not be enough for the horizontal treatment plant. JICA Cambodia Office also explained that there are key points to note that multi-level WTPs have some considerations as follows.

- Pumping cost becomes more expensive compared to the normal horizontal process.
- Also, additional waterproofing work and periodic rehabilitation are necessary.

- Future expansion is difficult due to space limitation.
- Facility layout needs to be carefully designed taking future improvement and rehabilitation work into consideration, and management would be complicated during renewal and rehabilitation.

If it is difficult to acquire new site and if PPWSA would not request vertical WTP, creation of extra space such as reclamation of the area outside of the fence near the river where banana plants are growing and demolition of existing water tower (elevated tank) will be necessary to construct a horizontal WTP. PPWSA explained that the existing water tower had been built in 2008 by the support of the World Bank, and depreciation period is 50 years so that it was difficult to demolish it. PPWSA preferred to construct horizontal type WTP though detailed study would be necessary to assess the extra space. If it is not large enough for a horizontal WTP, both sides confirmed that there was possibility to conduct reclamation for the site with the banana plants to avoid flooding by the Bassac River to enlarge the site for WTP.

PPWSA confirmed that there is no regulation for building construction such as building ratio. Foundation of old facilities may still remain under the ground so that the study should be conducted.

10. Replacement of the equipment after the completion of operation (lease contract)

PPWSA and JICA Cambodia Office discussed the condition of replacement for the equipment after the lease contract. PPWSA requested that the equipment should be handed over with the condition that the WTP can be operated at least 2 years without repair and/or replacement for budget approval and procurement procedure, depending on product lifecycle of the equipment, and JICA Cambodia Office took note of it.

11. Case of damages due to disaster occurred

PPWSA and JICA Cambodia Office discussed the obligation of rehabilitation/repair if there would be any cause of damage due to disaster such as flooding. PPWSA explained that Force Majeure clause under the agreement/contract for SPC might be applied.

(END)

Preparatory Survey for the Project for Expansion of Water Supply Systems in Ta Khmau in the Kingdom of Cambodia

1. **Purpose of the Mission**
   - to confirm the requests from Cambodian side
   - to explain New Grant Aid with SPC Projects scheme and tentative schedule of the project
   - to explain schedule and key points of the preparatory survey

2. **Schedule of Meetings**

Date and time		**Contents**	**Venue**
26 March 2019	8:30-12:00	Meeting with PPWSA	PPWSA
	14:00-15:30	Meeting with MIH	MIH
	15:30-	Site Visit at Proposed site at Ta Khumau	Ta Khumau WTP
27 March 2019	8:30-12:00	Meeting with PPWSA	PPWSA
	14:30-16:00	Meeting with MEF/GDICDB	MEF
28 March 2019	8:30-12:00	Meeting with PPWSA	PPWSA
	14:00-15:30	Site visit to Chamcar Mon WTP	CM WTP
29 March 2019	AM	Sign Minute of Meeting (PPWSA, MEF and JICA)	TBC
	14:00-15:00	Report to JICA Office	JICA
	15:30-16:30	Report to Embassy of Japan	EOJ

3. **Member list:**

JICA Members

No	Name	Title	Affiliation
1	Dr. Shigeyuki MATSUMOTO	Leader	Deputy Director General, Water Resources Group, Global Environment Department, JICA
2	Mr. Kazunori NAKAI	Cooperation Planning	Water Resources Team 1, Water Resources Group, Global Environment Department, JICA

Consultant Team

Name	**Title**	**Period**
Mr. Koichi OKAZAKI	Chief Consultant / Water Supply Facility Planning & Design Nihon Suido Consultants Co., Ltd.	From 18 March 2019
Mr. Takahiro NAKATA	Deputy Chief Consultant / Construction Planning & Cost Estimate Nihon Suido Consultants Co., Ltd.	
Mr. Hiroshi KUMAGAE	PPP Project Development Crown Agents Japan Ltd.	
Mr. Makoto KANEDA	Electrical Plant Process Planning & Design Nihon Suido Consultants Co., Ltd.	
Mr. Ryunan MATSUE	Environmental and Social Consideration / UXO Survey Nihon Suido Consultants Co., Ltd.	
Mr. Umi TOGASAWA	Business Modeling / Bidding & Contractual Development Crown Agents Japan Ltd.	
Mr. Takehiko OGA	Water Supply Planning Advisor Nihon Suido Consultants Co., Ltd.	

1. Domestic Law and regulations in Cambodia
    - Operation and Maintenance for Ta Khmau WTP will be implemented by SPC, which conducts civil works. Please confirm if it is possible to contract out to only Japanese companies for the construction works and O&M since the project is grant aid of Japanese ODA. Please confirm if article 3 of law on public procurement shall apply for this project.
    - Please confirm if VAT and other taxation can be exempted for the Project portion which is covered by Japanese grant, namely design and construction.
    - Please confirm the possibility for VAT exemption during the period of operation.
    - If the construction cost is partially covered by private investment, is it possible to contract out to only Japanese companies based on the procurement guidelines of grant aid? (application for article 3 of concession law)

2. Proposed type of contracts

   JICA explained PPWSA that the facilities should be handed over to PPWSA after the completion of construction due to the rule of Japan's ODA grant aid. In this regard, the following composition of the contract documents were currently considered.

   i. EPC Contract
   ii. Lease Contract to let SPC to use the constructed facilities (can be integrated into the Bulk Water Supply Contract below if the facility belongs to PPWSA)
   iii. Bulk Water Supply Contract
   iv. Overarching document to stipulate the relationship of these contract documents

   JICA also explained that the contents of each contract would be considered further during the Preparatory Survey. Are there any comments regarding proposed type of contracts from the position of MEF?

3. Government Guarantee
    - In case of failure to abide by conditions of contract from PPWSA, Is there any possibility to have government guarantee to reduce risk of SPC? In order for the government to provide the guarantee, what is the process for the approval? Are there any projects that the government provides guarantee? If not, what is idea for MEF in case of contractual default?

4. Off-take price

- JICA and PPWSA discussed off-take price as attached M/M, which requires further approval from MEF.
- What will be the process for the approval for off-take price within MEF. Does PPWSA need to go through approval process for bulk water supply contract?
- Is there any case of PPP contract which stipulates payment by foreign currency?

TECHNICAL NOTES ON THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU IN THE KINGDOM OF CAMBODIA

Based on the Minutes of Discussions (hereinafter referred to as "M/D") on the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau (hereinafter referred to as "the Project") signed on 29th March, 2019 between Japan International Cooperation Agency (hereinafter referred to as "JICA") and Phnom Penh Water Supply Authority (hereinafter referred to as "PPWSA"), the consultant members of the Preparatory Survey Team for the Outline Design (hereinafter referred to as "the Team") had a series of discussions and conducted field surveys from 1st April to 5th April, 2019.

As a result of the discussions and the surveys, both sides confirmed the technical and financial conditions described as per the attached.

It should be noted that this technical note does not mean the commitment of the project scope, project implementation, design and method to be implemented. The final project scope, project implementation, designs, etc. will be decided by the Government of Japan.

Phnom Penh, 5th April, 2019

Koichi OKAZAKI Chief Consultant / Water Supply Facility Planning and Design, JICA Preparatory Survey Team	SAMRETH Sovithiea Deputy Director General, in charge of Plan and Project, Phnom Penh Water Supply Authority

ATTACHMENT

Both parties agreed upon and confirmed the following items.

1 Layout Plan for Water Treatment Facility

The team explained the layout of WTP and treatment process, O&M cost structure, and distribution plan is shown in Annex-1. Cambodian side has no objection to the layout of WTP with intake tower and the capacity of service reservoir for cost estimation.

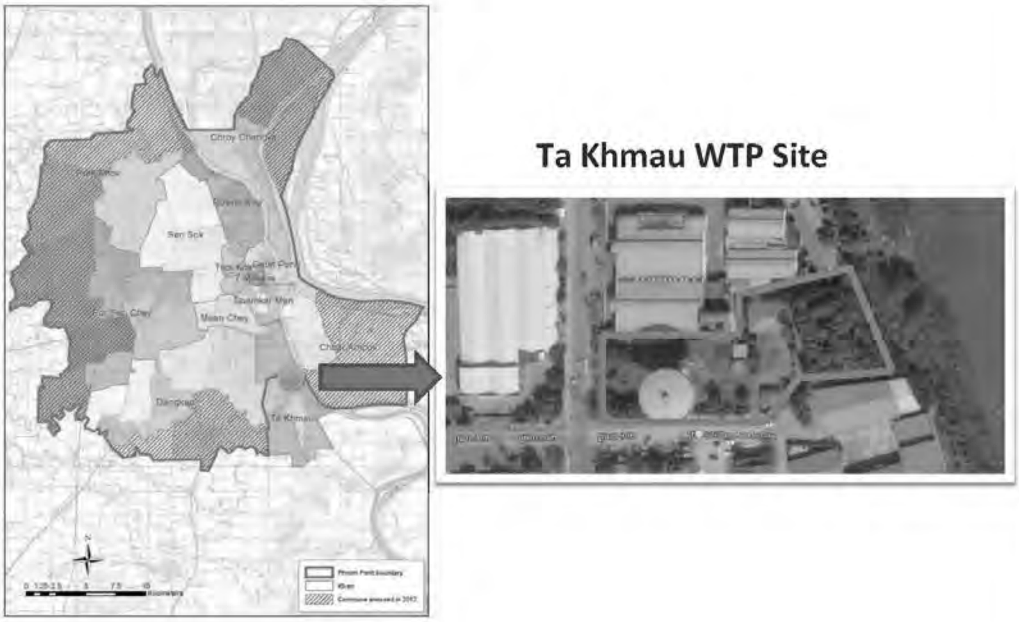
2 Contract Terms and Payment Mechanism

The team explained the basic principles of project structure, payment mechanism, risk allocation, contract terms, and bid evaluation methodologies and Cambodian side has no objection to the contents. (Annex-2)

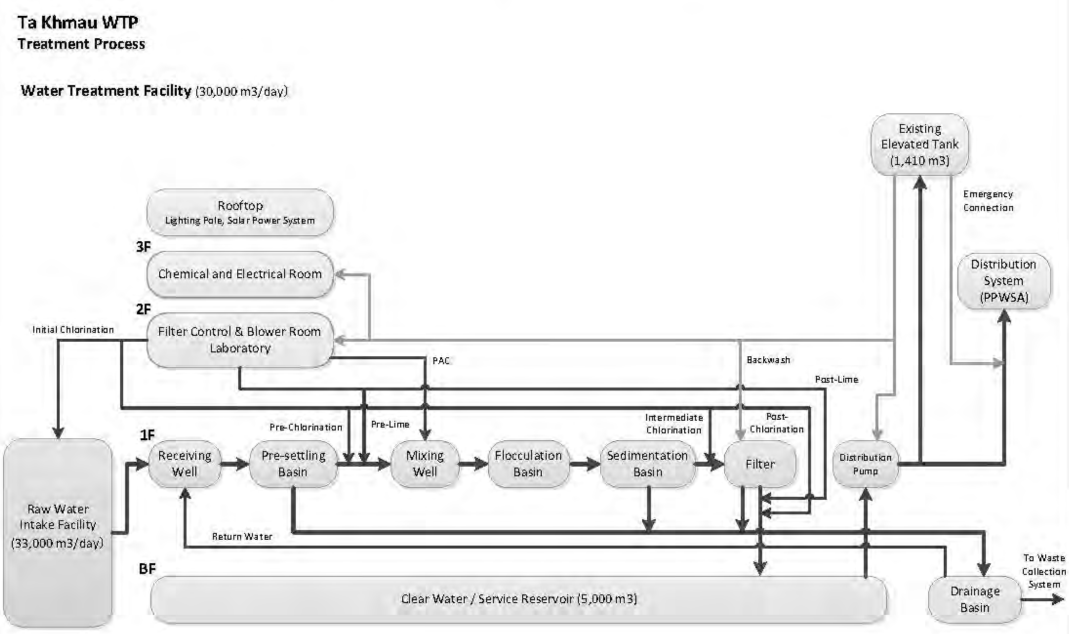
Annex-1

Draft Outline Design of Ta Khmau WTP

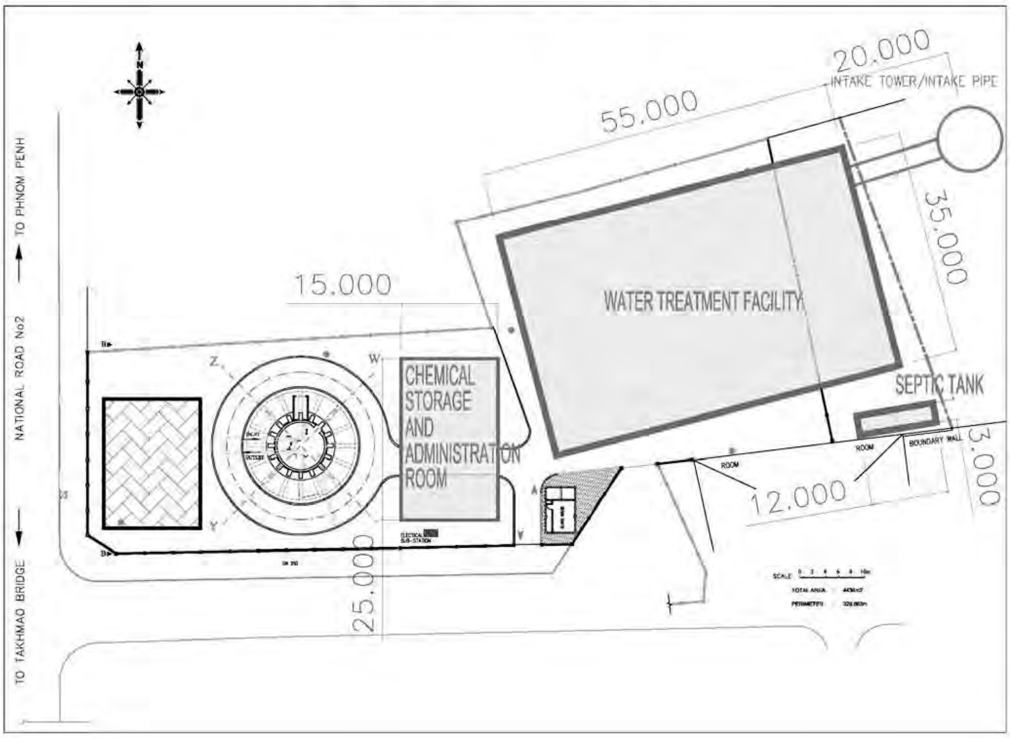
Location

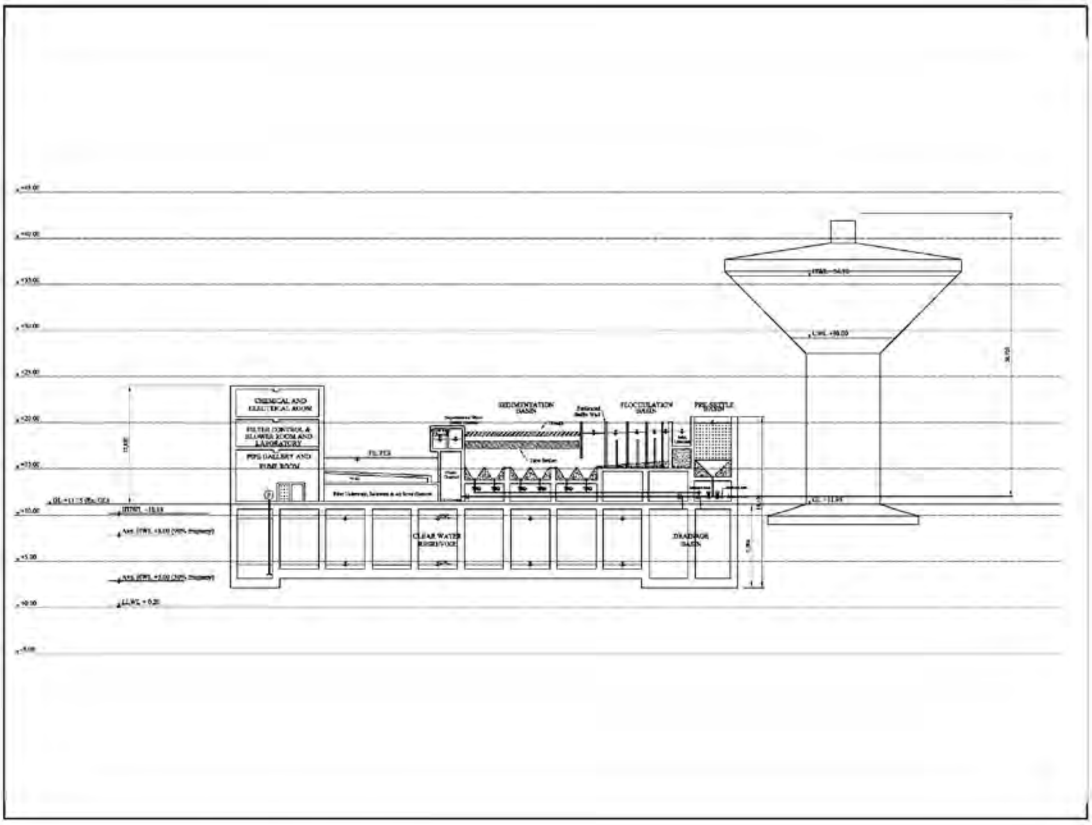


Treatment Process(Draft)



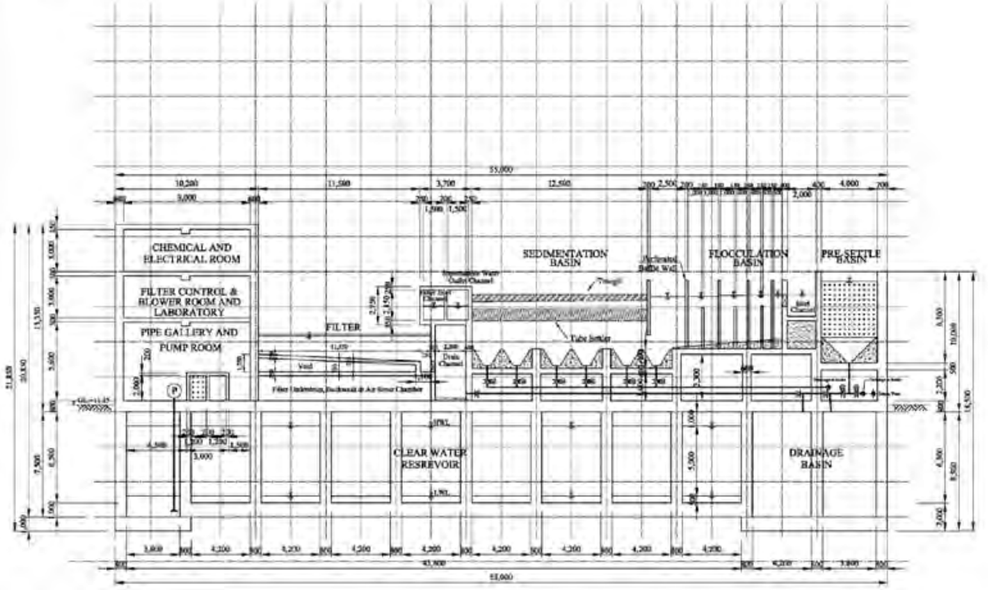
Draft Outline Design





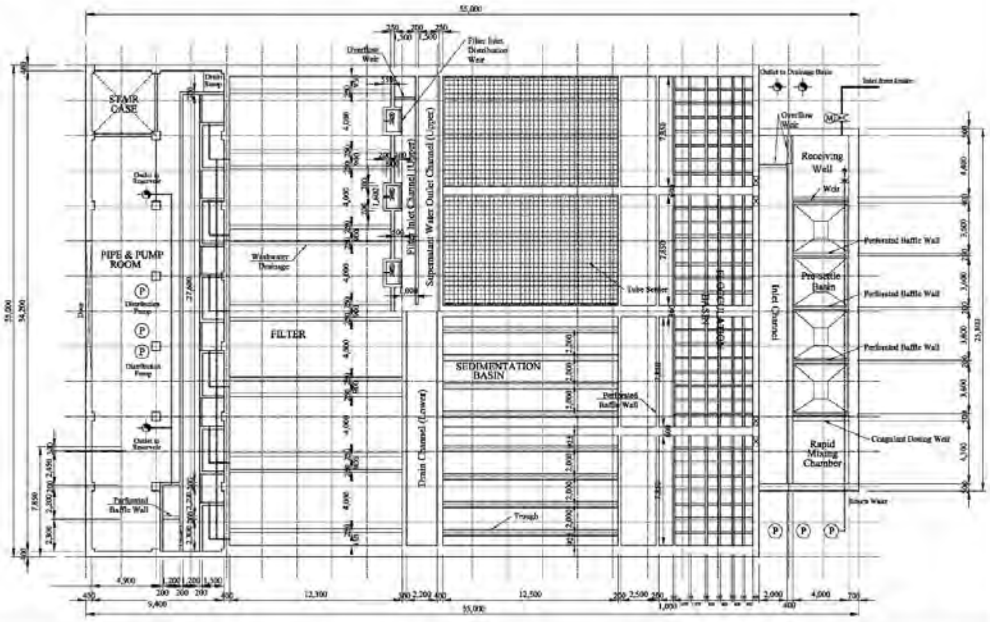
CLEAR WATER RESERVOIR AND DRAINAGE BASIN
Water Treatment Building
General Section
S=1:200

SECTION 1-1



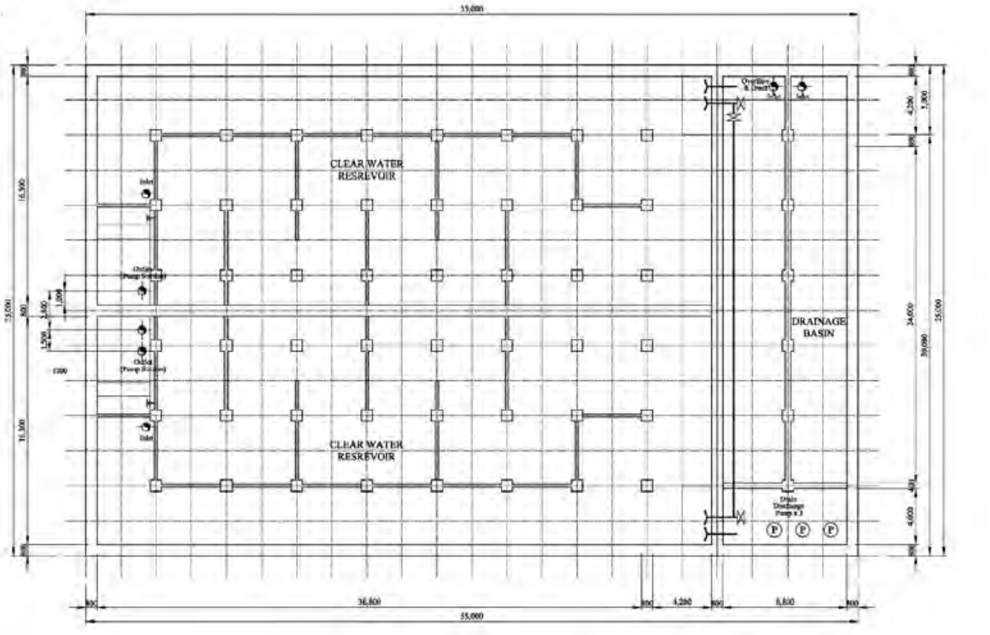
WATER TREATMENT FACILITY
Filter Control & Blower Room and Laboratory
2F
S=1:200

PLAN



CLEAR WATER RESERVOIR AND DRAINAGE BASIN
Water Treatment Building
BF
S=1:200

PLAN



Ta Khmau Reservoir

Day max. =	30000 m3/day		Res. Cap.=	5000 m3
=	1250.00 m3/hr		Effec. Dpt.=	5 m3
Day ave.=	30000.0 m3/day		Effec.Area=	1000 m2
	1250.0 m3/hr			4.0 hours

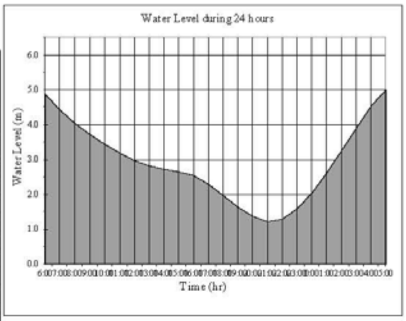
Time (hr)	Peak Factor	% of Daily Demand (%)	Water Demand (m3/hr)	Fire Demand (m3/hr)	Total Outlet	Inlet (m3/hr)	Volume (m3)	Water Level (m)
0								
6:00	1.10	4.6%	1,375		1,375	1,250	4,875	4.9
7:00	1.36	5.7%	1,700		1,700	1,250	4,425	4.4
8:00	1.31	5.5%	1,638		1,638	1,250	4,038	4.0
9:00	1.25	5.2%	1,563		1,563	1,250	3,725	3.7
10:00	1.22	5.1%	1,525		1,525	1,250	3,450	3.5
11:00	1.20	5.0%	1,500		1,500	1,250	3,200	3.2
12:00	1.18	4.9%	1,475		1,475	1,250	2,975	3.0
13:00	1.12	4.7%	1,400		1,400	1,250	2,825	2.8
14:00	1.08	4.5%	1,350		1,350	1,250	2,725	2.7
15:00	1.06	4.4%	1,325		1,325	1,250	2,650	2.7
16:00	1.08	4.5%	1,350		1,350	1,250	2,550	2.6
17:00	1.20	5.0%	1,500		1,500	1,250	2,300	2.3
18:00	1.26	5.3%	1,575		1,575	1,250	1,975	2.0
19:00	1.27	5.3%	1,588		1,588	1,250	1,638	1.6
20:00	1.21	5.0%	1,513		1,513	1,250	1,375	1.4
21:00	1.13	4.7%	1,413		1,413	1,250	1,213	1.2
22:00	0.94	3.9%	1,175		1,175	1,250	1,288	1.3
23:00	0.76	3.2%	950		950	1,250	1,588	1.6
0:00	0.64	2.7%	800		800	1,250	2,038	2.0
1:00	0.54	2.3%	675		675	1,250	2,613	2.6
2:00	0.49	2.0%	613		613	1,250	3,250	3.3
3:00	0.48	2.0%	600		600	1,250	3,900	3.9
4:00	0.49	2.0%	613		613	1,250	4,538	4.5
5:00	0.63	2.6%	788		788	1,250	5,000	5.0
Total	24	100%	30000	0		Min.	1212.50	1.21
			Total	30000				

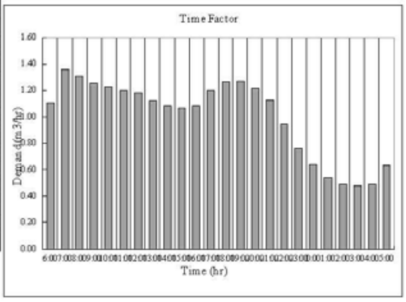
Max. 1.36

Min. 0.48

Required Min. Cap. of Res. (hour)

3.03 hr





Ta Khmau Reservoir

Day max. =	30000 m3/day		Res. Cap.=	5000 m3
=	1250.00 m3/hr		Effec. Dpt.=	5 m3
Day ave.=	30000.0 m3/day		Effec.Area=	1000 m2
	1250.0 m3/hr			4.0 hours

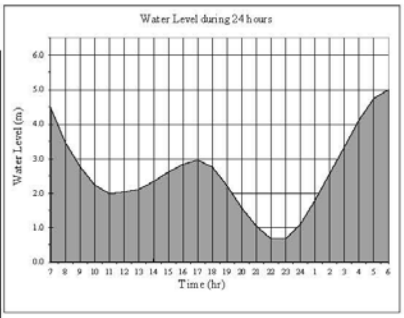
Time (hr)	Peak Factor	% of Daily Demand (%)	Water Demand (m3/hr)	Fire Demand (m3/hr)	Total Outlet	Inlet (m3/hr)	Volume (m3)	Water Level (m)
0								
7	1.42	5.9%	1,775		1,775	1,250	4,475	4.5
8	1.80	7.5%	2,250		2,250	1,250	3,475	3.5
9	1.56	6.5%	1,950		1,950	1,250	2,775	2.8
10	1.43	6.0%	1,788		1,788	1,250	2,238	2.2
11	1.20	5.0%	1,500		1,500	1,250	1,988	2.0
12	0.96	4.0%	1,200		1,200	1,250	2,038	2.0
13	0.94	3.9%	1,175		1,175	1,250	2,113	2.1
14	0.82	3.4%	1,025		1,025	1,250	2,338	2.3
15	0.78	3.3%	975		975	1,250	2,613	2.6
16	0.82	3.4%	1,025		1,025	1,250	2,838	2.8
17	0.90	3.8%	1,125		1,125	1,250	2,963	3.0
18	1.16	4.8%	1,450		1,450	1,250	2,763	2.8
19	1.43	6.0%	1,788		1,788	1,250	2,225	2.2
20	1.52	6.3%	1,900		1,900	1,250	1,575	1.6
21	1.42	5.9%	1,775		1,775	1,250	1,050	1.1
22	1.30	5.4%	1,625		1,625	1,250	675	0.7
23	1.00	4.2%	1,250		1,250	1,250	675	0.7
24	0.66	2.8%	825		825	1,250	1,100	1.1
1	0.44	1.8%	550		550	1,250	1,800	1.8
2	0.38	1.6%	475		475	1,250	2,575	2.6
3	0.38	1.6%	475		475	1,250	3,350	3.4
4	0.38	1.6%	475		475	1,250	4,125	4.1
5	0.50	2.1%	625		625	1,250	4,750	4.8
6	0.80	3.3%	1,000		1,000	1,250	5,000	5.0
Total	24	100%	30000	0		Min.	675.00	0.68
			Total	30000				

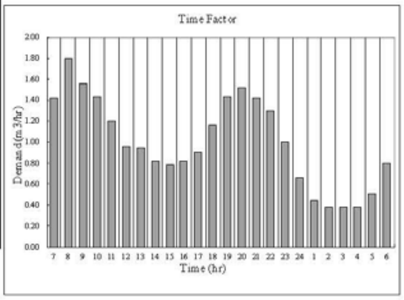
Max. 1.80

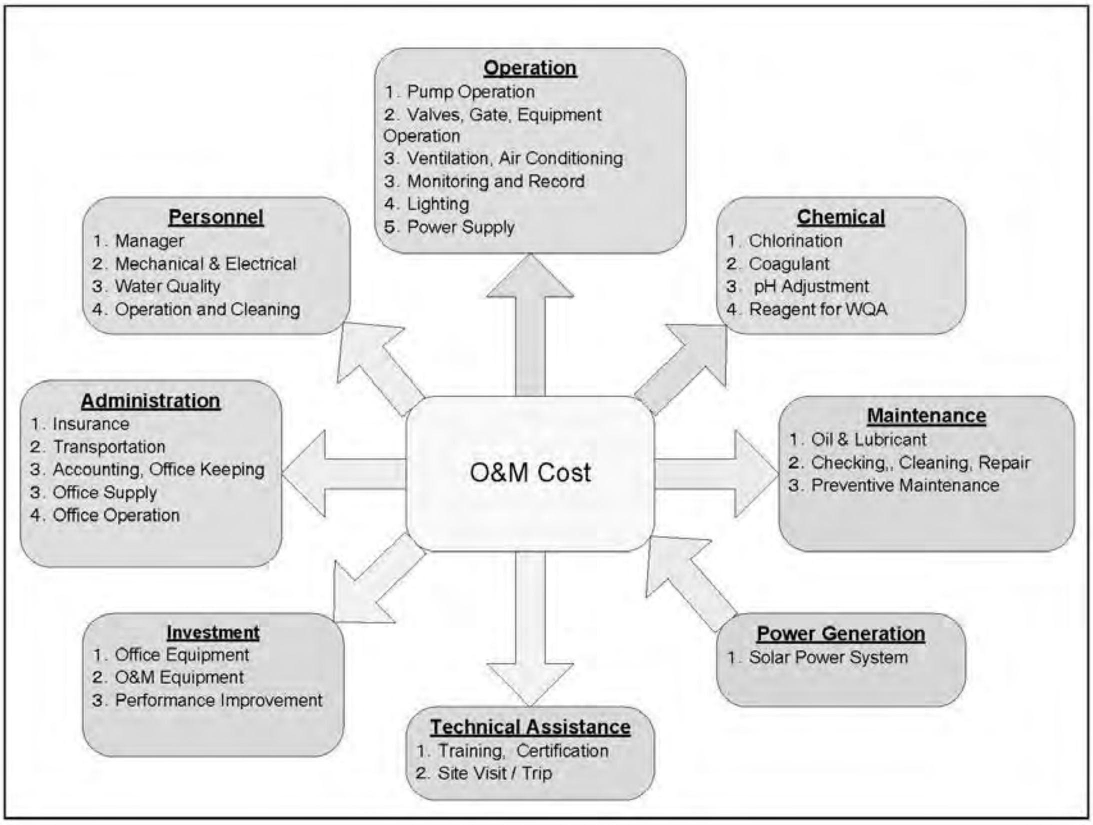
Min. 0.38

Required Min. Cap. of Res. (hour)

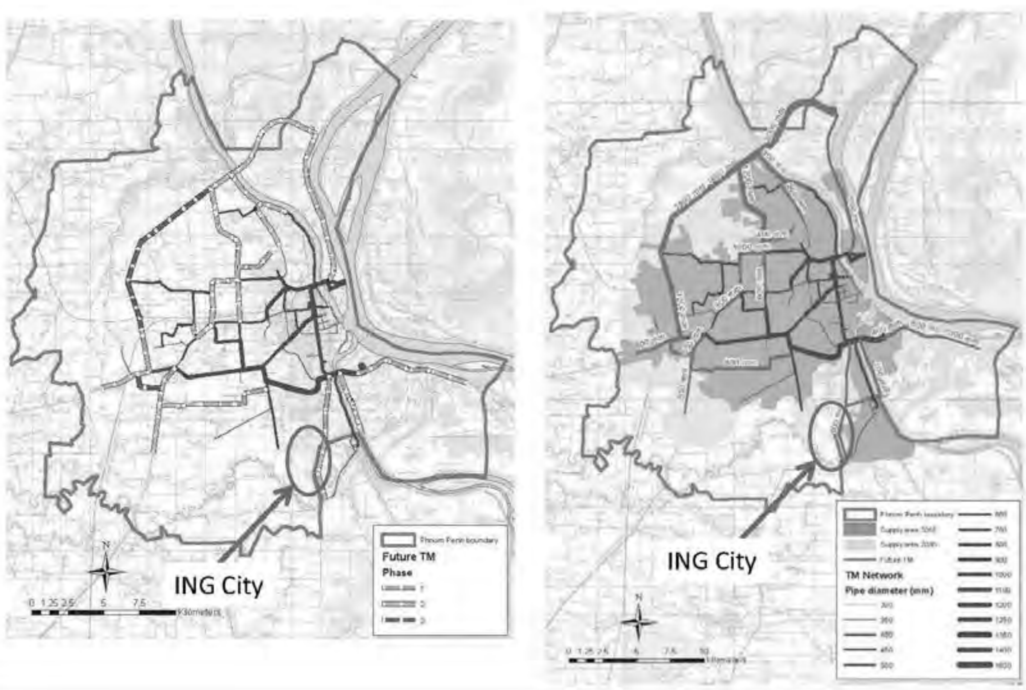
3.46 hr







Distribution Plan



Annex-2

CONFIDENTIAL / DRAFT / DISCUSSION PURPOSE ONLY

Abbreviations:

1. Project Outline

1.1 Project Background

- The water demand in the area supplied by PPWSA is projected to be double in 2030 and capacity of existing WTP in Phnom Penh will be insufficient to meet the demand in 2020.
- New WTP shall be developed to supply the water mainly in Ta Khmau area in which many low-income households need access to clean water at affordable water tariff and neighbor Phnom Penh areas where PPWSA develops water distribution system.
- The Government of Cambodia requested to the Government of Japan for the funds to implement the project for expansion of water supply system in Ta Khmau.

1.2 Project Objectives

The objective of the Project is to improve the access to safe water in Ta Khmau District through the expansion of water supply system including construction and operation and maintenance (hereinafter referred to as "O&M") of the new water treatment plant (hereinafter referred to as "WTP").

1.3 Project Structure

The Project would be implemented by applying the Japanese Grant Aid with O&M, whose outline is explained in Annex 3 of Minutes of Discussions on the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau dated 29th March 2019 in particular;

- The Japanese Grant Aid shall be used for construction of the facilities and procurement of equipment necessary for the Project, and the consulting service for, procurement, evaluation and approval of detail design prepared by SPC and supervision of the above-mentioned facilities and equipment,
- The SPC shall be responsible for the design, construction, procurement and O&M consistently,
- Contracts consist (a) comprehensive contract which consolidates both contracts for the purchase of the products and/or services and for the operation and maintenance, (b) contract(s) for the purchase of products and/or services and (c) contract(s) for the operation and maintenance, and
- The Government of the Recipient shall ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the Recipient with respect to the purchase of the products and/or the services be exempted or be borne by its designated authority without

using the Grant and its accrued interest, since the grant fund comes from the Japanese taxpayers.

1.4 Project Site

The construction site of the new WTP is located in Ta Khmau District, which is shown in Annex 1 of Minutes of Discussions on the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau dated 29th March 2019.

1.5 Risk Allocations

Risks	PPWSA	SPC	Remarks/Examples
EPC risk		O	Any additional costs shall be borne by SPC (e.g. inflation during construction period, design deficiency, change in natural conditions (e.g. unforeseen ground conditions)). Acts of PPWSA such as variation orders from PPWSA to SPC and UXO related costs will be paid by PPWSA.
Demand risk	O		PPWSA shall pay for treated water from SPC up to 30,000m3/day if SPC satisfies the required water pressure, regardless of any reason on PPWSA side (e.g. demand stays low or distribution pipes get damaged).
Operation risk		O	No payment shall be made if quality water is not delivered due to poor operation by SPC (e.g. facility malfunction, inappropriate usage of water treatment chemicals etc.). Penalty is applicable in case the water delivered by SPC does not comply with the drinking water standards of the WHO and national drinking water standards.
Electricity price risk	O		If the electricity price shall be covered by PPWSA according to the price formula.
Electricity availability risk	O	O	In case the electricity is not supplied to the facility due to blackout, SPC has no obligation to supply water and no payment shall be made for the period.
Inflation risk (during O&M period)	O		Increase in production costs caused by inflation (e.g. wages or raw materials) shall be paid by PPWSA calculated with the formula for the PPWSA payment to SPC.
Intake water quality risk	O		Additional cost of production due to change in quality of intake water shall be compensated to the SPC according to the methodology agreed in the contract.
Licensing risk	O		IEIA/EIA or any other permit/authorization necessary for

Risks	PPWSA	SPC	Remarks/Examples
			the SPC to operate the facility shall be obtained by PPWSA.
Legal risk (change of project specific law)	O		Additional cost caused by a change in law that specifically affects the project (e.g. upgrade of national quality standard for drinking water) shall be covered by PPWSA. SPC shall be compensated according to the methodology agreed between PPWSA and the SPC.
Legal risk (change of general law)		O	Additional cost caused by a change in general law that would affect the whole economy (e.g. VAT) shall be covered by the SPC.
Force Majeure risk	O	O	A Force Majeure is an event that is external, unpredictable, and irresistible and has a significant impact on the project. Both parties may terminate the contract if the impact of a Force Majeure lasts for a certain period (based on practice of water utilities). Neither party has any obligation to each other for the cost of mitigation measures to prevent increasing loss caused by Force Majeure. PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the Assets. The Value of the Assets shall be net book value of the assets.

1.6 Tender Evaluation

- The prime contractor(s), namely, special purpose company (hereinafter referred to as "SPC"), and the prime consulting firm, which enter into contracts with the Recipient, are limited to "Japanese nationals", in principle.
- Quality and Cost Based Selection (QCBS) that includes technical, commercial, financial and legal evaluation will be applied for the bidding of SPC.

Bidding evaluation (example)

Note: This shall be reviewed and approved by JICA.

Comprehensive Evaluation Score = Technical Score * X + Price Score * (1-X)

where X is a weight factor 1>X>0 supposedly 0.5-0.8

Technical Score (Example)

	Category	Score
1	Tenderers experience with respect to comparable projects;	TBA
2	Proposed Organization	TBA
3	Experience of key staff in relation to the scope of work;	TBA
4	Outline Design	TBA
5	Construction Work Plan	TBA
6	Operation and Maintenance and Monitoring Plan	TBA
	Maximum possible score	100

Price Score (Example)

The tenderer bids on 10-year Life Cycle Cost (LCC) where

(proposed) 10-year LCC = EPC price + Net present value of O&M costs + risk adjustments caused by proposals (Discount rate applicable for PPWSA project is 4.5%)

Price score = 100 * (1 - ((10-year LCC proposed + risk adjustment)/ LCC of comparator)) * Y

where Y is an adjustment factor defining price competition range and maximum price score is 100 required that

(1) EPC price is below the Grant budget, and

(2) O&M will be reflected in the contract price of bulk water

2. Contract Terms

Draft contracts for EPC and O&M will be prepared in accordance with JICA's standard form of contract and international best practices including items below;

	Contract Terms	Conditions
1	**O&M period**	10 years at the longest after commencement (definition is to be agreed) of O&M
2	**Equity structure of SPC**	100% owned by Japanese companies (likely be a Joint Venture by EPC and O&M companies)
3	**Engineering, Procurement, and Construction (EPC)**	The WTP shall be designed and constructed based on the EPC contract with the SPC. EPC contract shall be prepared by JICA. (Application of Global Standard EPC Contract is requested by PPWSA)
4	**Production of bulk water**	Production of bulk water is fundamentally a responsibility of the SPC. PPWSA however shall cover agreed risks in production costs that are out of SPC's control.
5	**Purchase of bulk water**	On a separate sheet
6	**Price of bulk water and risk allocation**	On a separate sheet
7	**Licensing risk**	IEIA/EIA shall be obtained by PPWSA before E/N and G/A.
8	**Land acquisition risk**	The land has already been acquired by PPWSA.
9	**Repairment**	While using the WTP free of charge, the SPC shall be responsible for any repairment of the facilities at its own cost. SPC shall keep good conditions of the facility and equipment, and SOP for operation to reduce the risk of breakdown soon after the hand-back.
10	**Conditions for the hand-back**	The WTP shall be handed back to PPWSA by the SPC under certain requirements.
11	**Invoice settlement**	SPC shall report and charge to PPWSA by 10th of each month for the bulk water produced in the previous month. PPWSA shall in return review the invoice and make payment within two months after the invoice receiving date. Currency to be used for the invoice settlement shall be agreed between PPWSA and SPC, either US Dollars or Cambodian Riel.
12	**Private investment**	The SPC may invest in some additional facilities, software, or any other equipment necessary for the operations. PPWSA has the right to purchase the private investments from the SPC at their residual value (net book value) at the end of O&M period.

13	**Operation data and financial information**	The SPC shall record and report all the operation data and financial information in a required format. PPWSA may utilizes the data to continue operation of the WTP after hand-back.
14	**Staff Employment**	1) PPWSA shall take over the employment contracts from the SPC at the end of O&M period. 2) If PPWSA wishes to send its employee to the SPC, conditions shall be discussed (role, responsibility, payment, reporting line, etc.)
15	**Monitoring**	Monitoring SPC operations is important not only for PPWSA but also for Japanese government as the project is finance by Japanese Grant. Cost for third party monitoring shall be covered within the project cash flow in a way that PPWSA and SPC establish a monitoring funds in SPC.
16	**Early termination / compensation events**	Termination for convenience (Unilateral termination) PPWSA has the right to terminate the contract early for public interest. In this case the SPC shall be compensated in full, for all the private investments, additional costs incurred by the termination of the contract, and opportunity costs for the equity. Termination for default by PPWSA The termination condition shall be in line with the case of the termination for convenience. Termination for default by SPC PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the Assets. The Value of the Asset shall be net book value of the assets minus cost of damages and losses suffered by PPWSA due to the termination of the contract. Termination for Force Majeure A Force Majeure is an event that is external, unpredictable, and irresistible and has a significant impact on the project. Both parties may terminate the contract if the impact of a Force Majeure lasts for a certain period. Neither party has any obligation to each other for the cost of mitigation measures to prevent increasing loss caused by Force Majeure. PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the Assets. The Value of the Asset shall be net book value of the assets.

Formula of SPC Invoice / PPWSA's payment to SPC

SPC Invoice (PPWSA payment to SPC) = (1) sales of bulk water + (2) additional services - (9) penalties

(1) Sales of bulk water = (3) volume of water delivered * (4) unit price of bulk water

(4) Unit price of bulk water =

α * (5) inflation index
+ β * (6) electricity price
+ (7) required margin for SPC
+ (8) additional production costs

if and only if caused by quality deterioration of intake water or change in water quality standard (Measures to compensate against raw water quality deterioration or upgrade of water quality standard shall be agreed in the contract)

where

α is a fixed (agreed) basis for O&M costs excluding electricity and

β is a fixed (agreed) volume of electricity usage per m3 and

(2) Additional services include deeper analysis of water quality or site visit tour or any other services that are not included in the ordinary O&M activities defined in the contract

Example for the month of June 2025 (all figures are assumptions)

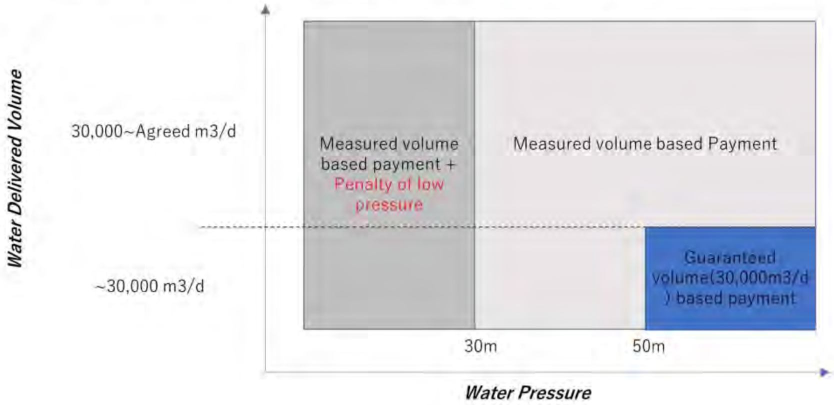
(1)			Sales of bulk water	= (3) * (4)	KHR559,800,000
	(3)		Volume of water delivered	as delivered by SPC	900,000m3 per month
	(4)		Unit price of bulk water	= α * (5) + β * (6) + (7) + (8)	KHR622/m3
		α	Basis for O&M costs excluding electricity	as defined in the contract	KHR300/m3
		(5)	Inflation index	= 200.05 for June 2025 / 176.02 for Jan 2021 at the time of contract (All item CPI from monthly report by the Bank of Cambodia)	1.13
		β	Volume of electricity usage per m3	as defined in the contract	270Wh/m3
		(6)	Electricity price	Electricity price for June 2025	KHR750/kWh
		(7)	Required margin	= (α * (5) + β * (6) +(8)) * 15% 15% as defined in the contract	KHR81/m3
		(8)	Additional production costs	Not applicable	0
(2)			Additional services	Work shop program requested by PPWSA	KHR4,000,000
(9)			Penalties	Not applicable	0
			SPC Invoice	= (1) + (2) + (9)	KHR563,800,000

8

Methodologies to determine volume of water delivered

- Water Pressure meter must be installed at the location near bulk meter according to the relevant regulations
- Guaranteed volume-based payment is applicable in case water pressure is more than 50m and the water delivered volume is less than 30,000m3.
- Penalty is applicable if the water distribution pressure does not satisfy the agreed minimum level (30 m is recommendable).

Water Delivered Volume and Water Presssure and Their Applicable Payment Methods



9

Minutes of Discussions
on the Preparatory Survey for the Project for
Expansion of Water Supply System in Ta Khmau

In response to the request from the Government of the Kingdom of Cambodia (hereinafter referred to as "Cambodia"), Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Survey Team for the Outline Design (hereinafter referred to as "the Team") of the Project for Expansion of Water Supply System in Ta Khmau (hereinafter referred to as "the Project") to the Government of Cambodia. The Team held a series of discussions with the officials of the Government of Cambodia and conducted a field survey. In the course of the discussions, both sides have confirmed the main items described in the attached sheets.

Phnom Penh, 28th June, 2019

Dr. Shigeyuki Matsumoto Leader Preparatory Survey Team Japan International Cooperation Agency Japan	H.E. Dr. Sim Sitha Director General Phnom Penh Water Supply Authority Kingdom of Cambodia

ATTACHMENT

Project Outline

1. Outline of comparator facility
   The Team explained the outline of comparator facilities as Annex 1. Both sides confirmed that comparator facilities were used only for estimating project cost, and the actual design of the facilities would be proposed by SPC in the later stage.

2. Risk allocation during the O&M period
   The Team explained the risk allocations described in Annex 2, and both sides agreed with it.

3. Project schedule
   The Team explained the tentative project schedule based on the comparator facilities described in Annex 2, which was shortened from the previous plan based on the requests from the Cambodian side. Both sides confirmed that the proposal for shortening the construction schedule by SPC should be included as one of the bidding evaluation items to encourage earlier completion.
   The Team also explained that the tentative schedule might be reconsidered with reflection of opinions in a project briefing session for Japanese companies to be held by JICA in Tokyo in July, 2019.

4. Basic framework of evaluation of Quality and Cost Based Selection (QCBS)
   The Team explained the basic framework of evaluation of QCBS described in Annex 2, and both sides agreed with it.

Requirements

5. Installation of solar power facilities
   The Team explained that the solar power facilities could not be covered by the Grant as the amount of Grant is limited, and the solar panel installation shall not be included in the tender. The Team also explained the result of scenario analysis which calculated the viability of the solar power investment described in Annex 3. WTP specification shall allow optional solar power installation with minimum 146kW, and PPWSA shall decide whether to install or request SPC to install solar power facilities after the tender.

6. Laboratory for water quality test in WTP
   PPWSA requested that the layout and equipment of the laboratory attached to WTP should be in accordance with ISO9001 and ISO17025. The Team took note of it.
   Both sides agreed that the laboratory in WTP should be equipped with enough equipment to analyze daily test items in the National Drinking Water Quality Standards.

7. Water quality standards
   Both sides confirmed the water quality standards which SPC should meet as Annex 4. The daily test items shall be analyzed by SPC in the laboratory attached to WTP, and quarterly and yearly test items shall be analyzed by PPWSA. PPWSA specifically requested that turbidity of treated water should be 1NTU or less. PPWSA also explained that it would not require SPC to treat trihalomethane precursors and odor substances.

8. Required pumping head of the distribution pumps and the water pressure requirement
   PPWSA requested the Team to design the pumping head of the distribution pumps at least 4.5 bars (0.45Mpa) based on the recommendation of the Master Plan, and to set up the water pressure requirement as 4 bars (0.4Mpa) at the off-take point (flow meter) subject to the hydrauric analysis by the Team. PPWSA accepts reasonable decline in water pressure if the demand exceeds 33,000 m^3/day.

9. Production amount
   SPC shall make best efforts to produce water 30,000-33,000m^3/day and the suspension of intake should be avoided as far as possible in any case of raw water deterioration. SPC shall also request a meeting to PPWSA in case the actual production amount is varied from the production plan which shall be submitted to PPWSA in advance.

<u>Contract Terms</u>

10. Contract terms
    The Team explained the contract terms including the conditions for hand-back after the termination of O&M contract and the conditions for hand-back after the termination of O&M contract described in Annex 2, and both sides agreed with

them.

11. Method for off-take price calculation

The Team explained the method for off-take price calculation described in Annex 2. PPWSA understood the composition of the price formula. The Team explained that through the bidding process, the proposals from SPC to reduce off-take price would be encouraged. Both sides also understood off-take price is subject to a proposal by SPC.

PPWSA strongly requested to refer to the benchmark of existing WTPs in terms of efficiency, namely 275 Wh/m^3 for unit electricity consumption and 346 Riel/m^3 for the unit production cost. PPWSA understood that the off-take price could be more than the benchmark because of the specific cost items required for the Grant Aid with O&M, but strongly requested that the off-take price should be less than 500 Riel/m^3.

Final approval of the off-take price will be made by the Board of Directors, but off-take price based on the comparator facility are basically discussed at the moment as attached Annex 5. PPWSA requested to further improve the efficiency of electricity consumption.

The Team explained the following three steps to decide the off-take price:

(1) Assumption based on the comparator facility to be agreed in the Preparatory Survey, which will be written in the Minutes of Discussions at the explanation of the draft report which is scheduled around October to November in 2019, and the schedule of Grant Agreement (G/A),

(2) Requirement to be written in the bidding document, which should be the same as the assumption above in principle, and

(3) Final decision to be fixed based on the proposal from SPC and the contract negotiation between SPC and PPWSA, which will be written in the contract.

The Team requested PPWSA to report to the Board of Directors about the progress of examination of the off-take price based on the comparator facility before the end of August 2019 and inform the Team of the result.

Both sides reconfirmed that the off-take price should be approved by the Board of Directors of PPWSA and no other approval from related authorities would be necessary.

Others

12. Stockyard and office for the consultant and SPC during the construction stage

    The Team requested PPWSA to find possible space for the stockyard and office necessary for the construction stage in the previous meeting. PPWSA explained that the space of Niroth WTP would be available for free of charge.

13. Technical transfer

    The Team proposed that the proposal of asset management and preventive maintenance by SPC, which are the advantage of Japanese companies, would be included as an item to be evaluated in the bidding. PPWSA agreed the proposal by the Team.

14. Trading currency

    The Team explained that some Japanese companies requested the payment of O&M contract from PPWSA to SPC in US dollar. PPWSA explained that only Cambodian Riel is acceptable, because the water tariff is collected in Riel.

15. Dispatch of staff from PPWSA to SPC

    PPWSA explained their intention to dispatch about 5 staff to SPC and bear their salary mainly for smooth hand-back at the termination of O&M period. PPWSA staff shall report to SPC in daily operation. Relative salaries shall be subtracted from the off-take price.

16. Salaries of local employees

    SPC's salaries to local employees shall be equivalent to those of PPWSA in principle.

17. Third party monitoring

    PPWSA explained that third party monitoring would not be necessary during O&M period.

Annex 1 Outline design of the comparator facilities

Annex 2 Term Sheet

Annex 3 Analysis of private investment for solar panel

Annex 4 Water quality standards

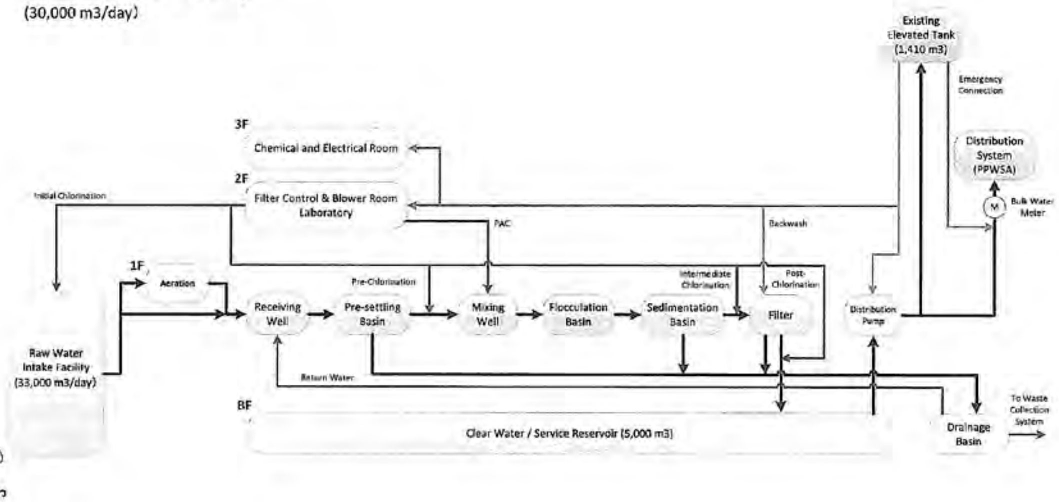
Annex 5 O&M cost analysis for off-take price

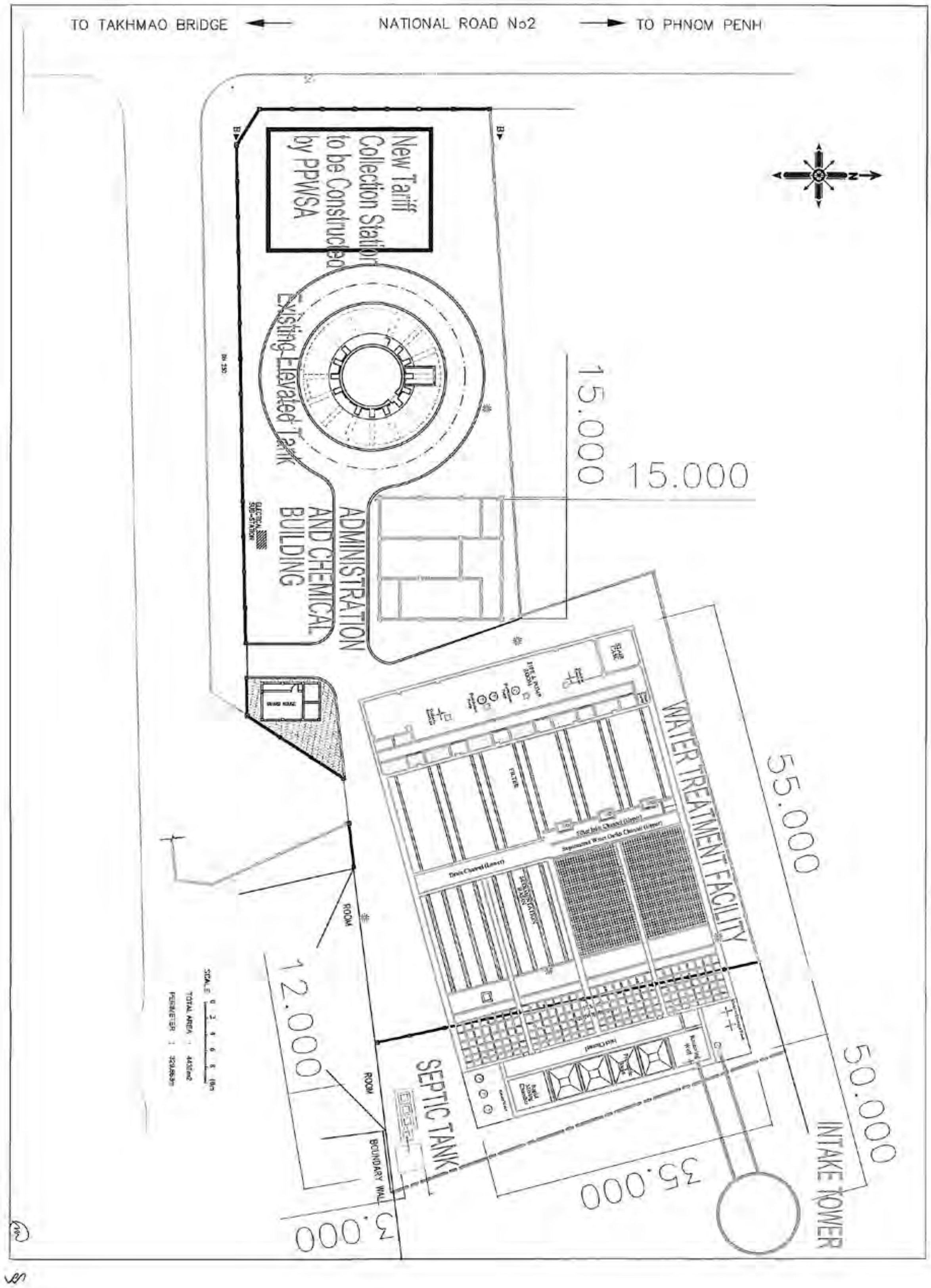
Ta Khmau WTP

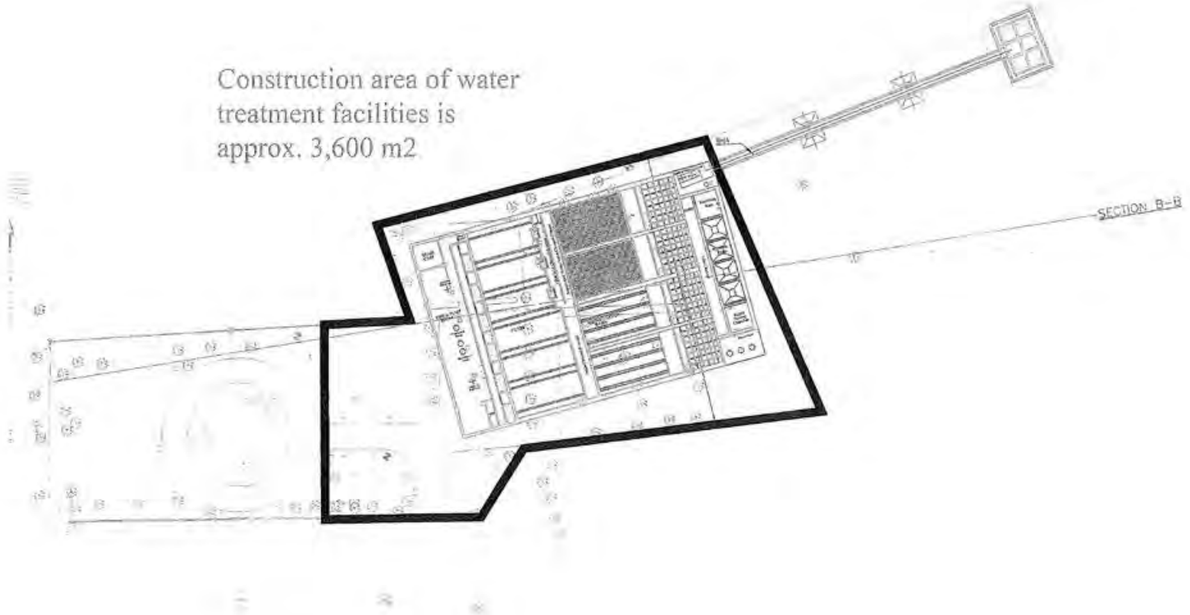
Treatment Process

Water Treatment Facility

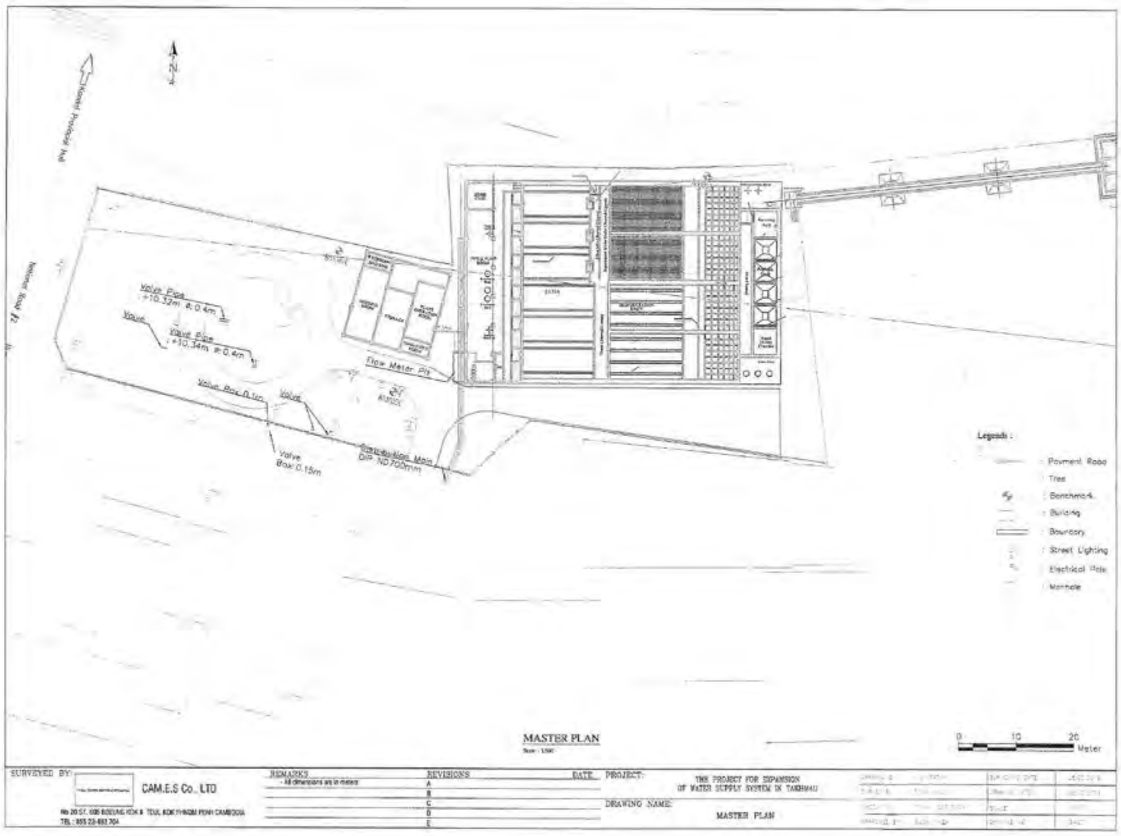
(30,000 m3/day)



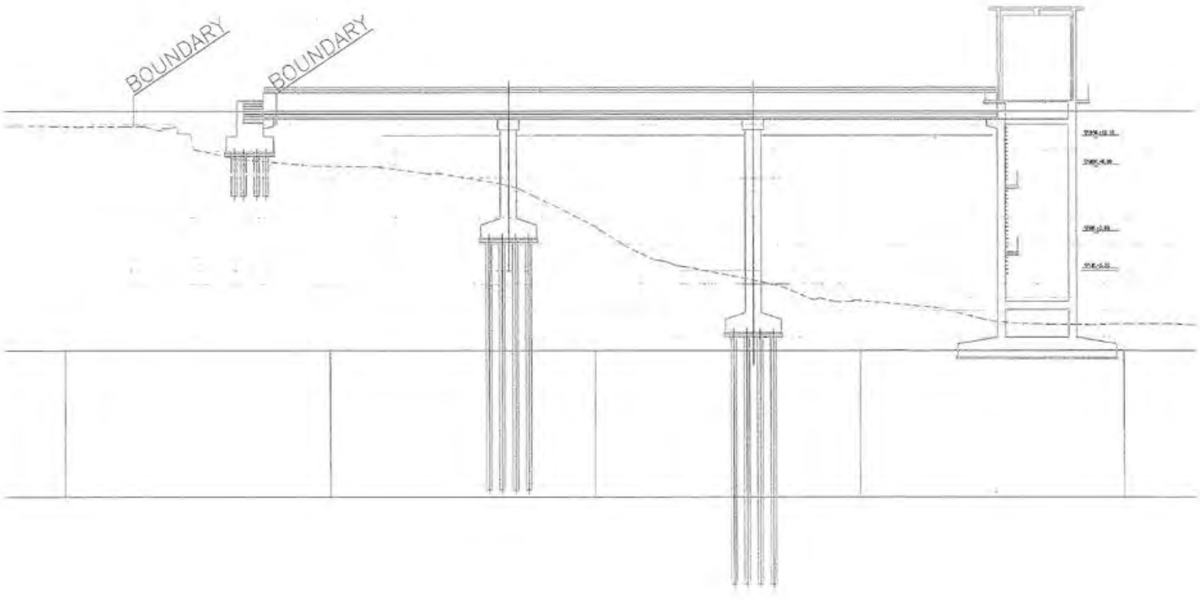

TO TAKHMAO BRIDGE
NATIONAL ROAD No2
TO PHNOM PENH
New Tariff Collection Station to be Constructed by PPWSA
Existing Elevated Tank
ADMINISTRATION AND CHEMICAL BUILDING
15.000
15.000
WATER TREATMENT FACILITY
55.000
50.000
35.000
12.000
3.000
SEPTIC TANK
INTAKE TOWER
ROOM
ROOM
BOUNDARY WALL

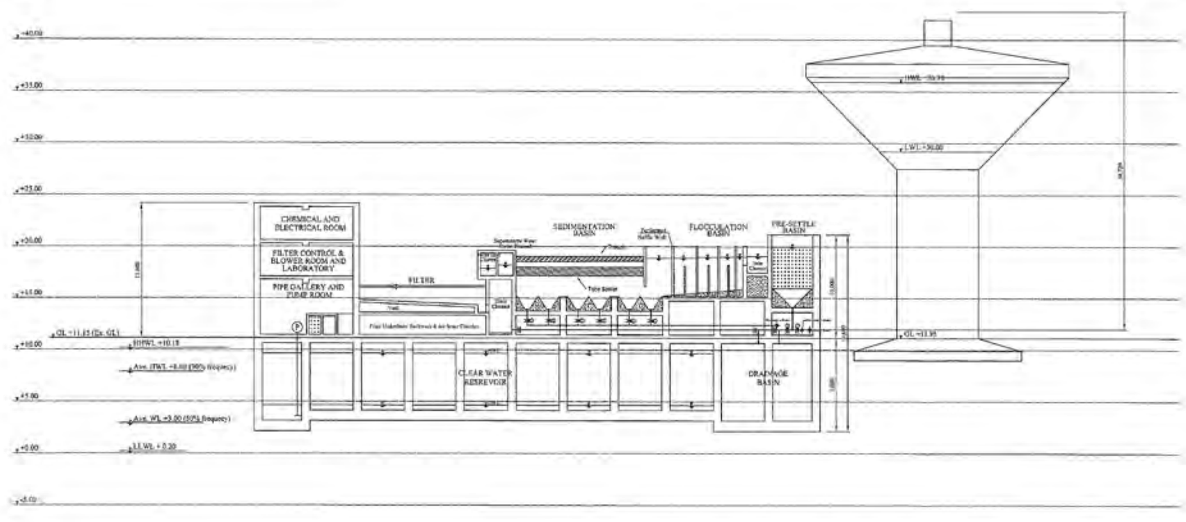


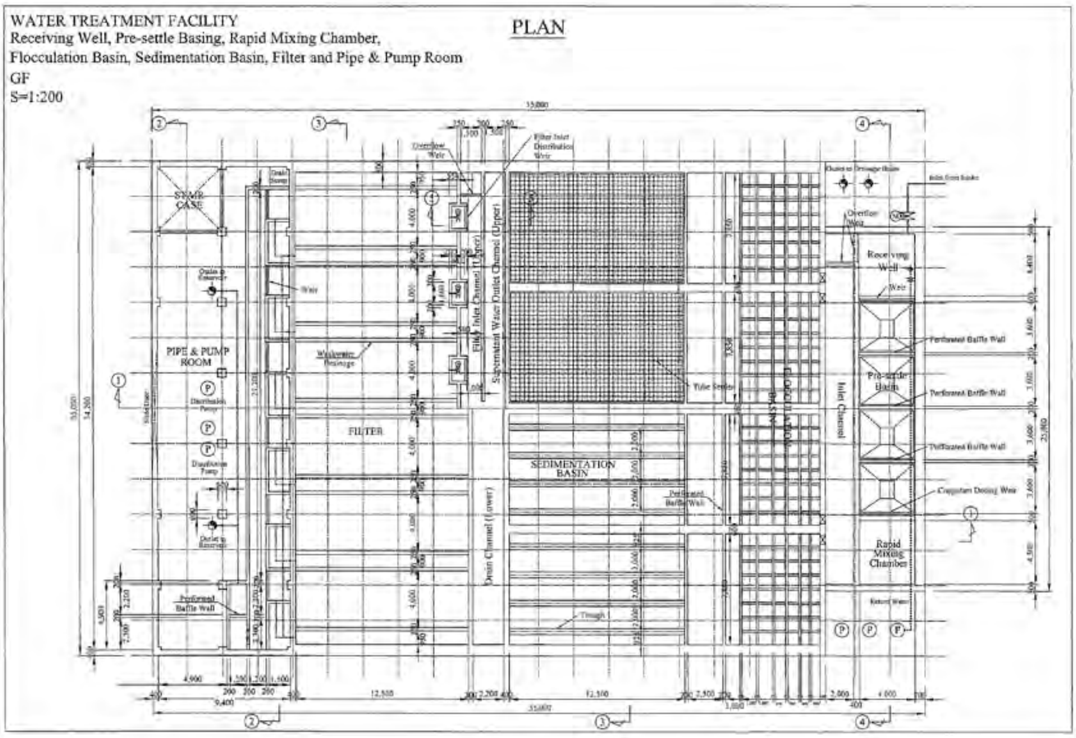
Construction area of water treatment facilities is approx. 3,600 m2
SECTION B-B

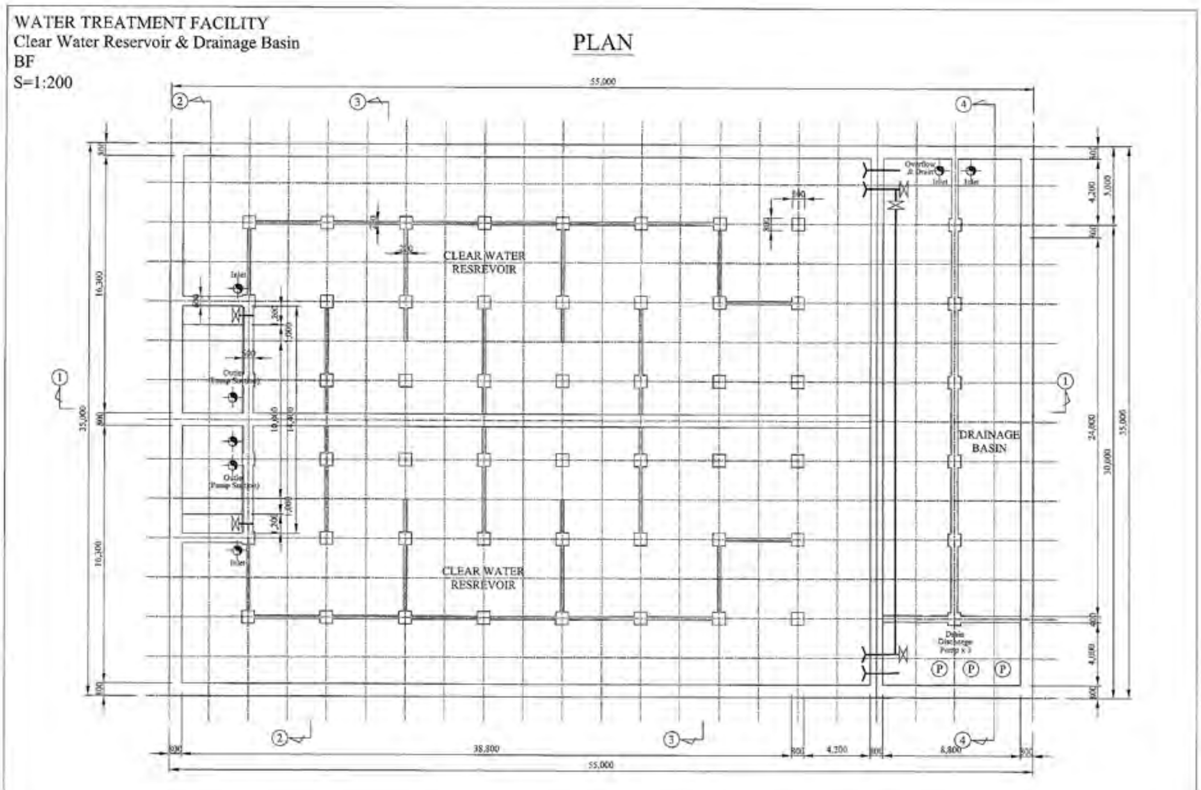


Legends :
Pavement Road
Tree
Benchmark
Building
Boundary
Street Lighting
Electrical Pole
Manhole
Flow Meter Pit
Distribution Main DIP ND700mm
MASTER PLAN
0
10
20
Meter
SURVEYED BY:
CAM.E.S Co., LTD
TEL : 855 23-882 704
REMARKS
- All dimensions are in meters
REVISIONS
A
B
C
D
E
DATE
PROJECT:
THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TAKHMAU
DRAWING NAME:
MASTER PLAN


BOUNDARY
BOUNDARY

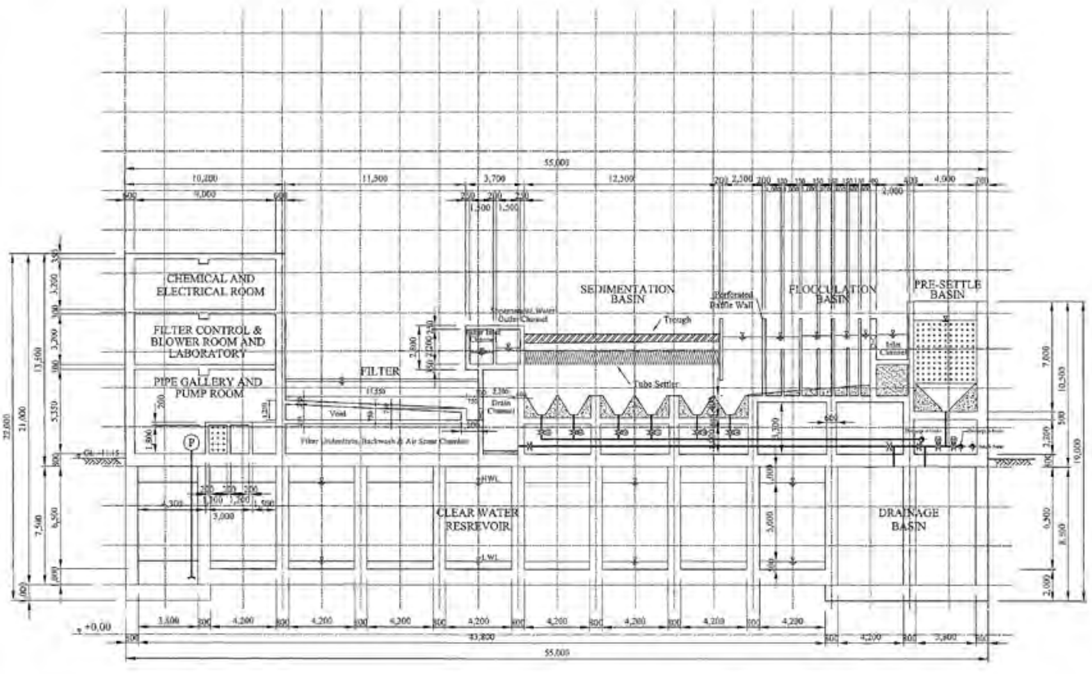

CHEMICAL AND ELECTRICAL ROOM
FILTER CONTROL & BLOWER ROOM AND LABORATORY
PIPE GALLERY AND PUMP ROOM
FILTER
SEDIMENTATION BASIN
FLOCCULATION BASIN
PRE-SETTLE BASIN
CLEAR WATER RESERVOIR
DRAINAGE BASIN


WATER TREATMENT FACILITY
Receiving Well, Pre-settle Basing, Rapid Mixing Chamber,
Flocculation Basin, Sedimentation Basin, Filter and Pipe & Pump Room
GF
S=1:200
PLAN
STAIR CASE
PIPE & PUMP ROOM
FILTER
SEDIMENTATION BASIN
Receiving Well
Rapid Mixing Chamber
Inlet Channel
Drain Channel (Lower)
Supernatant Water Outlet Channel (Upper)
Tube Settler
Perforated Baffle Wall
55,000


WATER TREATMENT FACILITY
Clear Water Reservoir & Drainage Basin
BF
S=1:200
PLAN
CLEAR WATER RESREVOIR
CLEAR WATER RESREVOIR
DRAINAGE BASIN
55,000
38,800
35,000

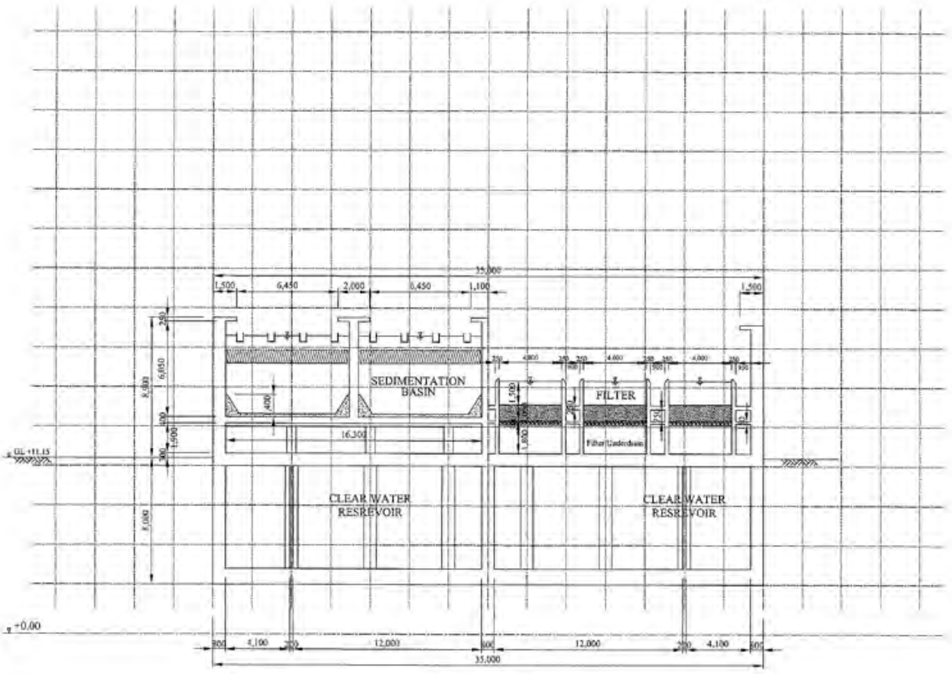
WATER TREATMENT FACILITY
General Section
S=1:200

GENERAL SECTION 1-1



WATER TREATMENT FACILITY
Section
S=1:200

SECTION 3-3



Annex 2

Document No.1 Term Sheet

THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU

CONFIDENTIAL / DRAFT / DISCUSSION PURPOSE ONLY

1. Project Outline

1.1 Project Background

- The water demand in the area supplied by PPWSA is projected to be double in 2030 and capacity of existing water treatment plants (hereinafter referred to as "WTP/WTPs") in Phnom Penh will be insufficient to meet the demand in 2020.
- The New WTP shall be developed to supply the water mainly in Ta Khmau area in which many low-income households need access to clean water at affordable water tariff and neighbor Phnom Penh areas where PPWSA develops water distribution system.
- The Government of Cambodia requested to the Government of Japan for the funds to implement the project for expansion of water supply system in Ta Khmau.

1.2 Project Objectives

The objective of the Project is to improve the access to safe water in Ta Khmau District through the expansion of water supply system including construction, operation and maintenance (hereinafter referred to as "O&M") of the new WTP.

1.3 Project Structure

The Project would be implemented by applying the Japanese Grant Aid with O&M, whose outline is explained in Annex 3 of Minutes of Discussions on the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau dated 29th March 2019 in particular;

- PPWSA will be the executing agency and the implementing agency for the Project.
- The Japanese Grant Aid shall be used for construction of the facilities and procurement of equipment necessary for the Project, and the consulting service to be assigned to consultants.
- A Japanese company or a joint venture of Japanese companies will be selected through a competitive tender and establish a Special Purpose Company (SPC) in Cambodia that shall be responsible for the design, construction, and O&M of the new WTP consistently,
- Contracts consist (a) comprehensive contract which consolidates both contracts for the purchase of the products and/or services and for the operation and maintenance, (b) contract(s) for the purchase of products and/or services and (c) contract(s) for the operation and maintenance, and
- The Government of Cambodia shall ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the Government of Cambodia with respect to the

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purchase of the products and/or the services be exempted or be borne by its designated authority without using the Grant and its accrued interest.

1.4 Project Site

The construction site of the new WTP is located in Ta Khmau District, which is shown in Annex 1 of Minutes of Discussions on the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau dated 29th March 2019.

1.5 Risk Allocations

Risks	PPWSA	SPC	Remarks/Examples
EPC risk	O	O	- Any additional costs caused by PPWSA shall be borne by PPWSA (e.g. variation orders from PPWSA to SPC, UXO related costs) - Any additional costs caused by change in external conditions shall be borne by PPWSA (e.g. unforeseen ground conditions, major inflation during construction period). These costs may be covered by the amount of the grant for contingency mentioned in the Grant Agreement which is applicable according to the JICA guideline. - Any additional costs caused by SPC shall be borne by SPC (e.g. design deficiency, inflation during construction period).
Demand risk	O		PPWSA shall pay for 30,000m3/day of treated water if SPC provides or is ready to provide 30,000m3/day of treated water that satisfies the required water quality on a monthly average, regardless of any reason on PPWSA side (e.g. demand stays low or distribution pipes get damaged).
Operation risk		O	No payment shall be made if the delivered water does not satisfy the water quality requirement due to poor operation by SPC (e.g. facility malfunction, inappropriate usage of water treatment chemicals etc.). In case the water delivered by SPC does not comply with national drinking water standards required by PPWSA, SPC shall compensate for any damage (e.g. compensation to end-customers) suffered by PPWSA as a result of such poor operation by SPC.
Electricity price	O		Any fluctuations in electricity price shall be covered by

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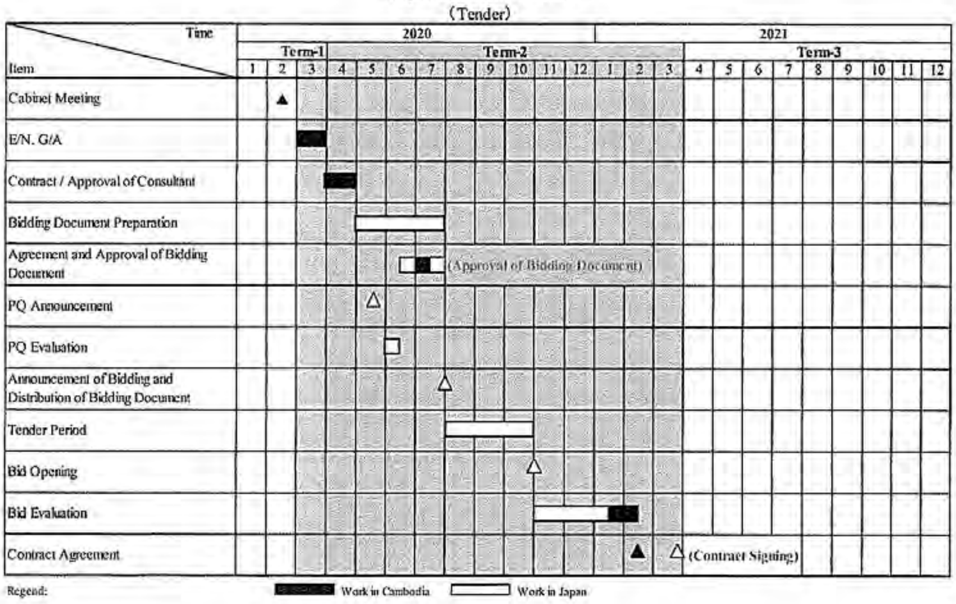
Risks	PPWSA	SPC	Remarks/Examples
risk			PPWSA according to the Price Formula for Bulk Water Supply.
Electricity availability risk		O	In case the electricity is not supplied to the facility due to blackout, neither SPC has obligation to supply water to PPWSA, nor PPWSA must pay SPC for the period. SPC does not have a right to claim operating loss caused by such blackout to PPWSA.
Inflation risk (during O&M period)	O		Increase in production costs caused by inflation (e.g. wages or raw materials) shall be covered by PPWSA according to the Price Formula for Bulk Water Supply.
Raw water quality risk	O		Additional cost of production due to change in quality of raw water shall be covered by PPWSA and compensated to the SPC.
Licensing risk	O		IEIA/EIA or any other permit/authorization necessary for the SPC to operate the facility shall be obtained by PPWSA.
Legal risk (change of project specific law)	O		Additional cost caused by a change in law that specifically affects the project (e.g. upgrade of national quality standard for drinking water) shall be covered by PPWSA and compensated to the SPC.
Legal risk (change of general law)		O	Additional cost caused by a change in general law that would affect the whole economy (e.g. VAT) shall be covered by the SPC.
Force Majeure risk	O	O	A Force Majeure is an event that is external, unpredictable, and irresistible and has a significant impact on the project. Both parties may terminate the contract if the impact of a Force Majeure lasts for a certain period (based on practice of water utilities). Neither party has any obligation to each other for the cost of mitigation measures to prevent increasing loss caused by Force Majeure. PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the assets. The value of the assets shall be net book value of the assets.

1.6 Project Schedule

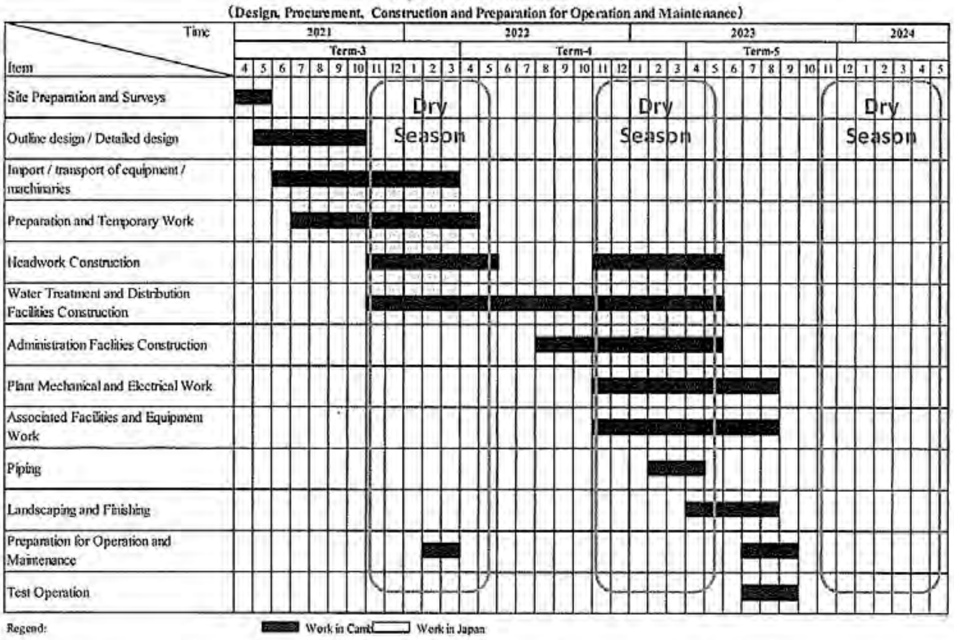
Implementation Schedule

(Tender)



Implementation Schedule

(Design, Procurement, Construction and Preparation for Operation and Maintenance)



The schedule above is based on the Comparator facilities (the Consultants plan) and SPC may propose shorter construction duration in the tender.

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1.7 Tender Evaluation

- The prime contractor(s), namely, SPC and the prime consulting firm, which enter into contracts with PPWSA, are limited to "Japanese nationals", in principle.
- Quality and Cost Based Selection (QCBS) that includes technical, commercial, financial and legal evaluation will be applied for the bidding of SPC.

Evaluation methodology

Note: This shall be reviewed and concurred by JICA.

Comprehensive Evaluation Score = Technical Score * X + Price Score * (1-X)

where X is a weight factor 1>X>0 (In this stage the Consultants propose 0.5 as X. Please refer the separate sheet for the analysis of the weight factor X of Price score)

Tentative Technical Score

	Category	Score
1	Tenderers experience with respect to comparable projects;	TBA
2	Proposed Organization	TBA
3	Experience of key staff in relation to the scope of work;	TBA
4	Proposed design by SPC for bidding	TBA
5	Construction Work Plan	TBA
6	Operation and Maintenance and Monitoring Plan	TBA
	Maximum possible score	100

Tentative Price Score

The tenderer bids on 10-year Life Cycle Cost (LCC) where

10-year LCC = EPC price + Net present value of O&M costs discounted at 4.5%

(SPC submit EPC price, 10-year average O&M Cost(α), 10-year average fixed volume of electricity usage(β), and the margin rate at bidding to calculate 10-year LCC)

Price score = Lowest Price / Price of the Tenderer * 100

Note that

(1) EPC price shall be below the Grant budget applicable to the EPC contract, and

(2) O&M cost will be reflected in the contract price of bulk water

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2. Requirements

2.1. Preconditions

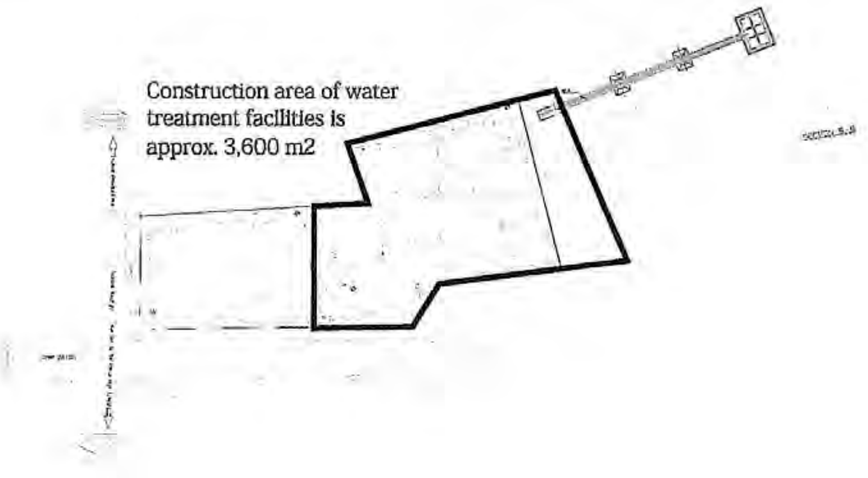
2.1.1. Construction Area

There are an existing elevated tank and a tariff collection station as major facilities within the PPWSA's property where the new WTP shall be constructed. The available construction area of water treatment facilities (WTFs) excluding headworks (intake and raw water transmission facilities) is approximately 3,600 m2.

Headworks shall be constructed in the river outside of PPWSA's property.

There is unleveled land along the river that are PPWSA's property but outside of existing fence. This area could be leveled as part of SPC's EPC work.

Existing tariff collection station shall be shifted to outside of construction area by PPWSA before commencement of the design-build work.



The site area is limited therefore, stockyard, workshop, temporary office etc. required for the constriction shall be provided by PPWSA.

Topographic and geotechnical features will be provided to SPC by PPWSA in later stage.

2.1.2. Raw Water Quality

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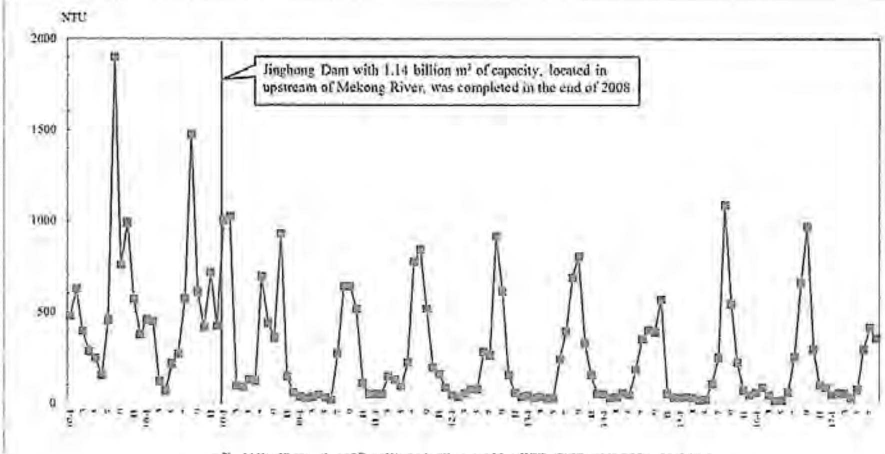
Raw water source shall be Bassac River.

The raw water quality recorded at intake of Chamcar Mon WTP located at upstream of Ta Khmau site along Bassasc River during 2009-2017 after Jinghong dam was commenced operation in 2008 shows following characteristics.

- Turbidities are quite different in dry season and wet season. Minimum turbidity in dry season was 7NTU, average turbidity in wet season is 250 NTU and maximum turbidity was 1088NTU.
- pH is generally high in wet season and low in dry season, average pH is 7.4, Minimum pH was 6.7.
- Color is a bit high, average color is approximately 30TCU.
- Average Ammonium (NH4) is approximately 0.5mg/l in wet season and approximately 0.2mg/l in dry season. However Ammonium (NH4) has been on the rise from 2016 and maximum was 1.81.

Followings are summary of raw water turbidity at intake of Chamcar Mon WTP during 2009-2016.

- Average Turbidity in Dry Season: 40NTU
- Average Turbidity in Wet Season: 245NTU
- Average Turbidity over 8 years: 115NTU
- Maximum Turbidity over 8 years: 1088NTU
- Minimum Turbidity over 8 years: 7NTU

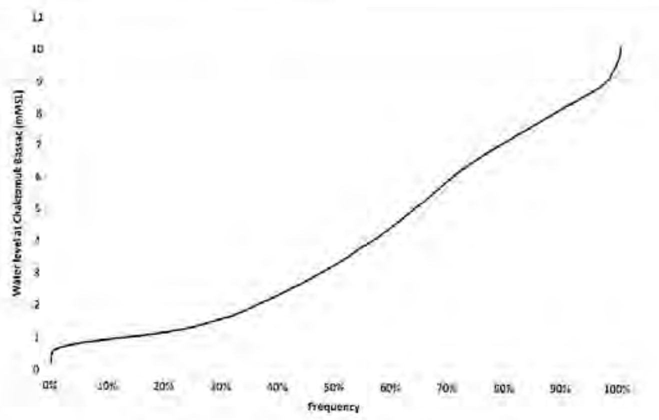


Turbidity Fluctuation of Raw Water in Chamcar Mon WTP (2007 to 2017, Monthly Max.)

The result of monthly raw water quality analysis of March-May 2017 at intake location of Ta Khumau Site carried out under our Survey will be provided separately.

2.1.3. Water Level of Bassac River

The feasibility study for expansion of Chamca Mon WTP gives minimum river water level and maximum river water level, as MSL+0.20m and MSL+10.28m respectively as shown below.



Based on these elements, the extreme levels for the 55 last years are as follows:

- ✓ Minimum Level : 0.20 m MSL (04/05/1960)
- ✓ Maximum Level : 10.18 m MSL (20/09/2000)

2.2. Output requirements

2.2.1. Requirement for the Facilities

2.2.1.1. Requirement of Treated Water Quantity

Water Treatment Capacity of 30,000 m3/day.

2.2.1.2. Required pumping head

The pumping head of the distribution pumps shall be at least 4.5 bars (0.45Mpa) based on the recommendation of the Master Plan.

2.2.1.3. Laboratory for water quality test in WTP

The layout and equipment of the laboratory attached to WTP should be in accordance with ISO9001 and ISO17025. The laboratory in WTP should be equipped with enough equipment to analyze daily test items in the National Drinking Water Quality Standards.

2.2.1.4. Intake Type

Intake facility shall be intake tower type.

2.2.1.5. Disinfection

Disinfection shall be by On-Site Electro-Chlorination System (OSEC System).

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2.2.2. Requirement for the Operation

2.2.2.1. Requirement of Treated Water Quantity

SPC shall make best efforts to produce water 30,000-33,000m3/day and the suspension of intake should be avoided as far as possible in any case of raw water deterioration. SPC shall also request a meeting to PPWSA in case the actual production amount is varied from the production plan which shall be submitted to PPWSA in advance.

2.2.2.2. Requirement of Treated Water Quality

The water quality standards which SPC should meet as Annex 4 of Minutes of Discussions signed on June 28^{th}, 2019 between PPWSA and JICA. The daily test items shall be analyzed by SPC in the laboratory attached to WTP, and quarterly and yearly test items shall be analyzed by PPWSA. Turbidity of treated water should be 1NTU or less. SPC would not be required to treat trihalomethane precursors and odor substances.

2.2.2.3. Requirement of Distribution Pressure

The water pressure shall be at least 4 bars (0.4Mpa) at off-take point (flow meter). Reasonable decline in distribution pressure is accepted if the demand exceeds 33,000 m3/day.

2.3. Work to be done by SPC

SPC shall work for followings.

1. Design of New WTP
    (a) Basic Design
    (b) Detailed Design
    (c) Application Work for Design
    (d) Laws and Regulations to be complied
2. Construction of New WTP
    (a) Civil and Equipment Works
    (b) Plant Mechanical Work
    (c) Plan Electrical Work
    (d) Application Work for Construction
3. Operation and Maintenance of New WTP
    (a) Water Quality Control
    (b) Treated Water Volume Control in case required by PPWSA
    (c) Monitoring and Control of Water Treatment
    (d) Maintenance and Repair
    (e) Procurement of Fuel, Chemical and Other Consumables
    (f) Management of Power Receiving, Water Use and Fuel / Chemical Storage and Safety
    (g) Cleaning

(h) Security and Safety

(i) Emergency Action

4. Hand-Over Work at the End of the O&M period

(a) Performance Test of WTP

(b) Asset Check and Evaluation

2.4. Cost to be borne by SPC

Following cost shall be borne by SPC.

Design and Build Stage:

(a) Head office over-head cost related to construction work

Operation Stage

(b) Head Office over-head cost related to the operation and maintenance work

(c) Any other cost which is not directly related with operation of the new WTP

2.5. Reporting Obligations

Following submittals shall be provided by SPC. Detail shall be provided in later stage

(a) At the time of work commencement

(i) Work commencement application

(ii) Design, Construction and Operation Plan

(iii) Organization structure for the operation

(b) Design and Build period

(i) Report related to construction works including progress record

(ii) Draft of Operation and Maintenance Manual

(iii) Draft of Self-monitoring Report

(iv) Modification and additional work confirmation report

(v) Commissioning reports

(c) At the time of hand-over

(i) Completion report or substantial completion certificate and list of outstanding works

(ii) Final operation and maintenance manual

(iii) Final self-monitoring reports template

(d) During operation period

(i) Monthly report including self-monitoring report

(e) At the time of hand-back

(i) Performance check list of the facilities.

(ii) Remaining book value calculation and confirmation sheet.

(iii) Purchase agreement of SPC's facilities, if any.

(iv) Letter of Waiver of claims and liens and release of rights relating this project from PPWSA to SPC.

(f) At the time of Expiration of warranty against defect period

(i) Report on Expiration of Warranty against Defect Period

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3. Contract Terms

Draft O&M contract shall be prepared based on the following items. Draft EPC contract shall be prepared separately in accordance with JICA's standard form of contract.

	Contract Terms	Conditions
1	**O&M period**	After the completion of the new WTP, the ownership of the WTP will be transferred from SPC to PPWSA, then PPWSA and SPC will agree the O&M contract for 10 years after commencement (definition is to be agreed) of O&M on the facilities owned by PPWSA.
2	**Production of bulk water**	Production of bulk water is fundamentally a responsibility of the SPC.
3	**Payment mechanism and price of bulk water**	On a separate sheet
4	**Repairment**	During O&M period, SPC may use leased facilities free of charge, however, the SPC shall be responsible for any repairment of the facilities at its own cost. SPC shall keep good conditions of the facility and equipment in accordance with PPWSA's Standard Operation Procedure (SOP).
5	**Conditions for the hand-back**	- After the end of O&M period, PPWSA has the right to be handed back the leased WTP facilities from the SPC under certain requirements (e.g. the result of the motor vibration test is within 5% of initial specification). - The SPC shall remove any additional facilities or equipment installed for its operation and restore the WTP to its initial condition at its own cost, if required by PPWSA. - PPWSA has the right to purchase any remaining inventories (e.g. raw materials) at their book value.
6	**Private investment**	The SPC may invest in some additional facilities, software, or any other equipment necessary for the operations. PPWSA has the right to purchase the private investments from the SPC at their residual value (net book value) at the end of O&M period.
7	**Self-monitoring**	SPC shall monitor and report to PPWSA its operation. Monitoring requirements shall be studied.
8	**Operation data and financial information**	The SPC shall record and report all the operation data and financial information in a required format. PPWSA may utilize the data to continue operation of the WTP after hand-back.
9	**Early termination / compensation events**	- Termination for convenience (Unilateral termination) PPWSA has the right to terminate the contract early for public

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		interest. In this case the SPC shall be compensated in full, for all the private investments, inventories and additional costs incurred by the termination of the contract, and opportunity costs for the equity. Opportunity costs for the equity shall be a sum of net profit for the remaining contract period based on the SPC's initial financial plan initially agreed in the contract. - Termination for default by PPWSA The termination condition shall be in line with the case of the termination for convenience. - Termination for default by SPC PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the assets and inventories. The value of the assets and inventories shall be net book value of the assets minus cost of damages and losses suffered by PPWSA due to the termination of the contract. - Termination for Force Majeure A Force Majeure is an event that is external, unpredictable, and irresistible and has a significant impact on the project. Both parties may terminate the contract if the impact of a Force Majeure lasts for 180 days. Neither party has any obligation to each other for the cost of mitigation measures to prevent increasing loss caused by Force Majeure. PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the assets and inventories. The value of the assets and inventories shall be net book value of the assets.
10	**Invoice settlement**	SPC shall report and charge to PPWSA by the 10th day of each month for the bulk water produced in the previous month. PPWSA shall in return review the invoice and make payment within two months after the invoice receiving date. Currency to be used for the invoice settlement shall be Cambodian Riel.
11	**Staff Employment**	1) PPWSA shall take over the employment contracts from the SPC at the end of O&M period. 2) PPWSA intends to dispatch about 5 staff to SPC and bear their salary. PPWSA staff shall report to SPC in daily operation. Relative salaries shall be subtracted from the off-take price.

Payment mechanism – Price Formula for Bulk Water Supply

In the bidding documents, SPC shall submit EPC price, 10-year average O&M Cost(α), 10-year average fixed volume of electricity usage(β), and the margin rate at bidding to calculate 10-year LCC

SPC Invoice (PPWSA payment to SPC) = (1) sales of bulk water + (2) additional services – (3) penalties

(1) Sales of bulk water = (4) volume of water delivered * (5) unit price of bulk water

(4) volume of water delivered shall be confirmed by a volume meter just after distribution pump

(5) Unit price of bulk water = α * (6) inflation index + β * (7) electricity price
+ (8) additional production costs + (9) agreed margin for SPC

α is a fixed (agreed) basis for O&M costs excluding electricity defined in the contract

(6) Inflation index for the first year of O&M shall be All Item Index of Consumer Price Index published by National Institute of Statistics for the latest available month at O&M commencement divided by that for the contract month. Inflation index shall be revised based on the same methodology annually.

β is a fixed (agreed) volume of electricity usage per m3 defined in the contract

(7) Electricity price shall be the price determined in the contract between PPWSA and the electricity supplier.

(8) applies if and only if quality deterioration of raw water or change in water quality standard cause additional production costs.

(9) = agreed margin rate * (α * (6) + β * (7) + (8))

Agreed margin rate is a fixed (agreed) rate defined in the contract

(2) Additional services include deeper analysis of water quality or site visit tour or any other services that are not included in the ordinary O&M activities defined in the contract.

(3) In case the water delivered by SPC does not comply with the drinking water standards of the WHO and national drinking water standards, PPWSA will not pay for the delivered water by SPC. In addition, SPC shall compensate for any damage (e.g. compensation to end-customers) suffered by PPWSA as a result of the such poor operation of SPC.

Based on the Comparator facilities, α is estimated KHR182/m3 and β 302Wh/m3.

Example for the month of June 2025 (all figures are assumptions)

(1)		Sales of bulk water	= (4) * (5)	KHR395,125,200
(4)		Volume of water delivered	as delivered by SPC	900,000m3 per month
(5)		Unit price of bulk water	$= \alpha * (6) + \beta * (7) + (8) + (9)$	KHR438/m3
	α	Basis for O&M costs excluding electricity	as defined in the contract	KHR182/m3
	(6)	Inflation index	= 200.05 for Jan 2025 / 176.02 for Jan 2021 at the time of contract (All item CPI from monthly report by the National Institute of Statistics)	1.13
	β	Volume of electricity usage per m3	as defined in the contract	302Wh/m3
	(7)	Electricity price	Electricity price for June 2025	KHR584/kWh
	(8)	Additional production costs	Not applicable	0
	(9)	Required margin	$= (\alpha * (6) + \beta * (7) + (8)) * 15\%$ 15% as defined in the contract	KHR57/m3
(2)		Additional services	Work shop program requested by PPWSA	KHR4,000,000
(3)		Compensation	Not applicable	0
		SPC Invoice	= (1) + (2) + (9)	KHR399,125,200

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Document No. 4 O&M Cost
O&M cost / Financial Evaluation for SPC Proposal

Annex 5

[illegible]	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
Annual production	m3		10,950,000	10,950,000	10,950,000	10,950,000	10,950,000	10,950,000	10,950,000	10,950,000	10,950,000	10,950,000	—(1)
FX rate	KHR/JPY	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	
Inflation rate	% growth		3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	
Inflation index	index	1.00	1.09	1.13	1.16	1.19	1.23	1.27	1.30	1.34	1.38	1.43	
Electricity price	KHR/kWh	584	584	584	584	584	584	584	584	584	584	584	
Discount rate	%	4.5%											

[illegible]	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
EPC price	000JPY	3,000,000										

[illegible]	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
Capacity													
Intake	kW		161.2	161.2	161.2	161.2	161.2	161.2	161.2	161.2	161.2	161.2	
Treatment	kW		88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	
Chemical	kW		40.8	40.8	40.8	40.8	40.8	40.8	40.8	40.8	40.8	40.8	
Distribution	kW		199.0	199.0	199.0	199.0	199.0	199.0	199.0	199.0	199.0	199.0	
Others	kW		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
Total			499.3	499.3	499.3	499.3	499.3	499.3	499.3	499.3	499.3	499.3	
Consumption													
Intake	kWh		1,412,112	1,412,112	1,412,112	1,412,112	1,412,112	1,412,112	1,412,112	1,412,112	1,412,112	1,412,112	
Treatment	kWh		64,459	64,459	64,459	64,459	64,459	64,459	64,459	64,459	64,459	64,459	
Chemical	kWh		59,568	59,568	59,568	59,568	59,568	59,568	59,568	59,568	59,568	59,568	
Distribution	kWh		1,743,240	1,743,240	1,743,240	1,743,240	1,743,240	1,743,240	1,743,240	1,743,240	1,743,240	1,743,240	
Others	kWh		29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	29,200	
Total	kWh		3,308,579	3,308,579	3,308,579	3,308,579	3,308,579	3,308,579	3,308,579	3,308,579	3,308,579	3,308,579	
per m3	Wh/m3		302	302	302	302	302	302	302	302	302	302	—(2)
Total cost	000KHR		1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	1,932,210	
per m3	KHR/m3		176	176	176	176	176	176	176	176	176	176	
% of total cost	%		52%	49%	49%	49%	49%	49%	49%	49%	49%	47%	

[illegible]	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
# of employees													
CEO	persons		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
O&M & technical training advisor	persons		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Chief manager	persons		1	1	1	1	1	1	1	1	1	1	
Facility manager	persons		1	1	1	1	1	1	1	1	1	1	
Quality manager	persons		1	1	1	1	1	1	1	1	1	1	
Admin/business staff	persons		3	3	3	3	3	3	3	3	3	3	
M&E Engineer	persons		1	1	1	1	1	1	1	1	1	1	
Operating staff	persons		6	6	6	6	6	6	6	6	6	6	
Total	persons		14	14	14	14	14	14	14	14	14	14	
Salaries (excl. inflation effect)													
CEO	000KHR		724,092	724,092	724,092	724,092	724,092	724,092	724,092	724,092	724,092	724,092	
O&M & technical training advisor	000KHR		724,092	724,092	724,092	724,092	724,092	724,092	724,092	724,092	724,092	724,092	
Chief manager	000KHR		60,221	60,221	60,221	60,221	60,221	60,221	60,221	60,221	60,221	60,221	
Facility manager	000KHR		47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	
Quality manager	000KHR		47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	
Admin/business staff	000KHR		35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	
M&E Engineer	000KHR		35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	
Operating staff	000KHR		35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	
Total wages													
CEO	000KHR		362,046	362,046	362,046	362,046	362,046	362,046	362,046	362,046	362,046	362,046	
O&M & technical training advisor	000KHR		362,046	362,046	362,046	362,046	362,046	362,046	362,046	362,046	362,046	362,046	
Chief manager	000KHR		60,221	60,221	60,221	60,221	60,221	60,221	60,221	60,221	60,221	60,221	
Facility manager	000KHR		47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	
Quality manager	000KHR		47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	47,634	
Admin/business staff	000KHR		105,141	105,141	105,141	105,141	105,141	105,141	105,141	105,141	105,141	105,141	
M&E Engineer	000KHR		35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	35,047	
Operating staff	000KHR		210,281	210,281	210,281	210,281	210,281	210,281	210,281	210,281	210,281	210,281	
Total	000KHR		1,230,049	1,230,049	1,230,049	1,230,049	1,230,049	1,230,049	1,230,049	1,230,049	1,230,049	1,230,049	—(3)
per m3	KHR/m3		112	112	112	112	112	112	112	112	112	112	
% of total cost	%		33%	31%	31%	31%	31%	31%	31%	31%	31%	30%	

[illegible]	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
Unit consumption													
PAC	g/m3		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
Chlorine	g/m3		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
Unit price (excl. inflation effect)													
PAC	KHR/kg		2,137	2,137	2,137	2,137	2,137	2,137	2,137	2,137	2,137	2,137	
Chlorine	KHR/kg		2,288	2,288	2,288	2,288	2,288	2,288	2,288	2,288	2,288	2,288	
Total cost													
PAC	000KHR		234,012	234,012	234,012	234,012	234,012	234,012	234,012	234,012	234,012	234,012	
Chlorine	000KHR		125,268	125,268	125,268	125,268	125,268	125,268	125,268	125,268	125,268	125,268	
Total	000KHR		359,280	359,280	359,280	359,280	359,280	359,280	359,280	359,280	359,280	359,280	—(4)
per m3	KHR/m3		33	33	33	33	33	33	33	33	33	33	
% of total cost	%		10%	9%	9%	9%	9%	9%	9%	9%	9%	9%	

[illegible]	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
Machinery	000KHR			108,614	108,614	108,614	108,614	108,614	108,614	108,614	108,614	217,227	
Electrical equipment	000KHR			72,409	72,409	72,409	72,409	72,409	72,409	72,409	72,409	144,818	
	000KHR		0	181,023	181,023	181,023	181,023	181,023	181,023	181,023	181,023	362,046	—(5)
per m3	KHR/m3		0	17	17	17	17	17	17	17	17	33	
% of total cost	%		0%	5%	5%	5%	5%	5%	5%	5%	5%	9%	

[illegible]	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
Employee social security	000KHR		6,720	6,720	6,720	6,720	6,720	6,720	6,720	6,720	6,720	6,720	
Transportation	000KHR		21,723	21,723	21,723	21,723	21,723	21,723	21,723	21,723	21,723	21,723	
Office keeping	000KHR		43,445	43,445	43,445	43,445	43,445	43,445	43,445	43,445	43,445	43,445	
Accounting audit / legal services	000KHR		21,723	21,723	21,723	21,723	21,723	21,723	21,723	21,723	21,723	21,723	
Other operating costs	000KHR		9,361	9,361	9,361	9,361	9,361	9,361	9,361	9,361	9,361	9,361	
VAT/import tax	000KHR		98,324	114,627	114,627	114,627	114,627	114,627	114,627	114,627	114,627	132,729	
	000KHR		190,497	217,599	217,599	217,599	217,599	217,599	217,599	217,599	217,599	235,701	—(6)
per m3	KHR/m3		18	20	20	20	20	20	20	20	20	22	
% of total cost	%		5%	6%	6%	6%	6%	6%	6%	6%	6%	6%	
[illegible]	%		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
O&M cost excl. electricity per m3 production	KHR/m3		179	204	210	217	223	230	237	244	251	265
O&M cost excl. electricity per m3 production excl. inflation effect	KHR/m3		163	182	182	182	182	182	182	182	182	200
Electricity cost per m3 production	KHR/m3		176	176	176	176	176	176	176	176	176	176
Total unit cost of m3 production	KHR/m3		355	381	387	393	400	406	413	420	428	441
Total unit cost of m3 production excl. inflation effect	KHR/m3		339	358	358	358	358	358	358	358	358	376

	Unit	Value		Formula
10 year total O&M cost excl. electricity	000KHR	19,879,511	—(7)	=sum((3)+(4)+(5)+(6))
10 year total production	m3	109,500,000	—(8)	=sum((1))
α 10 year average O&M cost excl. electricity excl. inflation effect	KHR/m3	182	—(9)	=(7)/(8)
β 10 year average consumption of electricity per m3 production	Wh/m3	302	—(10)	=average((2))

[illegible]	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
EPC	000KHR	108,613,728										
Operating margin	%		15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Offtake payment	000KHR		4,735,264	4,800,355	4,877,779	4,957,485	5,039,582	5,124,142	5,211,239	5,300,349	5,393,350	5,489,521
TOTAL	000KHR	108,613,728	4,735,264	4,800,355	4,877,779	4,957,485	5,039,582	5,124,142	5,211,239	5,300,349	5,393,350	5,489,521

10 year lifecycle cost to PPWSA (NPV)	KHR000	142,260,351

	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Unit Price of bulk water	KHR/m3	432	438	445	453	460	468	476	484	493	501

Annex 3

CROWN AGENTS
ACCELERATING SELF-SUFFICIENCY & PROSPERITY

DOCUMENT NO.3 SOLAR POWER TA KHMAU WATER PURIFICATION PLANT

Analysis of Private Investment for Solar Panel

Decision making is required for Solar Power Investment

- The solar power facilities cannot be covered by the Grant as the Grant budget is limited.
- PPWSA needs to decide whether to install the solar power facilities at its own investment or SPC' private investment.
- If the solar power facilities should be installed,
  - PPWSA shall discuss, negotiate, and agree with SPC at its own risk apart from this Grant scheme because private investment must be separated from the Grant component.
  - The Consultants shall prepare the requirements for the WTP to be consistent with the solar power installation.

- Given that the electricity price in Cambodia is relatively high @720KHR/kWh and Electricity price cut is expected in the near future, scenario analysis is provided on the next page for PPWSA's investment decision.

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Scenario Analysis for Solar Power Investment

Assumptions		
Capacity	kW	146
Efficiency coefficient	---	6
Electricity generation	kWh/year	319,740
Initial capital expenditure	JPY	40,000,000
FX rate	KHR/JPY	36.2
Initial capital expenditure	000KHR	1,448,183
Depreciation method	---	Straight-line
Lifetime	years	17

Economic analysis tells us that solar panel investment is worth to do, even the electricity price goes down to KHR400/kWh.
If it goes down below KHR300/kWh from the first year of this project period, it is not worth to invest.

Case 1		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17
Electricity price	KHR/kWh		720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720
Electricity value	000KHR		230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213
Depreciation	000KHR		85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187
Net profit	000KHR	0	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026	145,026
Cash in/out	000KHR	-1,448,183	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213	230,213
Internal Rate of Return	%	14.2%																	
NPV at 4.5%	000KHR	1,193,265																	

Case 2		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17
Electricity price	KHR/kWh		400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Electricity value	000KHR		127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896
Depreciation	000KHR		85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187
Net profit	000KHR	0	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709	42,709
Cash in/out	000KHR	-1,448,183	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896	127,896
Internal Rate of Return	%	4.9%																	
NPV at 4.5%	000KHR	47,005																	

Case 3		Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17
Electricity price	KHR/kWh		300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Electricity value	000KHR		95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922
Depreciation	000KHR		85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187	85,187
Net profit	000KHR	0	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735
Cash in/out	000KHR	-1,448,183	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922	95,922
Internal Rate of Return	%	1.4%																	
NPV at 4.5%	000KHR	-311,202																	

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For reference: Electricity price at other Asian Countries

- Actual Electricity cost in Phnom Phen Cambodia is 720KHR/kWh (USD 0.18)
- Electricity Price in nearby countries are as follows (June 2018 from Global PetrolPrices.com)

Country	USD/kWh
Myanmar	0.02
Malaysia	0.06
Vietnam	0.07
China	0.08
Taiwan	0.08
Thailand	0.12
Hong Kong	0.14
Singapore	0.16
Cambodia	0.18
Philippines	0.19
Japan	0.27

Electricity Cost in Cambodia is relatively expensive comparing other nearby countries.
Cost reduction is expected near future.
Thailand level is USD 0.12/kWh, (480KHR/kWh)
Malaysian level is USD 0.06/kWh, (240KHR/kWh)

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Table 5-1: Urban water system parameters

Items to be Analyzed and Recorded in Ta Khmau WTP	Parameter	Parameter			Exception	Formal Monitoring Examination level		
		Unit	Permissible limite			A	B	C
			National Drinking water Standard	Requirement for Ta Khmau WTP		Daily	Quarterly	Annually
	Microbial							
	E.Coli or thermoteloerant	CFU or MPN / 100 ml	0	0			B	
	Chemical							
	Aluminium (Al)	mg/l	0.2	0.2	in the case that alum is used		B	
	Ammonia (NH_3)	mg/l	1.5	1.5			B	
	Arsenic (As)	mg/l	0.05	0.05	for the case of groundwater source			C
	Barium (Ba)	mg/l	0.7	0.7				C
	Cadmium (Cd)	mg/l	0.003	0.003				C
	Chloride (Cl^-)	mg/l	250	250			B	
●	Chlorine Cl_2 * (free residual)	mg/l	0.1-1.0	0.1-1.0	for the case of using chlorine for disinfectant	A		
	Chromium (Cr)	mg/l	0.05	0.05				C

Items to be Analyzed and Recorded in Ta Khmau WTP	Parameter	Parameter			Exception	Formal Monitoring Examination level		
		Unit	Permissible limite			A	B	C
			National Drinking water Standard	Requirement for Ta Khmau WTP		Daily	Quarterly	Annually
	Copper (Cu)	mg/l	1	1	for the case that household plumbing uses copper pipes			C
	Fluoride (F)	mg/l	1.5	1.5	for the case of groundwater source			C
	Total hardness as $CaCO_3$	mg/l	300	300	For the case of groundwater source		B	
	Iron (Fe)	mg/l	0.3	0.3	case of groundwater		B	
	Lead (Pb)	mg/l	0.01	0.01				C
	Manganese (Mn)	mg/l	0.1	0.1	case of groundwater		B	
	Mercury (Hg)	mg/l	0.001	0.001				C
	Nitrate (NO_3^-)	mg/l	50	50			B	
	Nitrite (NO_2^-)	mg/l	3	3			B	
	Sodium (Na)	mg/l	250	250	case at coastal areas			C
	Sulfate ion (SO_4^{2-})	mg/l	250	250			B	
	Zinc (Zn)	mg/l	3	3				C

Items to be Analyzed and Recorded in Ta Khmau WTP	Parameter	Parameter			Exception	Formal Monitoring Examination level		
		Unit	Permissible limite			A	B	C
			National Drinking water Standard	Requirement for Ta Khmau WTP		Daily	Quarterly	Annually
	Physical							
●	Colour	TCU	5	5		A		
●	pH	n/a	6.5-8.5	6.5-8.5		A		
●	TDS or Conductivity	mg/l or µS/cm	800 or 1600	800 or 1600		A		
●	Turbidity	NTU	5	1		A		
●	Taste and Odour	-	Acceptable	Acceptable		A		

*Residual chlorine must be daily analysed in production system and fortnightly (two weeks) at end points of networks (water supply system with more than 3001 connections). The number of samples is dependent on situations of end points of networks of each unit or service provider. We can analyse thermoteloerant coliform bacteria for E Coli.

**Conductivity is an acceptable alternative to TDS. The above limits assume that Conductivity is twice TDS, but this relationship should be confirmed at each site if conductivity is used.

*** Whether the analysis of taste and odour by operators is acceptable depends on users.

Source: National Drinking Water Quality Standard (MIH)

Minutes of Discussions
on the Preparatory Survey for the Project for
Expansion of the Water Supply System in Ta Khmau
(Explanation on Draft Preparatory Survey Report)

With reference to the minutes of discussions signed between Phnom Penh Water Supply Authority (hereinafter referred to as "PPWSA") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") on 29th March,2019 and 28th June,2019, and in response to the request from the Government of Cambodia dated 8th August 2017, JICA dispatched the Preparatory Survey Team (hereinafter referred to as "the Team") for the explanation of Draft Preparatory Survey Report (hereinafter referred to as "the Draft Report") for the Project for Expansion of the Water Supply System in Ta Khmau (hereinafter referred to as "the Project").

As a result of the discussions, both sides agreed on the main items described in the attached sheets.

Phnom Pehn, 21st November, 2019

Dr. Shigeyuki Matsumoto
Leader
Preparatory Survey Team
Japan International Cooperation Agency
Japan

H.E. Dr. Sim Sitha
Director General
Phnom Penh Water Supply Authority (PPWSA)
Kingdom of Cambodia

ATTACHEMENT

1. Title of the Preparatory Survey
   Both sides confirmed the title of the Preparatory Survey as "the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau". However, PPWSA suggested that the spelling of "Ta Khmau" should be changed to "Ta Khmao" in accordance with the official website of Cambodian Government in the later stage. The Team agreed with it and would take necessary procedure to officially revise the spelling of the title in the later stage.

2. Contents of the Draft Report
   After the explanation of the contents of the Draft Report by the Team, the Cambodian side agreed to its contents. JICA will finalize the Preparatory Survey Report based on the confirmed items. The report will be sent to the Cambodian side around March 2020.

3. Cost estimate
   Both sides confirmed that the cost estimate including the contingency explained by the Team is provisional and will be examined further by the Government of Japan for its approval. The contingency would cover the additional cost against natural disaster, unexpected natural conditions, etc.

4. Confidentiality of the cost estimate and technical specifications
   Both sides confirmed that the cost estimate and technical specifications of the Project should never be disclosed to any third parties until all the contracts under the Project are concluded.

5. Timeline for the project implementation
   The Team explained to the Cambodian side that the expected timeline for the project implementation is as attached in Annex 1.

6. Expected outcomes and indicators
   Both sides agreed that key indicators for expected outcomes are as follows. The Cambodian side will be responsible for the achievement of agreed key indicators targeted in year 2026 and shall monitor the progress based on those indicators.

[Quantitative indicators]

Indicator	Baseline Data (Year 2015)	Target (Year 2026) 【3 years after completion of the new facilities】
daily average water supply amount (m^3/day)	11,440	30,000

[Qualitative indicators]

- Improving the water quantity and water pressure from tap
- Improving public health
- Increasing house connections for poor households
- Maintaining affordable water tariff for poor households
- Enhancing PPWSA's O&M capacity of WTP by technical transfer
- Creating a goodexample of O&M of WTP by SPC in Cambodia

7. Undertakings of the Project

Both sides confirmed the undertakings of the Project as described in Annex 2. With regard to exemption of customs duties, internal taxes and other fiscal levies as stipulated in (2) 5 of Annex 2, both sides confirmed that such customs duties, internal taxes and other fiscal levies, which shall be clarified in the bid documents by PPWSA during the implementation stage of the Project.

The Cambodian side assured to take the necessary measures and coordination including allocation of the necessary budget which are preconditions of implementation of the Project. It is further agreed that the costs are indicative, i.e. at Outline Design level.

Both sides confirmed that the area in the Niroth WTP and PPWSA's land in Kampong Samnanh Village in Ta Khmau city shall be provided during the EPC period for the stock yard free of charge as stipulated in (2)13 of Annex 2.

Both sides confirmed that PPWSA would be in charge of sludge disposal from the sludge basin as stipulated in (3)5 of Annex 2.

Both sides also confirmed that the Annex 2 will be used as an attachment of G/A.

8. Monitoring during the implementation

The Project will be monitored by PPWSA and reported to JICA by using the form of Project Monitoring Report (PMR) attached as Annex 3. The timing of submission of the PMR is described in Annex 2.

9. Project completion

Both sides confirmed that the Project completes when all the facilities constructed and equipment procured by the Grant. The completion of the Project will be reported to JICA promptly, but in any event not later than six months after completion of the Project.

10. Ex-Post Evaluation

JICA will conduct ex-post evaluation after three (3) years from the project completion, in principle, with respect to five evaluation criteria (Relevance, Effectiveness, Efficiency, Impact, Sustainability). The result of the evaluation will be publicized. The Cambodian side is required to provide necessary support for the data collection.

11. Environmental and Social Considerations

11-1. General Issues

11-1-1. Environmental Guidelines and Environmental Category

The Team explained that 'JICA Guidelines for Environmental and Social Considerations (April 2010)' (hereinafter referred to as "the Guidelines") is applicable for the Project. The Project is categorized as B because the Project is not located in a sensitive area, nor has sensitive characteristics, nor falls into sensitive sectors under the Guidelines, and its potential adverse impacts on the environment are not likely to be significant.

11-1-2. Environmental Checklist

The environmental and social considerations including major impacts and mitigation measures for the Project are summarized in the Environmental Checklist attached as Annex 4. Both sides confirmed that in case of major modification of the content of the Environmental Checklist, the Cambodian side shall submit the modified version to JICA in a timely manner.

11-2. Environmental Issues

11-2-1. Initial Environmental Impact Assessment (IEIA)

Both sides confirmed the IEIA report will be approved by Ministry of Environment in January, 2020. The Team requested that the IEIA report would be approved before Cabinet approval by the government of Japan in February.

11-2-2. Environmental Management Plan and Environmental Monitoring Plan

Both sides confirmed Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP) of the Project is as Annex 5, respectively. Both sides agreed that environmental mitigation measures and monitoring shall be conducted based on the EMP and EMoP, which may be updated during the detailed design stage.

11-3. Environmental and Social Monitoring

11-3-1. Environmental Monitoring

Both sides agreed that the Cambodian side will submit results of environmental monitoring to JICA by using the monitoring form attached as Annex 6. The timing of submission of the monitoring form is described in Annex 2.

11-3-2. Information Disclosure of Monitoring Results

Both sides confirmed that the Cambodian side will disclose results of environmental and social monitoring to local stakeholders through their website / in their field offices.

The Cambodian side agreed JICA will disclose results of environmental and social monitoring submitted by the Cambodian side as the monitoring forms attached as Annex 6 on its website.

12. Other Relevant Issues

Project Outline

12-1. Outline of the Comparator Facility

The Team explained final version of comparator facilities as Annex 7. The location of bulk water in the Ta Khumau WTP treatment process is added to the final version. PPWSA understood it.

12-2. Emergency Response against Unexpected Raw Water Quality

The Team explained emergency response of the following two cases.

a) In case turbidity becomes higher than 1000NTU, intake amount shall follow PPWSA's instruction as same as other PPWSA's treatment plants.

b) In case serious issue (such as toxic substance or oil discharge) happens, SPC can autonomously reduce or stop intake operation to avoid serious damage on WTP facilities and contaminated water supply to customers, and report to and discuss with PPWSA as soon as possible.

If above restricted intake conditions continue untill remaining water in the service reservoir is empty, both parties do not have responsibilities to suspend water supply.

PPWSA agreed those suggestions.

12-3. Responsibility of Damage of the Existing Elevated Tank

Both sides confirmed that EPC contractor/SPC would have responsibility against any damage on existing elevated tank due to EPC contractor/SPC's fault and PPWSA would have responsibility against aged deterioration. Before construction commences, both EPC contractor and PPWSA will evaluate the condition of the existing elevated tank.

12-4. Risk Allocation of Strengthening of Sludge Treatment Regulation

Both sides confirmed that the risk of strengthening of sludge treatment regulation was categorized in legal risk (change of project specific law) described in Annex 8, and necessary cost for additional facility and treatment to meet strengthened regulation would be borne by PPWSA. In case PPWSA outsource the task such as facility planning and additional O&M to SPC, PPWSA additionally needs to pay appropriate outsourcing fee to SPC.

12-5. Disinfection Method

Both sides confirmed that on-site chlorination system for disinfection method shall be included for requirements in the bidding documents.

Requirements

12-6. Items of Requirements

Both sides confirmed the following items shall be included for requirements in the bidding documents at this time and requirements would be finalized in the later stage.

- WTP capacity of nominal 30,000m^3/day
- 10 years O&M period
- Intake tower type
- On-site chlorination system
- Volume of service reservoir of 5,000 m^3 or more
- Pressure of 4 bar at off-take point
- 24 hours supply
- Water quality standards described in Annex 12
- O&M manual in both Khmer Language and English
- Prevention against adhesion of shell inside raw water transmission pipe
- 5 % of production loss ratio from intake to the bulk meter
- prevention of oil inflow into the WTP

Contract Terms

12-7. Insurance for WTP

The Team explained that Japanese companies requested to add insurance cost for WTP on off-take price to lower the hurdle to participate in the Project, because they operate PPWSA's asset so that there is possibility for them to accept liability for damages to the facilities or the third party.

The Team also explained options for this request with reference to Annex 9.

PPWSA explained that it has responsibility to cover asset insurance. Both sides agreed that insurance other than PPWSA's coverage can be included in off-take price in case initial off-take price is less than or equal to 500KHR/m^3, and social insurance for the staff dispatched from PPWSA will be covered by PPWSA.

12-8. Third party monitoring during O&M

PPWSA explained that third party monitoring would not be necessary during O&M period in the previous meeting. However, the Team explained that any monitoring would not be included in consultant service by Grant during O&M and suggested third party monitoring to assure good condition of WTP. PPWSA took note of it.

12-9. Chemical Procurement

Both sides confirmed that the necessary amount of chemical for O&M by SPC could be procured by PPWSA at the same price as PPWSA's. PPWSA explained that the procurement planning starts in September every year, so SPC should submit necessary amount of chemical for one year consumption by September and follow PPWSA's specification. The Team took note of it.

12-10. Frequency of Revision for the Unit Price of Bulk Water

The Team suggested that the frequency of revision of off-take price would be basically yearly base to mitigate inflation risk and electricity price variation risk on SPC in accordance with the risk category both sides had previously agreed. PPWSA explained that Board of Director and Ministry of Economy and Finance cannot accept yearly variable off-take price because water tariff cannot be revised in accordance with inflation rate. PPWSA suggested every three years or more for recalculation of off-take price.

Both sides agreed that initial off-take price shall be less than or equal to 500KHR/m^3 and that off-take price should be reviewed and adjusted at the end of third year, sixth year and ninth year from the effective date of O&M period. Both sides agreed such revision and adjustment should be in accordance with the formula described in Annex 8. The off-take price shall be revised only when the value calculated by the formula exceeds the previously-agreed off-take price. When the value calculated based on the formula exceeds 500KHR/m³, SPC should verify the cost structure based on inflation rate and electricity cost.

12-11. Contract Structure

The Team explained two options of contract structure for the Project described in Annex 10 and JICA decided Consortium for EPC+ local SPC for O&M would be more feasible for the Project with following reasons.

・It may take time to establish local SPC , register tax exemption and implement other necessary procedure to start the activity of local SPC. This might cause the miss of the critical pass of intake construction which should be commenced in November, 2021. And, it leads to the delay of the Project.

・Japanese companies which attended the project briefing session expressed the concern about above situation. This may cause no applicants for the Project.

Both sides agreed that Consortium for EPC+ local SPC for O&M would be selected for the Project.

12-12. Dispute Settlement during O&M

The Team proposed dispute settlement during O&M described in Annex 11. PPWSA took note of it. Both sides confirmed this would be finally decided through contract negotiation between PPWSA and SPC.

12-13. Payment Currency

The Team explained that some Japanese companies expressed their preference for the payment in US dollar. PPWSA explained only Khmer Riel can be applied for the payment to SPC, because water tariff is paid by KHR and most of expenses of SPC is also paid in KHR in accordance with Cambodian Procurement Law.

12-14. Contract Terms

The Team explained the latest version of contract terms described in Annex 8. Following items have been revised from the previous version.

・Emergency response against unexpected raw water quality

・Timeline for the project implementation

・Invoice settlement (mentioned below)

・Requirements for the Operation

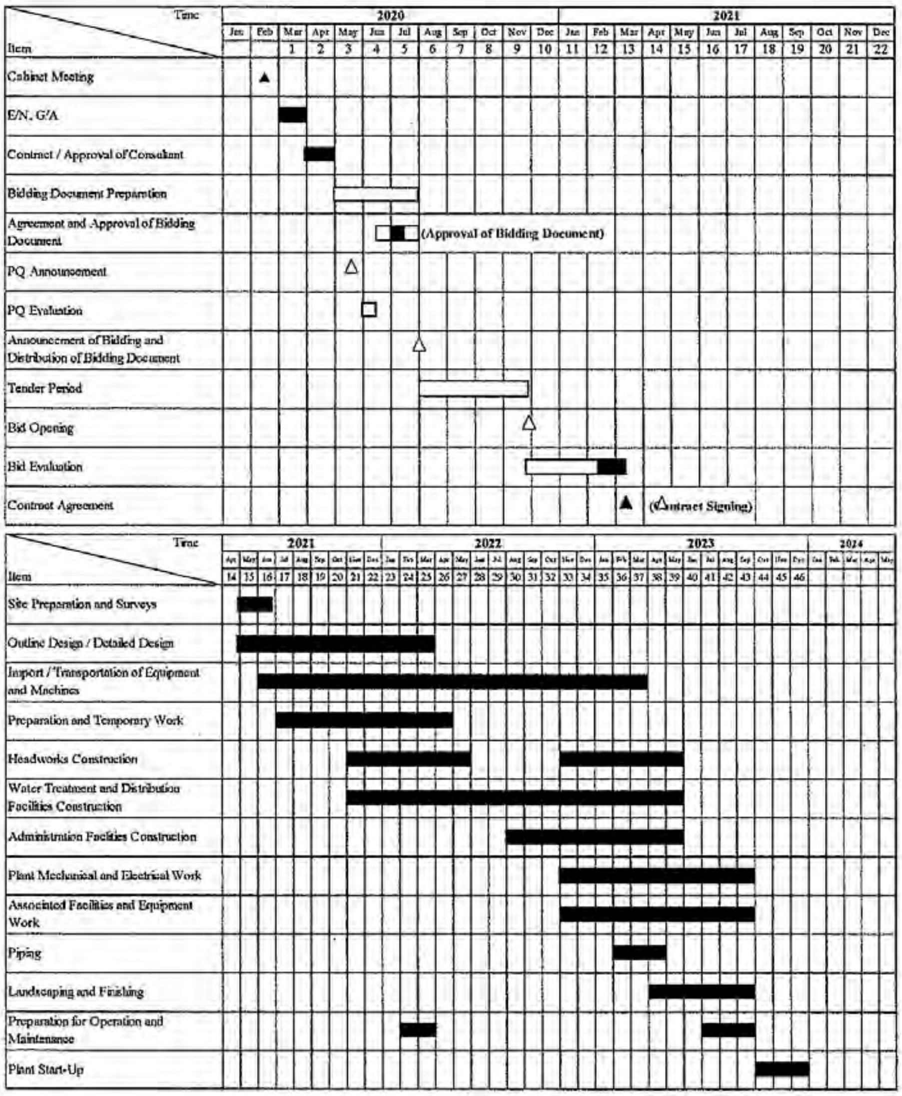
12-15. Invoice settlement
Deadline of payment from PPWSA to SPC was tentatively decided within two months after the invoice receiving day in the previous meeting.
The Team suggested 30 days as a deadline in consideration with the opinion from Japanese companies in order to maintain sound cash flow. PPWSA agreed with it.

Others
12-16. Report to the Board of Directors of PPWSA
The Team requested PPWSA to report to the Board of Directors about the result of the Preparatory Survey espescially the project scheme of Grant Aid with O&M, off-take price based on the comparator facility and bidding system in December, 2019, because the Japanese side would enter into the formal appraisal process at the government level. Both sides confirmed PPWSA would report to the Board of Directors on 5th December, 2019.

Annex 1 Project Implementation Schedule
Annex 2 Major Undertakings to be taken by the Cambodian side
Annex 3 Project Monitoring Report
Annex 4 Environmental Check List
Annex 5 Environmental Management Plan
Annex 6 Environmental Monitoring Form
Annex 7 Outline Design
Annex 8 Term Sheet
Annex 9 Insurance and limited equity contribution
Annex 10 Contract structure
Annex 11 Dispute Settlement
Annex 12 Water quality monitoring items

Annex1

Project Implementation Schedule



Annex 2

Major Undertakings to be taken by the Royal Government of Cambodia

1. Specific obligations of the Royal Government of Cambodia which will not be funded with the Grant

(1) Before the Bidding

No	Items	Deadline	In charge	Estimated Cost (USD)	Ref.
1	To open bank account (B/A)	within 1 month after the signing of the G/A	PPWSA	-	
2	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the consultant	within 1 month after the signing of the contract(s)	PPWSA	-	
3	To bear the following commissions to the Agent Bank for the banking services based upon B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	PPWSA/ NBC	50	
	2) Payment commission for A/P	every payment	PPWSA/ NBC	1,500	
4	To approve IEIA/EIA(Conditions of approval should be fulfilled, if any) and secure the necessary budget for implementation.	within 1 month after the signing of the G/A	PPWSA	-	
5	To notice the construction of the intake facility in the Bassac River to local authorities.	before notice of the bidding document(s)	PPWSA	-	
6	To secure, clear, level and reclaim the following lands/sites * 1) Site for Ta Khmau WTP	before notice of the bidding document(s)	PPWSA	-	
7	To explore landmines and UXO at construction site	before notice of the bidding document(s)	PPWSA	25,000	
8	To obtain water right for intake from the Bassac River from MOWRAM	before notice of the bidding document(s)	PPWSA	-	
9	To demolish and transfer the existing tariff collection office	before notice of the bidding document(s)	PPWSA	61,000	

(B/A: Banking Arrangement, A/P: Authorization to pay, N/A: Not Applicable)

NBC: National Bank of Cambodia

(2) During the Project Implementation (during EPC)

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Supplier(s)	within 1 month after the signing of the contract(s)	PPWSA	-	
2	To bear the following commissions to a bank in Japan for the banking services based upon the B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	PPWSA/ NBC	600(in total)	
	2) Payment commission for A/P	every payment	PPWSA/ NBC	30,000(in total)	
3	to ensure prompt unloading and customs clearance at ports of disembarkation in the country of the Recipient and to assist the Supplier(s) with internal transportation therein	during the Project	PPWSA	-	
4	To accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into Cambodia and stay therein for the performance of their work	during the Project	PPWSA	-	
5	To ensure that customs duties, VAT, internal taxes and other fiscal levies which may be imposed on prime contractors and subcontractors in Cambodia with respect to the purchase of the products and/or the services be exempted by its designated authority without using the Grant;	during the Project	MEF	-	
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	during the Project	PPWSA	-	
7	To notify JICA promptly of any incident or accident, which has, or is likely to have, a significant adverse effect on the environment, the affected communities, the public or workers.	during the construction	PPWSA		
8	1) To submit Project Monitoring Report	every month	PPWSA	-	
	2) To submit Project Monitoring Report (final)	within one month after signing of Certificate of Completion for the works under the contract(s)	PPWSA	-	
9	To submit a report concerning completion of the Project	within six months after completion of the Project	PPWSA	-	
10	To provide facilities for distribution of electricity, water supply and drainage and other incidental facilities necessary for the implementation of the Project outside the site(s)		PPWSA	-	
	1) Electricity Construction of utility poles and wiring work including conduit from the power receiving point to the transformer, procedures for receiving power, and procedures for receiving two lines.	before start of the construction		5,000	
	2) Drainage The city drainage main (for storm, sewer and others) to the site	before start of the construction			

11	To take necessary measure for safety of construction - Coordination with the police for traffic control - Coordination with relevant authority to ensure the safety of boats and ships in relation to the construction of intake facility	during the construction	PPWSA	-	
12	To implement EMP and EMoP	during the construction	PPWSA	31,250	
13	To submit results of environmental monitoring to JICA, by using the monitoring form, on a quarterly basis as a part of Project Monitoring Report	during the construction	PPWSA	-	
14	To provide sufficient space in Niroth WTP and PPWSA's land in Kampong Samnanh Village in Ta Khmau city as a stockyard and office space for free of charge	during the construction	PPWSA	-	

(3) During O&M

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To implement EMP and EMoP	for a period based on EMP and EMoP	PPWSA		
2	To submit results of environmental monitoring to JICA, by using the monitoring form, semiannually - The period of environmental monitoring may be extended if any significant negative impacts on the environment are found. The extension of environmental monitoring will be decided based on the agreement between PPWSA and JICA.	for three years after the commissioning	PPWSA		
3	To extend distribution network and facilitate the service connections.	for the O&M period	PPWSA		
4	To comply strictly with the O&M contract	for the O&M period	PPWSA		
5	To extract sludge from WTP and dispose it	for the O&M period	PPWSA		

Annex 3
G/A NO. XXXXXXX
PMR prepared on DD/MM/YY

Project Monitoring Report
on
the Project for Expansion of Water Supply System in Ta Khmau
Grant Agreement No. XXXXXXX
20XX, Month

Organizational Information

Signer of the G/A (Recipient)	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:
Executing Agency	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:
Line Ministry	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:

General Information:

Project Title	***Expansion of Water Supply System in Ta Khmau***
E/N	Signed date: Duration:
G/A	Signed date: Duration:
Source of Finance	Government of Japan: Not exceeding JPY ______ mil. Government of (________): ____________

1: Project Description

1-1 Project Objective

The project aims to achieve the objectives as follows; 1)Construct a water treatment plant (30,000m3 / day) for water distribution to Ta Khmau City and the surrounding area; 2) Improving water supply services, and 3)Contribute to improving the living environment in Ta Khmau and Phnom Penh.

1-2 Project Rationale

- Higher-level objectives to which the project contributes (national/regional/sectoral policies and strategies)
- Situation of the target groups to which the project addresses

The National Strategic Development Plan, issued by the Royal Government of the Kingdom of Cambodia (RGC) in 2006 and reviewed in 2008, aims to boost access to safe water in urban areas to 80% by 2015 and 100% by 2025.

Development of water supply in the country started in the mid-1990s, mainly in the capital city of Phnom Penh. JICA conducted the Study on Phnom Penh Water Supply System in 1993. With the support of the Government of Japan (hereinafter referred to as "GOJ") and other donors, water supply capacity in Phnom Penh has improved through the construction and rehabilitation of facilities and capacity building for operation and maintenance. Now, Phnom Penh has a service ratio of over 90 % for 24-hour water supply. Water supply is still inadequate in the surrounding areas because production capacity is not keeping up with the rapid increase in domestic and commercial demand. The expansion of water supply facilities is urgently needed.

Ta Khmau city is part of Kandal province and located south of Phnom Penh city. Public water had been supplied mainly from the Bassac river and wells within Ta Khmau city. At present, water is supplied directly through distribution pipes connected to the Phnom Penh system, which is operated by the Phnom Penh Water Supply Authority (hereinafter referred to as "PPWSA"). PPWSA was instructed to do so in 2004 by RGC due to the growing population and water quality problems (e.g. arsenic has been detected in multiple wells).

There are many low-income households in the area, and PPWSA takes measures to provide free connections and lower water tariffs.

1-3 Indicators for measurement of "Effectiveness"

Quantitative indicators to measure the attainment of project objectives		
Indicators	Original (Yr 2015)	Target (Yr 2027)
Daily Average Water Supply Volume	11,440 m3/ day	30,000 m3/day
Qualitative indicators to measure the attainment of project objectives		
1. *Increase of Service Ratio* 2. *Expansion of Service Area* 3. *Increase of Water Supply Volume* 4. *Increase of Water Pressure* 5. *Increase of Service Connetion of LowIncome Group*		

6. *Sustainment of Special Measurement against Low Income Group on Water Supply*
7. *7. Technology Transfer*

2: Details of the Project

2-1 Location

Components	Original *(proposed in the outline design)*	Actual
1.	Attachment 1: Map	

2-2 Scope of the work

Components	Original* *(proposed in the outline design)*	Actual*
1. Intake and Raw Water Transmission Facilities	- Intake Capacity : 33,000 m3/day - Raw Water Intake Tower - Raw Water Transmission Facility	
2. Water Treatment Facility	- Water Treatment Capacity : 30,000 m3/day - Water Treatment Facility	
3. Distribution Facilities	- Clear Water/Service Reservoir - Distribution Equipment - Bulk Meter (Count: 1)	
4. SCADA	- Central Supervisory System in the WTP	
5. Consulting Service	- Tender Assistance - Design Confirmation - Construction and Procurement Supervision - Support for O&M, and monitoring system	

Reasons for modification of scope (if any).

(PMR)

2-3 Implementation Schedule

Items	Original		Actual
	(proposed in the outline design)	*(at the time of signing the Grant Agreement)*	
E/N	Mar 2020		
G/A	Mar 2020		
PQ Announcement	May 2020		
Tender Announcement	July 2020		
Signing of Contract	Mar. 2021		
Completion of EPC	Dec 2023		
Defect Liability Date	Dec 2024		

Completion of O&M	Dec 2033		

Reasons for any changes of the schedule, and their effects on the project (if any)

2-4 Obligations by the Recipient

2-4-1 Progress of Specific Obligations
See Attachment 2.

2-4-2 Activities
See Attachment 3.

2-4-3 Report on RD
See Attachment 11.

2-5 Project Cost

2-5-1 Cost borne by the Grant(<u>Confidential until the Bidding</u>)

Components			Cost (Million Yen)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original1),2) *(proposed in the outline design)*	Actual
EPC	1. EPC			
Consulting Service	EPC Supervision			
Contingencies				
Total				

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar = Yen

2-5-2 Cost borne by the Recipient

Components			Cost (1,000 KHR)		Cost (Million JPY)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original1),2) *(proposed in the outline design)*	Actual	Original1),2) *(proposed in the outline design)*	Actual
Land preparation for WTP construction	1. Land preparation of WTP site		0			
	2. Relocation of tariff collection office		61,000			
Electrical Work	Cost for two-line power receiving such as procedures, construction.		5,000			
Unexploded or	Cost for		25,000			

mine survey	construction work for the primary side power receiving facility for water intake and WTP					
Environmental and social considerations	Expenses for investigating in advance whether there are unexploded bombs and landmines etc		31,250			
Banking fee	Environmental impact monitoring costs (2021-2024)				3.3	
			122,250		3.3	

Note: 1) Date of estimation: April, 2019
2) Exchange rate: 1 US Dollar = 111.21, 1 KHR = 0.026 JPY

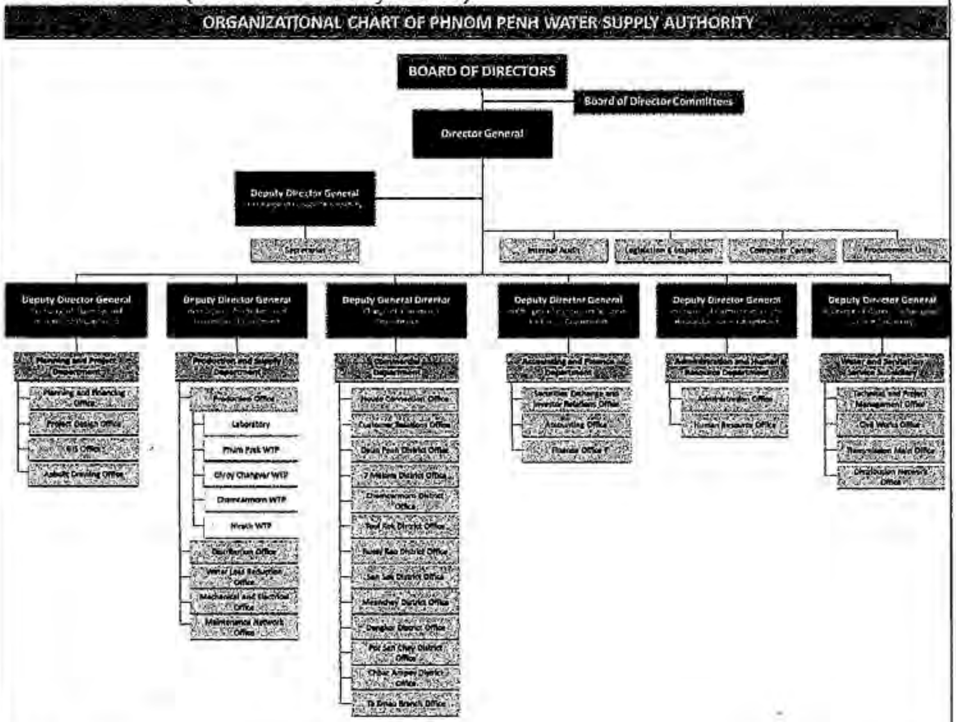
Reasons for the remarkable gaps between the original and actual cost, and the countermeasures (if any)

(PMR)

2-6 Executing Agency

- Organization's role, financial position, capacity, cost recovery etc,
- Organization Chart including the unit in charge of the implementation and number of employees.

Original *(at the time of outline design)*
name: Phnom Penh Water Supply Authority (PPWSA)
role:
financial situation:
institutional and organizational arrangement (organogram):
human resources (number and ability of staff):



Actual *(PMR)*

2-7 Environmental and Social Impacts

- The results of environmental monitoring based on Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- The results of social monitoring based on in Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- Disclosed information related to results of environmental and social monitoring to local stakeholders (whenever applicable).

3: Operation and Maintenance (O&M)

3-1 Physical Arrangement

- Plan for O&M (number and skills of the staff in the responsible division or section, availability of manuals and guidelines, availability of spareparts, etc.)

Original *(at the time of outline design)*
Actual *(PMR)*

3-2 Budgetary Arrangement
- Required O&M cost and actual budget allocation for O&M

Original *(at the time of outline design)*
Actual *(PMR)*

4: Potential Risks and Mitigation Measures

- Potential risks which may affect the project implementation, attainment of objectives, sustainability
- Mitigation measures corresponding to the potential risks

Assessment of Potential Risks *(at the time of outline design)*

Potential Risks	Assessment
1. Long wet period and high river water level	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	It shall be unforeseen case. if construction of intake is delayed, completion of overall construction will be delayed.
	Mitigation Measures:
	Extension of construction period
	Action required during the implementation stage:
	Contingency Plan (if applicable):
2. Deterioration of raw water quality	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Unforeseen contents may be contained in raw water which effect to treatment process.
	Mitigation Measures:
	Modification of treatment process.
	Action required during the implementation stage:

	Contingency Plan (if applicable):
3. Time takes long at commencement of works	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Approval or permission takes long time to establish entity at commencement of EPC effect overall construction period.
	Mitigation Measures:
	Extension of construction period
	Action required during the implementation stage:
	Contingency Plan (if applicable):
Actual Situation and Countermeasures	
(PMR)	

5: Evaluation and Monitoring Plan (after the work completion)

5-1 Overall evaluation

Please describe your overall evaluation on the project.

5-2 Lessons Learnt and Recommendations

Please raise any lessons learned from the project experience, which might be valuable for the future assistance or similar type of projects, as well as any recommendations, which might be beneficial for better realization of the project effect, impact and assurance of sustainability.

5-3 Monitoring Plan of the Indicators for Post-Evaluation

Please describe monitoring methods, section(s)/department(s) in charge of monitoring, frequency, the term to monitor the indicators stipulated in 1-3.

Attachment

1. Project Location Map
2. Specific obligations of the Recipient which will not be funded with the Grant
3. Monthly Report submitted by the Consultant

Appendix - Photocopy of Contractor's Progress Report (if any)
- Consultant Member List
- Contractor's Main Staff List

4. Check list for the Contract (including Record of Amendment of the Contract/ Agreement and Schedule of Payment)
5. Environmental Monitoring Form / Social Monitoring Form
6. Monitoring sheet on price of specified materials (Quarterly)
7. Report on Proportion of Procurement (Recipient Country, Japan and Third Countries) (PMR (final)only)
8. Pictures (by JPEG style by CD-R) (PMR (final)only)
9. Equipment List (PMR (final)only)
10. Drawing (PMR (final)only)
11. Report on RD (After project)

Attachment 6

Monitoring sheet on price of specified materials

1. Initial Conditions (Confirmed)

	Items of Specified Materials	Initial Volume A	Initial Unit Price (¥) B	Initial total Price C=A×B	1% of Contract Price D	Condition of payment	
						Price (Decreased) E=C−D	Price (Increased) F=C+D
1	Item 1	●●t	●	●	●	●	●
2	Item 2	●●t	●	●	●		
3	Item 3						
4	Item 4						
5	Item 5						

2. Monitoring of the Unit Price of Specified Materials

(1) Method of Monitoring : ●●

(2) Result of the Monitoring Survey on Unit Price for each specified materials

	Items of Specified Materials	1st ●month, 2015	2nd ●month, 2015	3rd ●month, 2015	4th	5th	6th
1	Item 1						
2	Item 2						
3	Item 3						
4	Item 4						
5	Item 5						

(3) Summary of Discussion with Contractor (if necessary)

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-
-

Attachment 7

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
(Actual Expenditure by Construction and Equipment each)

	Domestic Procurement (Recipient Country) A	Foreign Procurement (Japan) B	Foreign Procurement (Third Countries) C	Total D
Construction Cost	(A/D%)	(B/D%)	(C/D%)	
Direct Construction Cost	(A/D%)	(B/D%)	(C/D%)	
others	(A/D%)	(B/D%)	(C/D%)	
Equipment Cost	(A/D%)	(B/D%)	(C/D%)	
Design and Supervision Cost	(A/D%)	(B/D%)	(C/D%)	
Total	(A/D%)	(B/D%)	(C/D%)	

Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1. Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process?	Y	(a) Initial Environmental Impact Assessment (IEIA) report has been prepared and submitted to Ministry of Environment (MoE) in the end of August, 2019.
		(b) Have EIA reports been approved by authorities of the host country's government?	N	(b) The IEIA report is currently under review by MoE. It is expected that MoE will issue approval letter on the IEIA report by the end of November, 2019.
		(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?	N	(c) The IEIA report is currently under review by MoE.
		(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	N	(d) In addition to the above approvals, a permit for water intake is required. On Sep. 12, 2019, approval letter for the water extraction right was issued by Cambodia National Mekong Committee (CNMC) signed by Chief of Committee, H.E. LIM Kean Hor (Minister of Water Resources and Meteorology).
	(2) Explanation to the Public	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the local stakeholders?	Y	(a) Stakeholder consultation meetings were held in Derm Mien Village on June 22, 2019 and in Kandal Provincial Department of Environment (DoE) on July 18, 2019. During the meetings, the project contents and the potential impacts are explained to the local stakeholders. Understanding was obtained from the local stakeholders considering the discussion and comments collected from them during the meetings. In addition, information disclosure has been also carried out through local authorities and NGOs.
		(b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	Y	(b) Local residents required to increase house connection, regular water supply, appropriate water tariff and lower price of house connection. These comments and requirements have been reflected in the project design (increasing service population from current 48,000 to 120,000, providing 24 hours water supply, providing subsidized connections and tariff for low income households.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	Y	(a) Three alternative studies (without project, conventional treatment and advanced treatment) have been examined. In order to avoid land acquisition and resettlement, conventional treatment method is selected.
2. Mitigation Measure	(1) Air Quality	(a) Is there a possibility that chlorine from chlorine storage facilities and chlorine injection facilities will cause air pollution?	N	(a) On-site sodium hypochlorite generation system with high safety will be applied. Therefore, chlorine gas will not be used in the WTP and leakage of chlorine is not expected.
		(b) Do chlorine concentrations within the working environments comply with the country's occupational health and safety standards?	Y	(b) In the on-site sodium hypochlorite generation system, the disinfectant is produced and stored in liquid form. Therefore, there is no danger of gas leaks from high-pressure chlorine cylinders. In addition, in Cambodia there are no regulations on chlorine concentrations within working environments..

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Water Quality	(a) Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	Y	(a) During construction period: Domestic wastewater generated from construction site at Ta Khmau WTP will be discharged into existing sewerage system. During operation period: Wastewater from the WTP administration building will be treated at wastewater treatment facility before being discharged into existing sewerage system. SS, BOD, COD of effluents discharged from the WTP will comply with Cambodia effluent standards to sewerage system (Sub-decree No. 27 on the Water Pollution Control; SS<120 mg/L, BOD<80 mg/L and COD<100 mg/L).
	(3) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed in accordance with the country's regulations?	N	(a) In Cambodia, there are no laws or regulations on WTP sludge disposal. During construction phase: part of construction waste soil (app. 1,000 m^3) will be reused for backfilling at construction site. The remaining waste soil (app. 1,000 m^3) will be reused for backfilling of Boeng Tompun (lagoon, 3 km far from the WTP). During operation period: WTP sludge will be collected and transported to new landfill site by PPWSA who is conducting a detailed survey on the reuse of sludge for backfilling. In addition, the amount of the sludge is limited (app. 3 tDS/day).
	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as pumping stations comply with the country's standards?	Y	(a) During construction period: Current noise levels around the WTP are 57 to 69 dB(A). During construction, the noise level at boundary of the WTP is estimated to be 78-87 dB(A) due to construction equipment and vehicles operation, which exceeds the standard (75 dB) slightly. However, no sensitive facilities have been identified around the WTP site. In addition, EMP has been prepared and contractor will follow the EMP to minimize noise and vibration during construction period. Current vibration levels (equivalent levels) at the project area are 17 to 26 dB, which are much lower than that of Japanese standards (65 dB). Therefore, it is estimated that vibration levels during construction period will comply with Japanese standards (no vibration standards in Cambodia). During operation period: All pumps will be installed within pump stations, therefore, the noise and vibration level in outside of pump stations is considered to be same as the background level of the site.
	(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	N	(a) During construction period and operation period, no groundwater will be extracted. Therefore, the impacts of subsidence are not expected.
3. Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	N	(a) The project sites are not located in protected area or environmentally sensitive areas designated by Cambodia laws or international treaties. In addition, all proposed treatment facilities will be located within the existing WTP site. Therefore, there is no possibility that the project will affect the protected areas.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Ecosystem and Biota	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	N	(a) The project site doesn't encompass primeval forests, tropical rain forests, and ecologically valuable habitats.
		(b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	N	(b) Within the project site, there are no protected habitats of endangered species designated by Cambodia laws or international treaties and conventions.
		(c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?	N	(c) It is not anticipated to cause significant ecological impacts because there are no protected habitats in the area of the WTP site.
		(d) Is there a possibility that the amount of water (e.g., surface water, groundwater) used by the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	Y	(d) Raw water of 0.38 m^3/s will be intaken from Bassac River, which is much less than low flow (40 m^3/s) of the River. Therefore, the impacts of the project on aquatic environments of Bassac River are considered to be not significant. In addition, an approval letter has been obtained from Cambodia National Mekong Committee. PPWSA will prepare water supply plan during dry period in cooperation with MoE in order to ensure suitable environmental flow of Bassac River in the future.
	(3) Hydrology	a) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect surface water and groundwater flows?	N	(e) Compared with low flow (40 m^3/s) of Bassac River, intake volume (33,000 m^3/d or 0.38 m^3/s) will not have significant impacts on surface water and groundwater flow. In addition, an approval letter has been obtained from Cambodia National Mekong Committee.
4. Social Environment	(1) Resettlement	a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?	N	(a) Because the considerations for avoiding resettlement are made and the WTP will be constructed within existing WTP site of PPWSA, there is no resettlement caused by the project.
		(b) Is adequate explanation on compensation and resettlement given to affected people prior to resettlement?	N	(b) For the proposed project, no resettlement will take place.
		(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	N	(c) For the proposed project, neither resettlement nor land acquisition will take place. Therefore, preparation of resettlement plan including compensation is not needed.
		(d) Is the compensations going to be paid prior to the resettlement?	N	(d) For the proposed project, neither resettlement nor land acquisition will take place. Therefore, no compensations will be necessary for the resettlement.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(e) Is the compensation policies prepared in document?	N	(e) For the proposed project, neither resettlement nor land acquisition will take place. Therefore, preparation of compensation policies is not expected.
		(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	N	(f) For the proposed project, there is no resettlement or land acquisition.
		(g) Are agreements with the affected people obtained prior to resettlement?	N	(g) For the proposed project, there is no resettlement and land acquisition. Therefore, it is not necessary to get agreement with the affected people.
		(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	N	(h) For the proposed project, there is no resettlement and land acquisition.
		(i) Are any plans developed to monitor the impacts of resettlement?	N	(i) For the proposed project, alternative studies have been carried out to avoid resettlement. As the results, there is no resettlement or land acquisition will be required. Therefore, it is not necessary to monitoring the impacts of resettlement.
		(j) Is the grievance redress mechanism established?	N	(j) For the proposed project, there is no resettlement or land acquisition. Thus, it is not necessary to establish grievance redress mechanism.
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	N	(a) All proposed facilities will be located within the existing WTP site and will not affect the living environment of the land other than the construction site. The project is expected to improve the living environment as the water supply rate increases. Fishing activity is prohibited from July 1 to November 30 each year because this is the breeding season for all kinds of fish. Therefore, the impacts of the construction on fishing activity are not expected during this period. During fishing season, the construction of the WTP may create impacts on fishing activity. However, fishing activity can be conducted at upstream or downstream (500m or more) of intake construction site. Therefore, the impacts on fishing activity are low and mitigable
		(b) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	N	(a) Comparing with low flow (40 m^3/s) of Bassac River, intake amount (33,000 m^3/d or 0.38 m^3/s) will not have significant impacts on the existing water uses and water area uses. In addition, an approval letter has been obtained from Cambodia National Mekong Committee.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	N	(a) Ta Khmau WTP site is located within existing WTP site. Thus, the impact is considered to be negligible.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	N	(a) The WTP is located within the existing WTP site, and area is small (0.45 ha). In addition, tree planting will be conducted in the WTP.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?	Y	(a) There is no ethnic minority or indigenous group in the project area. In addition, water service rate will be increased up to 100%.
		(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	Y	(b) Ditto
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?	Y	(a) Cambodian laws and ordinances (such as Labor Law 1997 and amendment Law 2018, the Law on Social Security, Sub-Decree 11/16, on Health Care Scheme etc.) associated with working conditions (such as wage and hours of work etc.) will be followed by the project proponent during construction works and operation of the project based on Environmental Management Plan (EMP).
		(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?	Y	(b) Safety considerations will be taken during construction works and operation of the project based on the EMP prepared (such as ear protection equipment must be provided to workers when a noise level exceeds 80 dB(A) in the WTP construction site or within pump station). In addition, inspections of PPWSA and other authorities on safety will be conducted.
		(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?	Y	(c) Safety and health program and safety training for workers will be planned and implemented during construction works and operation of the project based on EMP prepared. (such as wearing safety shoes and elements during construction, following Standard Operation Procedures for the works during operation)
		(d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	Y	(d) Appropriate measures will be taken based on EMP prepared. (such as specific security guards will be assigned by contractor and PPWSA will conduct regular inspection during construction and operation)
5. Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?	Y	(a) Mitigation measures on utilization of local resources (fishing), water usage/water right, traffic control, poor households, accidents (such as safety plan preparation, O/M manual etc.), air pollution (such as covering trucks and spraying exposed areas with water etc.), water pollution, wastes (sludge reuse methods etc.), noise and vibrations (such as application of reasonable construction schedule and methods etc.) have been proposed.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts?	Y	(b) All construction works of Ta Khmau WTP will be carried out within the existing WTP site. Therefore, the impacts on the natural environment (ecosystem) will be very limited.
		(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	Y	(c) Before construction starts, information will be delivered to fisherman via commune and village chiefs in advance. A detailed traffic control plan will be prepared. In addition, proper construction schedule and methods to reduce traffic disruption and traffic accident. Education of staff/workers on the safety and fire will also be conducted to reduce impacts.
		(d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	Y	(d) Proper construction plan of the WTP and traffic control plan will be prepared before construction.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?	Y	(a) Environmental monitoring program has been prepared in the IEIA report based on the recommendations from the JICA Survey Team.
		(b) What are the items, methods and frequencies of the monitoring program?	Y	(b) The items, methods and frequencies of the monitoring program have been proposed and presented in Preparatory Survey Report. Basically, air quality (CO, NO_2, SO_2, O_3, Pb TSP PM_{10} and $PM_{2.5}$): time/6 months; basin water quality (pH, temperature, TDS, TSS, DO, BOD, COD, Oil and Grease, NO_3, T-N, T-P, As, Hg, Total Coliform etc. 17 parameters): time/two weeks, noise and vibration: time/6 months, traffic (along National Highway 102): regularly.
		(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?	Y	(c) Monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework) has been prepared.
		(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	Y	(d) Monitoring format has been proposed.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Dam and River Projects checklist should also be checked.	N	(a) Not necessary.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	Y	(b) Not necessary.

Environmental Management Plan

Impacts	Mitigation Measures	Implementing Organization	Responsible Organization	Cost
Before / During Construction				
Traffic	1) Prepare a detailed traffic control plan and to coordinate with local government. 2) Prepare proper construction schedule and methods to reduce traffic disruption and traffic accident. 3) Assign traffic control person at the entrance of the WTP while construction is taking place.	Contractor	PPWSA	Included in the construction cost
Air Pollution	1) Cover stored materials with plastic or other materials. 2) Cover trucks, and to spray exposed areas with water. 3) Wash vehicles before going out the construction site. 4) Minimize traffic over freshly exposed surfaces. 5) Install barrier walls for limiting wind dispersing if necessary. 6) Prepare air quality monitoring plan and carry out it during construction. 7) Update the Environmental Monitoring Plan during Detailed Design	Contractor	PPWSA	2,000 USD/year (Included in the construction cost)
Waste	1) Prepare reasonable plan for solid waste disposal, especially for excavated soil. 2) Install temporary toilet at the construction site for workers, and set sanitary bins for domestic wastes. 3) PPWSA has a plan to sell the surplus waste soil to buyer as backfilling materials. 4) Dispose solid wastes appropriately	Contractor	PPWSA	Included in the construction cost
Noise	1) Prepare a detailed plan for noise control and coordinate with local government. 2) Prepare proper construction schedule and methods. 3) Set speed limits for vehicles and train workers on mitigation measures for environmental impacts. 4) Use low noise level equipment, if necessary. 5) Prepare noise monitoring plan and carrying out monitoring during construction.	Contractor	PPWSA	1,000 USD/year (Included in the construction cost)
Water Pollution	1) The embankment will be constructed to prevent land erosion during the rainfall. 2) Carry out water quality monitoring. 3) Install wastewater treatment system within the WTP to treat domestic wastewater during construction and operation.	Contractor	PPWSA	1,000 USD/year (Included in the construction cost)
During Operation				
Air quality	1) Preparing air quality monitoring plan. 2) Implementation of air quality monitoring.	Operator	PPWSA	1,000 USD/year (Included in the O&M cost)
Waste	1) Monitoring on volume of sludge and solid wastes from the WTP. 2) Implementation of EMP for operation of the WTP.	Operator	PPWSA	Included in the O&M cost
Water pollution	1) Preparing water quality monitoring plan. 2) Implementation of water quality monitoring at downstream of the WTP.	Operator	PPWSA	2,000 USD/year (Included in the O&M cost)

Environmental Monitoring Form (Construction Phase)

The latest results of the below monitoring items should be submitted to JICA Cambodia Office as part of Quarterly Progress Report throughout the construction phase.

1. Response/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
Number and contents of formal comments made by the public	
Number and contents of responses from government agencies (such as MoE etc.)	

2. Pollution

2.1 Water Quality

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	To be meet the requirements instructed by PPWSA	Measurement Point	Frequency
pH	-					To be confirmed	2 points (1 at upstream of WTP intake, 1 at downstream of the WTP intake) for intake construction	Preconstruction: 1 time/point Construction: 1 time/point
SS	mg/L					To be confirmed		
Turbidity	mg/L					To be confirmed		
COD	mg/L					To be confirmed		
NH_4-N	mg/L					To be confirmed		
Coliform	MPN/100mL					To be confirmed		
SS	mg/L			120	80	120	1 point (at the discharge point to existing sewerage system) for sewage management in construction site	1 time/point/month
BOD	mg/L			80	40	80		
COD	mg/L			100	40	100		

2.2 Air Quality

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
CO	mg/m^3			20	20	20	1 point (1 at the WTP site)	Preconstruction: 1 time/point Construction:
NO_2				0.1	0.04	0.1		
SO_2				0.3	0.04	0.3		

O_3				0.2	0.06	0.2		1 time/point/6 months
Pb				0.005	-	0.005		
TSP				0.33	0.1	0.33		
PM_{10}				0.005	-	0.005		
$PM_{2.5}$				0.025	0.015	0.025		

2.3 Noise and Vibration and Solid Waste

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Waste Disposal Method	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
Equivalent continuous A sound level (Laeq, 10)	dB(A)			-	75 (6:00-18:00)	70	75	2 points (1 at the WTP, 1 at western boundary of the WTP)	Preconstruction: 1 time/point Construction: 1 time/point/6 months
Vibration level (Lv10)	dB(A)			-	-	65 (8:00-19:00)	65	2 points (1 at the WTP, 1 at western boundary of the WTP)	Preconstruction: 1 time/point Construction: 1 time/point/6 months
Volume of wastes (waste soil)	m^3				-	-	-	2 points (1 at Gate of the WTP, 1 at Boeng Tompun Lagoon)	1 time (24 hr)/month
Volume of wastes (other construction wastes)	m^3				-	-	-	2 points (1 at Gate of the WTP, 1 at existing Dangkor landfill site by 2021 or new landfill sit after 2021)	1 time (24 hr)/month

Environmental Monitoring Form (Operation Phase)

3.1 Water Quality

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
SS	mg/L			120	80	120	1 point (at the discharge point to existing sewerage system)	1 time/point/month
BOD	mg/L			80	40	80		
COD	mg/L			100	40	100		

3.2 Air Quality

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
CO	mg/m^3			20	20	20	1 point (1 at the WTP site)	Preconstruction : 1 time/point Construction: 1 time/point/6 months
NO_2				0.1	0.04	0.1		
SO_2				0.3	0.04	0.3		
O_3				0.2	0.06	0.2		
Pb				0.005	-	0.005		
TSP				0.33	0.1	0.33		
PM_{10}				0.005	-	0.005		
$PM_{2.5}$				0.025	0.015	0.025		

3.3 Solid Waste

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Sludge Disposal Method	Cambodian Standards	Standards for Contract	Measurement Point	Frequency
Volume of sludge	m^3			[1] Landfill [2] Reuse for backfilling [3] Other	-	-	2 points (1 at Gate of the WTP, 1 at new landfill site or reuse site)	1 time (24 hr)/6 months

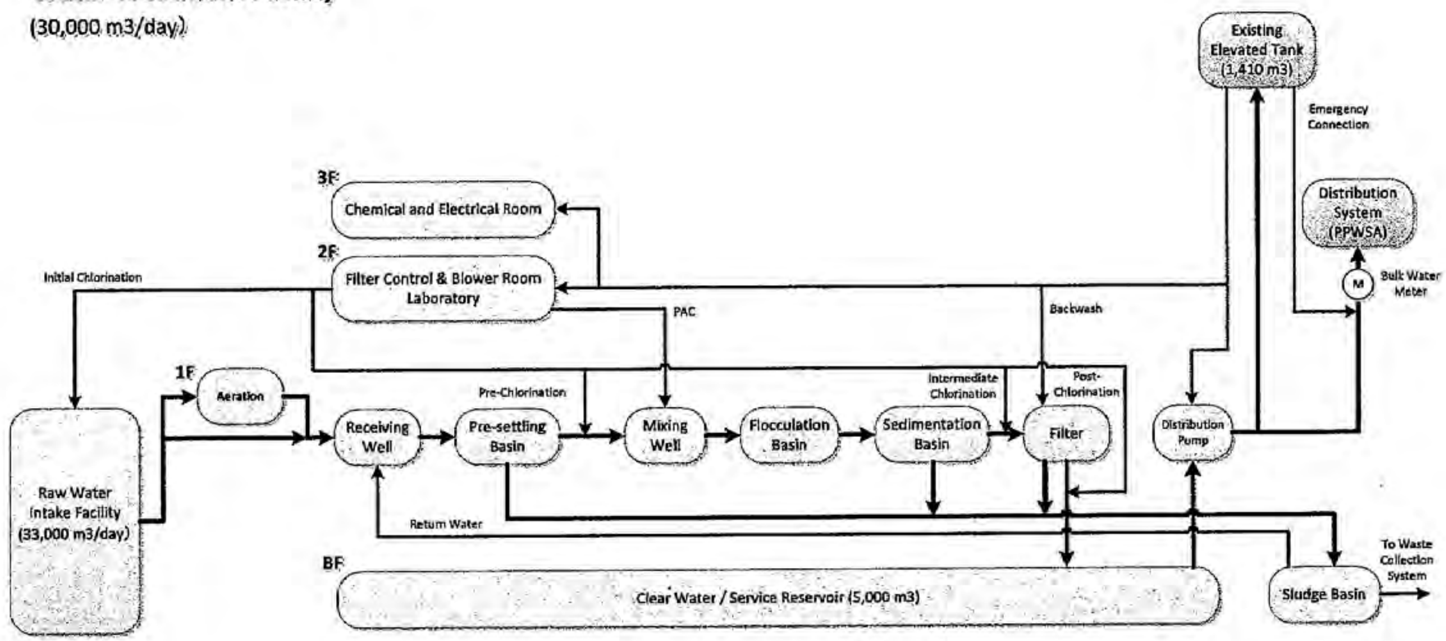
Annex 7

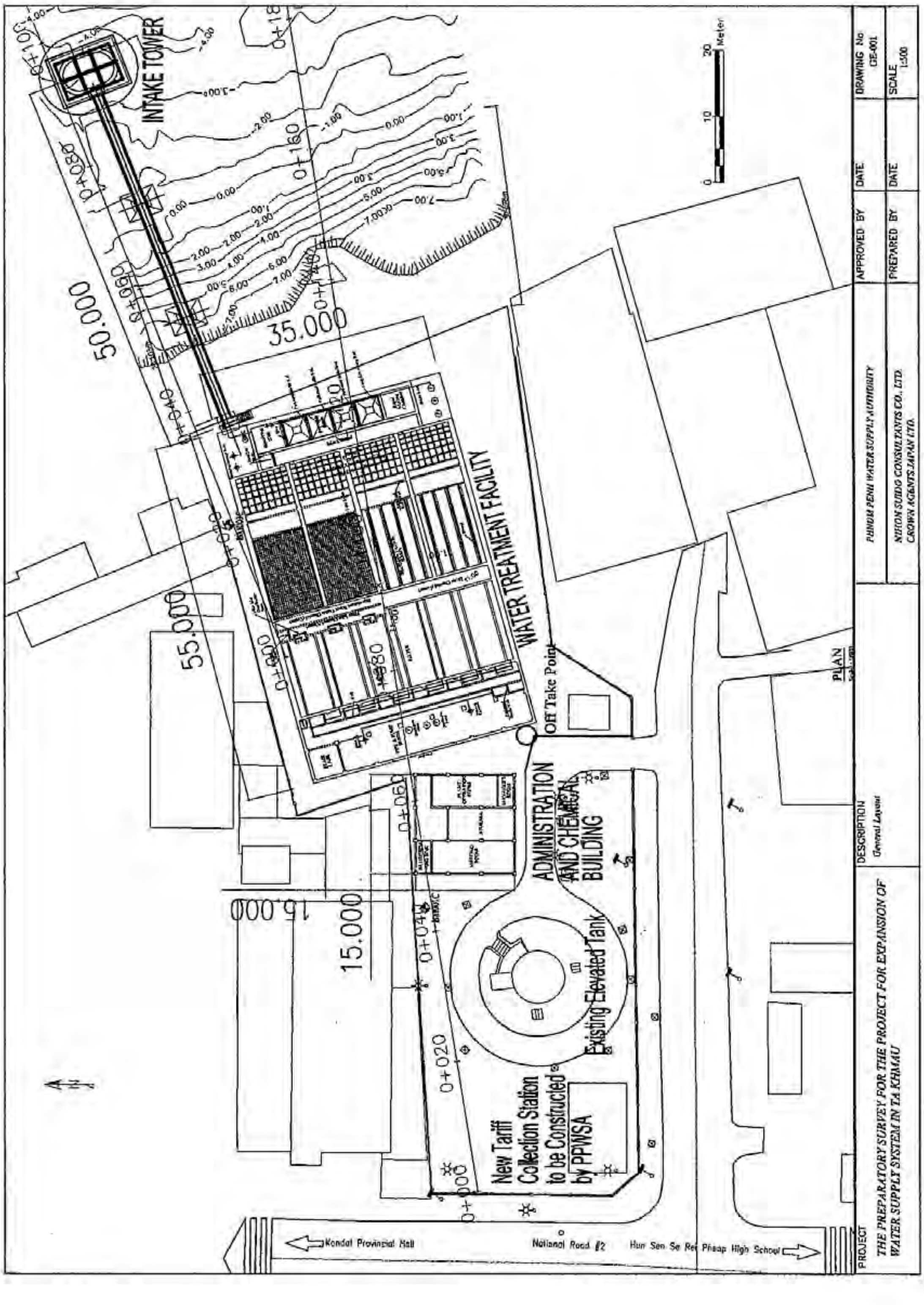
Ta Khmau WTP

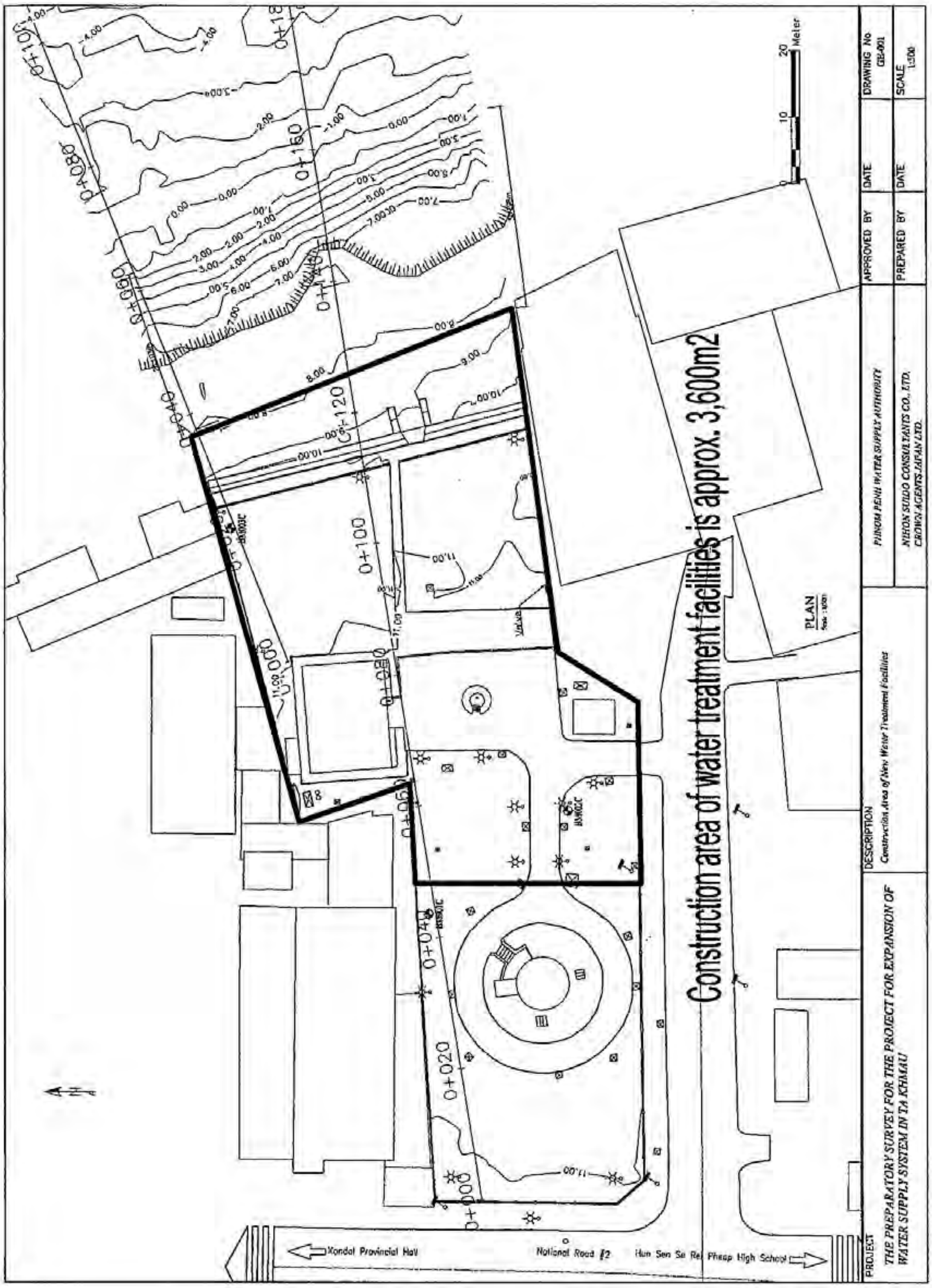
Treatment Process

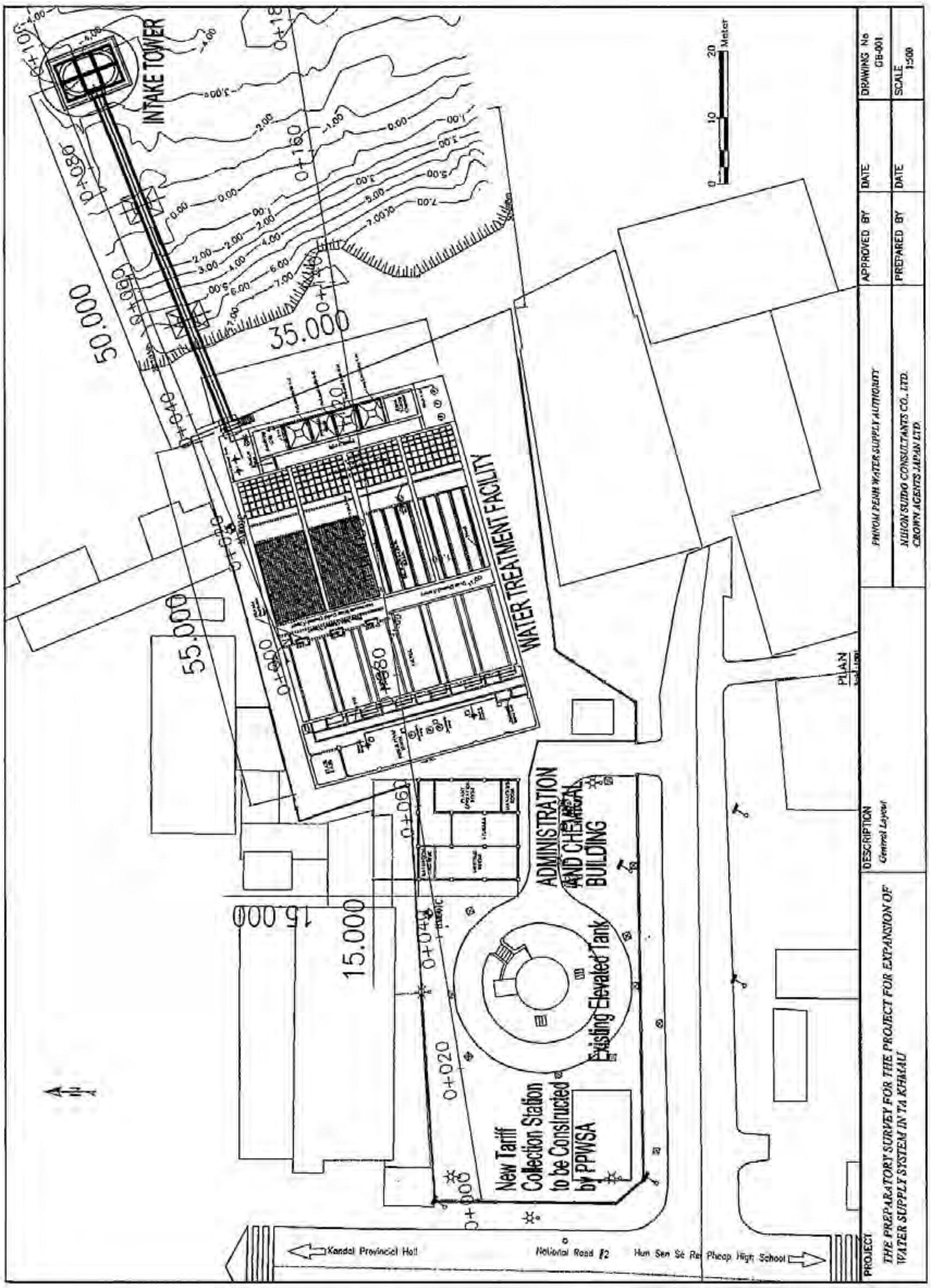
Water Treatment Facility

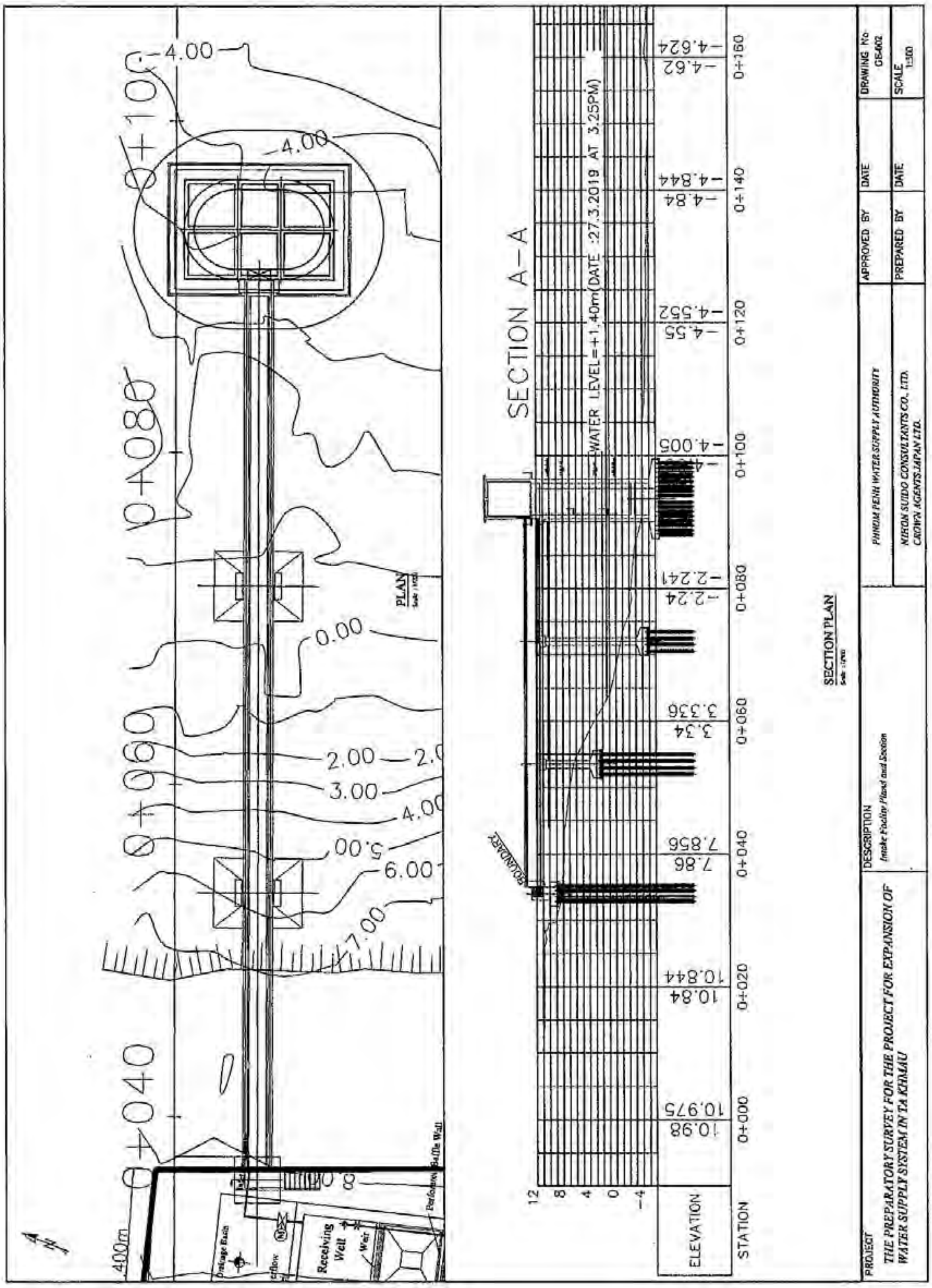
(30,000 m3/day)




INTAKE TOWER
WATER TREATMENT FACILITY
Off Take Point
ADMINISTRATION AND CHEMICAL BUILDING
Existing Elevated Tank
New Tariff Collection Station to be Constructed by PPWSA
Kondal Provincial Hall
National Road #2
Hun Sen Se Re Phsap High School
PLAN
PROJECT
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU
DESCRIPTION
General Layout
PHNOM PENH WATER SUPPLY AUTHORITY
NIHON SUIDO CONSULTANTS CO., LTD.
CROWN AGENTS JAPAN LTD.
APPROVED BY
PREPARED BY
DATE
DRAWING No.
GE-001
SCALE
1:500

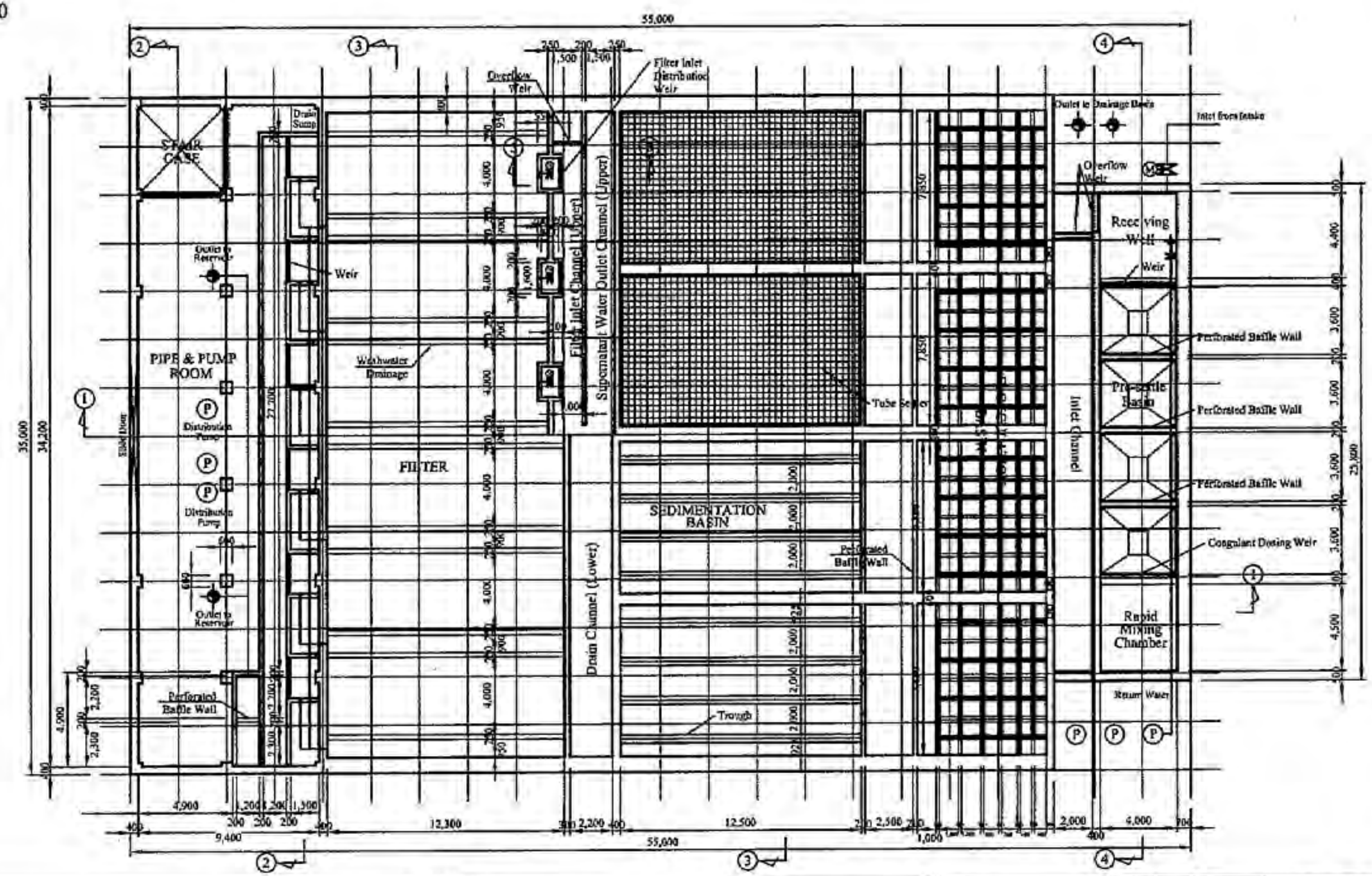

Construction area of water treatment facilities is approx. 3,600m2
PLAN
Valve
0 10 20 Meter
Kandal Provincial Hall
National Road #2
Hun Sen Se Re Pheap High School
PROJECT
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU
DESCRIPTION
Construction Area of New Water Treatment Facilities
PHNOM PENH WATER SUPPLY AUTHORITY
NIHON SUIDO CONSULTANTS CO., LTD.
CROWN AGENTS JAPAN LTD.
APPROVED BY
DATE
PREPARED BY
DATE
DRAWING No.
SCALE
1:500


INTAKE TOWER
WATER TREATMENT FACILITY
ADMINISTRATION AND CHEMICAL BUILDING
Existing Elevated Tank
New Tariff Collection Station to be Constructed by PPWSA
50.000
35.000
55.000
15.000
PLAN
Kandal Provincial Hall
National Road #2
Hun Sen Sa Re Pheap High School
PROJECT
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU
DESCRIPTION
General Layout
PHNOM PENH WATER SUPPLY AUTHORITY
NIHON SUIDO CONSULTANTS CO., LTD.
CROWN AGENTS JAPAN LTD.
APPROVED BY
PREPARED BY
DATE
DRAWING No
GB-001
SCALE
1:500
Meter

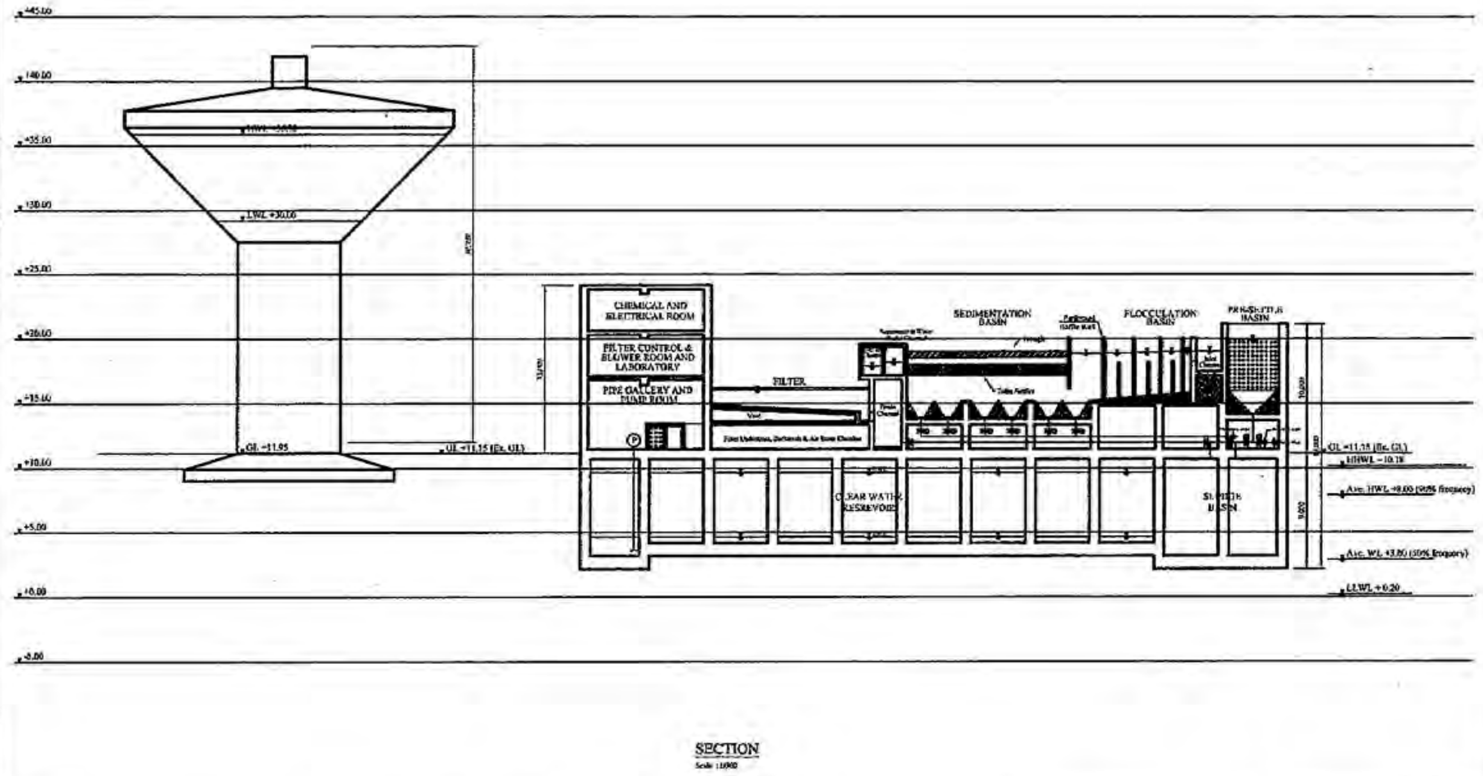

SECTION A–A
WATER LEVEL=+1.40m(DATE :27.3.2019 AT 3.25PM)
PLAN
SECTION PLAN
ELEVATION
STATION
0+000
0+020
0+040
0+060
0+080
0+100
0+120
0+140
0+160
10.98
10.975
10.84
10.844
7.86
7.856
3.34
3.336
-2.24
-2.241
-4.005
-4.55
-4.552
-4.84
-4.844
-4.62
-4.624
Receiving Well
PROJECT
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU
DESCRIPTION
Intake Facility Plant and Section
PHNOM PENH WATER SUPPLY AUTHORITY
NIHON SUIDO CONSULTANTS CO., LTD.
CROWN AGENTS JAPAN LTD.
APPROVED BY
PREPARED BY
DATE
DRAWING No.
SCALE

WATER TREATMENT FACILITY
Receiving Well, Pre-settle Basing, Rapid Mixing Chamber,
Flocculation Basin, Sedimentation Basin, Filter and Pipe & Pump Room
GF
S=1:200

PLAN

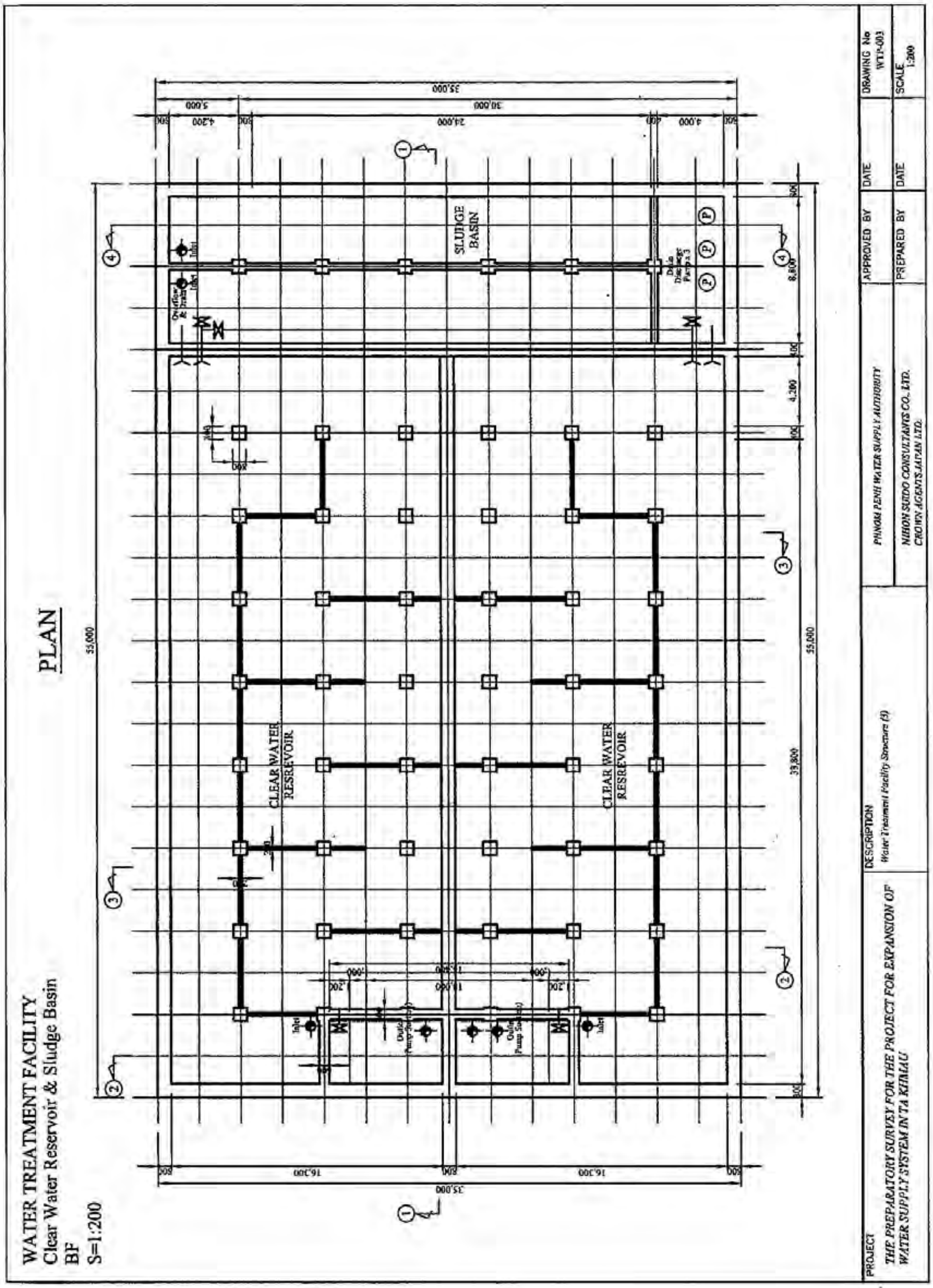


PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU	Water Treatment Facility Structure (1)	PHNOM PENH WATER SUPPLY AUTHORITY			WTP-001
		NIHON SUIDO CONSULTANTS CO., LTD. CROWN AGENTS JAPAN LTD.	PREPARED BY	DATE	SCALE 1:200



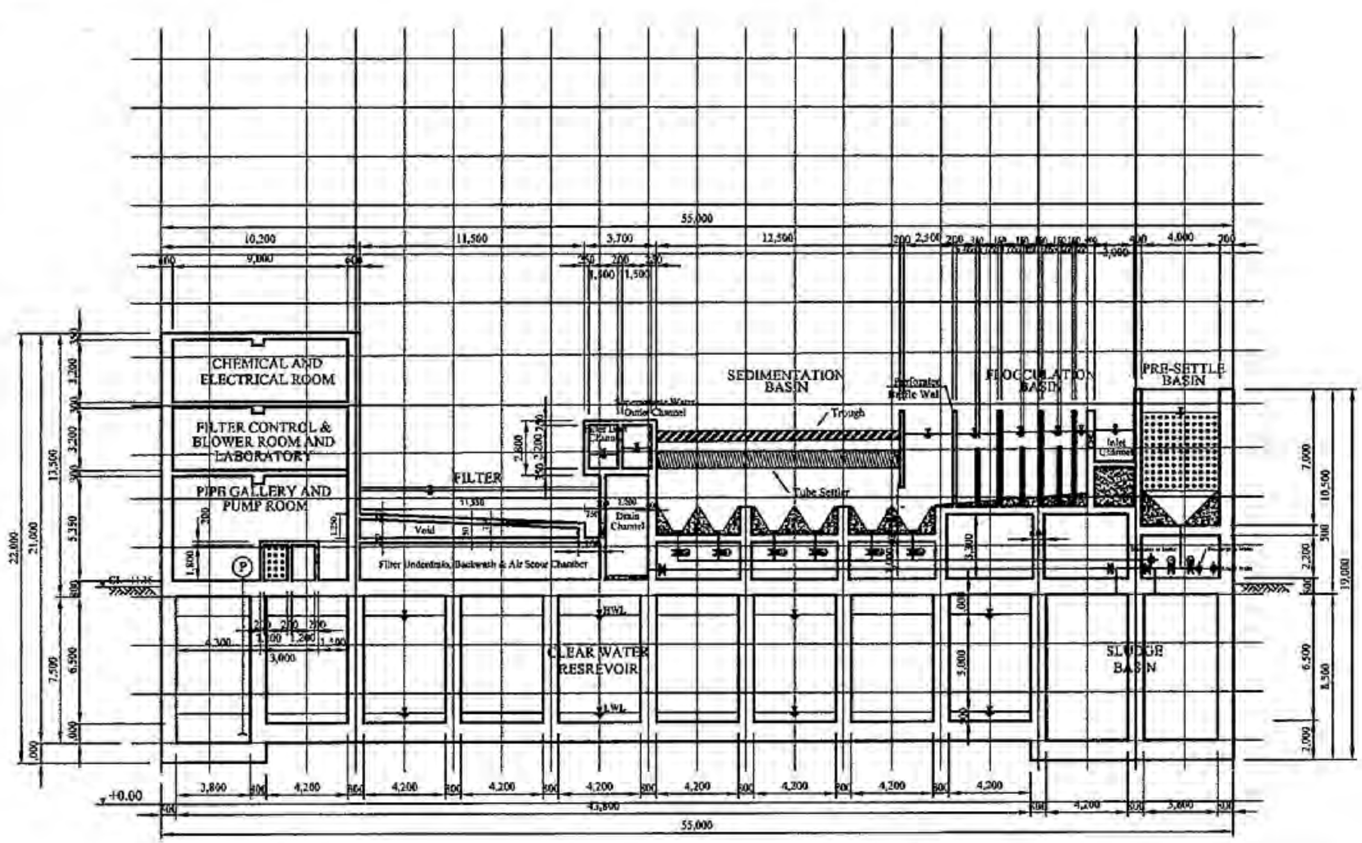
SECTION

PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU	Water Treatment Facility Structure (2)	PHNOM PENH WATER SUPPLY AUTHORITY			WTP-002
		NIHON SUIDO CONSULTANTS CO., LTD. CROWN AGENTS JAPAN LTD.	PREPARED BY	DATE	SCALE 1:300


WATER TREATMENT FACILITY
Clear Water Reservoir & Sludge Basin
BF
S=1:200
PLAN
CLEAR WATER RESREVOIR
CLEAR WATER RESREVOIR
SLUDGE BASIN
PROJECT
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU
DESCRIPTION
Water Treatment Facility Structure (5)
PHNOM PENH WATER SUPPLY AUTHORITY
NIHON SUIDO CONSULTANTS CO., LTD.
CROWN AGENTS JAPAN LTD.
APPROVED BY
DATE
PREPARED BY
DATE
DRAWING No
WTP-003
SCALE
1:200

WATER TREATMENT FACILITY
General Section
S=1:200

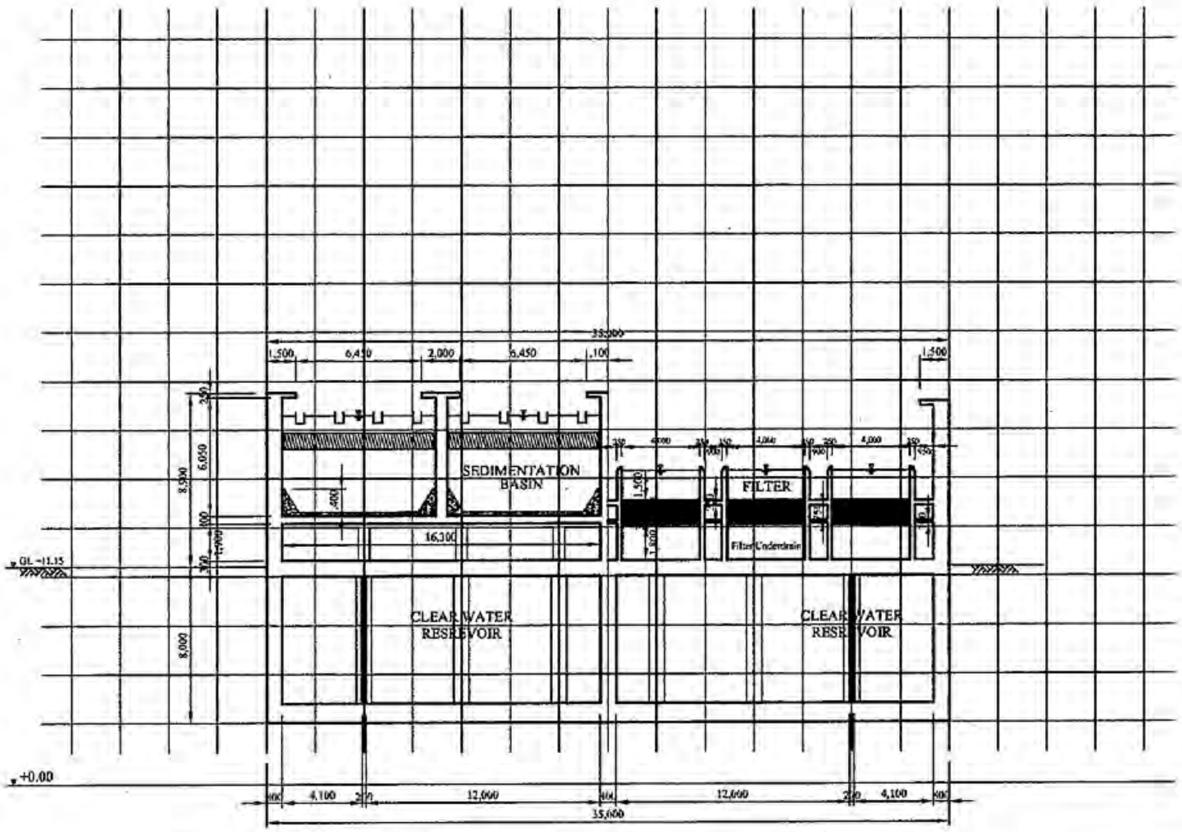
GENERAL SECTION 1-1



PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU	Water Treatment Facility Structure (4)	PHNOM PENH WATER SUPPLY AUTHORITY			WTP-004
		NIHON SUIDO CONSULTANTS CO., LTD. CROWN AGENTS JAPAN LTD.	PREPARED BY	DATE	SCALE 1:200

WATER TREATMENT FACILITY
Section
S=1:200

SECTION 3-3



PROJECT	DESCRIPTION		APPROVED BY	DATE	DRAWING No
THE PREPARATORY SURVEY FOR THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU	*Water Treatment Facility Structure (5)*	*PHNOM PENH WATER SUPPLY AUTHORITY*			WTP-005
		NIHON SUIDO CONSULTANTS CO., LTD. CROWN AGENTS JAPAN LTD.	PREPARED BY	DATE	SCALE 1:200

Document No.1 Term Sheet

THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN TA KHMAU

CONFIDENTIAL / DRAFT / DISCUSSION PURPOSE ONLY

1. Project Outline

1.1 Project Background

- The water demand in the area supplied by PPWSA is projected to be double in 2030 and capacity of existing water treatment plants (hereinafter referred to as "WTP/WTPs") in Phnom Penh will be insufficient to meet the demand in 2020.
- The New WTP shall be developed to supply the water mainly in Ta Khmau area in which many low-income households need access to clean water at affordable water tariff and neighbor Phnom Penh areas where PPWSA develops water distribution system.
- The Government of Cambodia requested to the Government of Japan for the funds to implement the project for expansion of water supply system in Ta Khmau.

1.2 Project Objectives

The objective of the Project is to improve the access to safe water in Ta Khmau District through the expansion of water supply system including construction, operation and maintenance (hereinafter referred to as "O&M") of the new WTP.

1.3 Project Structure

The Project would be implemented by applying the Japanese Grant Aid with O&M, whose outline is explained in Annex 3 of Minutes of Discussions on the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau dated 29th March 2019 in particular;

- PPWSA will be the executing agency and the implementing agency for the Project.
- The Japanese Grant Aid shall be used for construction of the facilities and procurement of equipment necessary for the Project, and the consulting service to be assigned to consultants.
- A Japanese company or a joint venture of Japanese companies will be selected through a competitive tender and establish a Special Purpose Company (SPC) in Cambodia that shall be responsible for the design, construction, and O&M of the new WTP consistently,
- Contracts consist (a) comprehensive contract which consolidates both contracts for the purchase of the products and/or services and for the operation and maintenance, (b) contract(s) for the purchase of products and/or services and (c) contract(s) for the operation and maintenance, and
- The Government of Cambodia shall ensure that customs duties, internal taxes and other

fiscal levies which may be imposed in the Government of Cambodia with respect to the purchase of the products and/or the services be exempted or be borne by its designated authority without using the Grant and its accrued interest.

1.4 Project Site

The construction site of the new WTP is located in Ta Khmau District, which is shown in Annex 1 of Minutes of Discussions on the Preparatory Survey for the Project for Expansion of Water Supply System in Ta Khmau dated 29th March 2019.

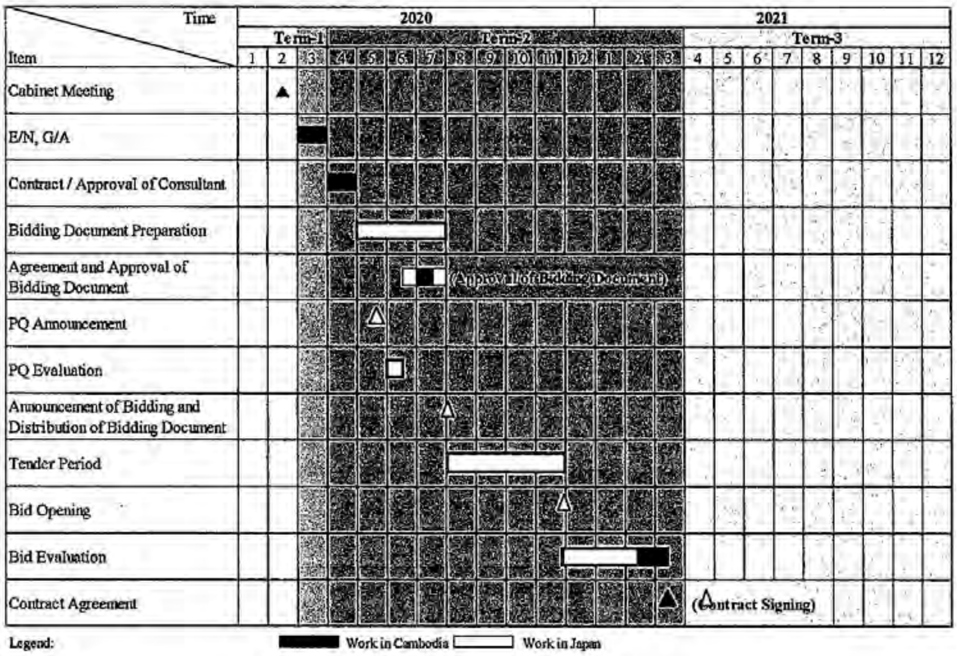
1.5 Risk Allocations

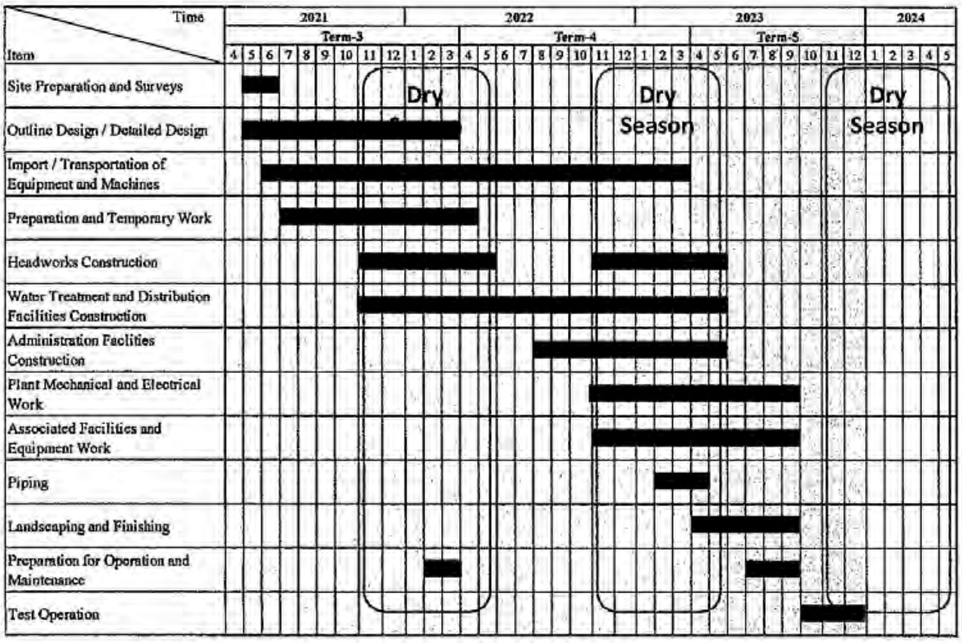
Risks	PPWSA	SPC	Remarks/Examples
Risks related to EPC contract			
EPC risk	O	O	- **Any additional costs caused by PPWSA shall be borne by PPWSA (e.g. variation orders from PPWSA to SPC, UXO related costs)** - **Any additional costs caused by change in external conditions shall be borne by PPWSA (e.g. unforeseen ground conditions, major inflation during construction period). These costs may be covered by the amount of the grant for contingency mentioned in the Grant Agreement which is applicable according to the JICA guideline.** - **Any additional costs caused by SPC shall be borne by SPC (e.g. design deficiency, inflation during construction period).**
Force majeure risk at the facility construction stage	O		A Force Majeure is an event that is external, unpredictable, and irresistible and has a significant impact on the project. However, if a Force Majeure occurred during the facility construction stage, such cost shall be borne by PPWSA. (However, such compensation amount will be within the JICA's contingency budget.)
Risks related to O&M contract			
Demand risk	O		**PPWSA shall pay for 30,000m3/day of treated water if SPC provides or is ready to provide 30,000m3/day of treated water that satisfies the required water quality on a monthly average, regardless of any reason on**

			PPWSA side (e.g. demand stays low or distribution pipes get damaged).
Operation risk		O	No payment shall be made if the delivered water does not satisfy the water quality requirement due to poor operation by SPC (e.g. facility malfunction, inappropriate usage of water treatment chemicals etc.). In case the water delivered by SPC does not comply with national drinking water standards required by PPWSA, SPC shall compensate for any damage (e.g. compensation to end-customers) suffered by PPWSA as a result of such poor operation by SPC.
Electricity price risk	O		Any fluctuations in electricity price shall be covered by PPWSA according to the Price Formula for Bulk Water Supply.
Electricity availability risk		O	In case the electricity is not supplied to the facility due to blackout, neither SPC has obligation to supply water to PPWSA, nor PPWSA must pay SPC for the period. SPC does not have a right to claim operating loss caused by such blackout to PPWSA.
Inflation risk (during O&M period)	O	O	off-take price is reviewed and adjusted at the end of third year, sixth year and ninth year from the effective date of O&M period according to inflation fluctuation.
Foreign exchange rate risk		O	Foreign exchange rate risk associated with SPC equity and profit/dividend shall borne by SPC.
Raw water quality risk	O		Additional cost of production due to change in quality of raw water shall be covered by PPWSA and compensated to the SPC.
Licensing risk	O		IEIA/EIA or any other permit/authorization necessary for the SPC to operate the facility shall be obtained by PPWSA.
Legal risk (change of project specific law)	O		Additional cost caused by a change in law that specifically affects the project (e.g. upgrade of national quality standard for drinking water) shall be covered by PPWSA and compensated to the SPC.
Legal risk (change of general law)		O	Additional cost caused by a change in general law that would affect the whole economy (e.g. VAT) shall be covered by the SPC.
Force Majeure	O	O	A Force Majeure is an event that is external, unpredictable,

risk			and irresistible and has a significant impact on the project. Both parties may terminate the contract if the impact of a Force Majeure lasts for a certain period (based on practice of water utilities). Neither party has any obligation to each other for the cost of mitigation measures to prevent increasing loss caused by Force Majeure. PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the assets. The value of the assets shall be net book value of the assets.

1.6 Project Schedule





The schedule above is based on the Comparator facilities (the Consultants plan) and SPC may propose shorter construction duration in the tender.

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1.7 Tender Evaluation

- The prime contractor(s), namely, SPC and the prime consulting firm, which enter into contracts with PPWSA, are limited to "Japanese nationals", in principle.
- Quality and Cost Based Selection (QCBS) that includes technical, commercial, financial and legal evaluation will be applied for the bidding of SPC.

Evaluation methodology

Note: This shall be reviewed and concurred by JICA.

Comprehensive Evaluation Score = Technical Score * X + Price Score * (1-X)

where X is a weight factor 1>X>0 (In this stage the Consultants propose 0.5 as X. Please refer the separate sheet for the analysis of the weight factor X of Price score)

Tentative Technical Score

	Category	Score
1	Tenderers experience with respect to comparable projects;	TBA
2	Proposed Organization	TBA
3	Experience of key staff in relation to the scope of work;	TBA
4	Proposed design by SPC for bidding	TBA
5	Construction Work Plan	TBA
6	Operation and Maintenance and Monitoring Plan	TBA
	Maximum possible score	100

Tentative Price Score

The tenderer bids on 10-year Life Cycle Cost (LCC) where

10-year LCC = EPC price + Net present value of O&M costs discounted at 4.5%

(SPC submit EPC price, 10-year average O&M Cost(α), 10-year average fixed volume of electricity usage(β), and the margin rate at bidding to calculate 10-year LCC)

Price score = Lowest Price / Price of the Tenderer * 100

Note that

(1) EPC price shall be below the Grant budget applicable to the EPC contract, and

(2) O&M cost will be reflected in the contract price of bulk water

2. Requirements

2.1 Preconditions

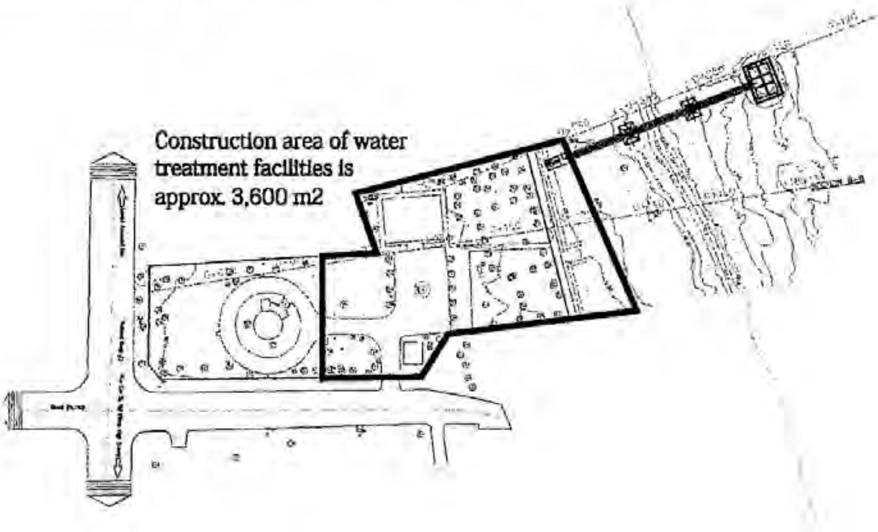
2.1.1. Construction Area

There are an existing elevated tank and a tariff collection station as major facilities within the PPWSA's property where the new WTP shall be constructed. The available construction area of water treatment facilities (WTFs) excluding headworks (intake and raw water transmission facilities) is approximately 3,600 m2.

Headworks shall be constructed in the river outside of PPWSA's property.

There is unleveled land along the river that are PPWSA's property but outside of existing fence. This area could be leveled as part of SPC's EPC work.

Existing tariff collection station shall be shifted to outside of construction area by PPWSA before commencement of the design-build work.



The site area is limited therefore, stockyard, workshop, temporary office etc. required for the constriction shall be provided by PPWSA.

Topographic and geotechnical features will be provided to SPC by PPWSA in later stage.

2.1.2. Raw Water Quality

7

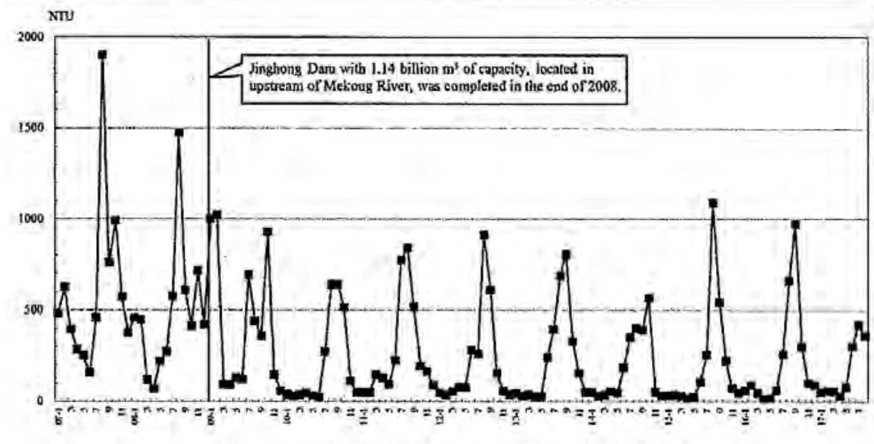
Raw water source shall be Bassac River.

The raw water quality recorded at intake of Chamcar Mon WTP located at upstream of Ta Khmau site along Bassasc River during 2009-2017 after Jinghong dam was commenced operation in 2008 shows following characteristics.

- Turbidities are quite different in dry season and wet season. Minimum turbidity in dry season was 7NTU, average turbidity in wet season is 250 NTU and maximum turbidity was 1088NTU.
- pH is generally high in wet season and low in dry season, average pH is 7.4, Minimum pH was 6.7.
- Color is a bit high, average color is approximately 30TCU.
- Average Ammonium (MH4) is approximately 0.5mg/l in wet season and approximately 0.2mg/l in dry season. However Ammonium (NH4) has been on the rise from 2016 and maximum was 1.81.

Followings are summary of raw water turbidity at intake of Chamcar Mon WTP during 2009-2016.

- Average Turbidity in Dry Season: 40NTU
- Average Turbidity in Wet Season: 245NTU
- Average Turbidity over 8 years: 115NTU
- Maximum Turbidity over 8 years: 1088NTU
- Minimum Turbidity over 8 years: 7NTU



Turbidity Fluctuation of Raw Water in Chamcar Mon WTP (2007 to 2017, Monthly Max.)

The result of monthly raw water quality analysis of March-May 2017 at intake location of Ta Khumau Site carried out under our Survey will be provided separately.

Emergency Response against Unexpected Raw Water Quality

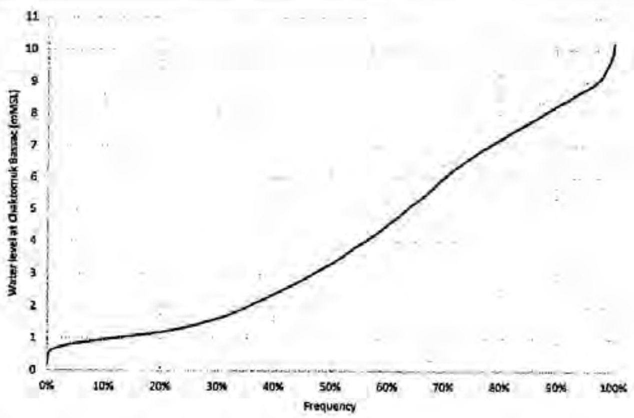
a) In case turbidity becomes higher than 1000NTU, intake amount shall follow PPWSA's instruction as same as other PPWSA's treatment plants.

b) In case serious issue (such as toxic substance or oil discharge) happens, SPC can autonomously reduce or stop intake operation to avoid serious damage on WTP facilities and contaminated water supply to customers, and report to and discuss with PPWSA as soon as possible.

If above restricted intake conditions continue until remaining water in the service reservoir is empty, both parties do not have responsibilities to suspend water supply.

2.1.3. Water Level of Bassac River

The feasibility study for expansion of Chamca Mon WTP gives minimum river water level and maximum river water level, as MSL+0.20m and MSL+10.28m respectively as shown below.



Based on these elements, the extreme levels for the 55 last years are as follows:

- ✓ Minimum Level : 0,20 m MSL (04/05/1960)
- ✓ Maximum Level : 10,18 m MSL (20/09/2000)

2.2. Output requirements

2.2.1. Requirement for the Facilities

2.2.1.1. Requirement of Treated Water Quantity

Water Treatment Capacity of nominal 30,000 m3/day.

2.2.1.2. Laboratory for water quality test in WTP

The layout and equipment of the laboratory attached to WTP should be in accordance with ISO9001 and ISO17025. The laboratory in WTP should be equipped with enough equipment to analyze daily test items in the National Drinking Water Quality Standards.

2.2.1.3. Intake Type

Intake facility shall be intake tower type.

2.2.1.4. Disinfection

Disinfection shall be by On-Site Electro-Chlorination System (OSEC System).

2.2.2. Requirements for the Operation

- WTP capacity of nominal 30,000m^3/day
- 10 years O&M period
- Intake tower type
- On-site chlorination system
- Volume of service reservoir of 5,000 m^3 or more
- Pressure of 4 bar at off-take point
- 24 hours supply
- Water quality standards described in Annex 13
- O&M manual in both Khmer Language and English
- Prevention against adhesion of shell inside raw water transmission pipe
- 5 % of production loss ratio from intake to the bulk meter
- prevention of oil inflow into the WTP

2.3. Work to be done by SPC

SPC shall work for followings.

1. Design of New WTP
   - (a) Basic Design
   - (b) Detailed Design
   - (c) Application Work for Design
   - (d) Laws and Regulations to be complied.
2. Construction of New WTP
   - (a) Civil and Equipment Works
   - (b) Plant Mechanical Work
   - (c) Plan Electrical Work
   - (d) Application Work for Construction
3. Operation and Maintenance of New WTP
   - (a) Water Quality Control
   - (b) Treated Water Volume Control in case required by PPWSA
   - (c) Monitoring and Control of Water Treatment
   - (d) Maintenance and Repair
   - (e) Procurement of Fuel, Chemical and Other Consumables

(f) Management of Power Receiving, Water Use and Fuel / Chemical Storage and Safety
(g) Cleaning
(h) Security and Safety
(i) Emergency Action

4. Hand-Over Work at the End of the O&M period
(a) Performance Test of WTP
(b) Asset Check and Evaluation

2.4. Cost to be borne by SPC

Following cost shall be borne by SPC.

Design and Build Stage:

(a) Head office over-head cost related to construction work

Operation Stage

(b) Head Office over-head cost related to the operation and maintenance work
(c) Any other cost which is not directly related with operation of the new WTP

2.5. Reporting Obligations

Following submittals shall be provided by SPC. Detail shall be provided in later stage

(a) At the time of work commencement
 (i) Work commencement application
 (ii) Design, Construction and Operation Plan
 (iii) Organization structure for the operation
(b) Design and Build period
 (i) Report related to construction works including progress record
 (ii) Draft of Operation and Maintenance Manual
 (iii) Draft of Self-monitoring Report
 (iv) Modification and additional work confirmation report
 (v) Commissioning reports
(c) At the time of hand-over
 (i) Completion report or substantial completion certificate and list of outstanding works
 (ii) Final operation and maintenance manual
 (iii) Final self-monitoring reports template
(d) During operation period
 (i) Monthly report including self-monitoring report
(e) At the time of hand-back
 (i) Performance check list of the facilities.
 (ii) Remaining book value calculation and confirmation sheet.
 (iii) Purchase agreement of SPC's facilities, if any.
 (iv) Letter of Waiver of claims and liens and release of rights relating this project from PPWSA

to SPC.

(f) At the time of Expiration of warranty against defect period

(i) Report on Expiration of Warranty against Defect Period

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3. Contract Terms

Draft O&M contract shall be prepared based on the following items. Draft EPC contract shall be prepared separately in accordance with JICA's standard form of contract.

1	**O&M period**	After the completion of the new WTP, the ownership of the WTP will be transferred from SPC to PPWSA, then PPWSA and SPC will agree the O&M contract for 10 years after commencement (definition is to be agreed) of O&M on the facilities owned by PPWSA.
2	**Production of bulk water**	Production of bulk water is fundamentally a responsibility of the SPC.
3	**Payment mechanism and price of bulk water**	On a separate sheet
4	**Repairment**	During O&M period, SPC may use leased facilities free of charge, however, the SPC shall be responsible for any repairment of the facilities at its own cost. SPC shall keep good conditions of the facility and equipment in accordance with PPWSA's Standard Operation Procedure (SOP).
5	**Conditions for the hand-back**	- After the end of O&M period, PPWSA has the right to be handed back the leased WTP facilities from the SPC under certain requirements (e.g. the result of the motor vibration test is within 5% of initial specification). - The SPC shall remove any additional facilities or equipment installed for its operation and restore the WTP to its initial condition at its own cost, if required by PPWSA. - PPWSA has the right to purchase any remaining inventories (e.g. raw materials) at their book value.
6	**Private investment**	The SPC may invest in some additional facilities, software, or any other equipment necessary for the operations. PPWSA has the right to purchase the private investments from the SPC at their residual value (net book value) at the end of O&M period.
7	**Self-monitoring**	SPC shall monitor and report to PPWSA its operation. Monitoring requirements shall be studied.
8	**Operation data and financial information**	The SPC shall record and report all the operation data and financial information in a required format. PPWSA may utilize the data to continue operation of the WTP after hand-back.
9	**Early termination / compensation events**	- Termination for convenience (Unilateral termination) PPWSA has the right to terminate the contract early for public

		interest. In this case the SPC shall be compensated in full, for all the private investments, inventories and additional costs incurred by the termination of the contract, and opportunity costs for the equity. Opportunity costs for the equity shall be a sum of net profit for the remaining contract period based on the SPC's initial financial plan initially agreed in the contract. - Termination for default by PPWSA The termination condition shall be in line with the case of the termination for convenience. - Termination for default by SPC PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the assets and inventories. The value of the assets and inventories shall be net book value of the assets minus cost of damages and losses suffered by PPWSA due to the termination of the contract. - Termination for Force Majeure A Force Majeure is an event that is external, unpredictable, and irresistible and has a significant impact on the project. Both parties may terminate the contract if the impact of a Force Majeure lasts for 180 days. Neither party has any obligation to each other for the cost of mitigation measures to prevent increasing loss caused by Force Majeure. PPWSA shall have the option to require SPC to transfer to PPWSA all of its right, title and interest in and to the assets and inventories. The value of the assets and inventories shall be net book value of the assets.
10	**Invoice settlement**	SPC shall report and charge to PPWSA by the 10th day of each month for the bulk water produced in the previous month. PPWSA shall in return review the invoice and make payment within 30 days after the invoice receiving date. Currency to be used for the invoice settlement shall be Cambodian Riel.
11	**Staff Employment**	1) PPWSA shall take over the employment contracts from the SPC at the end of O&M period. 2) PPWSA intends to dispatch about 5 staff to SPC and bear their salary. PPWSA staff shall report to SPC in daily operation. Relative salaries shall be subtracted from the off-take price.

Payment mechanism – Price Formula for Bulk Water Supply

In the bidding documents, SPC shall submit EPC price, 10-year average O&M Cost(α), 10-year average fixed volume of electricity usage(β), and the margin rate at bidding to calculate 10-year LCC

SPC Invoice (PPWSA payment to SPC) = (1) sales of bulk water + (2) additional services – (3) penalties

(1) Sales of bulk water = (4) volume of water delivered * (5) unit price of bulk water

(4) volume of water delivered shall be confirmed by a volume meter just after distribution pump

(5) Unit price of bulk water = α * (6) inflation index + β * (7) electricity price
+ (8) additional production costs + (9) agreed margin for SPC

α is a fixed (agreed) basis for O&M costs excluding electricity defined in the contract

(6) Inflation index shall be All Item Index of Consumer Price Index published by National Institute of Statistics.

β is a fixed (agreed) volume of electricity usage per m3 defined in the contract

(7) Electricity price shall be the price determined in the contract between PPWSA and the electricity supplier.

(8) applies if and only if quality deterioration of raw water or change in water quality standard cause additional production costs.

(9) = agreed margin rate * (α * (6) + β * (7) + (8))

Agreed margin rate is a fixed (agreed) rate defined in the contract

(2) Additional services include deeper analysis of water quality or site visit tour or any other services that are not included in the ordinary O&M activities defined in the contract.

(3) In case the water delivered by SPC does not comply with required water quality, PPWSA will not pay for the delivered water by SPC. In addition, SPC shall compensate for any damage (e.g. compensation to end-customers) suffered by PPWSA as a result of the such poor operation of SPC.

Insurance or limited liability

In the private hearing carried out in Aug-Oct by JICA, we found that most of the private companies responded that **they would need Company Comprehensive Insurance to cover the facilities and third party compensation during O&M**.

This is the reasonable requirements from the tender participants because following cases could be happned.

1) Electrical leakage may cause fire, and such fire may damages monitoring system and electrical equipment.
2) Equipments could be soaked and damabed by the water of fire fighting activities
3) Visitors may be injured during their site visit; this project will be a model case of privately operated water purification plant, so a lot of plant visitors may be expected to come.

In actual situation, PPWSA does not use insurance, however no other third parties are involved in the operation, so any damage caused by any accident will be repaired or compensated by PPWSA.

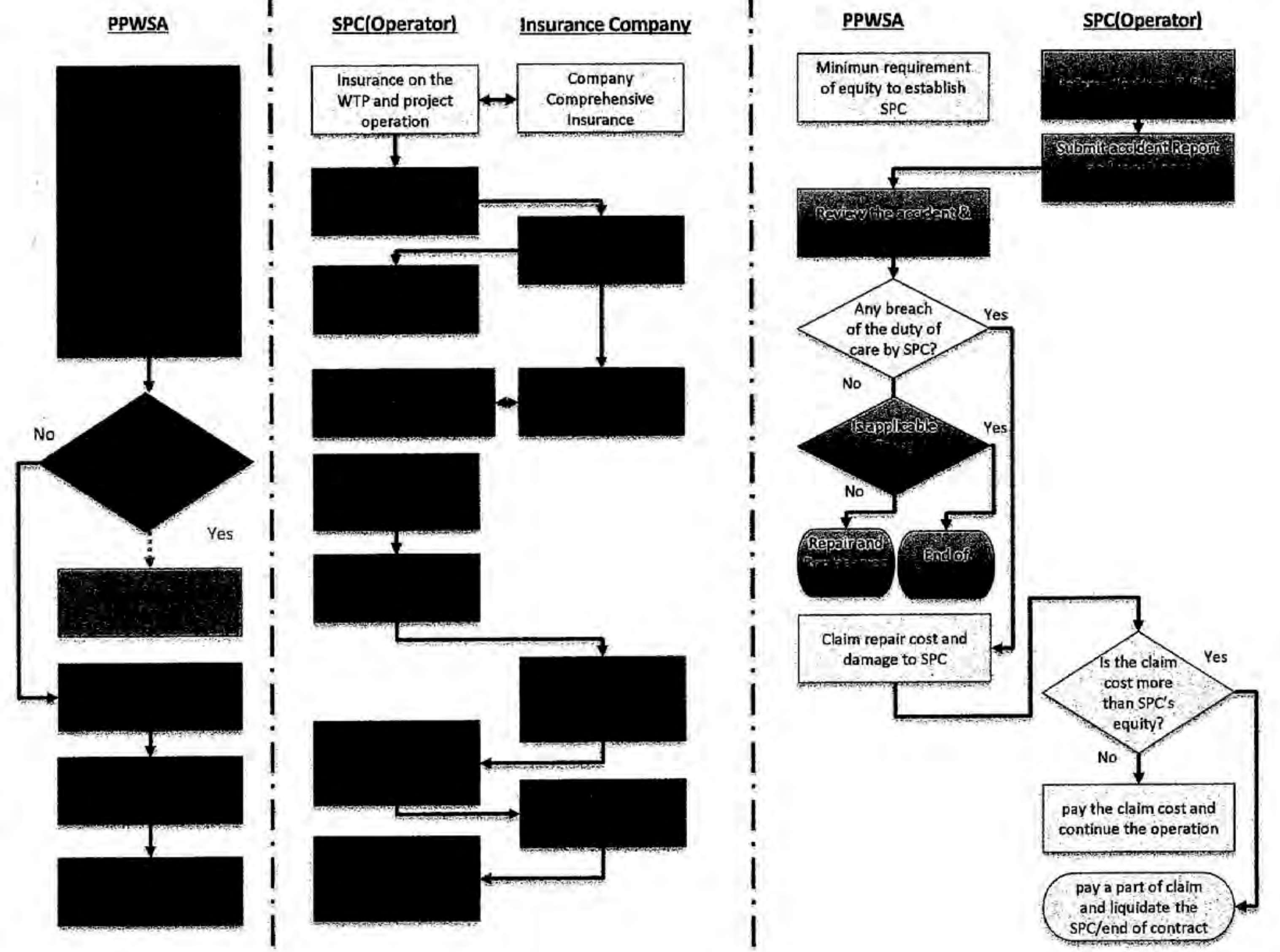
However once the outsouce the WTP operation to other company(SPC), such company must have an obligation of the duty of care on their operation.

In order to assure competitive bidding and to avoid "no participants to the tender", we need to modify the contract terms.

We propose either;

1. PPWSA accepts to include insurance cost in the price of bulk water, or
2. PPWSA accepts that SPC will compensate the damage to the facilities or third party liabilities only to the extent of its equity whether or not it is caused by SPC's breach of the duty of care or Force Majeure.

Actual Operation | **Recommendation 1: Insurance Coverage** | **Recommendation 2: Small equity and limited liability**



Recommendation 1: Insurance Coverage

According to our research on the insurance cost, it will be USD38,500~79,000/year, or KHR15.5~31.7/m3 as additional bulk water charge. Risk category will be assessed by insurance company, and accident prevention system may reduce the risk of the project and modify the risk category.

risk category	Insurance Value (USD)	Insurance USD/year	m3/year	USD/m3	Riel/m3
low risk	27,270,000	38,500	10,950,000	0.003516	15.5
high risk	27,270,000	79,000	10,950,000	0.007215	31.7

Source: Estimation of Cambodian Insurance company, Forte Insurance

Recommendation 2: Small equity and limited liability

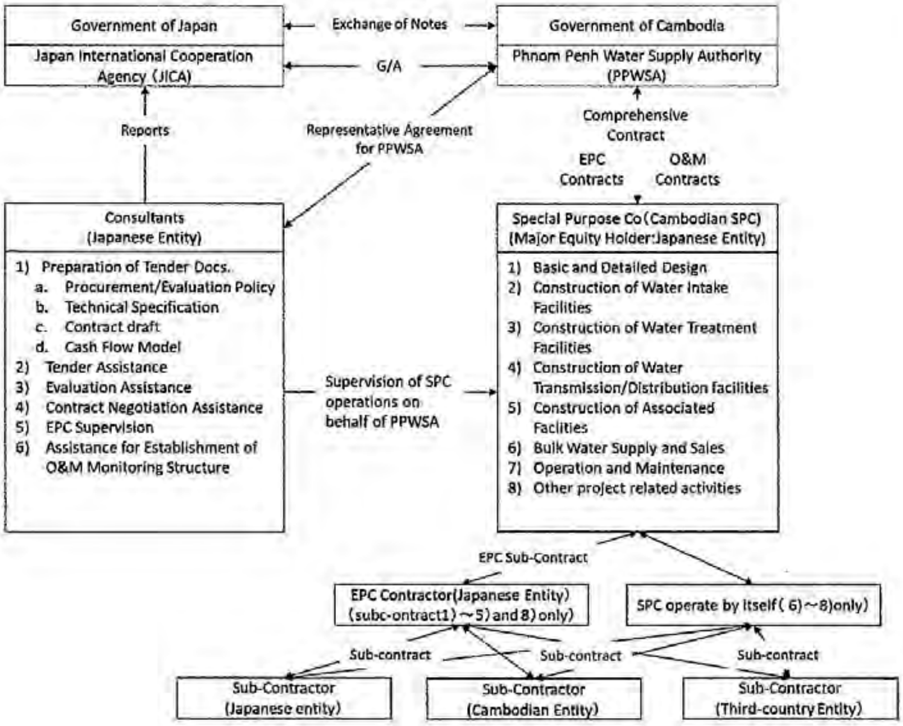
1) SPC will take limited guarantee

PPWSA accepts that SPC will compensate the damage to the facilities or third party liabilities only to the extent of its equity whether or not it is caused by SPC's breach of the duty of care or Force Majeure.

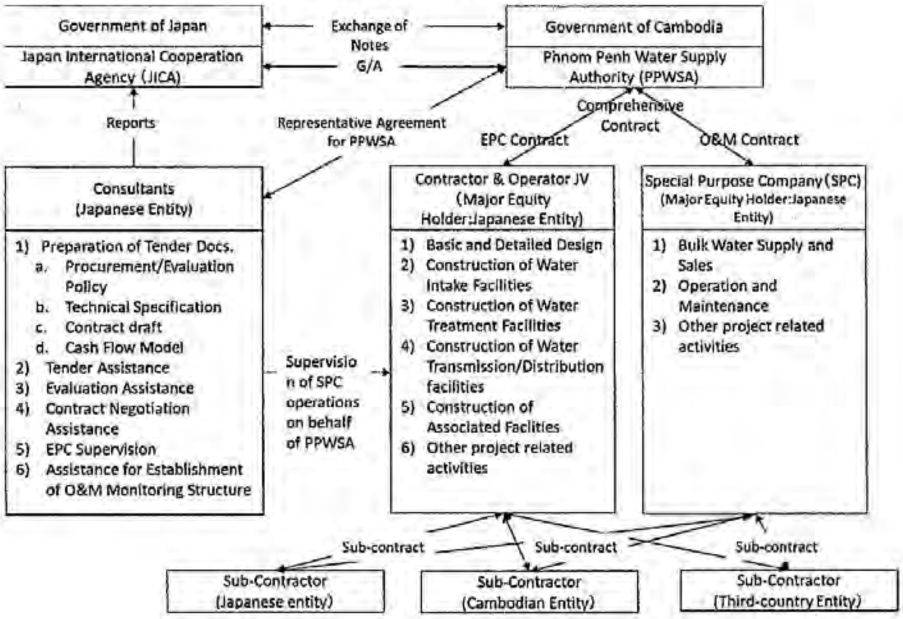
2) Minimum equity contribution required to SPC

When we draft tender documents, we have to decide minimum equity contribution, for example, a working capital for 3 months of operation gives about JPY30,000,000. or USD272,700.- this is equivalent to 1% of total value of construction.

Option A (local SPC for EPC and O&M)



Option B (Consortium for EPC+ local SPC for O&M)



1. Governing law of disputes and lawsuit and contracts

According to the procedure for preparing the contract for JICA grant aid, the disputes and lawsuit and governing law of contracts are as follows.

> 17. Dispute and lawsuit
>
> Following procedure shall be indicated; Firstly, try to settle problems, and if they cannot be resolved with the best effort, then necessary procedures can be taken thorough an international arbitration institution such as the Japan Commercial Arbitration Association (JCAA) or the International Chamber of Commerce (ICC).
>
> 18. Contract law
>
> Consult with the client to determine the country of the contract law.

Since the general grant aid is only for the facility construction, and the funds for facility construction payments are secured, no disputes or lawsuit related to the loss of the procurement agent are envisaged. Even if the governing law is Japanese law, the Cambodian government (the beneficiary government) may accept it.

However, considering the signing of O&M and bulk water sales contracts with the responsibility to pay for the purchase of bulk water, including facility maintenance and operation costs, Cambodia law will be required as applicable governing law of the contract.

The situation in Cambodia regarding litigation and arbitration is as follows.

• In 1960, Cambodia joined the New York Convention (the Convention on the Approval and Enforcement of Foreign Arbitration Judgments), but the law on the implementation of the New York Convention was enacted in 2001.

• The Arbitration Law was enacted in May 2006, and the Civil Procedure Law was enacted in July.

• Although the National Commercial Arbitration Center (NCAC) was established in the same year, the official operation of NCAC started in January 2013. In July 2014, the NCAC internal rules and NCAC rules were established at the first general meeting. Although it has been adopted, there are not many cases where NCAC is selected as an arbitration institution because not many days has passed after the establishment.

The following six international arbitration institutions will be alternatives to select:

1. **ICC (International Court of Arbitration)**
   Handles more than 21,900 arbitration cases since its establishment in 1923 (in recent years, about 1,000 cases per year). It has offices in Afghanistan, Australia, Bangladesh, China, Taiwan, Hong Kong, India, Indonesia, Japan, Korea, Macau, Malaysia, New Zealand, Pakistan, Philippines, Singapore, Sri Lanka and Thailand.
2. **The London Court of International Arbitration(LCIA)**
   Established in 1892. It is said that over 80% of cases referred to LCIA include non-UK parties, but due to confidentiality laws, LCIA has not disclosed facts and statistics regarding matters to be determined. In addition to headquarters in London, there are branches in India, Dubai and Mauritius.
3. **The American Arbitration Association-International Centre for Dispute Resolution(AAA-ICDR)**
   Established in 1996. In addition to the New York headquarters, it has regional offices throughout the United States and offices in Mexico City, Singapore and Bahrain.
4. **The Hong Kong International Arbitration Centre(HKIAC)**
   Established in 1985. In addition to Hong Kong headquarters, there is a branch in Seoul. Approximately 65% of all HKIAC arbitration cases are related to international disputes. Strong in China-related projects.
5. **The Singapore International Arbitration Centre (SIAC)**
   Established in 1990. They have a strategy to be international dispute resolution center in Asia. Established Maxwell Chambers, a complex dispute settlement facility, in 2009. The facility has offices of major European and American arbitration institutions such as ICC and AAA-ICDR and law firms specializing in arbitration. There are branch offices in Singapore and Mumbai.
6. **The Japan Commercial Arbitration Association (JCAA)**
   Established in 1953. There are offices in Tokyo and Osaka, handling both domestic and international arbitration.

Although this case is grant aid, since O&M and bulk water sales in Cambodia are included in the contract, the governing law is considered to be Cambodian law, and it is unlikely that the arbitration institution will be JCAA. .

It is considered necessary for PPWSA to adopt Cambodian law as a governing law, however choosing NCAC as an arbitration institution is not the best option for both parties because NCAC has a little experience in arbitration. Considering the geographical factors of Cambodia, it would be desirable for PPWSA and private operators to choose Singapore ICC or SIAC as the applicable arbitration institution.

Table 5-1: Urban water system parameters

Items to be Analyzed and Recorded in Ta Khmau WTP	Parameter	Parameter			Exception	Formal Monitoring Examination level		
		Unit	Permissible limite			A	B	C
			National Drinking water Standard	Requirement for Ta Khmau WTP		Daily	Quarterly	Annually
	Microbial							
	E.Coli or thermoteloerant	CFU or MPN / 100 ml	0	0			B	
	Chemical							
	Aluminium (Al)	mg/l	0.2	0.2	in the case that alum is used		B	
	Ammonia (NH_3)	mg/l	1.5	1.5			B	
	Arsenic (As)	mg/l	0.05	0.05	for the case of groundwater source			C
	Barium (Ba)	mg/l	0.7	0.7				C
	Cadmium (Cd)	mg/l	0.003	0.003				C
	Chloride (Cl^-)	mg/l	250	250			B	
●	Chlorine Cl_2 * (free residual)	mg/l	0.1-1.0	0.1-1.0	for the case of using chlorine for disinfectant	A		
	Chromium (Cr)	mg/l	0.05	0.05				C

Items to be Analyzed and Recorded in Ta Khmau WTP	Parameter	Parameter			Exception	Formal Monitoring Examination level		
		Unit	Permissible limite			A	B	C
			National Drinking water Standard	Requirement for Ta Khmau WTP		Daily	Quarterly	Annually
	Copper (Cu)	mg/l	1	1	for the case that household plumbing uses copper pipes			C
	Fluoride (F)	mg/l	1.5	1.5	for the case of groundwater source			C
	Total hardness as $CaCO_3$	mg/l	300	300	For the case of groundwater source		B	
	Iron (Fe)	mg/l	0.3	0.3	case of groundwater		B	
	Lead (Pb)	mg/l	0.01	0.01				C
	Manganese (Mn)	mg/l	0.1	0.1	case of groundwater		B	
	Mercury (Hg)	mg/l	0.001	0.001				C
	Nitrate (NO_3^-)	mg/l	50	50			B	
	Nitrite (NO_2^-)	mg/l	3	3			B	
	Sodium (Na)	mg/l	250	250	case at coastal areas			C
	Sulfate ion (SO_4^{2-})	mg/l	250	250			B	
	Zinc (Zn)	mg/l	3	3				C

Items to be Analyzed and Recorded in Ta Khmau WTP	Parameter	Parameter			Exception	Formal Monitoring Examination level		
		Unit	Permissible limite: National Drinking water Standard	Permissible limite: Requirement for Ta Khmau WTP		A Daily	B Quarterly	C Annually
	Physical							
●	Colour	TCU	5	5		A		
●	pH	n/a	6.5-8.5	6.5-8.5		A		
●	TDS or Conductivity	mg/l or µS/cm	800 or 1600	800 or 1600		A		
●	Turbidity	NTU	5	1		A		
●	Taste and Odour	-	Acceptable	Acceptable		A		

*Residual chlorine must be daily analysed in production system and fortnightly (two weeks) at end points of networks (water supply system with more than 3001 connections). The number of samples is dependent on situations of end points of networks of each unit or service provider. We can analyse thermoteloerant coliform bacteria for E Coli.

**Conductivity is an acceptable alternative to TDS. The above limits assume that Conductivity is twice TDS, but this relationship should be confirmed at each site if conductivity is used.

*** Whether the analysis of taste and odour by operators is acceptable depends on users.

Source: National Drinking Water Quality Standard (MIH)

資　料 5　参考資料（収集資料リスト）

収集資料リスト

		プロジェクト ID		調査団番号			
地域	東南アジア	調査名	タクマウ上水道拡張計画準備調査	調査の種類	協力準備調査	担当部課	地球環境部水資源グループ
国名	カンボジア	配属機関名	プノンペン水道公社（PPWSA）	現地調査期間	2019/3-2020/3		

発行機関	No.	資料名	説明	形式	収集資料	専門家作成資料	JICA作成資料	言語	翻訳状況	取り扱い区分	図書館記入欄	備考
PPWSA	A-1	As built drawing of Ta Khmau	タクマウ浄水場高架水槽建設工事竣工図	電子データ PDF	○			英語				
PPWSA	A-2	PPWSA-Organization Chart	PPWSA 組織図	電子データ PDF	○			英語				
PPWSA	A-3	Existing WTP WQ	既存浄水場の水質記録	電子データ エクセル	○			英語				
PPWSA	A-4	Master Plan	マスタープラン	電子データ PDF	○			英語				
PPWSA	A-5	Production Data WTP	各浄水場の浄水量、薬品使用量、電気使用量	電子データ Excel	○			英語				
EDC	A-6	Energy charge (Received 22kV and installed Photovoltaic solar generation system)	電力量料金（通常の場合と太陽光発電を導入した場合）	電子データ PDF	○			英語				
PPWSA	A-7	Data of Photovoltaic solar generation power generation at Phum Prek WTP from 2014 (monthly amount of power generation)	プンプレック浄水場の毎月の発電量データ	電子データ PDF	○			英語				
PPWSA	A-8	Data of Electricity Consumption from 2005	各浄水場の毎月の消費電力	電子データ PDF	○			英語				
MEF	B-1	Policy Paper on Public-Private Partnership for Public Investment Project Management (2016-2020)	公共投資プロジェクト管理のための PPP についての政策文書	電子データ PDF	○			英語				
MIH	B-2	PRAKAS ON	水道事業の事業許可の発行、改	電子データ			○	英語				

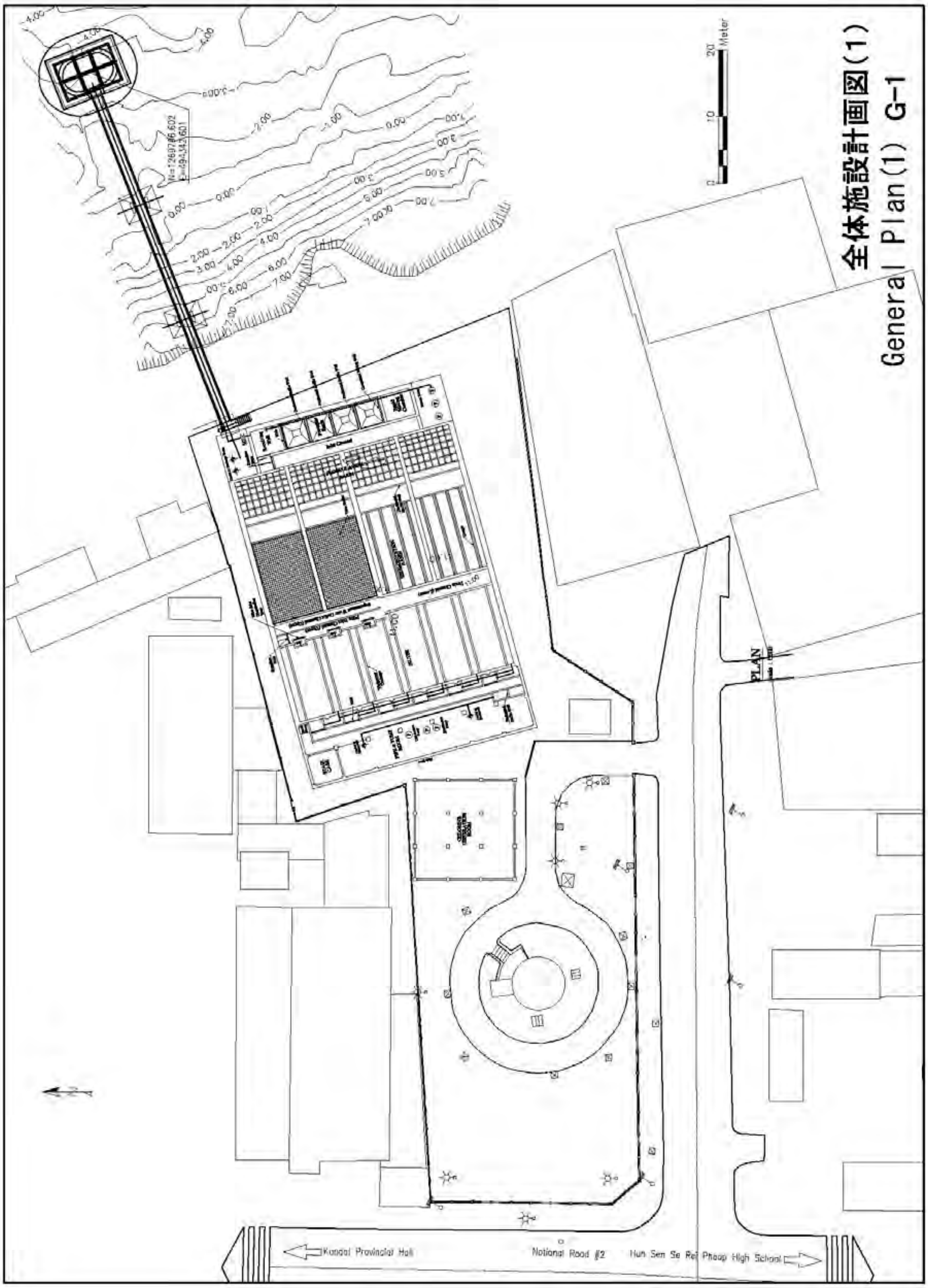
発行機関	No.	資料名	説明	形式	収集資料	専門家作成資料	JICA作成資料	言語	翻訳状況	取り扱い区分	図書館記入欄	備考
		PROCEDURE FOR ISSUING, REVISING, SUSPENDING AND REVOKING PERMIT FOR WATER SUPPLY BUSINESS	正、一時停止、取消手続きに関する省令	PDF								
TECHNICAL SECRETARIAT/ CENTRAL PUBLIC-PRIVATE PARTNERSHIP (PPP) UNIT, MEF	B-3	DRAFT PROCUREMENT MANUAL for PUBLIC-PRIVATE PARTNERSHIP PROJECTS, SELECTION OF CONSULTANTS AND PRIVATE PARTNERS	PPP 事業の調達アニュアルドラフト、コンサルタントと民間パートナーの選定	電子データ PDF	○			英語				
The Royal Government of Cambodia	B-4	Sub Decree on the Implementation of the Law on the Amendment to the Law on Investment, No. 111 ANK/BK DATED SEPTEMBER 27, 2005	修正投資法施行の Sub Decree	電子データ PDF	○			英語				
MEF	B-5	Law on Public Finance System	公共財政システム法	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-6	Law on Foreign Exchange	外国為替法	電子データ PDF	○			英語				
MEF	B-7	Law on Expropriation	収用に関する法律	電子データ PDF	○			英語				
MLMUPC (Ministry of Land Management, Urban Planning and Construction)	B-8	Law on Amendment to the Law on Investment of Cambodia	修正投資法	電子データ PDF	○			英語				
National Accounting Council (NAC)	B-9	Law on Accounting and Auditing	会計監査法	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-10	Law on Investment	投資法	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-11	Law on Concessions	コンセッション法	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-12	Procurement Manual	調達マニュアル	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-13	Law on the General Statue of Public Enterprises	公営企業に関する一般法	電子データ PDF	○			英語				
The Kingdom of	B-14	Law on Water Resources	水資源マネジメント法	電子データ	○			英語				

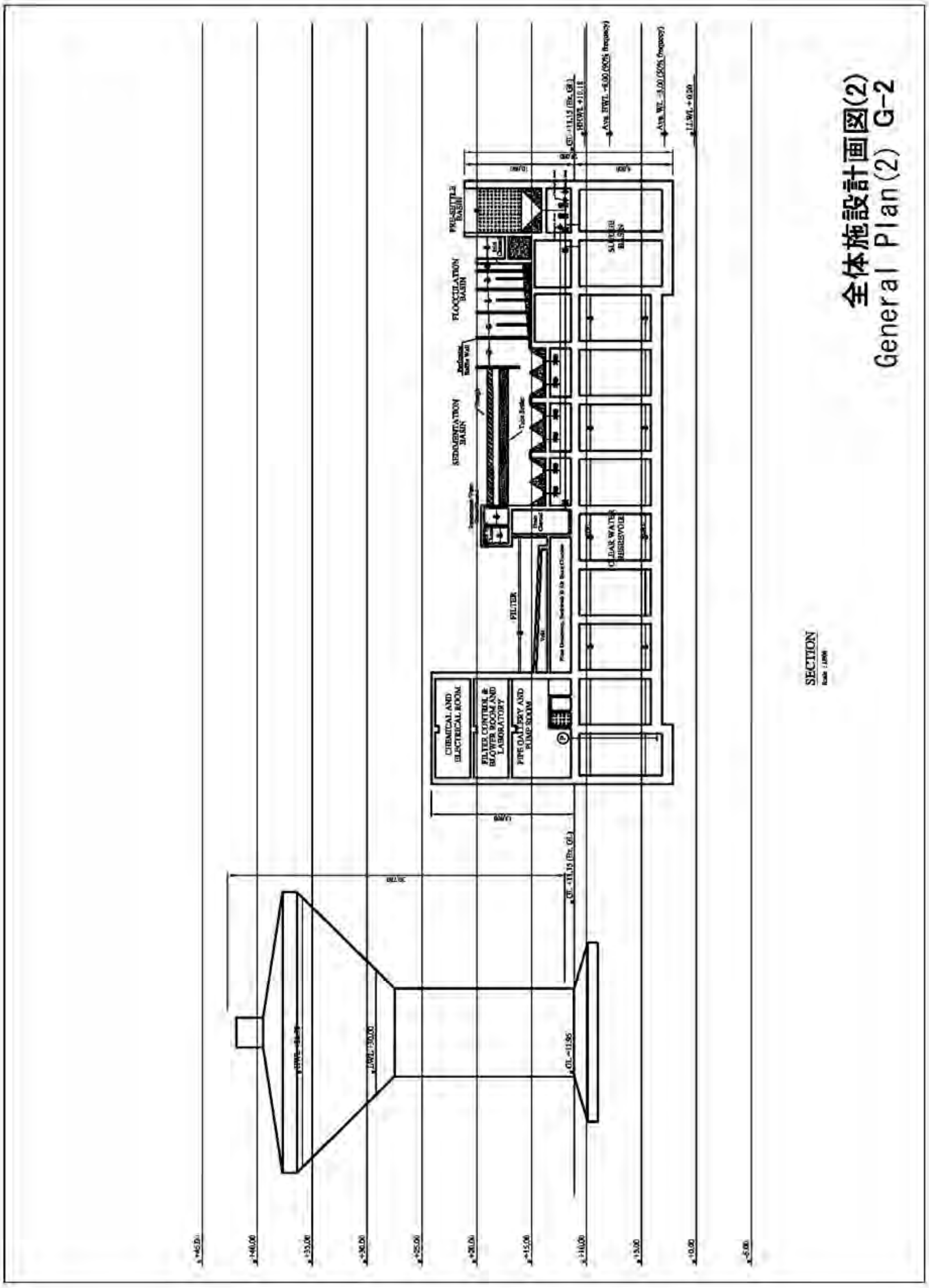
発行機関	No.	資料名	説明	形式	収集資料	専門家作成資料	JICA作成資料	言語	翻訳状況	取り扱い区分	図書館記入欄	備考
Cambodia		Management		PDF								
The Kingdom of Cambodia	B-15	Law on Commercial Enterprises	企業法	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-16	Law on Labour	労働法	電子データ PDF	○			英語				
Ministry of Labor and Vocational Training	B-17	Guideline on The Procedure to Apply for and Extend Foreign Work Permit and Foreign Employment Card	外国労働許可と外国雇用カードへの申し込みと延長のガイドライン	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-18	Civil Law of Cambodia	カンボジア王国民法典	電子データ PDF	○			日本語				
ADB	B-19	Cambodia, Water Supply and Sanitation Sector Assessment, Strategy, and Road Map	カンボジアの水道、衛生セクターの評価、戦略、ロードマップ	電子データ PDF	○			英語				
PPWSA	B-20	PPWSA Charter	PPWSA 設立許可書	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-21	Land Registration	土地登録書	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-22	Law on Public Procurement	公共調達法	電子データ PDF	○			英語				
PPWSA	B-23	Financial Information	PPWSA 財務情報	電子データ PDF	○			英語				
PPWSA	B-24	Debt and Loan Information	PPWSA ローン情報	電子データ PDF	○			英語				
PPWSA	B-25	Water Tariff History	PPWSA 料金改正履歴	電子データ PDF	○			英語				
PPWSA	B-26	Water Connection Fee	PPWSA 新規接続料金表	電子データ PDF	○			英語				
The Kingdom of Cambodia	B-27	Prakas on Mechanism for VAT Refund	VAT 還付に関する省令	電子データ PDF	○			英語（翻訳）				

資　料 6　その他の資料・情報

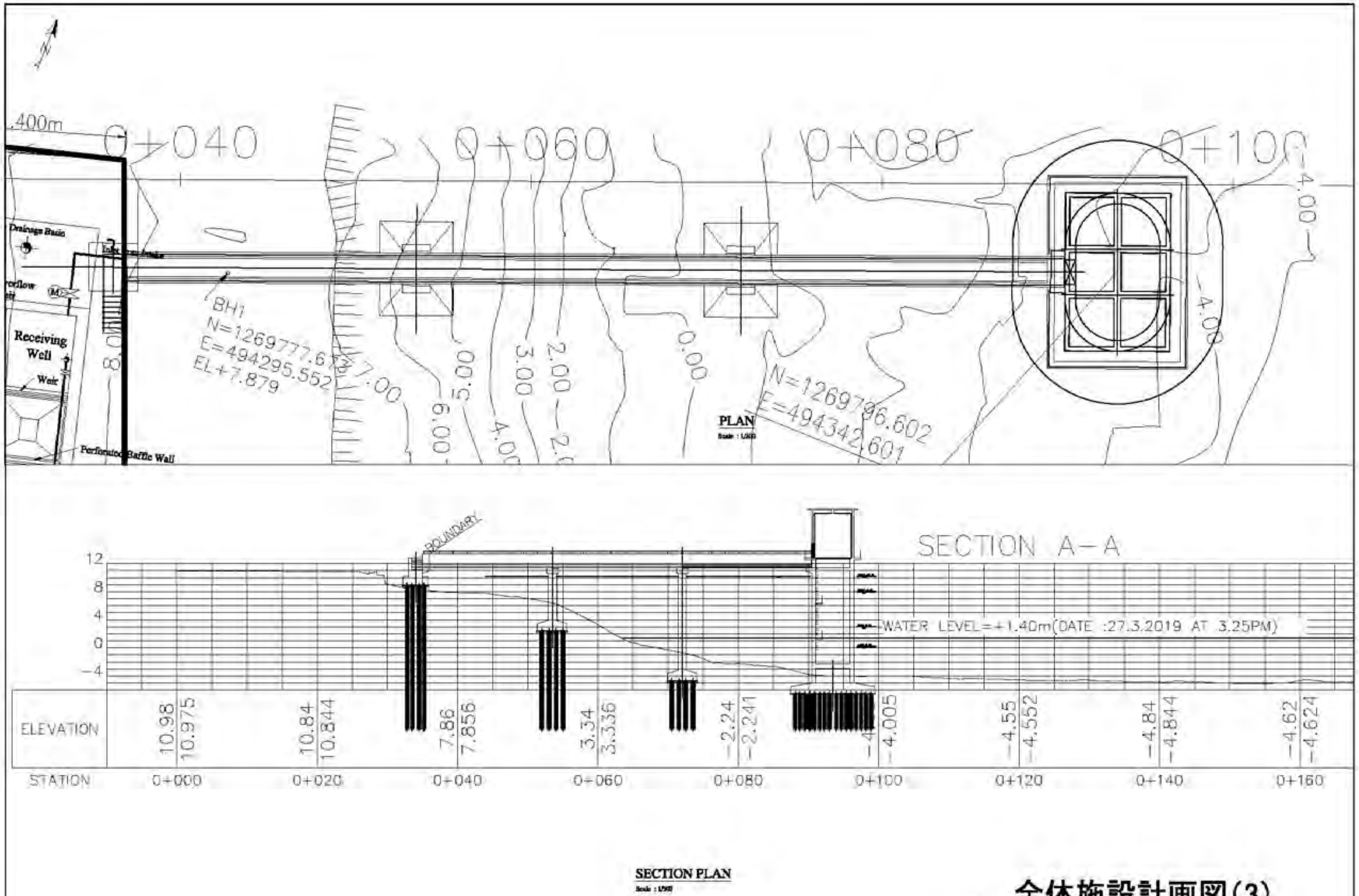
資　料 6.1　概略設計図

番号	施設区分	図面標題	図番号
1	全体施設	全体施設計画図（１）	G-1
2		全体施設計画図（２）	G-2
3		全体施設計画図（３）	G-3
4	取水施設	取水施設計画図（１）	I-1
5		取水施設計画図（２）	I-2
6		取水施設計画図（３）	I-3
7		取水施設計画図（４）	I-4
8		取水施設計画図（５）	I-5
9		取水施設計画図（６）	I-6
10		取水施設計画図（７）	I-7
11	浄水施設	浄水施設計画図（１）	W-1
12		浄水施設計画図（２）	W-2
13		浄水施設計画図（３）	W-3
14		浄水施設計画図（４）	W-4
15		浄水施設計画図（５）	W-5
16		浄水施設計画図（６）	W-6
17		浄水施設計画図（７）	W-7
18		浄水施設計画図（８）	W-8
19		浄水施設計画図（９）	W-9
20		浄水施設計画図（１０）	W-10


全体施設計画図(1)
General Plan(1) G-1
Meter
Kandal Provincial Hall
National Road #2
Hun Sen Se Rei Phoap High School
PLAN



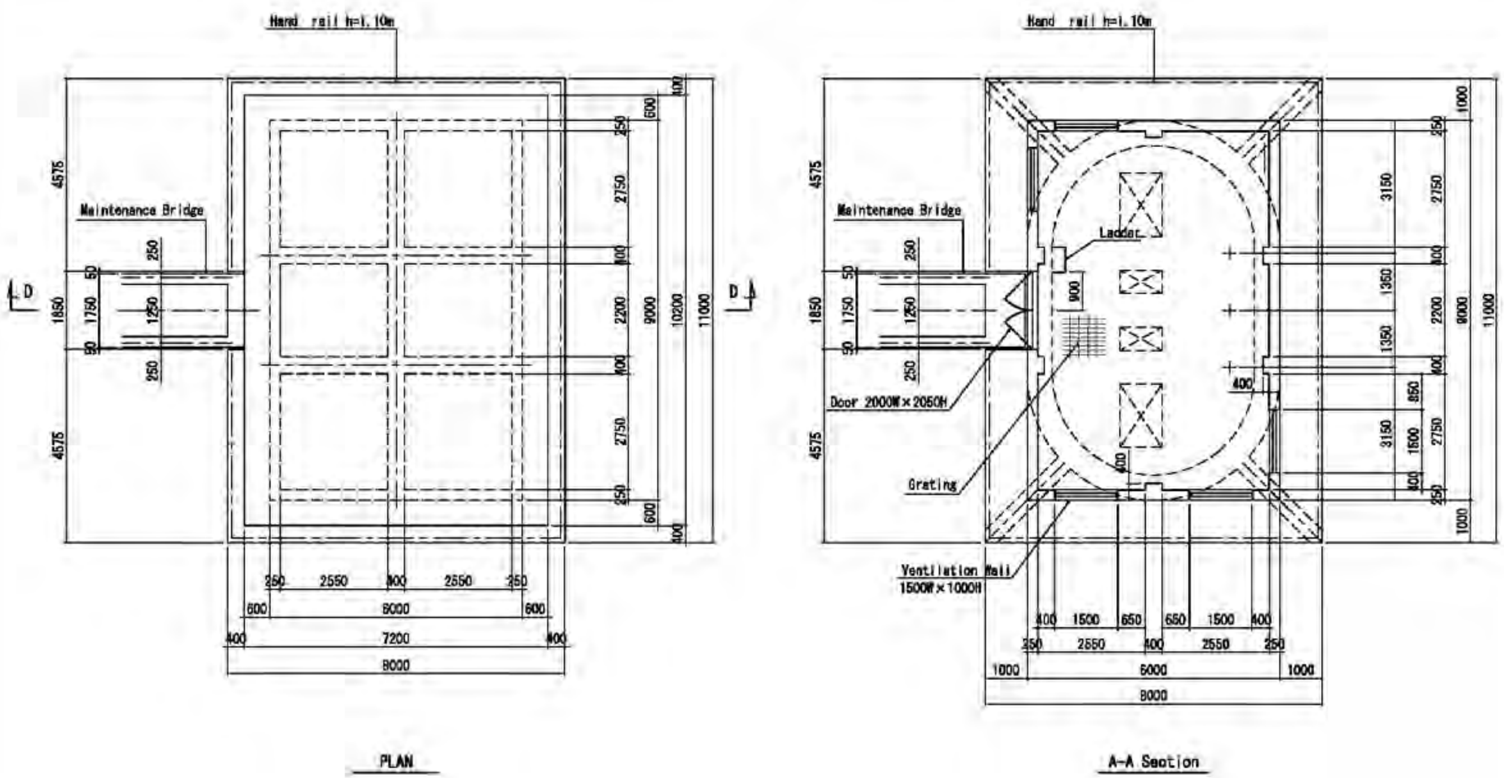
全体施設計画図(2)
General Plan(2) G-2
SECTION
CHEMICAL AND ELECTRICAL ROOM
FILTER CONTROL & BLOWER ROOM AND LABORATORY
PIPE GALLERY AND PUMP ROOM
FILTER
CLEAR WATER RESERVOIR
SEDIMENTATION BASIN
FLOCCULATION BASIN
PRE-SETTLE BASIN
SLUDGE BASIN



全体施設計画図(3)
General Plan(3) G-3

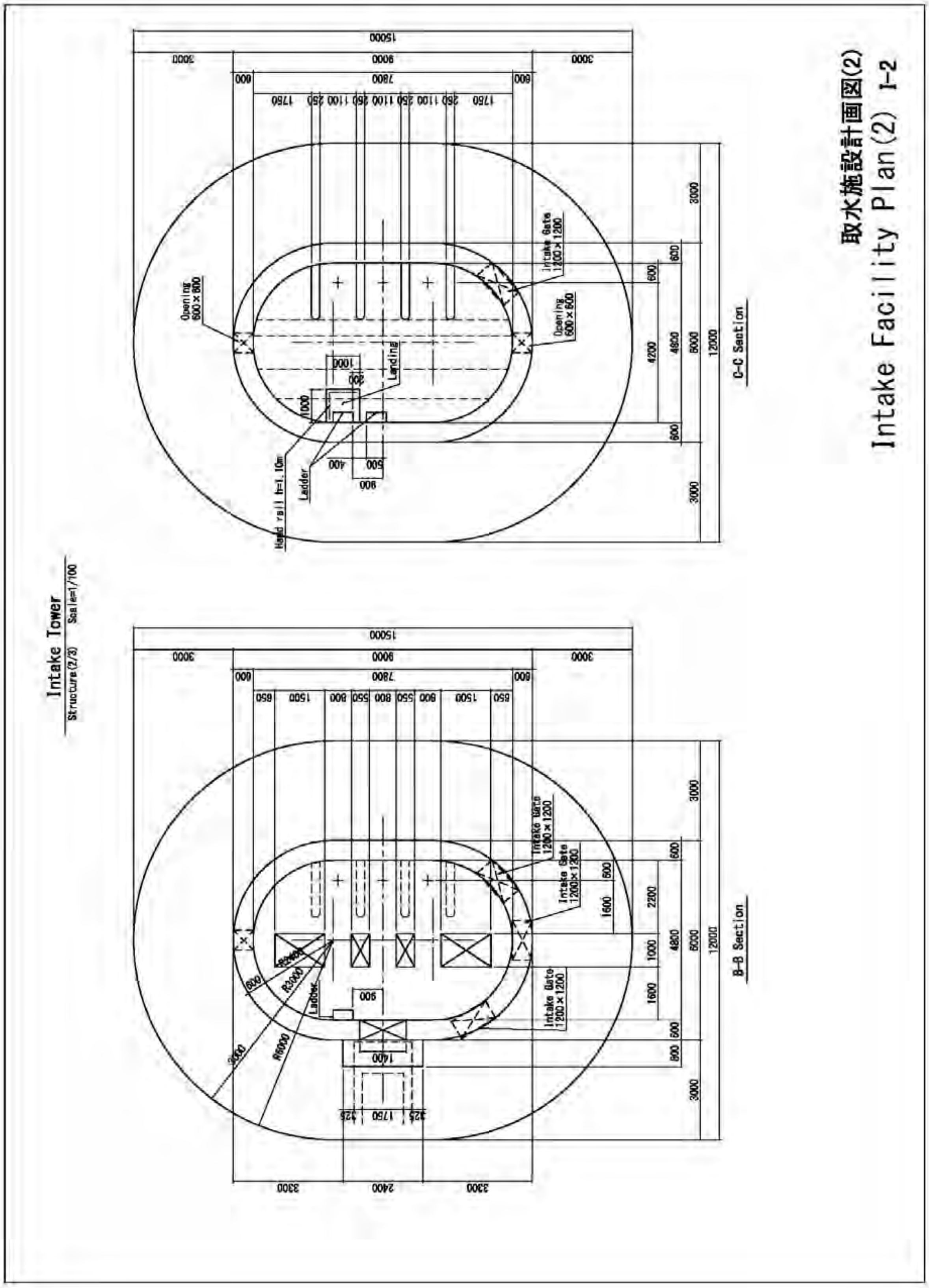
Intake Tower

Structure(1/3) Scale=1/100

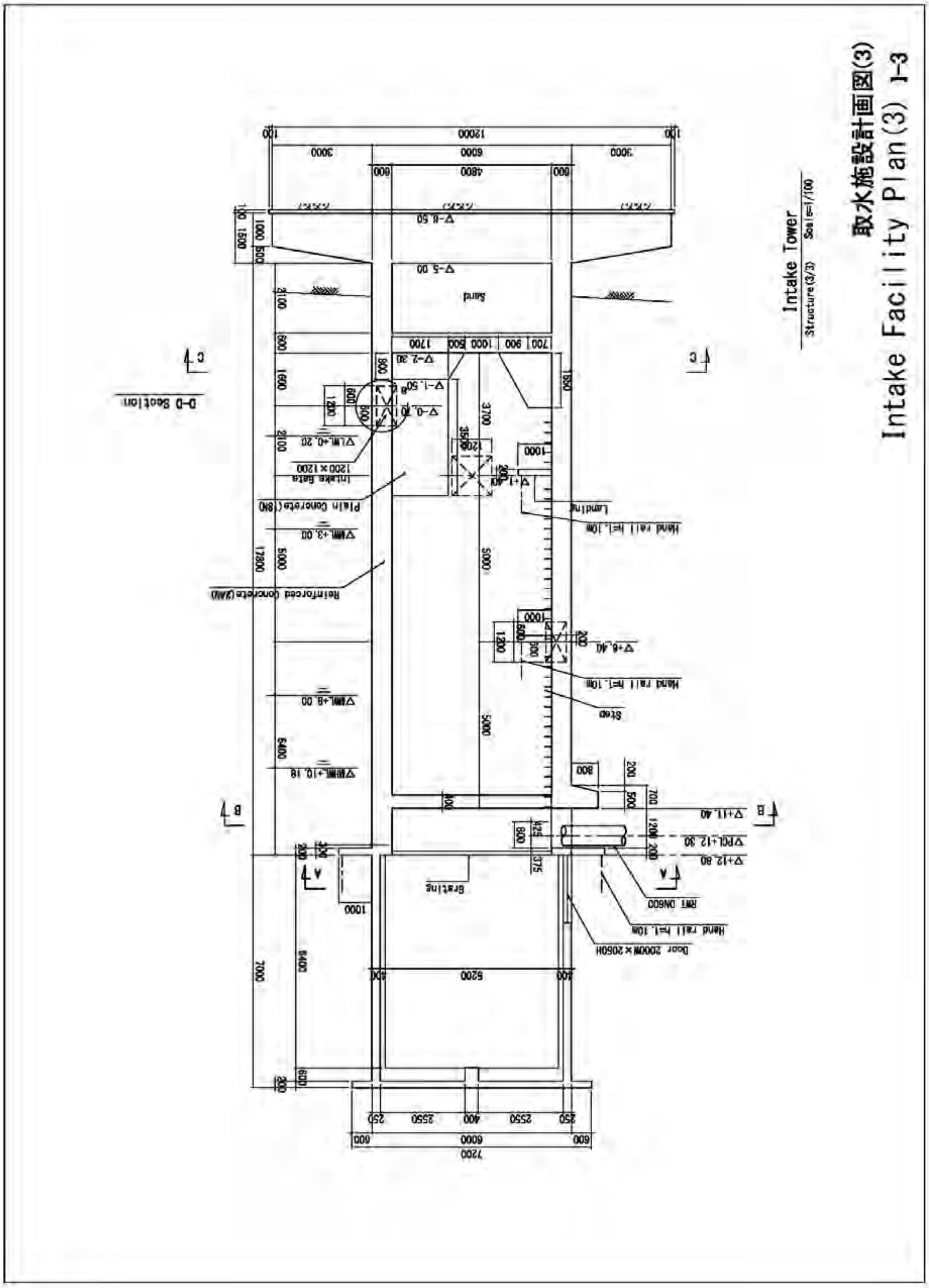


取水施設計画図(1)

Intake Facility Plan(1) I-1

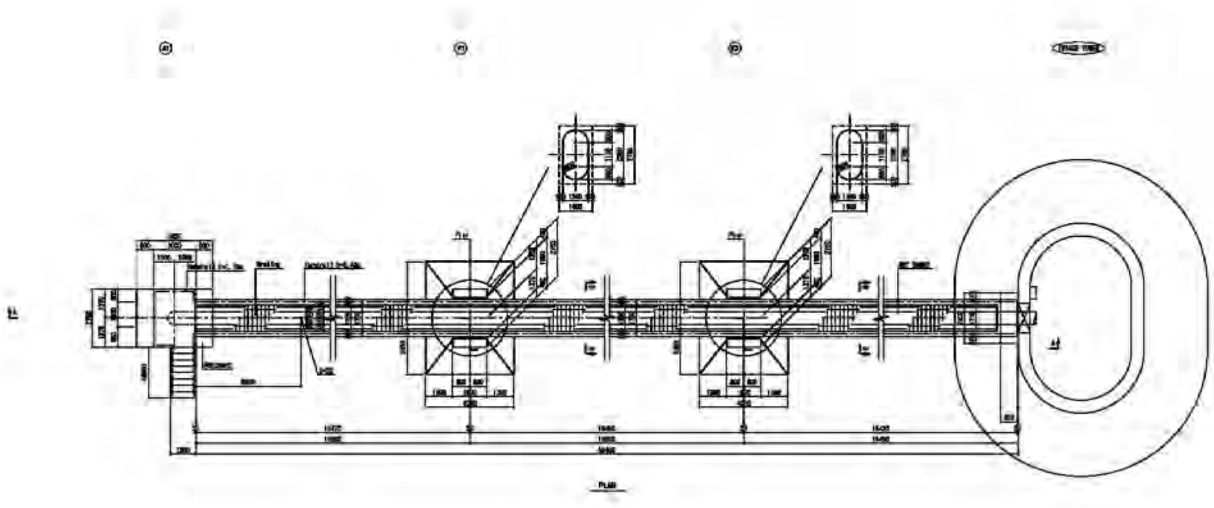


Intake Tower
Structure(2/3) Scale=1/100
B-B Section
C-C Section
Intake Gate 1200×1200
Opening 600×600
Ladder
Landing
Hand rail h=1.10m
取水施設計画図(2)
Intake Facility Plan(2) I-2


取水施設計画図(3)
Intake Facility Plan(3) I-3
Intake Tower
Structure(3/3) Scale=1/100
D-D Section

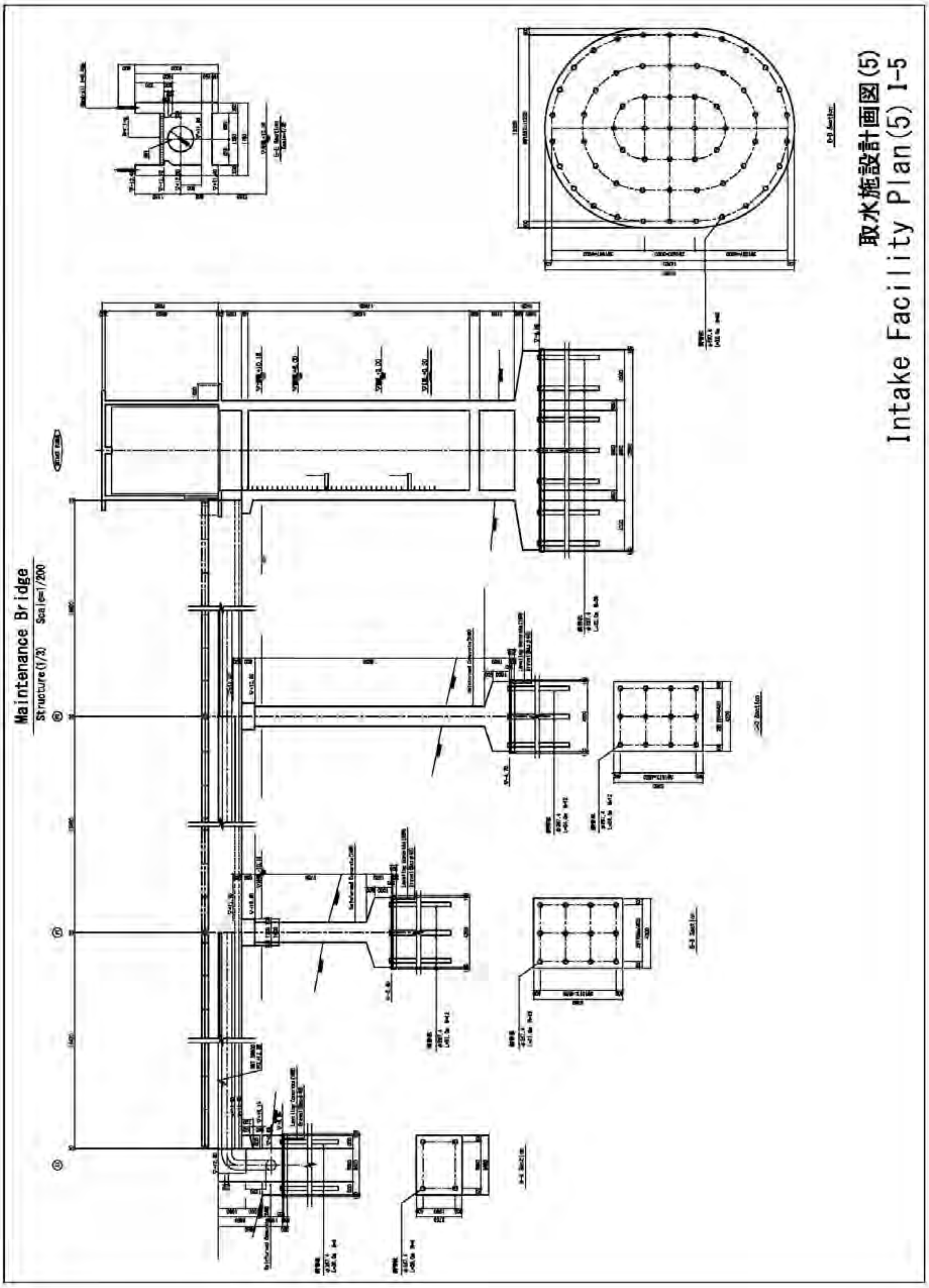
Maintenance Bridge

Structure (1/2)　Scale=1/200

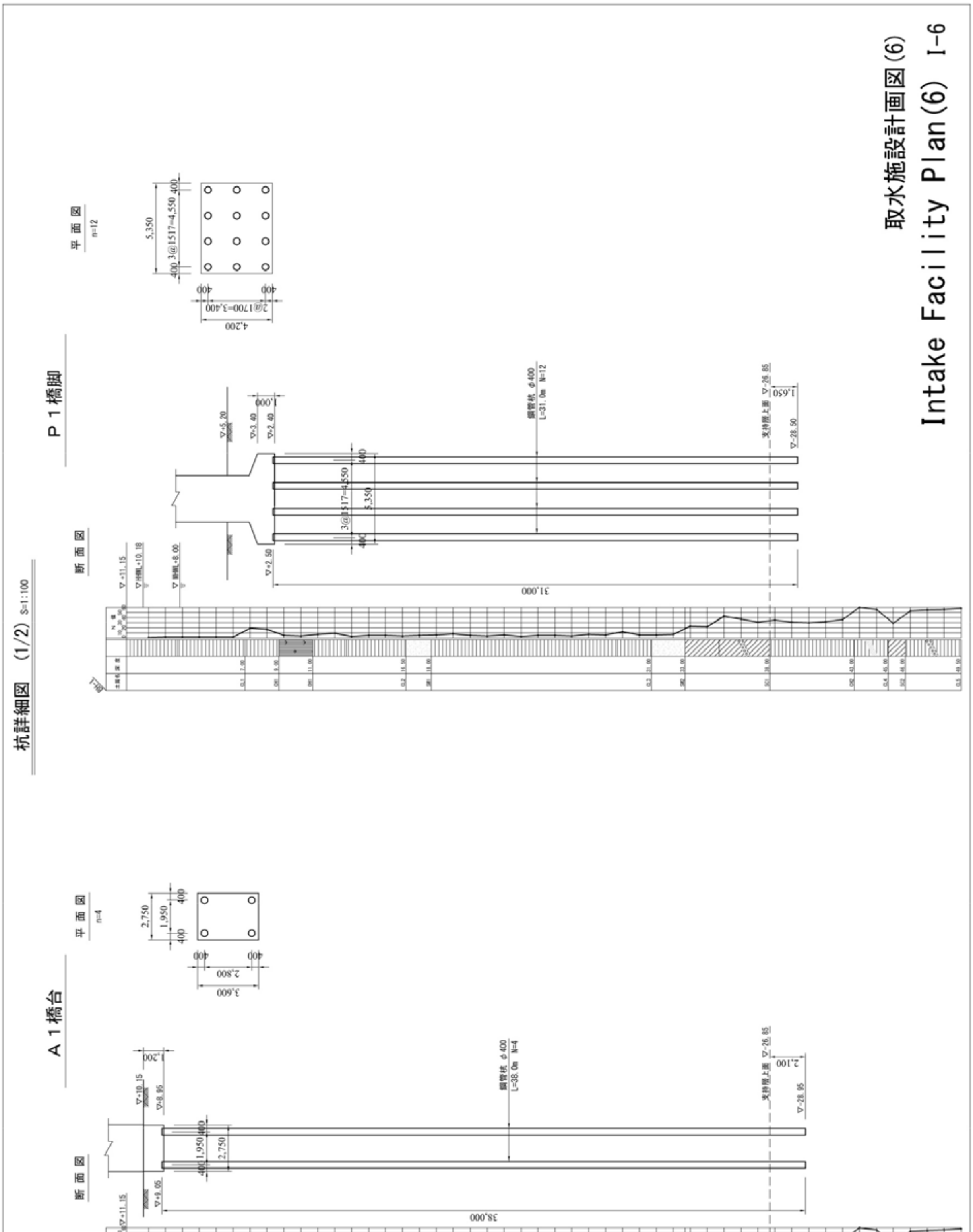


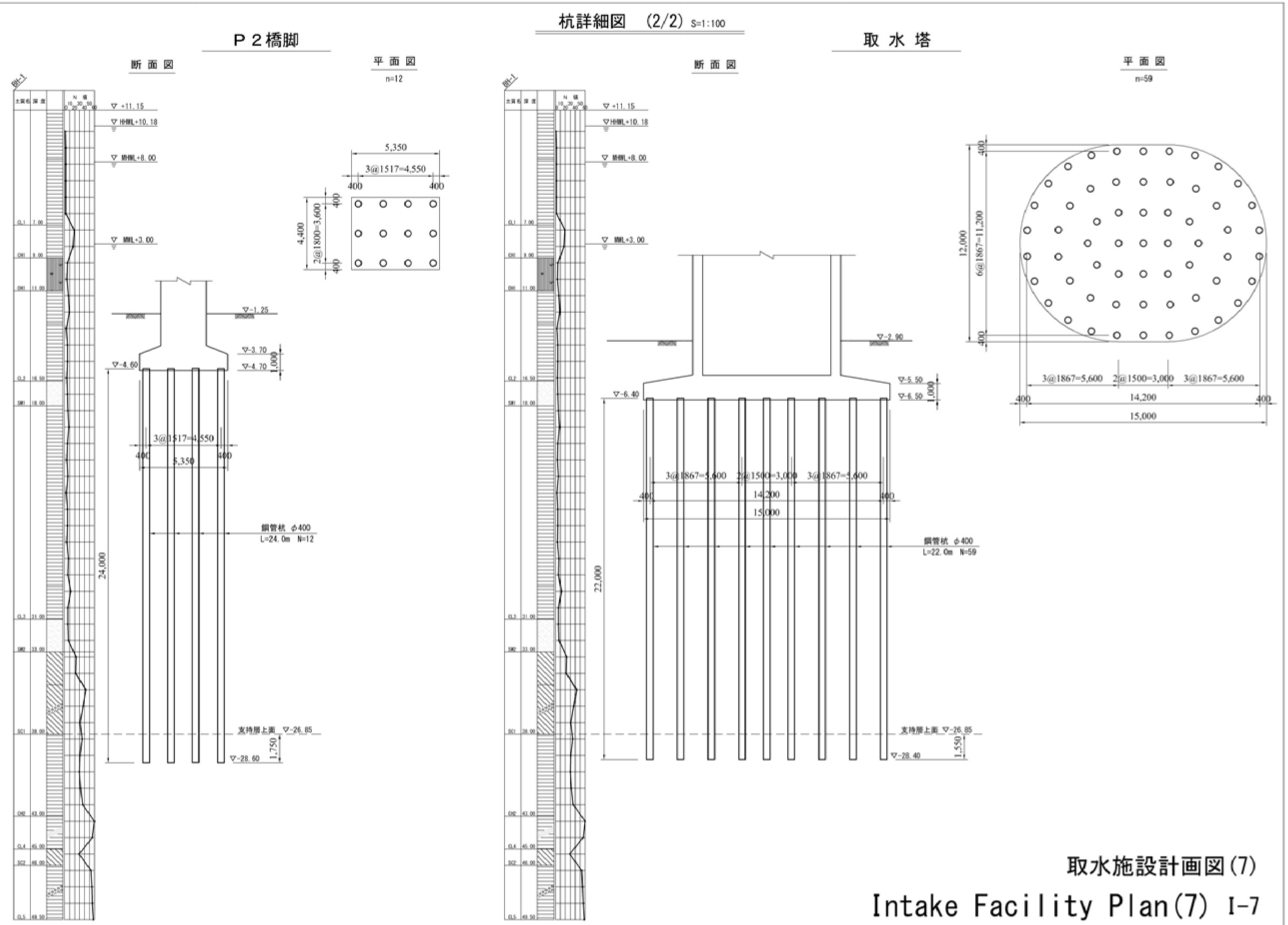
取水施設計画図(4)

Intake Facility Plan (4) I-4



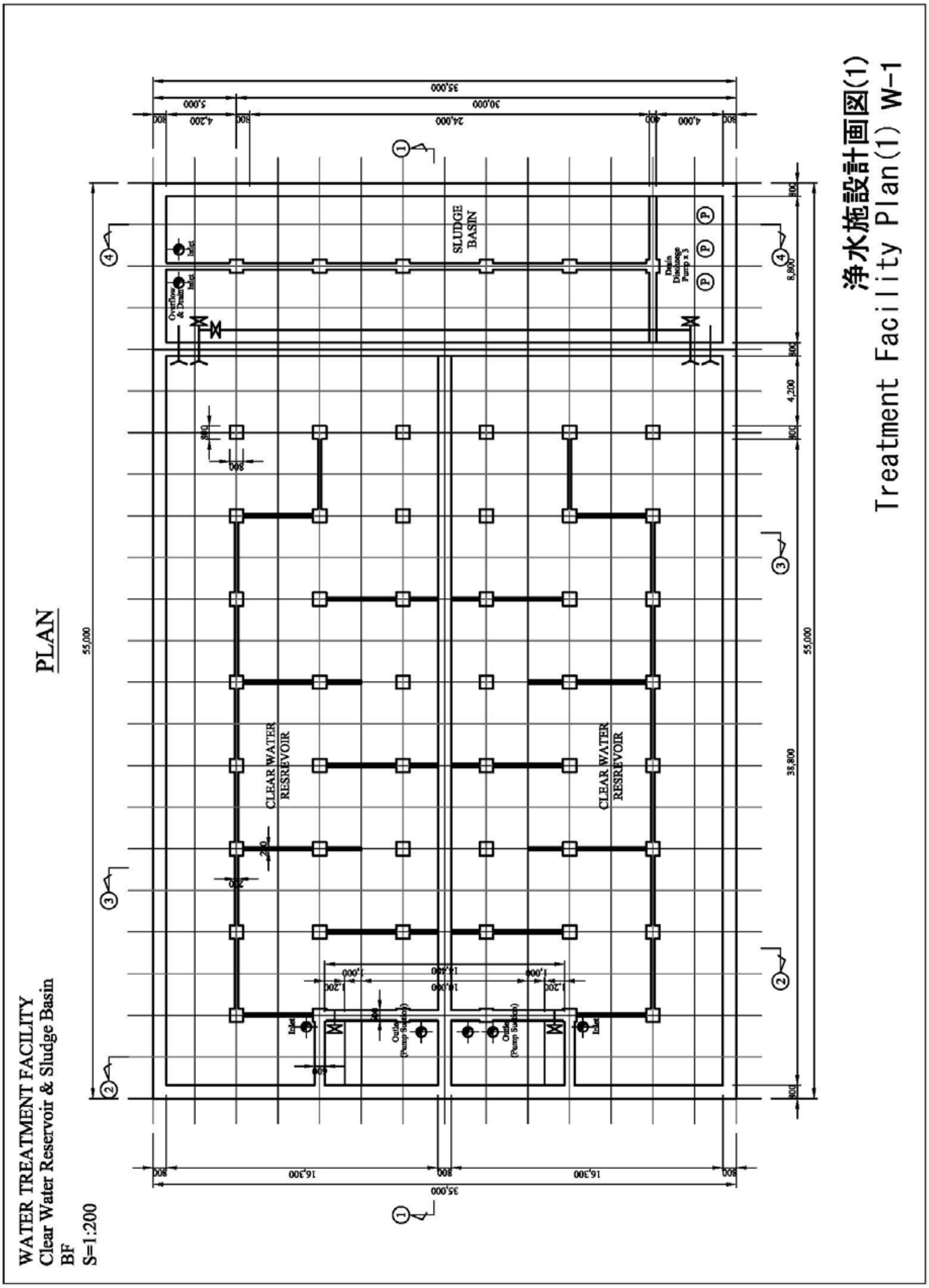
Maintenance Bridge
Structure(1/3) Scale=1/200
取水施設計画図(5)
Intake Facility Plan(5) I-5


取水施設計画図(6)
Intake Facility Plan(6) I-6
杭詳細図 (1/2) S=1:100
P1橋脚
断面図
平面図
n=12
31,000
A1橋台
断面図
平面図
n=4
38,000



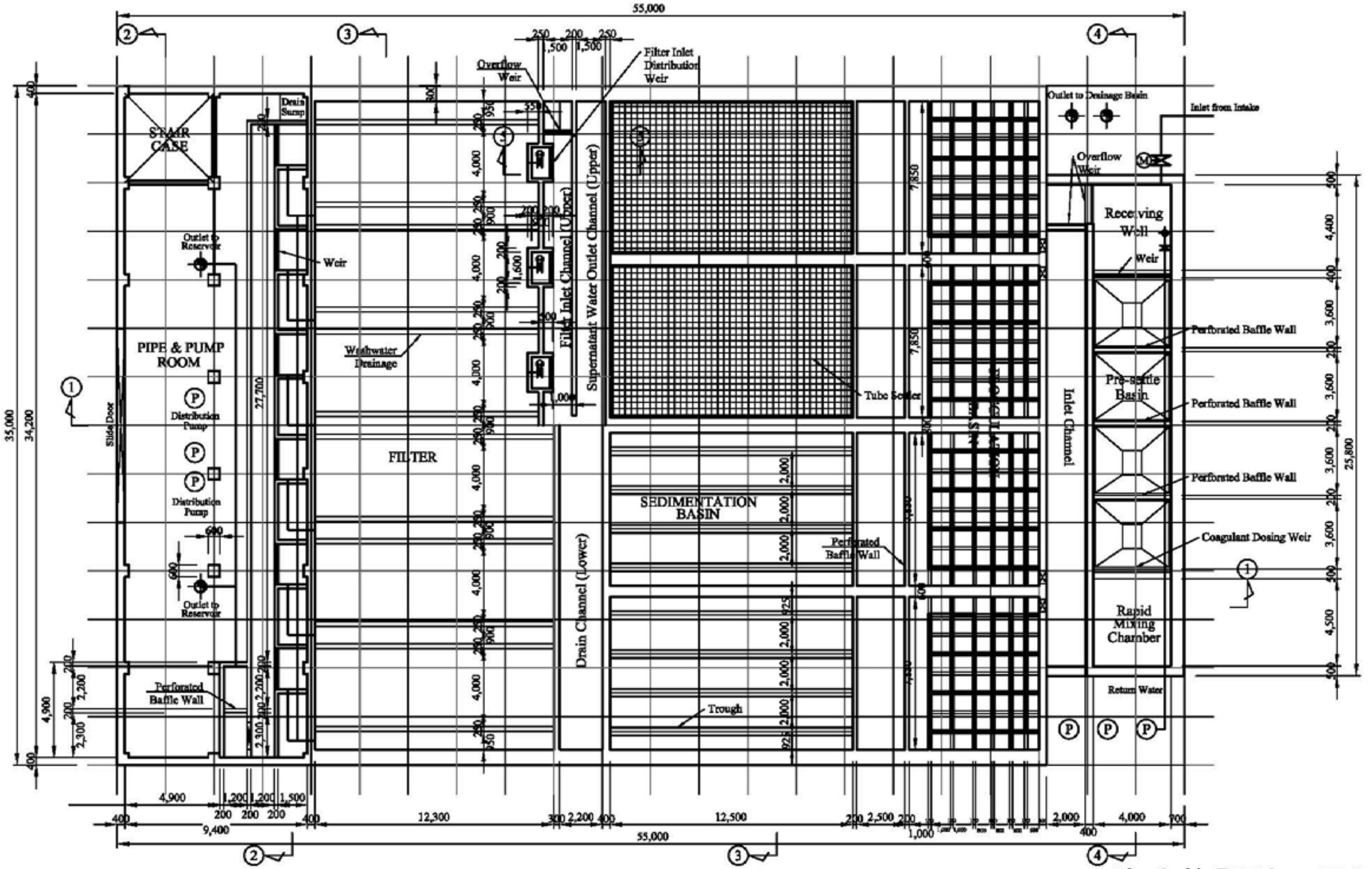
取水施設計画図(7)

Intake Facility Plan(7) I-7


WATER TREATMENT FACILITY
Clear Water Reservoir & Sludge Basin
BF
S=1:200
PLAN
SLUDGE BASIN
CLEAR WATER RESREVOIR
CLEAR WATER RESREVOIR
Inlet
Overflow & Drain
Drain Discharge Pump x 3
Outlet (Pump Station)
35,000
30,000
24,000
16,300
55,000
38,800
8,800
4,200
800
净水施設計画図(1)
Treatment Facility Plan(1) W-1

WATER TREATMENT FACILITY
Receiving Well, Pre-settle Basing, Rapid Mixing Chamber,
Flocculation Basin, Sedimentation Basin, Filter and Pipe & Pump Room
GF
S=1:200

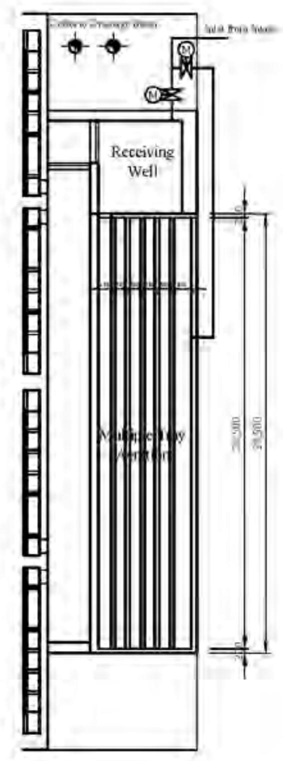
PLAN



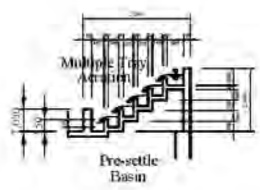
浄水施設計画図(2)
Treatment Facility Plan(2) W-2

WATER TREATMENT FACILITY
Multiple Tray Aeration
GF
S=1:200

PLAN



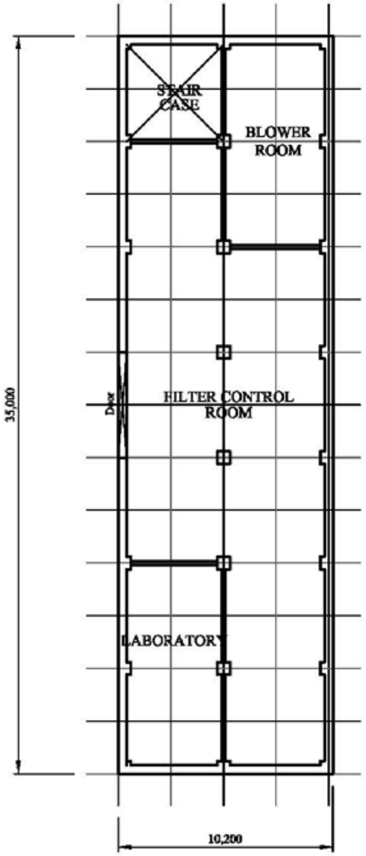
SECTION



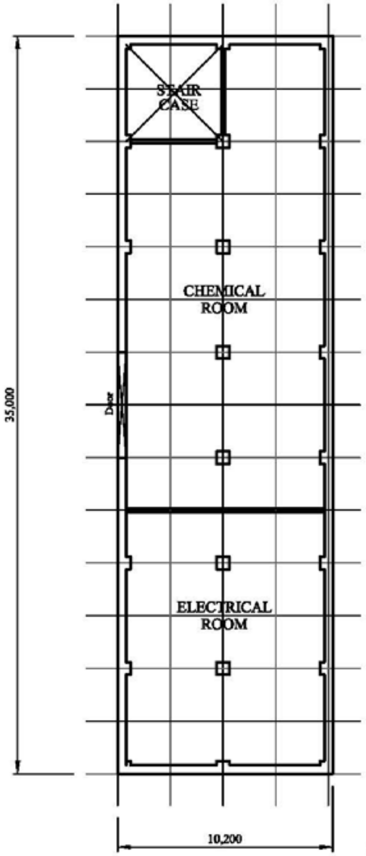
浄水施設計画図(3)
Treatment Facility Plan(3) W-3

WATER TREATMENT FACILITY
2F - Filter Control Room
3F - Chemical & Electrical Room
S=1:200

2F PLAN



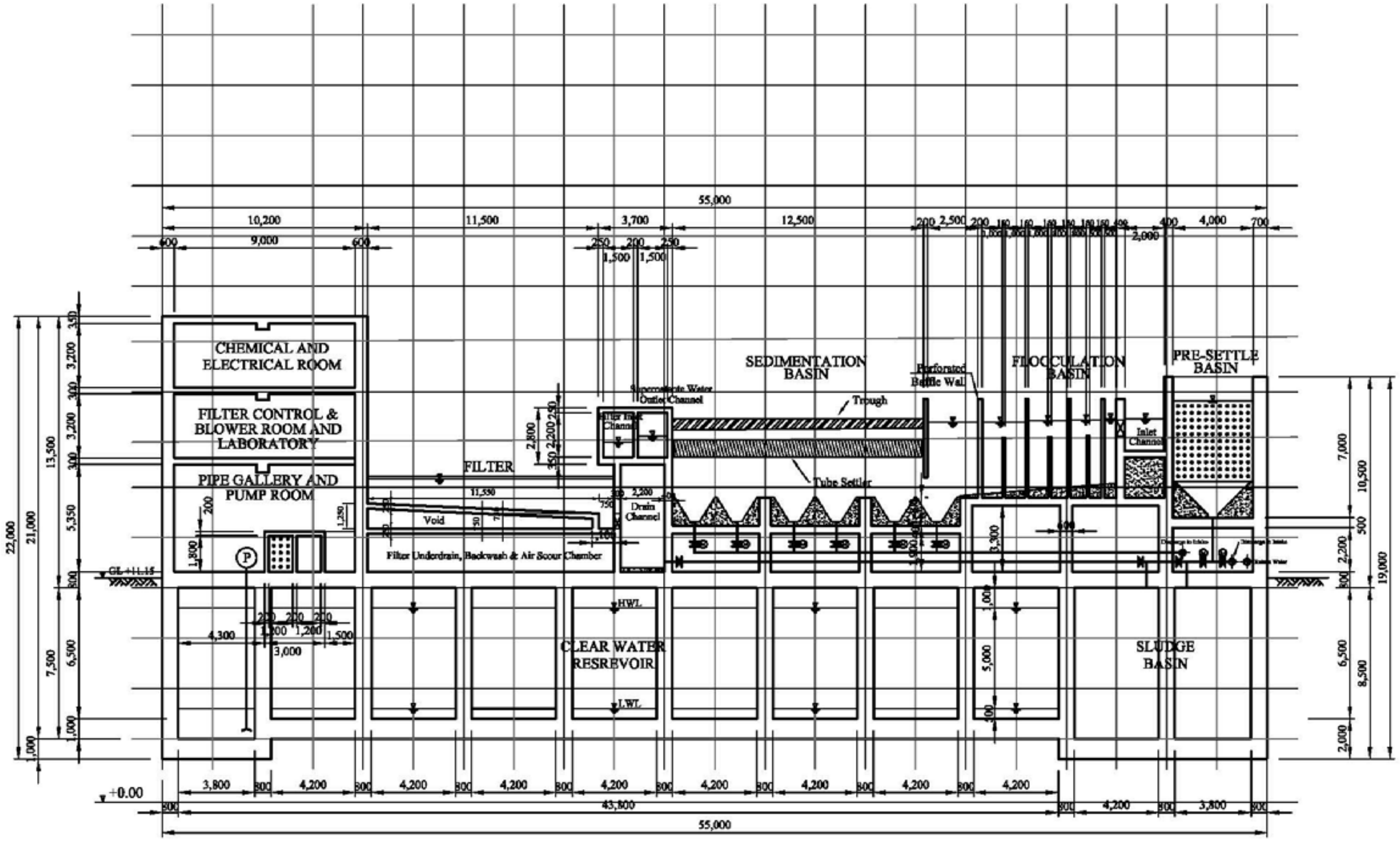
3F PLAN



浄水施設計画図(4)
Treatment Facility Plan(4) W-4

WATER TREATMENT FACILITY
General Section
S=1:200

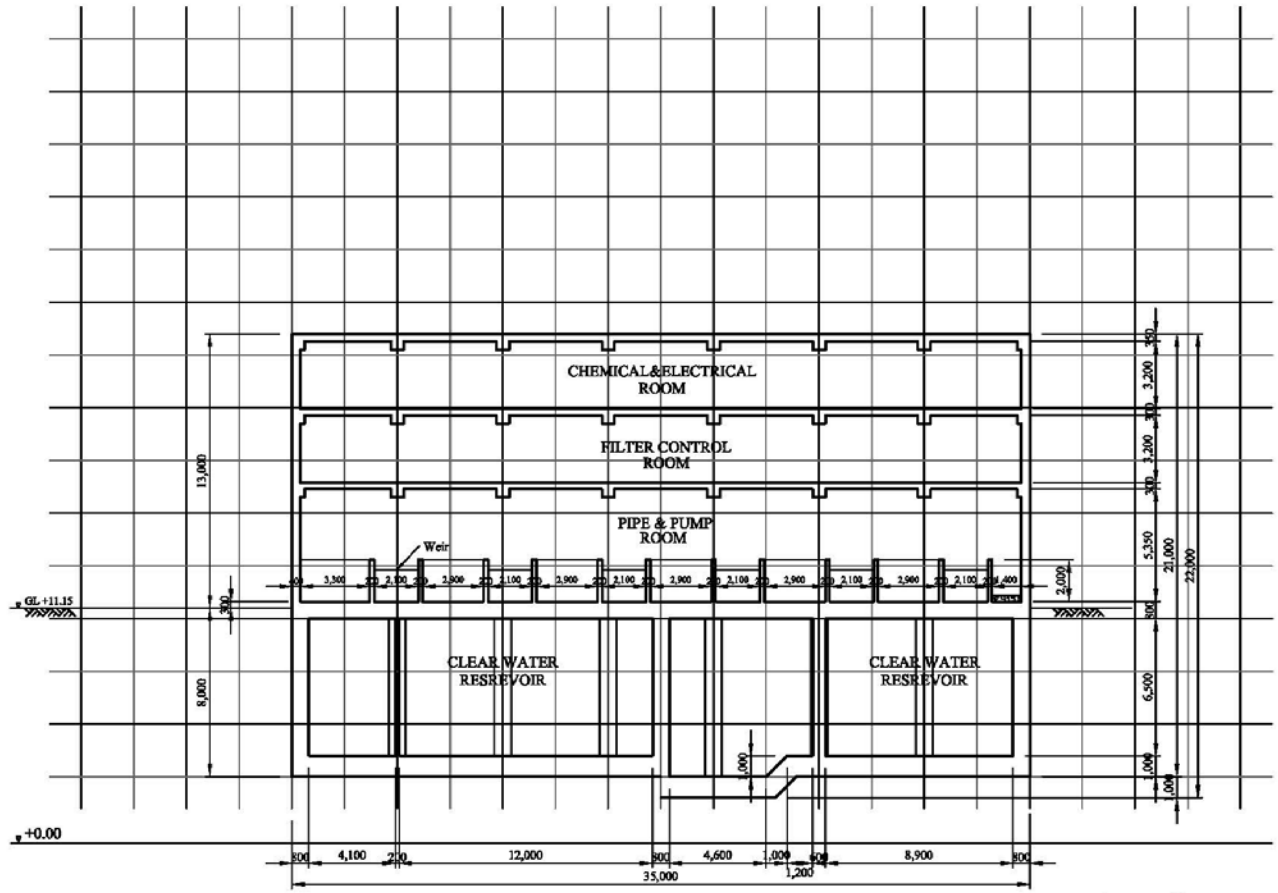
GENERAL SECTION 1-1



浄水施設計画図(5)
Treatment Facility Plan(5) W-5

WATER TREATMENT FACILITY
Section
S=1:200

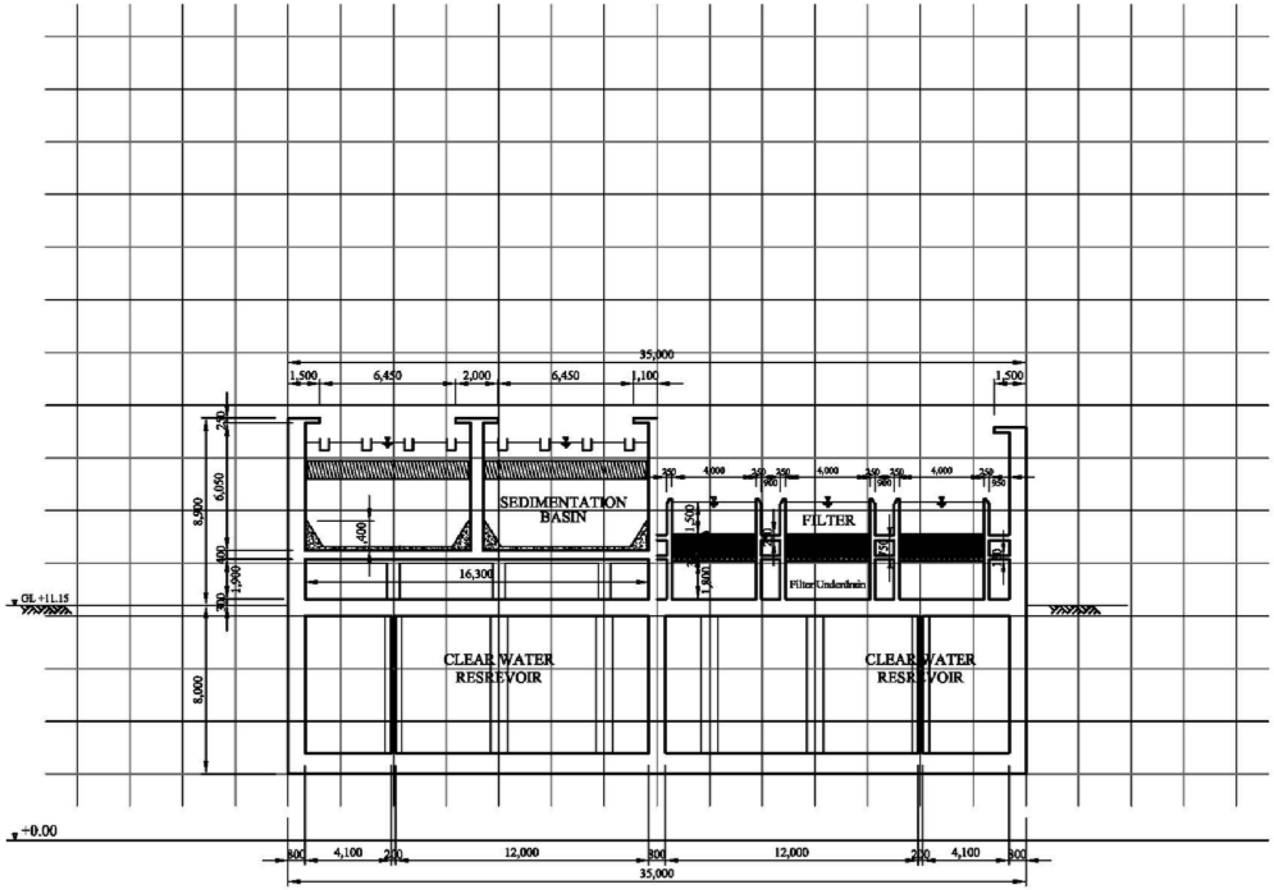
SECTION 2-2



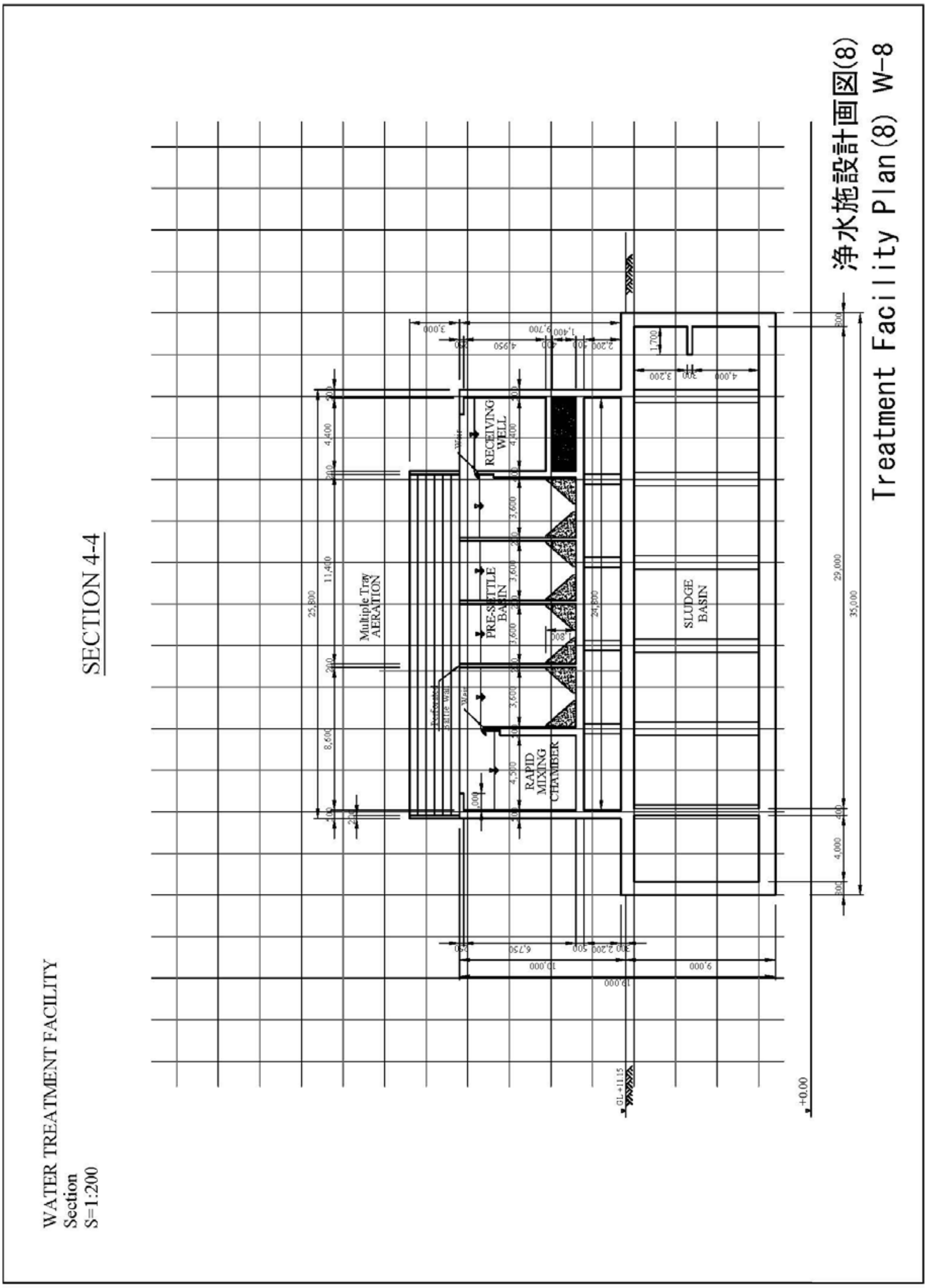
浄水施設計画図(6)
Treatment Facility Plan(6) W-6

WATER TREATMENT FACILITY
Section
S=1:200

SECTION 3-3

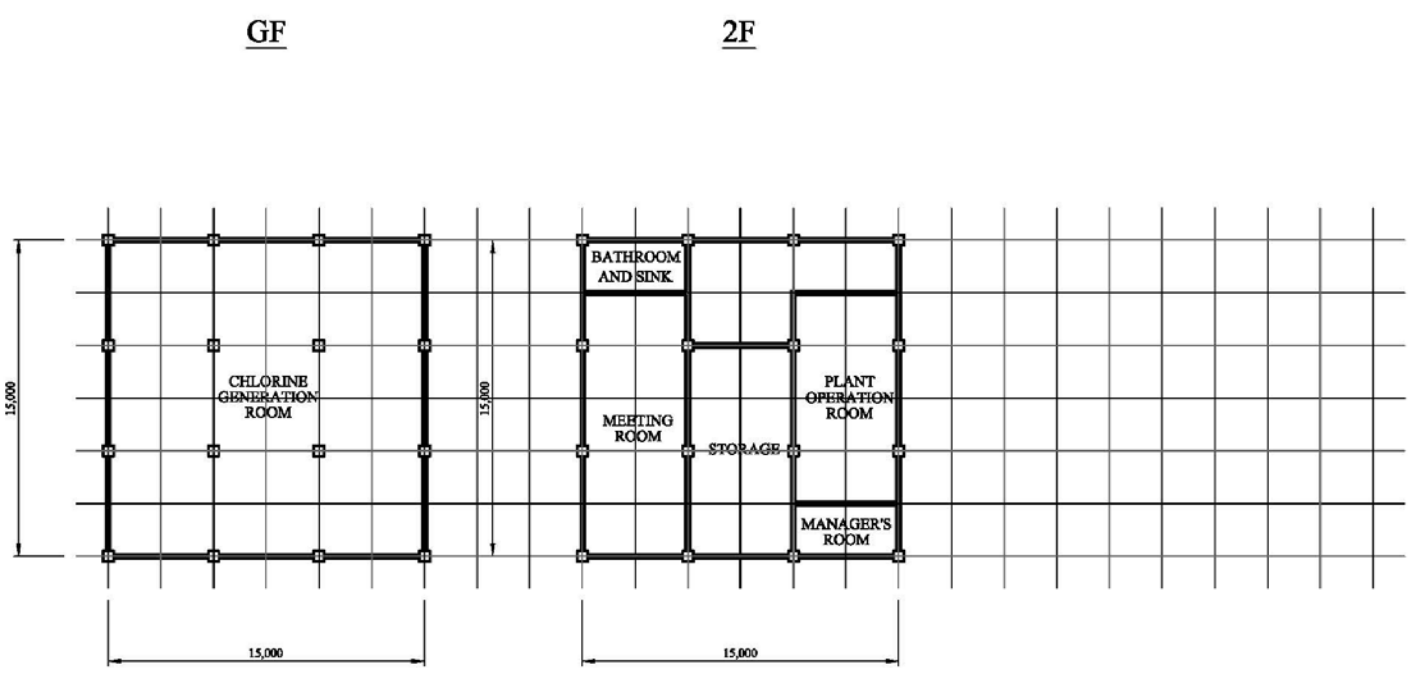


浄水施設計画図(7)
Treatment Facility Plan(7) W-7


WATER TREATMENT FACILITY
Section
S=1:200
SECTION 4-4
Multiple Tray
AERATION
RECEIVING
WELL
PRE-SETTLE
BASIN
RAPID
MIXING
CHAMBER
SLUDGE
BASIN
Perforated
Baffle Wall
Weir
25,800
11,400
8,600
4,400
24,800
29,000
35,000
10,000
9,000
19,000
GL+11.15
+0.00
浄水施設計画図(8)
Treatment Facility Plan(8) W-8

CHEMICAL STORAGE AND ADMINISTRATION ROOM
S=1:200

PLAN

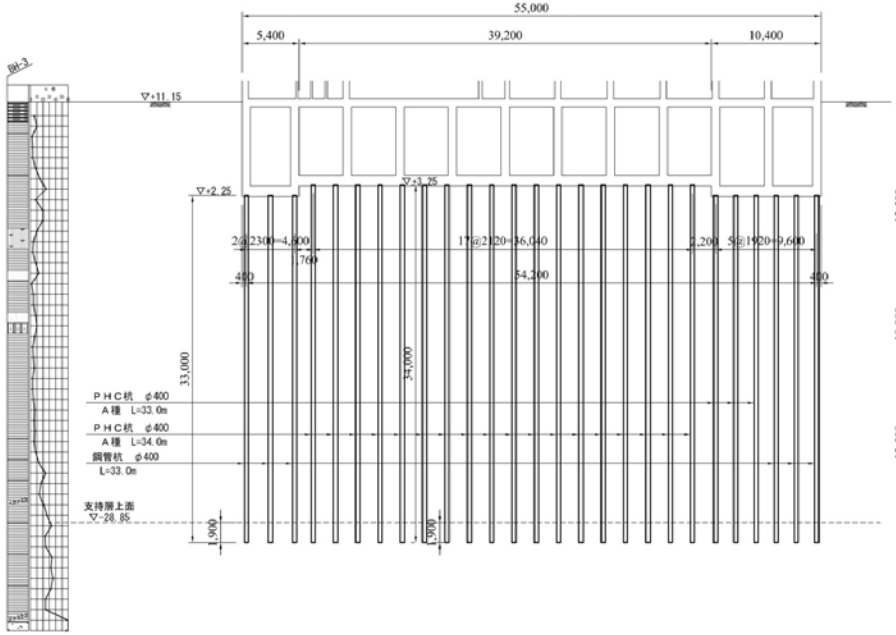


净水施設計画図(9)
Treatment Facility Plan(9) W-9

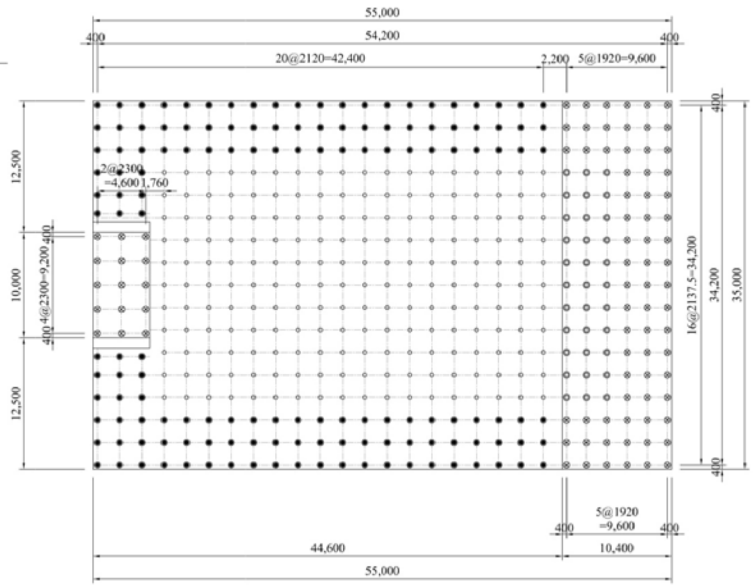
杭詳細図 S=1:200

浄水施設

断 面 図



平 面 図



		杭天端標高	杭長	杭本数
		+ m	m	本
PHC杭 φ400 A種	○	3.25	34.0	198
PHC杭 φ400 A種	◎	2.25	33.0	33
鋼管杭 φ400	◉	3.25	34.0	144
鋼管杭 φ400	⊗	2.25	33.0	84
Σ				459

浄水施設計画図(10)

Treatment Facility Plan(10) W-10

資　料 6.2　配水管網の水理検討

本調査の送配水管の管網計算は、EPANET ver2.0 を用い、下記条件で行った。

<table>
<tr><th>Item</th><th colspan="4">Condition</th><th>Notes</th></tr>
<tr><td>Calculation</td><td colspan="4">Hazen Williams Equation</td><td></td></tr>
<tr><td>C Value</td><td colspan="4">110</td><td>JWWA(2012) Design Criteria for Waterworks Facilities</td></tr>
<tr><td>Pump Head</td><td colspan="4">2019:25m(Elevated Tank)
2024:40m
2030:40m</td><td></td></tr>
<tr><td>Peak Factor</td><td colspan="4">2019:1.0
2024:1.6
2030:1.6</td><td></td></tr>
<tr><td rowspan="3">Distribution Area and Demand(m^3/day)(Day Max) from Ta Khmau WTP</td><td></td><td>2019</td><td>2024</td><td>2030</td><td rowspan="3">Chak Angre Krom(MC04) is located in Phnom Penh</td></tr>
<tr><td>Ta Khmau</td><td>18,000</td><td>24,000</td><td>30,000</td></tr>
<tr><td>Chak Angre Krom(MC04)</td><td>-</td><td>6,000</td><td>0</td></tr>
</table>

施設建設後の 2024 年に浄水量 30,000m^3/日に対して、タクマウの水需要は約 24,000m^3/日である。そのため、浄水量の余剰分 6,000m^3/日については、プノンペン南部に配水する条件とした。

既存管網における水理計算管網モデル、管網計算データ及び計算結果は次のとおり。

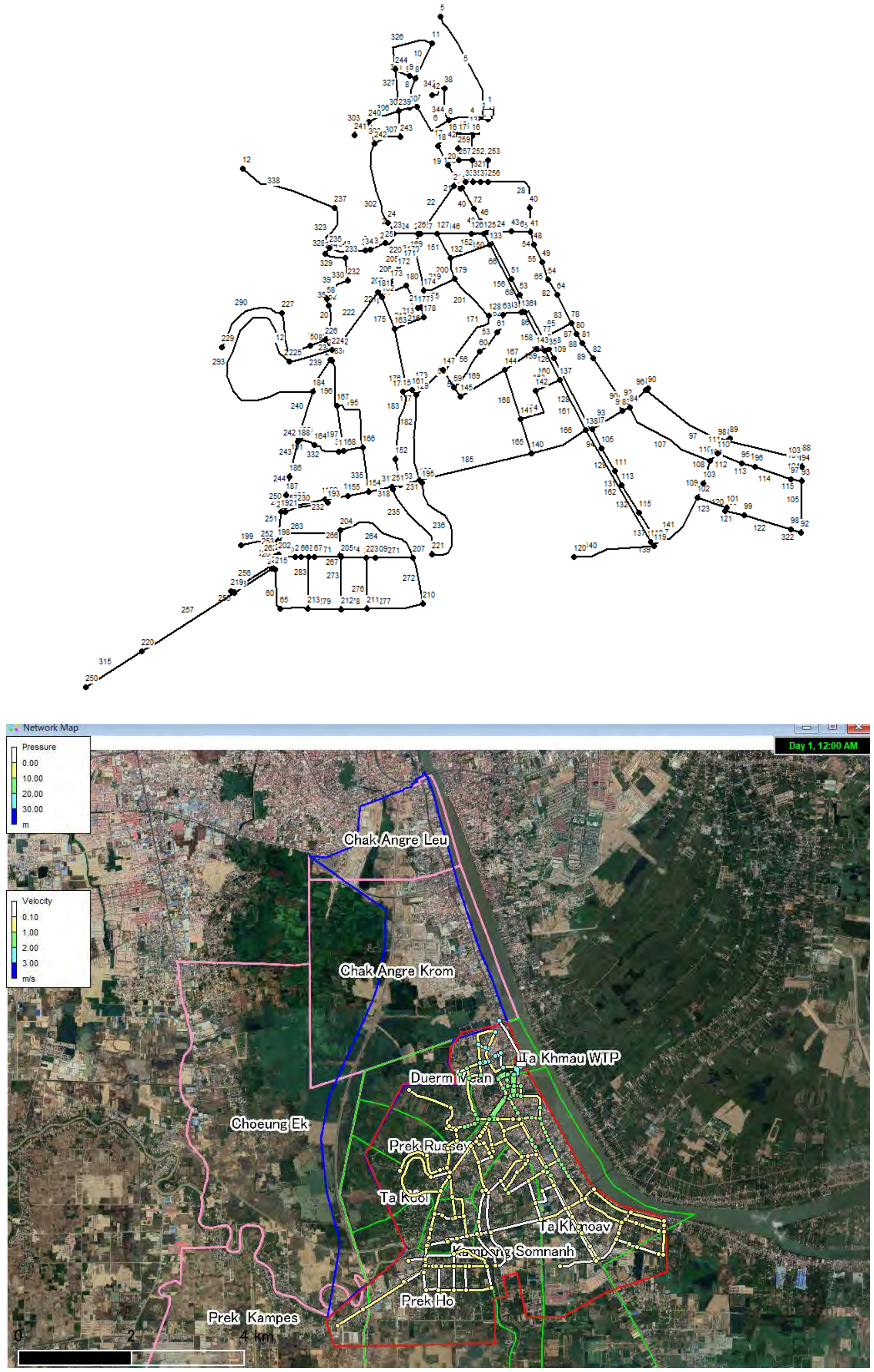


図 **A6.1**　水理計算管網モデルと管網計算結果（**Pipe Network Analysis in 2019**）

表 A6.1 管網計算結果（節点）（Pipe Network Analysis in 2019）

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
2	0	24.9	24.9
3	0	24.6	24.6
4	0	24.6	24.6
5	0	24.9	24.9
6	0	24.4	24.4
7	0	24.2	24.2
8	0	24.1	24.1
9	0	23.9	23.9
10	0	22.6	22.6
11	0	24.1	24.1
14	0	18.7	18.7
15	0	18.1	18.1
16	0	18.6	18.6
17	0	18.0	18.0
18	650	17.1	17.1
20	0	16.3	16.3
21	650	15.6	15.6
22	650	12.2	12.2
23	0	12.2	12.2
24	0	12.8	12.8
25	0	11.6	11.6
26	0	12.2	12.2
31	0	15.6	15.6
32	0	15.6	15.6
33	0	15.9	15.9
35	650	16.1	16.1
37	0	16.0	16.0
40	0	14.2	14.2
41	650	13.5	13.5
43	0	13.6	13.6
45	650	13.6	13.6
46	0	14.1	14.1
48	0	13.2	13.2
49	0	12.7	12.7
51	650	12.3	12.3
53	0	12.0	12.0
54	0	12.3	12.3
64	650	11.9	11.9
72	0	14.7	14.7
77	0	11.2	11.2
78	0	11.3	11.3
80	0	11.1	11.1
81	0	10.5	10.5
82	650	10.2	10.2
83	0	9.6	9.6
84	0	9.4	9.4
85	715	9.1	9.1
86	715	8.3	8.3
87	715	8.2	8.2
88	0	8.2	8.2

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
89	0	8.3	8.3
90	0	9.1	9.1
92	715	7.9	7.9
93	0	8.1	8.1
94	0	8.1	8.1
95	0	8.2	8.2
96	0	8.2	8.2
97	0	8.2	8.2
98	0	7.9	7.9
99	0	7.9	7.9
100	0	7.9	7.9
101	0	7.9	7.9
102	715	7.9	7.9
103	0	8.0	8.0
104	0	8.3	8.3
105	0	9.4	9.4
107	0	9.8	9.8
108	0	11.0	11.0
109	650	10.8	10.8
110	0	8.3	8.3
111	0	9.0	9.0
113	0	8.8	8.8
115	0	8.3	8.3
117	0	7.8	7.8
118	715	7.8	7.8
119	0	7.8	7.8
120	0	7.8	7.8
125	0	8.4	8.4
126	0	8.8	8.8
127	0	9.8	9.8
128	650	7.9	7.9
129	715	7.8	7.8
130	715	7.7	7.7
131	0	9.6	9.6
132	0	9.0	9.0
133	0	8.3	8.3
134	650	7.9	7.9
135	0	7.8	7.8
136	0	7.9	7.9
137	0	7.8	7.8
138	715	7.7	7.7
140	715	7.7	7.7
141	0	7.7	7.7
142	0	7.8	7.8
143	0	7.8	7.8
144	650	7.7	7.7
145	0	7.7	7.7
147	650	7.7	7.7
151	0	7.8	7.8
152	0	7.8	7.8

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
153	0	7.7	7.7
154	715	7.7	7.7
155	0	7.7	7.7
156	0	7.7	7.7
157	0	7.7	7.7
158	0	8.1	8.1
160	0	8.7	8.7
161	0	7.9	7.9
162	0	9.6	9.6
163	0	8.9	8.9
164	0	8.1	8.1
165	0	8.1	8.1
166	0	8.0	8.0
167	0	8.3	8.3
168	0	8.1	8.1
169	0	9.0	9.0
170	0	9.0	9.0
171	0	9.1	9.1
172	0	9.3	9.3
173	0	9.4	9.4
174	650	8.7	8.7
175	0	8.9	8.9
176	0	8.9	8.9
177	0	9.0	9.0
178	0	8.9	8.9
179	650	8.6	8.6
180	0	9.2	9.2
181	650	9.9	9.9
182	715	8.9	8.9
183	0	8.8	8.8
184	0	8.5	8.5
185	715	8.1	8.1
186	0	7.9	7.9
187	0	7.8	7.8
188	0	8.1	8.1
191	0	7.7	7.7
192	715	7.7	7.7
193	0	7.7	7.7
194	0	7.7	7.7
195	0	7.7	7.7
198	0	7.6	7.6
199	0	7.6	7.6
200	0	7.5	7.5
201	0	7.5	7.5
202	0	7.5	7.5
203	0	7.4	7.4
204	0	7.4	7.4
205	0	7.4	7.4
207	715	7.0	7.0
209	0	7.2	7.2

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
210	715	7.0	7.0
211	0	7.3	7.3
212	0	7.4	7.4
213	0	7.4	7.4
214	0	7.5	7.5
215	0	7.5	7.5
216	0	7.5	7.5
217	0	7.4	7.4
218	0	7.5	7.5
219	715	7.5	7.5
220	0	7.4	7.4
221	0	7.7	7.7
223	0	7.3	7.3
224	0	8.9	8.9
225	0	8.8	8.8
226	0	8.9	8.9
227	0	8.4	8.4
229	715	7.9	7.9
232	0	9.1	9.1
233	0	9.2	9.2
234	0	9.3	9.3
235	715	9.3	9.3
237	0	9.0	9.0
239	0	20.0	20.0
240	0	18.4	18.4
241	0	18.4	18.4
242	650	17.1	17.1
243	0	19.3	19.3
244	650	23.3	23.3
250	715	7.0	7.0
251	0	7.7	7.7
252	0	17.2	17.2
253	0	16.7	16.7
256	650	15.9	15.9
257	0	17.5	17.5
259	0	17.8	17.8
12	715	8.4	8.4
13	0	10.9	10.9
34	0	10.7	10.7
38	0	24.4	24.4
42	0	24.4	24.4
50	0	8.8	8.8
52	0	9.0	9.0
58	0	9.0	9.0
59	0	7.7	7.7
60	0	7.8	7.8
61	0	7.9	7.9
63	0	7.9	7.9
65	0	7.4	7.4
66	0	7.5	7.5
67	0	7.4	7.4

表 A6.2 管網計算結果（管）（Pipe Network Analysis in 2019）

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
2	2	3	27.18	400	110	Open	17,089	1.57
3	3	4	10.87	400	110	Open	14,884	1.37
4	3	6	312.42	300	110	Open	2,205	0.36
5	2	5	900.15	250	110	Open	0	0
6	6	7	385.89	300	110	Open	2,205	0.36
7	7	10	56.56	110	110	Open	1,143	1.39
8	7	8	240.17	300	110	Open	1,063	0.17
9	8	9	46.95	110	110	Open	424	0.52
10	8	11	305.7	300	110	Open	639	0.1
13	4	14	244.2	300	110	Open	14,884	2.44
14	14	16	13.83	300	110	Open	7,769	1.27
15	14	15	105.74	300	110	Open	7,115	1.16
16	15	17	20.74	150	110	Open	855	0.56
17	15	18	210.31	300	110	Open	6,259	1.02
19	18	20	169.63	300	110	Open	5,863	0.96
21	20	21	184.4	300	110	Open	5,863	0.96
22	21	22	458.88	300	110	Open	7,888	1.29
23	22	26	18.79	160	110	Open	−199	0.11
24	26	23	193.56	160	110	Open	−199	0.11
25	23	24	98.95	160	110	Open	−1,412	0.81
26	23	25	125.34	160	110	Open	1,213	0.7
32	31	21	76.83	300	110	Open	2,422	0.4
33	31	32	17.8	300	110	Open	−2,422	0.4
34	32	33	65.73	300	110	Open	−5,406	0.89
36	33	35	59.18	300	110	Open	−5,406	0.89
38	35	37	63.31	225	110	Open	1,661	0.48
40	32	72	189.04	225	110	Open	2,984	0.87
45	40	41	187.67	225	110	Open	2,425	0.71
46	41	43	154.11	160	110	Open	−278	0.16
48	72	46	111.47	225	110	Open	2,984	0.87
50	46	45	101.35	225	110	Open	2,984	0.87
54	41	48	104.45	225	110	Open	2,307	0.67
55	48	49	155.62	225	110	Open	2,307	0.67
65	49	54	143.09	225	110	Open	2,307	0.67
66	45	51	417.79	225	110	Open	2,310	0.67
68	51	53	144.07	225	110	Open	1,914	0.56
82	54	64	138.9	225	110	Open	2,307	0.67
83	64	78	255.3	225	110	Open	1,910	0.56
85	78	77	252.69	90	110	Open	77	0.14
86	53	77	391.46	225	110	Open	1,914	0.56
87	78	80	91.9	225	110	Open	1,833	0.53
88	80	81	285.79	225	110	Open	1,833	0.53
89	81	82	149.02	225	110	Open	1,833	0.53
90	82	83	489.98	225	110	Open	1,437	0.42
91	83	84	63.82	225	110	Open	2,310	0.67
92	84	85	194.61	225	110	Open	1,689	0.49
93	83	107	276.77	225	110	Open	−873	0.25
94	107	105	166.1	160	110	Open	720	0.41
96	85	90	24.11	160	110	Open	0	0
97	85	86	768.88	225	110	Open	1,253	0.36
98	86	89	27.93	160	110	Open	0	0
100	86	87	616.51	225	110	Open	608	0.18
101	87	94	61.35	160	110	Open	172	0.1
103	88	87	19.75	160	110	Open	0	0
104	94	93	110.6	160	110	Open	172	0.1
105	93	92	406.94	160	110	Open	402	0.23
107	84	104	788.69	160	110	Open	621	0.36
108	104	103	186.16	160	110	Open	600	0.35
109	103	102	122.52	160	110	Open	600	0.35
110	104	110	86.63	160	110	Open	21	0.01

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
111	110	86	125.24	160	110	Open	−209	0.12
112	110	95	209.06	160	110	Open	230	0.13
113	95	96	107.46	160	110	Open	230	0.13
114	96	97	299.79	160	110	Open	230	0.13
115	97	93	92.22	160	110	Open	230	0.13
120	101	100	28.76	160	110	Open	34	0.02
121	100	99	149.53	160	110	Open	34	0.02
122	99	98	388.58	160	110	Open	34	0.02
123	102	101	241.09	160	110	Open	34	0.02
124	77	108	97.16	225	110	Open	1,990	0.58
126	108	109	79.98	225	110	Open	1,990	0.58
128	109	107	649.05	225	110	Open	1,594	0.46
129	105	111	210.69	160	110	Open	720	0.41
131	111	113	123.66	160	110	Open	720	0.41
132	113	115	260.86	160	110	Open	720	0.41
137	115	117	258.79	160	110	Open	720	0.41
138	117	118	44.16	250	110	Open	850	0.2
139	118	119	39.5	250	110	Open	0	0
140	119	120	645.75	160	110	Open	0	0
141	117	102	504.75	160	110	Open	−129	0.07
146	127	126	272.57	160	110	Open	1,052	0.61
147	126	125	102.72	160	110	Open	1,052	0.61
150	125	133	98.06	250	110	Open	1,052	0.25
151	127	132	221.07	160	110	Open	1,036	0.6
152	133	132	332.95	110	110	Open	−274	0.33
155	136	134	25.68	160	110	Open	−66	0.04
156	133	134	604.2	250	110	Open	1,326	0.31
158	134	135	344.51	250	110	Open	864	0.2
159	143	135	66.74	160	110	Open	−280	0.16
160	135	137	258.04	250	110	Open	584	0.14
161	137	138	445.65	250	110	Open	422	0.1
162	138	118	1027.9	250	110	Open	−414	0.1
163	137	142	212.46	160	110	Open	162	0.09
164	142	141	375.09	160	110	Open	162	0.09
165	141	140	289.84	160	110	Open	132	0.08
166	138	140	476.94	225	110	Open	400	0.12
167	143	144	300.24	160	110	Open	280	0.16
168	144	141	410.99	110	110	Open	−30	0.04
169	144	145	413.28	160	110	Open	−86	0.05
171	128	147	598.71	160	110	Open	271	0.16
173	147	129	293.36	160	110	Open	−121	0.07
174	131	162	27.47	160	110	Open	805	0.46
175	162	163	272.14	160	110	Open	805	0.46
176	163	161	506.93	160	110	Open	775	0.45
177	161	129	53.84	160	110	Open	712	0.41
178	161	151	74.03	110	110	Open	63	0.08
182	129	130	681.68	160	110	Open	155	0.09
183	151	152	552.87	110	110	Open	63	0.08
184	152	153	686.29	110	110	Open	63	0.08
185	140	130	911.28	225	110	Open	95	0.03
186	130	153	157	225	110	Open	−159	0.05
188	154	155	168.89	225	110	Open	−53	0.02
189	155	156	180.54	225	110	Open	−53	0.02
190	156	157	322.27	225	110	Open	−37	0.01
191	158	164	124.35	110	110	Open	−4	0
195	167	166	503.36	160	110	Open	372	0.21
196	160	167	363.39	160	110	Open	510	0.29
197	167	168	362.07	110	110	Open	138	0.17
200	132	179	168.35	160	110	Open	762	0.44
201	179	128	401.89	160	110	Open	692	0.4

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
203	169	170	48.22	110	110	Open	-165	0.2
204	170	171	149.19	110	110	Open	-165	0.2
205	171	172	266	110	110	Open	-165	0.2
206	172	173	107.93	110	110	Open	-165	0.2
207	173	131	123.5	160	110	Open	-694	0.4
209	169	174	333.47	110	110	Open	165	0.2
210	174	175	119.64	160	110	Open	-559	0.32
211	173	180	167.26	160	110	Open	529	0.3
213	180	177	217.72	160	110	Open	529	0.3
215	177	176	72.45	160	110	Open	529	0.3
216	176	178	80.03	110	110	Open	-30	0.04
217	178	163	249.56	110	110	Open	-30	0.04
218	175	176	51.35	160	110	Open	-559	0.32
219	179	174	260.71	160	110	Open	-327	0.19
220	22	181	578.59	300	110	Open	5,603	0.92
221	181	131	25.02	150	110	Open	1,499	0.98
222	181	182	563.66	300	110	Open	3,708	0.61
230	193	191	349.77	160	110	Open	-17	0.01
231	130	195	22.34	160	110	Open	-27	0.02
232	156	193	31.21	160	110	Open	-17	0.01
233	157	191	126.11	225	110	Open	-37	0.01
234	191	192	31.85	250	110	Open	-53	0.01
235	194	221	634.06	225	110	Open	27	0.01
236	195	221	782.73	160	110	Open	-27	0.02
237	160	183	60.22	150	110	Open	-510	0.33
238	182	183	88.77	300	110	Open	2,971	0.49
239	183	184	286.9	300	110	Open	2,462	0.4
240	184	185	395.9	300	110	Open	2,666	0.44
241	185	158	16.02	150	110	Open	-4	0
242	185	188	19.85	300	110	Open	2,234	0.37
243	188	186	285.51	300	110	Open	2,234	0.37
244	186	187	146.45	300	110	Open	2,234	0.37
250	187	192	137.55	300	110	Open	2,234	0.37
251	192	198	238.62	300	110	Open	1,745	0.29
252	198	199	290.5	160	110	Open	0	0
253	198	200	119.83	300	110	Open	1,745	0.29
254	200	219	460.49	300	110	Open	817	0.13
255	219	218	25.44	200	110	Open	381	0.14
256	214	218	353.29	160	110	Open	55	0.03
257	218	220	868.13	225	110	Open	436	0.13
259	214	215	33.75	160	110	Open	161	0.09
260	201	214	107.36	160	110	Open	216	0.12
261	200	201	28.28	200	110	Open	928	0.34
262	201	202	17.78	110	110	Open	80	0.1
263	202	204	632.9	110	110	Open	80	0.1
264	204	207	713.14	110	110	Open	124	0.15
266	203	204	199.48	160	110	Open	44	0.03
267	203	205	16.29	160	110	Open	-44	0.03
271	209	207	300.21	160	110	Open	374	0.22
272	207	210	374.55	110	110	Open	62	0.08
273	205	212	412.83	225	110	Open	164	0.05
274	205	223	203.47	160	110	Open	381	0.22
275	223	209	69.13	160	110	Open	374	0.22
276	223	211	406.91	110	110	Open	8	0.01
277	211	210	449.15	160	110	Open	374	0.22
278	212	211	203.44	160	110	Open	367	0.21
279	213	212	270.61	160	110	Open	203	0.12
280	201	216	126.42	225	110	Open	631	0.18
283	217	213	412.13	110	110	Open	42	0.05
286	182	224	35.61	225	110	Open	300	0.09

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
287	224	226	97.56	160	110	Open	95	0.05
290	227	229	653.56	160	110	Open	436	0.25
292	224	225	348.98	225	110	Open	205	0.06
293	225	184	1849.61	160	110	Open	205	0.12
302	242	24	658.31	160	110	Open	1,412	0.81
303	240	241	173.51	160	110	Open	0	0
304	242	240	181.77	160	110	Open	-1,424	0.82
305	10	239	94.41	110	110	Open	1,143	1.39
306	239	240	251.41	160	110	Open	1,424	0.82
307	239	243	209.09	110	110	Open	385	0.47
308	243	242	216.99	90	110	Open	385	0.7
311	9	244	128.73	110	110	Open	424	0.52
315	220	250	526.13	160	110	Open	436	0.25
316	154	251	188.69	225	110	Open	123	0.04
317	251	153	69.35	225	110	Open	96	0.03
318	251	194	20.58	225	110	Open	27	0.01
319	16	252	193.95	300	110	Open	7,769	1.27
320	252	35	170.73	300	110	Open	7,463	1.22
42	17	259	94.34	160	110	Open	855	0.49
153	259	257	94.52	160	110	Open	855	0.49
193	257	252	111.05	160	110	Open	855	0.49
223	252	253	122.83	160	110	Open	1,161	0.67
321	253	256	172.15	160	110	Open	1,161	0.67
322	98	92	86.27	160	110	Open	34	0.02
323	235	237	381.35	160	110	Open	436	0.25
324	45	43	187.67	160	110	Open	278	0.16
326	244	11	496.38	160	110	Open	-639	0.37
327	239	244	329.6	110	110	Open	-666	0.81
328	235	234	55.05	160	110	Open	341	0.2
329	234	233	167.35	160	110	Open	341	0.2
330	233	232	182.39	160	110	Open	341	0.2
332	164	165	207.25	110	110	Open	-4	0
333	165	168	38.67	110	110	Open	-4	0
334	168	166	157.76	110	110	Open	134	0.16
335	166	154	349.81	160	110	Open	506	0.29
338	237	12	802.56	160	110	Open	436	0.25
341	25	13	131.31	160	110	Open	1,213	0.7
342	13	34	43.17	160	110	Open	1,213	0.7
343	34	235	284.57	160	110	Open	1,213	0.7
344	6	38	262.11	160	110	Open	0	0
346	38	42	143.69	160	110	Open	0	0
11	226	50	126.42	160	110	Open	436	0.25
12	50	227	499.62	160	110	Open	436	0.25
20	226	52	280.96	160	110	Open	-341	0.2
35	52	58	55.77	160	110	Open	-341	0.2
39	58	232	243.77	160	110	Open	-341	0.2
43	136	63	151.36	160	110	Open	66	0.04
51	63	128	111.52	160	110	Open	-25	0.01
52	63	61	156.22	110	110	Open	91	0.11
53	61	60	211	110	110	Open	91	0.11
56	60	59	353.71	110	110	Open	91	0.11
58	145	59	90.41	110	110	Open	-86	0.11
59	59	147	162.77	110	110	Open	5	0.01
60	215	65	318.75	160	110	Open	161	0.09
62	65	213	220	160	110	Open	161	0.09
67	216	66	49.94	225	110	Open	631	0.18
69	66	217	55.55	225	110	Open	631	0.18
70	217	67	46.22	225	110	Open	589	0.17
71	67	205	211.73	225	110	Open	589	0.17
27	127	22	128.62	150	110	Open	-2,088	1.37
1	1	2	19.87	400	110	Open	17,089	1.57
18	256	37	56.5	225	110	Open	-1,661	0.48
28	256	40	511.28	225	110	Open	2,425	0.71

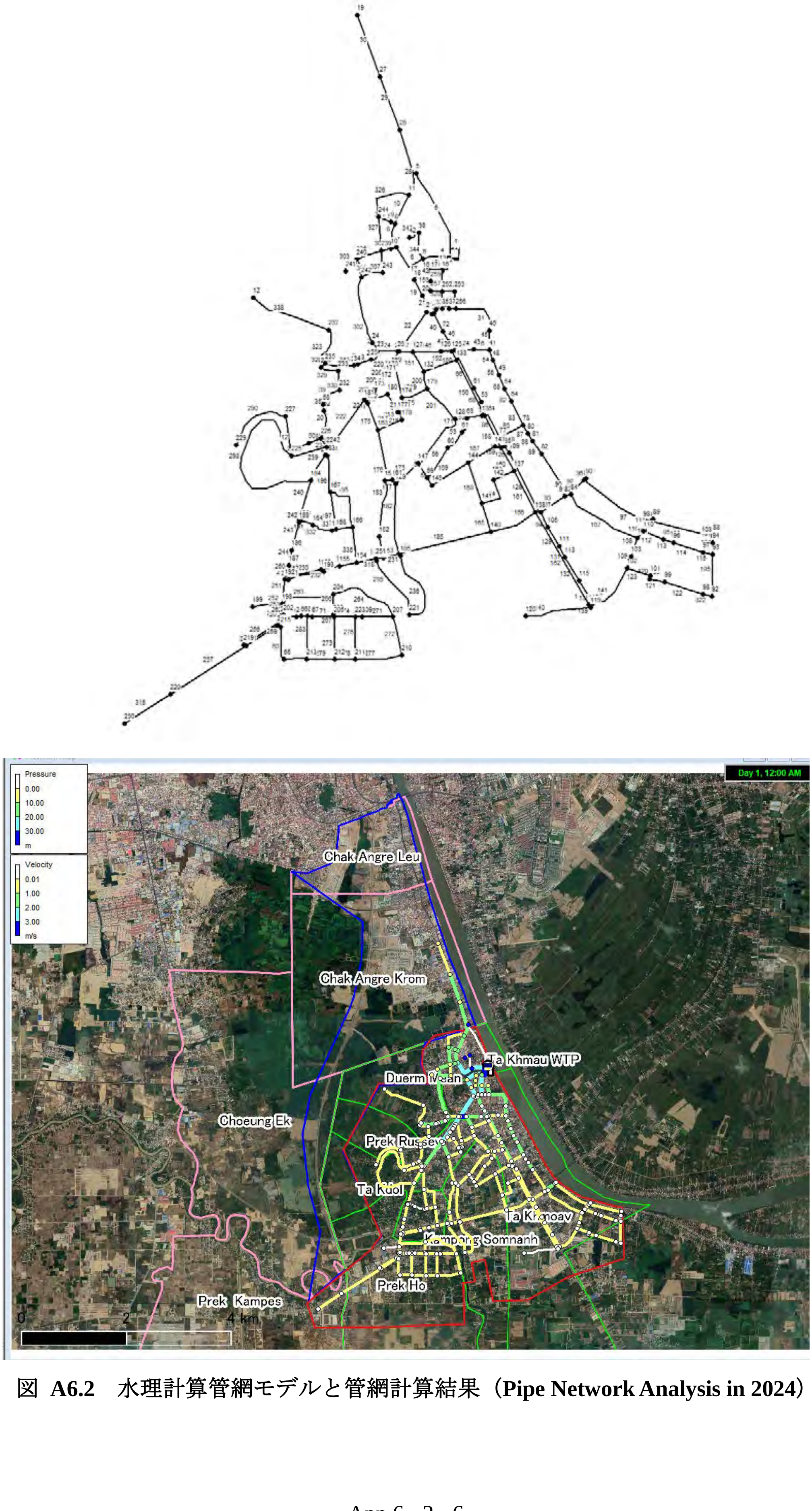


図 A6.2　水理計算管網モデルと管網計算結果（**Pipe Network Analysis in 2024**）

表 A6.3　管網計算結果（節点）（Pipe Network Analysis in 2024）

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
2	0	40.0	40.0
3	0	38.6	38.6
4	0	38.3	38.3
5	0	40.0	40.0
6	0	31.8	31.8
7	0	23.5	23.5
8	0	19.8	19.8
9	0	18.5	18.5
10	0	17.1	17.1
11	0	16.0	16.0
14	0	11.4	11.4
15	0	8.5	8.5
16	0	11.0	11.0
17	0	8.1	8.1
18	600	3.8	3.8
20	0	0.5	0.5
21	600	-3.2	-3.2
22	600	-18.5	-18.5
23	0	-18.5	-18.5
24	0	-16.5	-16.5
25	0	-21.0	-21.0
26	0	-18.5	-18.5
31	0	-2.9	-2.9
32	0	-2.8	-2.8
33	0	-1.7	-1.7
35	600	-0.5	-0.5
37	0	-0.9	-0.9
40	0	-9.2	-9.2
41	600	-12.1	-12.1
43	0	-11.9	-11.9
45	600	-11.7	-11.7
46	0	-9.5	-9.5
48	0	-13.6	-13.6
49	0	-15.7	-15.7
51	600	-17.5	-17.5
53	0	-18.8	-18.8
54	0	-17.7	-17.7
64	600	-19.6	-19.6
72	0	-7.0	-7.0
77	0	-22.5	-22.5
78	0	-22.0	-22.0
80	0	-22.8	-22.8
81	0	-25.2	-25.2
82	600	-26.5	-26.5
83	0	-29.1	-29.1
84	0	-29.9	-29.9
85	571	-31.3	-31.3
86	571	-34.4	-34.4
87	571	-35.1	-35.1
88	0	-35.1	-35.1
89	0	-34.4	-34.4
90	0	-31.3	-31.3
92	571	-36.3	-36.3
93	0	-35.2	-35.2
94	0	-35.1	-35.1
95	0	-34.7	-34.7
96	0	-34.8	-34.8
97	0	-35.1	-35.1
98	0	-36.3	-36.3
99	0	-36.3	-36.3
100	0	-36.3	-36.3
101	0	-36.3	-36.3
102	571	-36.3	-36.3
103	0	-35.6	-35.6
104	0	-34.5	-34.5
105	0	-29.8	-29.8
107	0	-28.5	-28.5
108	0	-23.5	-23.5
109	600	-24.3	-24.3
110	0	-34.5	-34.5
111	0	-31.5	-31.5
113	0	-32.5	-32.5
115	0	-34.5	-34.5
117	0	-36.6	-36.6
118	571	-36.6	-36.6
119	0	-36.6	-36.6
120	0	-36.6	-36.6
125	0	-34.7	-34.7
126	0	-33.0	-33.0
127	0	-28.7	-28.7
128	600	-36.6	-36.6
129	571	-37.1	-37.1
130	571	-37.3	-37.3
131	0	-29.2	-29.2
132	0	-32.2	-32.2
133	0	-34.8	-34.8
134	600	-36.5	-36.5
135	0	-36.9	-36.9
136	0	-36.5	-36.5
137	0	-37.0	-37.0
138	571	-37.1	-37.1
140	571	-37.3	-37.3
141	0	-37.2	-37.2
142	0	-37.1	-37.1
143	0	-37.0	-37.0
144	600	-37.4	-37.4
145	0	-37.4	-37.4
147	600	-37.3	-37.3
151	0	-36.7	-36.7
152	0	-37.0	-37.0
153	0	-37.2	-37.2
154	571	-37.2	-37.2
155	0	-37.2	-37.2
156	0	-37.2	-37.2
157	0	-37.2	-37.2
158	0	-35.4	-35.4
160	0	-33.1	-33.1
161	0	-36.7	-36.7
162	0	-29.5	-29.5
163	0	-32.2	-32.2
164	0	-35.4	-35.4
165	0	-35.4	-35.4
166	0	-35.8	-35.8
167	0	-34.6	-34.6
168	0	-35.4	-35.4
169	0	-32.1	-32.1
170	0	-32.0	-32.0
171	0	-31.5	-31.5
172	0	-30.5	-30.5
173	0	-30.2	-30.2
174	600	-33.3	-33.3
175	0	-32.6	-32.6
176	0	-32.3	-32.3
177	0	-32.0	-32.0
178	0	-32.3	-32.3
179	600	-33.8	-33.8
180	0	-31.0	-31.0
181	600	-28.1	-28.1
182	571	-32.3	-32.3
183	0	-32.7	-32.7
184	0	-33.8	-33.8
185	571	-35.4	-35.4
186	0	-36.3	-36.3
187	0	-36.8	-36.8
188	0	-35.5	-35.5
191	0	-37.2	-37.2
192	571	-37.2	-37.2
193	0	-37.2	-37.2
194	0	-37.2	-37.2
195	0	-37.3	-37.3
198	0	-37.6	-37.6
199	0	-37.6	-37.6
200	0	-37.8	-37.8
201	0	-37.9	-37.9
202	0	-37.9	-37.9
203	0	-38.4	-38.4
204	0	-38.4	-38.4
205	0	-38.4	-38.4
207	571	-39.7	-39.7
209	0	-39.0	-39.0
210	571	-39.9	-39.9
211	0	-38.9	-38.9
212	0	-38.5	-38.5
213	0	-38.3	-38.3
214	0	-38.0	-38.0
215	0	-38.0	-38.0
216	0	-38.1	-38.1
217	0	-38.2	-38.2
218	0	-38.0	-38.0
219	571	-38.0	-38.0
220	0	-38.5	-38.5
221	0	-37.2	-37.2
223	0	-38.9	-38.9
224	0	-32.3	-32.3
225	0	-32.4	-32.4
226	0	-32.3	-32.3
227	0	-34.1	-34.1
229	571	-36.1	-36.1
232	0	-31.1	-31.1
233	0	-30.7	-30.7
234	0	-30.4	-30.4
235	571	-30.2	-30.2
237	0	-31.4	-31.4
239	0	6.5	6.5
240	0	0.7	0.7
241	0	0.7	0.7
242	600	-3.4	-3.4
243	0	3.9	3.9
244	600	14.7	14.7
250	572	-40.1	-40.1
251	0	-37.2	-37.2
252	0	4.6	4.6
253	0	2.1	2.1
256	600	-1.5	-1.5
257	0	5.9	5.9
259	0	7.0	7.0
12	571	-33.7	-33.7
13	0	-23.6	-23.6
34	0	-24.5	-24.5
38	0	31.8	31.8
42	0	31.8	31.8
50	0	-32.7	-32.7
52	0	-31.7	-31.7
58	0	-31.6	-31.6
59	0	-37.3	-37.3
60	0	-36.9	-36.9
61	0	-36.7	-36.7
63	0	-36.6	-36.6
65	0	-38.2	-38.2
66	0	-38.1	-38.1
67	0	-38.2	-38.2
19	2000	5.4	5.4
27	2000	6.2	6.2
28	2000	9.0	9.0

表 A6.4　管網計算結果（管）（**Pipe Network Analysis in 2024**）

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
2	2	3	27.18	400	110	Open	47,987	4.42
3	3	4	10.87	400	110	Open	33,894	3.12
4	3	6	312.42	300	110	Open	14,093	2.31
5	2	5	900.16	250	110	Open	0	0
6	6	7	385.89	300	110	Open	14,093	2.31
7	7	10	56.56	110	110	Open	2,449	2.98
8	7	8	240.17	300	110	Open	11,644	1.91
9	8	9	46.95	110	110	Open	1,181	1.44
10	8	11	305.7	300	110	Open	10,463	1.71
13	4	14	244.2	300	110	Open	33,894	5.55
14	14	16	13.83	300	110	Open	17,658	2.89
15	14	15	105.74	300	110	Open	16,236	2.66
16	15	17	20.74	150	110	Open	1,939	1.27
17	15	18	210.31	300	110	Open	14,298	2.34
19	18	20	169.63	300	110	Open	13,338	2.18
21	20	21	184.4	300	110	Open	13,338	2.18
22	21	22	458.88	300	110	Open	17,788	2.91
23	22	26	18.79	160	110	Open	21	0.01
24	26	23	193.56	160	110	Open	21	0.01
25	23	24	98.95	160	110	Open	−2,573	1.48
26	23	25	125.34	160	110	Open	2,594	1.49
32	31	21	76.83	300	110	Open	5,410	0.89
33	31	32	17.8	300	110	Open	−5,410	0.89
34	32	33	65.73	300	110	Open	−12,106	1.98
36	33	35	73.14	300	110	Open	−12,106	1.98
38	35	37	49.39	225	110	Open	3,899	1.13
40	32	72	189.04	225	110	Open	6,696	1.95
45	40	41	187.67	225	110	Open	5,570	1.62
46	41	43	154.11	160	110	Open	−557	0.32
48	72	46	111.47	225	110	Open	6,696	1.95
50	46	45	101.35	225	110	Open	6,696	1.95
54	41	48	104.45	225	110	Open	5,167	1.5
55	48	49	155.62	225	110	Open	5,167	1.5
65	49	54	143.09	225	110	Open	5,167	1.5
66	45	51	417.79	225	110	Open	5,179	1.51
68	51	53	144.07	225	110	Open	4,219	1.23
82	54	64	138.9	225	110	Open	5,167	1.5
83	64	78	255.3	225	110	Open	4,207	1.22
85	78	77	252.69	90	110	Open	176	0.32
86	53	77	391.46	225	110	Open	4,219	1.23
87	78	80	91.9	225	110	Open	4,032	1.17
88	80	81	285.79	225	110	Open	4,032	1.17
89	81	82	149.02	225	110	Open	4,032	1.17
90	82	83	489.98	225	110	Open	3,072	0.89
91	83	84	63.82	225	110	Open	4,941	1.44
92	84	85	194.61	225	110	Open	3,607	1.05
93	83	107	276.77	225	110	Open	−1,869	0.54
94	107	105	166.1	160	110	Open	1,566	0.9
96	85	90	24.11	160	110	Open	0	0
97	85	86	768.88	225	110	Open	2,693	0.78
98	86	89	27.93	160	110	Open	0	0
100	86	87	616.51	225	110	Open	1,305	0.38
101	87	94	61.35	160	110	Open	392	0.23
103	88	87	19.75	160	110	Open	0	0
104	94	93	110.6	160	110	Open	392	0.23
105	93	92	406.94	160	110	Open	884	0.51
107	84	104	788.69	160	110	Open	1,334	0.77
108	104	103	186.16	160	110	Open	1,316	0.76
109	103	102	122.52	160	110	Open	1,316	0.76
110	104	110	86.63	160	110	Open	18	0.01

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
111	110	86	125.24	160	110	Open	−474	0.27
112	110	95	209.06	160	110	Open	492	0.28
113	95	96	107.46	160	110	Open	492	0.28
114	96	97	299.79	160	110	Open	492	0.28
115	97	93	92.22	160	110	Open	492	0.28
120	101	100	28.76	160	110	Open	30	0.02
121	100	99	149.53	160	110	Open	30	0.02
122	99	98	388.58	160	110	Open	30	0.02
123	102	101	241.09	160	110	Open	30	0.02
124	77	108	97.16	225	110	Open	4,395	1.28
126	108	109	79.98	225	110	Open	4,395	1.28
128	109	107	649.05	225	110	Open	3,435	1
129	105	111	210.69	160	110	Open	1,566	0.9
131	111	113	123.66	160	110	Open	1,566	0.9
132	113	115	260.86	160	110	Open	1,566	0.9
137	115	117	258.79	160	110	Open	1,566	0.9
138	117	118	44.16	250	110	Open	1,938	0.46
139	118	119	39.5	250	110	Open	0	0
140	119	120	645.75	160	110	Open	0	0
141	117	102	504.75	160	110	Open	−373	0.21
146	127	126	272.57	160	110	Open	2,291	1.32
147	126	125	102.72	160	110	Open	2,291	1.32
150	125	133	98.06	250	110	Open	2,291	0.54
151	127	132	221.07	160	110	Open	2,294	1.32
152	133	132	332.95	110	110	Open	−585	0.71
155	136	134	25.68	160	110	Open	−252	0.15
156	133	134	604.2	250	110	Open	2,876	0.68
158	134	135	344.51	250	110	Open	1,664	0.39
159	143	135	66.74	160	110	Open	−645	0.37
160	135	137	258.04	250	110	Open	1,019	0.24
161	137	138	445.65	250	110	Open	695	0.16
162	138	118	1027.9	250	110	Open	−1,025	0.24
163	137	142	212.46	160	110	Open	324	0.19
164	142	141	375.09	160	110	Open	324	0.19
165	141	140	289.84	160	110	Open	193	0.11
166	138	140	476.94	225	110	Open	806	0.23
167	143	144	300.24	160	110	Open	645	0.37
168	144	141	410.99	110	110	Open	−132	0.16
169	144	145	413.28	160	110	Open	−183	0.11
171	128	147	598.71	160	110	Open	564	0.32
173	147	129	293.36	160	110	Open	−389	0.22
174	131	162	27.47	160	110	Open	1,779	1.02
175	162	163	272.14	160	110	Open	1,779	1.02
176	163	161	506.93	160	110	Open	1,665	0.96
177	161	129	53.84	160	110	Open	1,544	0.89
178	161	151	74.03	110	110	Open	120	0.15
182	129	130	681.68	160	110	Open	241	0.14
183	151	152	552.87	110	110	Open	120	0.15
184	152	153	686.29	110	110	Open	120	0.15
185	140	130	911.27	225	110	Open	85	0.02
186	130	153	157	225	110	Open	−499	0.15
188	154	155	168.89	225	110	Open	−276	0.08
189	155	156	180.54	225	110	Open	−276	0.08
190	156	157	322.27	225	110	Open	−191	0.06
191	158	164	124.35	110	110	Open	1	0
195	167	166	503.36	160	110	Open	807	0.46
196	160	167	363.39	160	110	Open	1,104	0.64
197	167	168	362.07	110	110	Open	296	0.36
200	132	179	168.35	160	110	Open	1,709	0.98
201	179	128	401.89	160	110	Open	1,462	0.84

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
203	169	170	48.22	110	110	Open	-373	0.45
204	170	171	149.19	110	110	Open	-373	0.45
205	171	172	266	110	110	Open	-373	0.45
206	172	173	107.93	110	110	Open	-373	0.45
207	173	131	123.5	160	110	Open	-1,559	0.9
209	169	174	333.47	110	110	Open	373	0.45
210	174	175	119.64	160	110	Open	-1,300	0.75
211	173	180	167.26	160	110	Open	1,186	0.68
213	180	177	217.72	160	110	Open	1,186	0.68
215	177	176	72.45	160	110	Open	1,186	0.68
216	176	178	80.03	110	110	Open	-115	0.14
217	178	163	249.56	110	110	Open	-115	0.14
218	175	176	51.35	160	110	Open	-1,300	0.75
219	179	174	260.72	160	110	Open	-714	0.41
220	22	181	578.59	300	110	Open	12,222	2
221	181	131	25.02	150	110	Open	3,338	2.19
222	181	182	563.66	300	110	Open	7,924	1.3
230	193	191	349.77	160	110	Open	-85	0.05
231	130	195	22.35	160	110	Open	-88	0.05
232	156	193	31.21	160	110	Open	-85	0.05
233	157	191	126.11	225	110	Open	-191	0.06
234	191	192	31.85	250	110	Open	-276	0.07
235	194	221	634.06	225	110	Open	88	0.03
236	195	221	782.73	160	110	Open	-88	0.05
237	160	183	60.22	150	110	Open	-1,104	0.72
238	182	183	88.77	300	110	Open	6,421	1.05
239	183	184	286.9	300	110	Open	5,317	0.87
240	184	185	395.9	300	110	Open	5,760	0.94
241	185	158	16.02	150	110	Open	1	0
242	185	188	19.85	300	110	Open	4,846	0.79
243	188	186	285.51	300	110	Open	4,846	0.79
244	186	187	146.45	300	110	Open	4,846	0.79
250	187	192	137.55	300	110	Open	4,846	0.79
251	192	198	238.62	300	110	Open	3,656	0.6
252	198	199	290.5	160	110	Open	0	0
253	198	200	119.83	300	110	Open	3,656	0.6
254	200	219	460.49	300	110	Open	1,713	0.28
255	219	218	25.44	200	110	Open	799	0.29
256	214	218	353.29	160	110	Open	116	0.07
257	218	220	868.14	225	110	Open	915	0.27
259	214	215	33.75	160	110	Open	338	0.19
260	201	214	107.36	160	110	Open	454	0.26
261	200	201	28.28	200	110	Open	1,943	0.72
262	201	202	17.78	110	110	Open	168	0.2
263	202	204	632.9	110	110	Open	168	0.2
264	204	207	713.14	110	110	Open	260	0.32
266	203	204	199.48	160	110	Open	92	0.05
267	203	205	16.29	160	110	Open	-92	0.05
271	209	207	300.21	160	110	Open	783	0.45
272	207	210	374.55	110	110	Open	130	0.16
273	205	212	412.83	225	110	Open	343	0.1
274	205	223	203.47	160	110	Open	799	0.46
275	223	209	69.13	160	110	Open	783	0.45
276	223	211	406.91	110	110	Open	16	0.02
277	211	210	449.15	160	110	Open	784	0.45
278	212	211	203.44	160	110	Open	768	0.44
279	213	212	270.61	160	110	Open	425	0.24
280	201	216	126.42	225	110	Open	1,321	0.38
283	217	213	412.13	110	110	Open	87	0.11
286	182	224	35.61	225	110	Open	590	0.17

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
287	224	226	97.56	160	110	Open	147	0.08
290	227	229	653.56	160	110	Open	914	0.53
292	224	225	348.99	225	110	Open	443	0.13
293	225	184	1849.61	160	110	Open	443	0.25
302	242	24	658.31	160	110	Open	2,573	1.48
303	240	241	173.51	160	110	Open	0	0
304	242	240	181.77	160	110	Open	-2,781	1.6
305	10	239	94.41	110	110	Open	2,449	2.98
306	239	240	251.41	160	110	Open	2,781	1.6
307	239	243	209.09	110	110	Open	753	0.92
308	243	242	216.99	90	110	Open	753	1.37
311	9	244	128.73	110	110	Open	1,181	1.44
315	220	250	526.13	160	110	Open	915	0.53
316	154	251	188.69	225	110	Open	467	0.14
317	251	153	69.35	225	110	Open	378	0.11
318	251	194	20.58	225	110	Open	88	0.03
319	16	252	193.95	300	110	Open	17,658	2.89
320	252	35	167.94	300	110	Open	16,965	2.78
42	17	259	94.34	160	110	Open	1,939	1.12
153	259	257	94.52	160	110	Open	1,939	1.12
193	257	252	111.05	160	110	Open	1,939	1.12
223	252	253	122.83	160	110	Open	2,631	1.51
321	253	256	170.34	160	110	Open	2,631	1.51
322	98	92	86.27	160	110	Open	30	0.02
323	235	237	381.35	160	110	Open	914	0.53
324	45	43	187.67	160	110	Open	557	0.32
326	244	11	496.38	160	110	Open	-863	0.5
327	239	244	329.6	110	110	Open	-1,084	1.32
328	235	234	55.05	160	110	Open	767	0.44
329	234	233	167.35	160	110	Open	767	0.44
330	233	232	182.39	160	110	Open	767	0.44
332	164	165	207.25	110	110	Open	1	0
333	165	168	38.67	110	110	Open	1	0
334	168	166	157.76	110	110	Open	297	0.36
335	166	154	349.81	160	110	Open	1,104	0.64
338	237	12	802.56	160	110	Open	914	0.53
341	25	13	131.31	160	110	Open	2,594	1.49
342	13	34	43.17	160	110	Open	2,594	1.49
343	34	235	284.57	160	110	Open	2,594	1.49
344	6	38	262.11	160	110	Open	0	0
346	38	42	143.69	160	110	Open	0	0
11	226	50	126.42	160	110	Open	914	0.53
12	50	227	499.62	160	110	Open	914	0.53
20	226	52	280.96	160	110	Open	-767	0.44
35	52	58	55.77	160	110	Open	-767	0.44
39	58	232	243.77	160	110	Open	-767	0.44
43	136	63	151.36	160	110	Open	252	0.15
51	63	128	111.52	160	110	Open	62	0.04
52	63	61	156.22	110	110	Open	191	0.23
53	61	60	211	110	110	Open	191	0.23
56	60	59	353.71	110	110	Open	191	0.23
58	145	59	90.41	110	110	Open	-183	0.22
59	59	147	162.77	110	110	Open	7	0.01
60	215	65	318.75	160	110	Open	338	0.19
62	65	213	220	160	110	Open	338	0.19
67	216	66	49.94	225	110	Open	1,321	0.38
69	66	217	55.55	225	110	Open	1,321	0.38
70	217	67	46.22	225	110	Open	1,234	0.36
71	67	205	211.73	225	110	Open	1,234	0.36
27	127	22	128.62	150	110	Open	-4,585	3
28	11	28	658.78	300	110	Open	9,600	1.57
29	28	27	550.12	300	110	Open	6,400	1.05
30	27	19	633.7	300	110	Open	3,200	0.52
18	256	37	65.6	225	110	Open	-3,899	1.13
31	256	40	487.51	225	110	Open	5,570	1.62

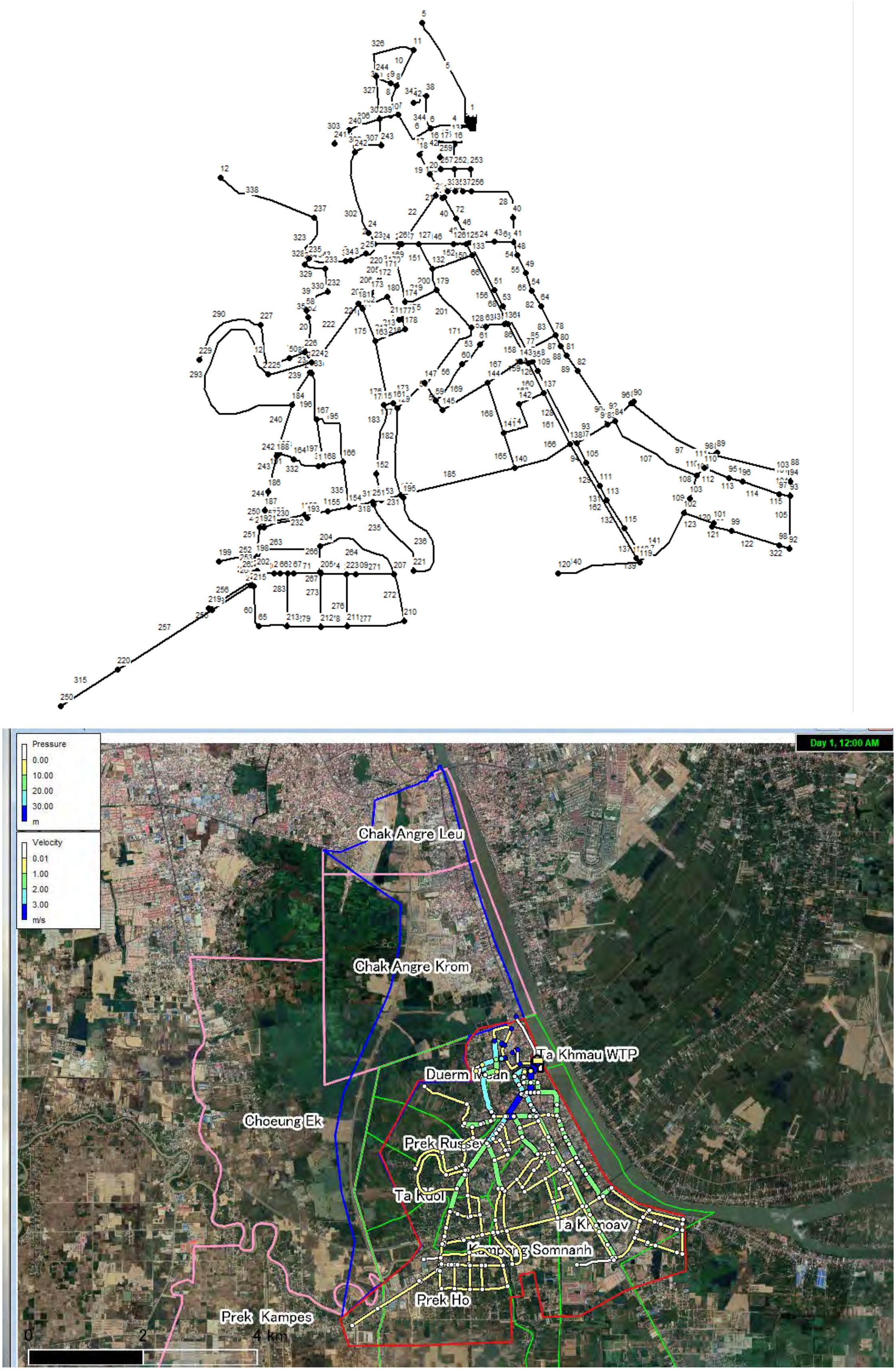


図 **A6.3**　水理計算管網モデルと管網計算結果（**Pipe Network Analysis in 2030**）

表 A6.5　管網計算結果（節点）（Pipe Network Analysis in 2030）

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
2	0	41.7	41.7
3	0	40.5	40.5
4	0	40.1	40.1
5	0	41.7	41.7
6	0	39.2	39.2
7	0	37.6	37.6
8	0	37.3	37.3
9	0	36.1	36.1
10	0	28.3	28.3
11	0	37.2	37.2
14	0	5.2	5.2
15	0	1.3	1.3
16	0	4.6	4.6
17	0	0.9	0.9
18	650	-4.8	-4.8
20	0	-9.1	-9.1
21	650	-13.8	-13.8
22	650	-34.1	-34.1
23	0	-33.8	-33.8
24	0	-30.0	-30.0
25	0	-37.5	-37.5
26	0	-34.0	-34.0
31	0	-13.5	-13.5
32	0	-13.4	-13.4
33	0	-12.0	-12.0
35	650	-10.4	-10.4
37	0	-10.9	-10.9
40	0	-21.8	-21.8
41	650	-25.7	-25.7
43	0	-25.4	-25.4
45	650	-25.1	-25.1
46	0	-22.1	-22.1
48	0	-27.6	-27.6
49	0	-30.5	-30.5
51	650	-32.8	-32.8
53	0	-34.7	-34.7
54	0	-33.1	-33.1
64	650	-35.7	-35.7
72	0	-18.9	-18.9
77	0	-39.8	-39.8
78	0	-39.0	-39.0
80	0	-40.1	-40.1
81	0	-43.6	-43.6
82	650	-45.4	-45.4
83	0	-49.1	-49.1
84	0	-50.3	-50.3
85	715	-52.3	-52.3
86	715	-56.9	-56.9
87	715	-57.9	-57.9
88	0	-57.9	-57.9

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
89	0	-56.9	-56.9
90	0	-52.3	-52.3
92	715	-59.6	-59.6
93	0	-58.0	-58.0
94	0	-57.9	-57.9
95	0	-57.3	-57.3
96	0	-57.5	-57.5
97	0	-57.9	-57.9
98	0	-59.6	-59.6
99	0	-59.5	-59.5
100	0	-59.5	-59.5
101	0	-59.5	-59.5
102	715	-59.5	-59.5
103	0	-58.5	-58.5
104	0	-57.0	-57.0
105	0	-50.1	-50.1
107	0	-48.3	-48.3
108	0	-41.1	-41.1
109	650	-42.2	-42.2
110	0	-57.0	-57.0
111	0	-52.5	-52.5
113	0	-53.9	-53.9
115	0	-56.9	-56.9
117	0	-59.8	-59.8
118	715	-59.9	-59.9
119	0	-59.9	-59.9
120	0	-59.9	-59.9
125	0	-56.7	-56.7
126	0	-54.3	-54.3
127	0	-48.2	-48.2
128	650	-59.3	-59.3
129	715	-60.3	-60.3
130	715	-60.7	-60.7
131	0	-49.1	-49.1
132	0	-53.0	-53.0
133	0	-56.9	-56.9
134	650	-59.3	-59.3
135	0	-59.9	-59.9
136	0	-59.3	-59.3
137	0	-60.1	-60.1
138	715	-60.3	-60.3
140	715	-60.7	-60.7
141	0	-60.5	-60.5
142	0	-60.3	-60.3
143	0	-60.0	-60.0
144	650	-60.6	-60.6
145	0	-60.5	-60.5
147	650	-60.4	-60.4
151	0	-59.8	-59.8
152	0	-60.2	-60.2

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
153	0	-60.7	-60.7
154	715	-60.7	-60.7
155	0	-60.7	-60.7
156	0	-60.7	-60.7
157	0	-60.7	-60.7
158	0	-58.2	-58.2
160	0	-54.9	-54.9
161	0	-59.7	-59.7
162	0	-49.5	-49.5
163	0	-53.2	-53.2
164	0	-58.2	-58.2
165	0	-58.2	-58.2
166	0	-58.7	-58.7
167	0	-57.0	-57.0
168	0	-58.2	-58.2
169	0	-53.0	-53.0
170	0	-52.7	-52.7
171	0	-52.1	-52.1
172	0	-50.9	-50.9
173	0	-50.4	-50.4
174	650	-54.5	-54.5
175	0	-53.6	-53.6
176	0	-53.3	-53.3
177	0	-52.8	-52.8
178	0	-53.2	-53.2
179	650	-55.1	-55.1
180	0	-51.4	-51.4
181	650	-47.6	-47.6
182	715	-53.7	-53.7
183	0	-54.4	-54.4
184	0	-55.8	-55.8
185	715	-58.2	-58.2
186	0	-59.5	-59.5
187	0	-60.1	-60.1
188	0	-58.3	-58.3
191	0	-60.7	-60.7
192	715	-60.7	-60.7
193	0	-60.7	-60.7
194	0	-60.7	-60.7
195	0	-60.7	-60.7
198	0	-61.3	-61.3
199	0	-61.3	-61.3
200	0	-61.6	-61.6
201	0	-61.8	-61.8
202	0	-61.8	-61.8
203	0	-62.6	-62.6
204	0	-62.6	-62.6
205	0	-62.6	-62.6
207	715	-64.5	-64.5
209	0	-63.5	-63.5

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
210	715	-64.8	-64.8
211	0	-63.3	-63.3
212	0	-62.6	-62.6
213	0	-62.4	-62.4
214	0	-61.9	-61.9
215	0	-62.0	-62.0
216	0	-62.0	-62.0
217	0	-62.2	-62.2
218	0	-62.0	-62.0
219	715	-62.0	-62.0
220	0	-62.7	-62.7
221	0	-60.7	-60.7
223	0	-63.3	-63.3
224	0	-53.7	-53.7
225	0	-53.8	-53.8
226	0	-53.8	-53.8
227	0	-56.5	-56.5
229	715	-59.4	-59.4
232	0	-52.1	-52.1
233	0	-51.6	-51.6
234	0	-51.2	-51.2
235	715	-51.0	-51.0
237	0	-52.7	-52.7
239	0	12.9	12.9
240	0	2.9	2.9
241	0	2.9	2.9
242	650	-4.3	-4.3
243	0	8.3	8.3
244	650	32.7	32.7
250	715	-65.0	-65.0
251	0	-60.7	-60.7
252	0	-3.7	-3.7
253	0	-7.0	-7.0
256	650	-11.6	-11.6
257	0	-2.0	-2.0
259	0	-0.6	-0.6
12	715	-56.3	-56.3
13	0	-41.4	-41.4
34	0	-42.7	-42.7
38	0	39.2	39.2
42	0	39.2	39.2
50	0	-54.3	-54.3
52	0	-53.0	-53.0
58	0	-52.8	-52.8
59	0	-60.4	-60.4
60	0	-59.9	-59.9
61	0	-59.6	-59.6
63	0	-59.3	-59.3
65	0	-62.2	-62.2
66	0	-62.1	-62.1
67	0	-62.3	-62.3

表 A6.6 管網計算結果（管）（Pipe Network Analysis in 2030）

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
2	2	3	27.18	400	110	Open	44,824	4.13
3	3	4	10.87	400	110	Open	39,037	3.6
4	3	6	312.42	300	110	Open	5,787	0.95
5	2	5	900.16	250	110	Open	0	0
6	6	7	385.89	300	110	Open	5,787	0.95
7	7	10	56.56	110	110	Open	2,998	3.65
8	7	8	240.17	300	110	Open	2,788	0.46
9	8	9	46.95	110	110	Open	1,113	1.36
10	8	11	305.7	300	110	Open	1,676	0.27
13	4	14	244.2	300	110	Open	39,037	6.39
14	14	16	13.83	300	110	Open	20,342	3.33
15	14	15	105.74	300	110	Open	18,696	3.06
16	15	17	20.74	150	110	Open	2,234	1.46
17	15	18	210.31	300	110	Open	16,462	2.7
19	18	20	169.63	300	110	Open	15,422	2.53
21	20	21	184.4	300	110	Open	15,422	2.53
22	21	22	458.88	300	110	Open	20,672	3.38
23	22	26	18.79	160	110	Open	−526	0.3
24	26	23	193.56	160	110	Open	−526	0.3
25	23	24	98.95	160	110	Open	−3,707	2.13
26	23	25	125.34	160	110	Open	3,181	1.83
32	31	21	76.83	300	110	Open	6,290	1.03
33	31	32	17.8	300	110	Open	−6,290	1.03
34	32	33	65.73	300	110	Open	−14,054	2.3
36	33	35	73.14	300	110	Open	−14,054	2.3
38	35	37	49.39	225	110	Open	4,454	1.3
40	32	72	189.04	225	110	Open	7,764	2.26
45	40	41	187.67	225	110	Open	6,442	1.88
46	41	43	154.11	160	110	Open	−664	0.38
48	72	46	111.47	225	110	Open	7,764	2.26
50	46	45	101.35	225	110	Open	7,764	2.26
54	41	48	104.45	225	110	Open	6,066	1.77
55	48	49	155.62	225	110	Open	6,066	1.77
65	49	54	143.09	225	110	Open	6,066	1.77
66	45	51	417.79	225	110	Open	6,059	1.76
68	51	53	144.07	225	110	Open	5,019	1.46
82	54	64	138.9	225	110	Open	6,066	1.77
83	64	78	255.3	225	110	Open	5,026	1.46
85	78	77	252.69	90	110	Open	206	0.38
86	53	77	391.46	225	110	Open	5,019	1.46
87	78	80	91.9	225	110	Open	4,820	1.4
88	80	81	285.79	225	110	Open	4,820	1.4
89	81	82	149.02	225	110	Open	4,820	1.4
90	82	83	489.98	225	110	Open	3,780	1.1
91	83	84	63.82	225	110	Open	6,070	1.77
92	84	85	194.61	225	110	Open	4,438	1.29
93	83	107	276.77	225	110	Open	−2,290	0.67
94	107	105	166.1	160	110	Open	1,895	1.09
96	85	90	24.11	160	110	Open	0	0
97	85	86	768.88	225	110	Open	3,294	0.96
98	86	89	27.93	160	110	Open	0	0
100	86	87	616.51	225	110	Open	1,599	0.47
101	87	94	61.35	160	110	Open	455	0.26
103	88	87	19.75	160	110	Open	0	0
104	94	93	110.6	160	110	Open	455	0.26
105	93	92	406.94	160	110	Open	1,058	0.61
107	84	104	788.69	160	110	Open	1,632	0.94
108	104	103	186.16	160	110	Open	1,580	0.91
109	103	102	122.52	160	110	Open	1,580	0.91
110	104	110	86.63	160	110	Open	52	0.03

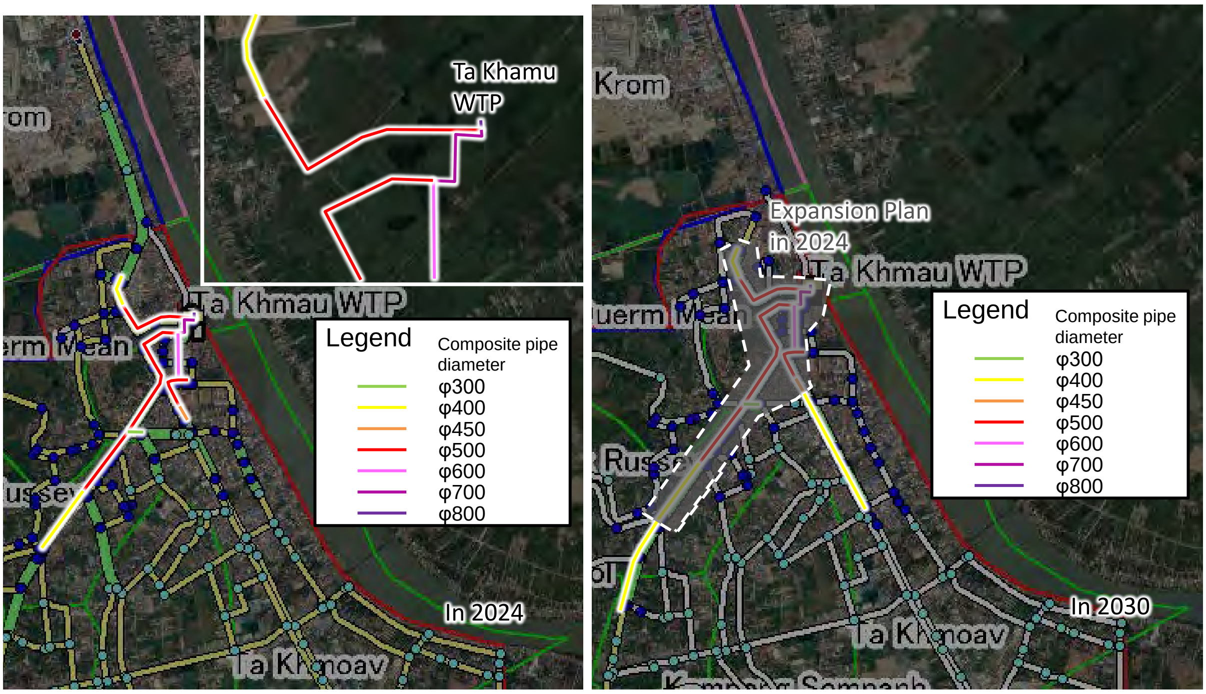
Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
111	110	86	125.24	160	110	Open	−551	0.32
112	110	95	209.06	160	110	Open	603	0.35
113	95	96	107.46	160	110	Open	603	0.35
114	96	97	299.79	160	110	Open	603	0.35
115	97	93	92.22	160	110	Open	603	0.35
120	101	100	28.76	160	110	Open	86	0.05
121	100	99	149.53	160	110	Open	86	0.05
122	99	98	388.58	160	110	Open	86	0.05
123	102	101	241.09	160	110	Open	86	0.05
124	77	108	97.16	225	110	Open	5,225	1.52
126	108	109	79.98	225	110	Open	5,225	1.52
128	109	107	649.05	225	110	Open	4,185	1.22
129	105	111	210.69	160	110	Open	1,895	1.09
131	111	113	123.66	160	110	Open	1,895	1.09
132	113	115	260.86	160	110	Open	1,895	1.09
137	115	117	258.79	160	110	Open	1,895	1.09
138	117	118	44.16	250	110	Open	2,245	0.53
139	118	119	39.5	250	110	Open	0	0
140	119	120	645.75	160	110	Open	0	0
141	117	102	504.75	160	110	Open	−350	0.2
146	127	126	272.57	160	110	Open	2,756	1.59
147	126	125	102.72	160	110	Open	2,756	1.59
150	125	133	98.06	250	110	Open	2,756	0.65
151	127	132	221.07	160	110	Open	2,715	1.56
152	133	132	332.95	110	110	Open	−719	0.88
155	136	134	25.68	160	110	Open	−175	0.1
156	133	134	604.2	250	110	Open	3,475	0.82
158	134	135	344.51	250	110	Open	2,260	0.53
159	143	135	66.74	160	110	Open	−735	0.42
160	135	137	258.04	250	110	Open	1,524	0.36
161	137	138	445.65	250	110	Open	1,100	0.26
162	138	118	1027.9	250	110	Open	−1,101	0.26
163	137	142	212.46	160	110	Open	425	0.24
164	142	141	375.09	160	110	Open	425	0.24
165	141	140	289.84	160	110	Open	346	0.2
166	138	140	476.94	225	110	Open	1,057	0.31
167	143	144	300.24	160	110	Open	735	0.42
168	144	141	410.99	110	110	Open	−79	0.1
169	144	145	413.28	160	110	Open	−226	0.13
171	128	147	598.71	160	110	Open	710	0.41
173	147	129	293.36	160	110	Open	−317	0.18
174	131	162	27.47	160	110	Open	2,110	1.21
175	162	163	272.14	160	110	Open	2,110	1.21
176	163	161	506.93	160	110	Open	2,031	1.17
177	161	129	53.84	160	110	Open	1,865	1.07
178	161	151	74.03	110	110	Open	166	0.2
182	129	130	681.68	160	110	Open	405	0.23
183	151	152	552.87	110	110	Open	166	0.2
184	152	153	686.29	110	110	Open	166	0.2
185	140	130	911.28	225	110	Open	259	0.08
186	130	153	157	225	110	Open	−411	0.12
188	154	155	168.89	225	110	Open	−133	0.04
189	155	156	180.54	225	110	Open	−133	0.04
190	156	157	322.27	225	110	Open	−95	0.03
191	158	164	124.35	110	110	Open	−10	0.01
195	167	166	503.36	160	110	Open	975	0.56
196	160	167	363.39	160	110	Open	1,336	0.77
197	167	168	362.07	110	110	Open	361	0.44
200	132	179	168.35	160	110	Open	1,997	1.15
201	179	128	401.89	160	110	Open	1,814	1.04

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
203	169	170	48.22	110	110	Open	-432	0.53
204	170	171	149.19	110	110	Open	-432	0.53
205	171	172	266	110	110	Open	-432	0.53
206	172	173	107.93	110	110	Open	-432	0.53
207	173	131	123.5	160	110	Open	-1,819	1.05
209	169	174	333.47	110	110	Open	432	0.53
210	174	175	119.64	160	110	Open	-1,465	0.84
211	173	180	167.26	160	110	Open	1,387	0.8
213	180	177	217.72	160	110	Open	1,387	0.8
215	177	176	72.45	160	110	Open	1,387	0.8
216	176	178	80.03	110	110	Open	-78	0.1
217	178	163	249.56	110	110	Open	-78	0.1
218	175	176	51.35	160	110	Open	-1,465	0.84
219	179	174	260.71	160	110	Open	-857	0.49
220	22	181	578.59	300	110	Open	14,687	2.4
221	181	131	25.02	150	110	Open	3,929	2.57
222	181	182	563.66	300	110	Open	9,718	1.59
230	193	191	349.77	160	110	Open	-38	0.02
231	130	195	22.34	160	110	Open	-70	0.04
232	156	193	31.21	160	110	Open	-38	0.02
233	157	191	38.44	225	110	Open	-95	0.03
234	191	192	31.85	250	110	Open	-133	0.03
235	194	221	634.06	225	110	Open	70	0.02
236	195	221	782.73	160	110	Open	-70	0.04
237	160	183	60.22	150	110	Open	-1,336	0.87
238	182	183	88.77	300	110	Open	7,786	1.27
239	183	184	286.9	300	110	Open	6,450	1.06
240	184	185	395.9	300	110	Open	6,987	1.14
241	185	158	16.02	150	110	Open	-10	0.01
242	185	188	19.85	300	110	Open	5,853	0.96
243	188	186	285.51	300	110	Open	5,853	0.96
244	186	187	146.45	300	110	Open	5,853	0.96
250	187	192	137.55	300	110	Open	5,853	0.96
251	192	198	238.62	300	110	Open	4,576	0.75
252	198	199	290.5	160	110	Open	0	0
253	198	200	119.83	300	110	Open	4,576	0.75
254	200	219	460.49	300	110	Open	2,143	0.35
255	219	218	25.44	200	110	Open	999	0.37
256	214	218	353.29	160	110	Open	145	0.08
257	218	220	868.13	225	110	Open	1,144	0.33
259	214	215	33.75	160	110	Open	423	0.24
260	201	214	107.36	160	110	Open	568	0.33
261	200	201	28.28	200	110	Open	2,433	0.9
262	201	202	17.78	110	110	Open	211	0.26
263	202	204	632.9	110	110	Open	211	0.26
264	204	207	713.14	110	110	Open	326	0.4
266	203	204	199.48	160	110	Open	115	0.07
267	203	205	16.29	160	110	Open	-115	0.07
271	209	207	300.21	160	110	Open	980	0.56
272	207	210	374.55	110	110	Open	162	0.2
273	205	212	412.83	225	110	Open	429	0.13
274	205	223	203.47	160	110	Open	1,000	0.58
275	223	209	69.13	160	110	Open	980	0.56
276	223	211	406.91	110	110	Open	20	0.02
277	211	210	449.15	160	110	Open	982	0.57
278	212	211	203.44	160	110	Open	961	0.55
279	213	212	270.61	160	110	Open	532	0.31
280	201	216	126.42	225	110	Open	1,654	0.48
283	217	213	412.13	110	110	Open	109	0.13
286	182	224	35.61	225	110	Open	788	0.23

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
287	224	226	97.56	160	110	Open	251	0.14
290	227	229	653.56	160	110	Open	1,144	0.66
292	224	225	348.98	225	110	Open	537	0.16
293	225	184	1849.61	160	110	Open	537	0.31
302	242	24	658.31	160	110	Open	3,707	2.13
303	240	241	173.51	160	110	Open	0	0
304	242	240	181.77	160	110	Open	-3,736	2.15
305	10	239	94.41	110	110	Open	2,998	3.65
306	239	240	251.41	160	110	Open	3,736	2.15
307	239	243	209.09	110	110	Open	1,011	1.23
308	243	242	216.99	90	110	Open	1,011	1.84
311	9	244	128.73	110	110	Open	1,113	1.36
315	220	250	526.13	160	110	Open	1,144	0.66
316	154	251	188.69	225	110	Open	315	0.09
317	251	153	69.35	225	110	Open	245	0.07
318	251	194	20.58	225	110	Open	70	0.02
319	16	252	193.95	300	110	Open	20,342	3.33
320	252	35	167.94	300	110	Open	19,548	3.2
42	17	259	94.34	160	110	Open	2,234	1.29
153	259	257	94.52	160	110	Open	2,234	1.29
193	257	252	111.05	160	110	Open	2,234	1.29
223	252	253	122.83	160	110	Open	3,028	1.74
321	253	256	170.34	160	110	Open	3,028	1.74
322	98	92	86.27	160	110	Open	86	0.05
323	235	237	381.35	160	110	Open	1,144	0.66
324	45	43	187.67	160	110	Open	664	0.38
326	244	11	496.38	160	110	Open	-1,676	0.96
327	239	244	329.6	110	110	Open	-1,748	2.13
328	235	234	55.05	160	110	Open	893	0.51
329	234	233	167.35	160	110	Open	893	0.51
330	233	232	182.39	160	110	Open	893	0.51
332	164	165	207.25	110	110	Open	-10	0.01
333	165	168	38.67	110	110	Open	-10	0.01
334	168	166	157.76	110	110	Open	351	0.43
335	166	154	349.81	160	110	Open	1,326	0.76
338	237	12	802.56	160	110	Open	1,144	0.66
341	25	13	131.31	160	110	Open	3,181	1.83
342	13	34	43.17	160	110	Open	3,181	1.83
343	34	235	284.57	160	110	Open	3,181	1.83
344	6	38	262.11	160	110	Open	0	0
346	38	42	143.69	160	110	Open	0	0
11	226	50	126.42	160	110	Open	1,144	0.66
12	50	227	499.62	160	110	Open	1,144	0.66
20	226	52	280.96	160	110	Open	-893	0.51
35	52	58	55.77	160	110	Open	-893	0.51
39	58	232	243.77	160	110	Open	-893	0.51
43	136	63	151.36	160	110	Open	175	0.1
51	63	128	111.52	160	110	Open	-64	0.04
52	63	61	156.22	110	110	Open	239	0.29
53	61	60	211	110	110	Open	239	0.29
56	60	59	353.71	110	110	Open	239	0.29
58	145	59	90.41	110	110	Open	-226	0.27
59	59	147	162.77	110	110	Open	14	0.02
60	215	65	318.75	160	110	Open	423	0.24
62	65	213	220	160	110	Open	423	0.24
67	216	66	49.94	225	110	Open	1,654	0.48
69	66	217	55.55	225	110	Open	1,654	0.48
70	217	67	46.22	225	110	Open	1,545	0.45
71	67	205	211.73	225	110	Open	1,545	0.45
27	127	22	128.62	150	110	Open	-5,471	3.58
18	256	37	65.6	225	110	Open	-4,454	1.3
28	256	40	493.84	225	110	Open	6,442	1.88

管網計算結果から、既存管網では、時間最大時に末端配水圧 20m 以上の確保が困難であることが明らかとなった。

そのため、時間最大時に末端配水圧の確保できるように口径検討を行った結果、図 **A6.4** に示すような新たな配管整備が必要となる。新たな配水本管の整備に基づく管網計算結果は次のとおりである。



Ex. Pipe	New Pipe	Expansion Length in 2024	Expansion Length in 2030
400	700	15	
400	800	30	
300	350	815	780
300	450	2635	
300	600	385	
300	700	250	
200	400	0	960
200	450	115	105
200	500	190	
150	300	130	
		unit m	unit m

図 **A6.4** 配水本管の整備概要

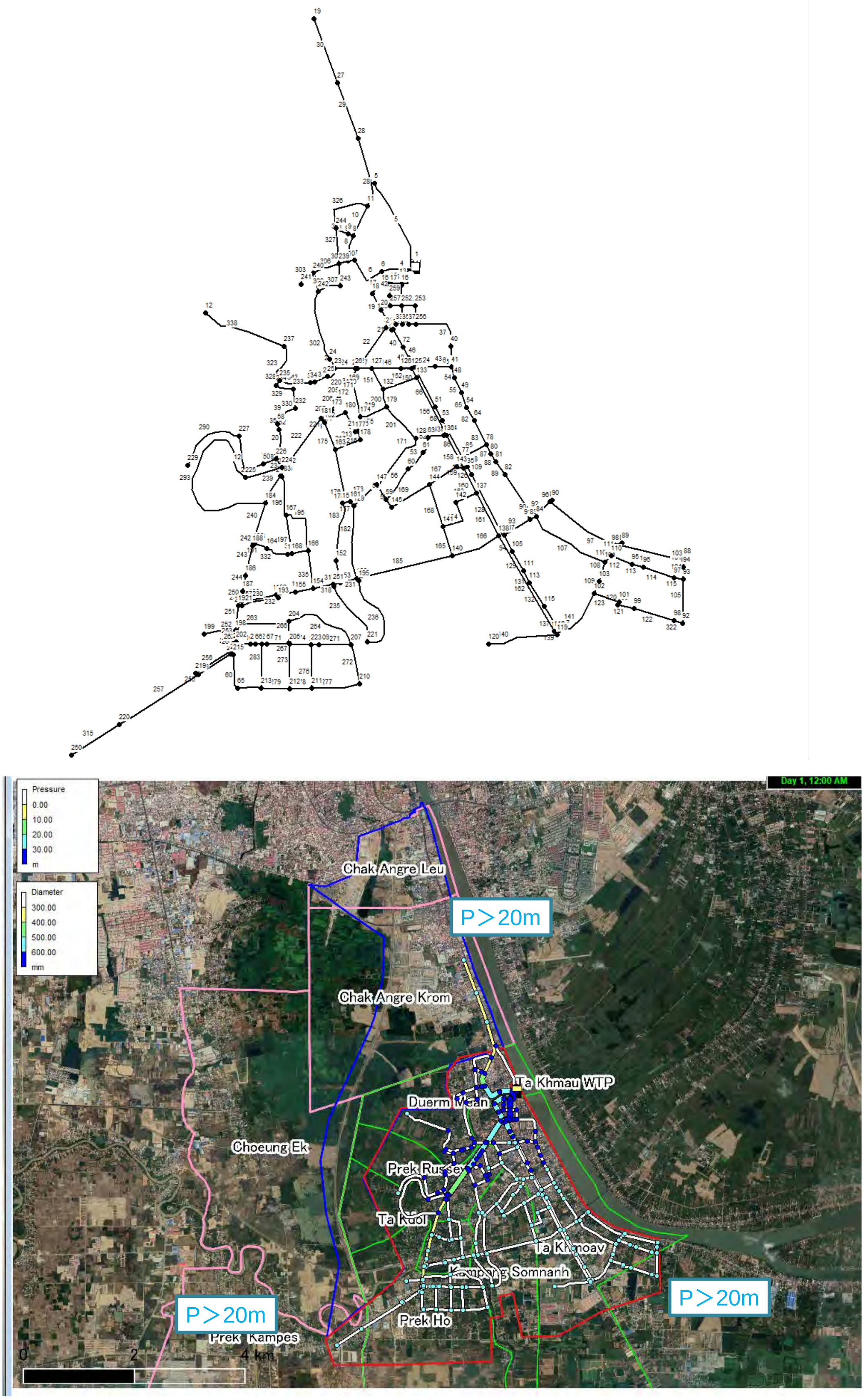


図　**A6.5**　水理計算管網モデルと管網計算結果（**Pipe Expansion Plan in 2024**）

表 A6.7 管網計算結果（節点）（Pipe Expansion Plan in 2024）

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
2	0	40.0	40.0
3	0	40.0	40.0
4	0	39.9	39.9
5	0	40.0	40.0
6	0	39.6	39.6
7	0	39.1	39.1
8	0	38.4	38.4
9	0	37.5	37.5
10	0	37.7	37.7
11	0	35.2	35.2
14	0	39.4	39.4
15	0	39.2	39.2
16	0	39.4	39.4
17	0	39.2	39.2
18	600	38.7	38.7
20	0	38.3	38.3
21	600	37.9	37.9
22	600	36.0	36.0
23	0	34.7	34.7
24	0	34.7	34.7
25	0	33.9	33.9
26	0	35.8	35.8
31	0	38.5	38.5
32	0	38.7	38.7
33	0	38.8	38.8
35	600	38.9	38.9
37	0	38.9	38.9
40	0	35.3	35.3
41	600	34.1	34.1
43	0	35.0	35.0
45	600	36.2	36.2
46	0	38.5	38.5
48	0	33.2	33.2
49	0	32.0	32.0
51	600	32.0	32.0
53	0	31.1	31.1
54	0	30.9	30.9
64	600	29.8	29.8
72	0	38.6	38.6
77	0	28.6	28.6
78	0	28.6	28.6
80	0	28.1	28.1
81	0	26.8	26.8
82	600	26.0	26.0
83	0	24.9	24.9
84	0	24.4	24.4
85	571	23.6	23.6
86	571	22.1	22.1
87	571	21.7	21.7
88	0	21.7	21.7

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
89	0	22.1	22.1
90	0	23.6	23.6
92	571	21.3	21.3
93	0	21.7	21.7
94	0	21.7	21.7
95	0	22.0	22.0
96	0	21.9	21.9
97	0	21.7	21.7
98	0	21.4	21.4
99	0	21.6	21.6
100	0	21.8	21.8
101	0	21.8	21.8
102	571	22.0	22.0
103	0	22.0	22.0
104	0	22.2	22.2
105	0	25.1	25.1
107	0	25.4	25.4
108	0	28.0	28.0
109	600	27.5	27.5
110	0	22.1	22.1
111	0	24.7	24.7
113	0	24.4	24.4
115	0	23.9	23.9
117	0	23.4	23.4
118	571	23.4	23.4
119	0	23.4	23.4
120	0	23.4	23.4
125	0	27.7	27.7
126	0	29.8	29.8
127	0	35.5	35.5
128	600	25.3	25.3
129	571	25.0	25.0
130	571	24.9	24.9
131	0	33.6	33.6
132	0	30.9	30.9
133	0	27.4	27.4
134	600	25.3	25.3
135	0	24.6	24.6
136	0	25.3	25.3
137	0	24.3	24.3
138	571	23.9	23.9
140	571	24.0	24.0
141	0	24.1	24.1
142	0	24.2	24.2
143	0	24.5	24.5
144	600	24.1	24.1
145	0	24.3	24.3
147	600	24.6	24.6
151	0	25.4	25.4
152	0	25.3	25.3

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
153	0	25.1	25.1
154	571	25.6	25.6
155	0	25.8	25.8
156	0	25.9	25.9
157	0	26.1	26.1
158	0	28.7	28.7
160	0	31.9	31.9
161	0	25.4	25.4
162	0	33.3	33.3
163	0	30.4	30.4
164	0	28.7	28.7
165	0	28.7	28.7
166	0	27.9	27.9
167	0	29.7	29.7
168	0	28.6	28.6
169	0	30.6	30.6
170	0	30.8	30.8
171	0	31.3	31.3
172	0	32.2	32.2
173	0	32.6	32.6
174	600	29.4	29.4
175	0	30.1	30.1
176	0	30.4	30.4
177	0	30.7	30.7
178	0	30.4	30.4
179	600	29.0	29.0
180	0	31.8	31.8
181	600	34.8	34.8
182	571	33.0	33.0
183	0	32.4	32.4
184	0	31.0	31.0
185	571	28.7	28.7
186	0	27.4	27.4
187	0	26.8	26.8
188	0	28.6	28.6
191	0	26.2	26.2
192	571	26.2	26.2
193	0	26.0	26.0
194	0	25.2	25.2
195	0	24.9	24.9
198	0	25.8	25.8
199	0	25.8	25.8
200	0	25.6	25.6
201	0	25.5	25.5
202	0	25.4	25.4
203	0	25.0	25.0
204	0	24.9	24.9
205	0	25.0	25.0
207	571	23.7	23.7
209	0	24.3	24.3

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
210	571	23.5	23.5
211	0	24.5	24.5
212	0	24.9	24.9
213	0	25.1	25.1
214	0	25.4	25.4
215	0	25.4	25.4
216	0	25.3	25.3
217	0	25.2	25.2
218	0	25.3	25.3
219	571	25.4	25.4
220	0	24.9	24.9
221	0	25.2	25.2
223	0	24.5	24.5
224	0	33.0	33.0
225	0	32.9	32.9
226	0	32.3	32.3
227	0	30.5	30.5
229	571	28.6	28.6
232	0	31.7	31.7
233	0	31.5	31.5
234	0	31.4	31.4
235	571	31.3	31.3
237	0	30.2	30.2
239	0	35.5	35.5
240	0	35.0	35.0
241	0	35.0	35.0
242	600	34.6	34.6
243	0	35.2	35.2
244	600	35.2	35.2
250	572	23.3	23.3
251	0	25.2	25.2
252	0	39.2	39.2
253	0	38.9	38.9
256	600	38.5	38.5
257	0	39.2	39.2
259	0	39.2	39.2
12	571	27.9	27.9
13	0	33.2	33.2
34	0	32.9	32.9
50	0	31.9	31.9
52	0	32.0	32.0
58	0	32.0	32.0
59	0	24.5	24.5
60	0	24.9	24.9
61	0	25.1	25.1
63	0	25.3	25.3
65	0	25.2	25.2
66	0	25.3	25.3
67	0	25.2	25.2
19	2000	24.5	24.5
27	2000	25.4	25.4
28	2000	28.2	28.2

表 A6.8　管網計算結果（管）（Pipe Expansion Plan in 2024）

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
2	2	3	27.18	800	110	Open	47,987	1.1
3	3	4	10.87	700	110	Open	36,517	1.1
4	3	6	312.42	500	110	Open	11,470	0.68
5	2	5	900.16	250	110	Open	0	0
6	6	7	385.89	500	110	Open	11,470	0.68
7	7	10	56.56	110	110	Open	1,069	1.3
8	7	8	240.17	400	110	Open	10,401	0.96
9	8	9	46.95	110	110	Open	910	1.11
10	8	11	305.7	300	110	Open	9,491	1.55
13	4	14	244.2	700	110	Open	36,517	1.1
14	14	16	13.83	600	110	Open	19,948	0.82
15	14	15	105.74	500	110	Open	16,570	0.98
16	15	17	20.74	150	110	Open	155	0.1
17	15	18	210.31	500	110	Open	16,414	0.97
19	18	20	169.63	500	110	Open	15,454	0.91
21	20	21	184.4	500	110	Open	15,454	0.91
22	21	22	458.88	500	110	Open	22,543	1.33
23	22	26	18.79	160	110	Open	1,364	0.79
24	26	23	193.56	160	110	Open	1,364	0.79
25	23	24	98.95	160	110	Open	50	0.03
26	23	25	125.34	160	110	Open	1,314	0.76
32	31	21	76.83	300	110	Open	8,049	1.32
33	31	32	17.8	300	110	Open	−8,049	1.32
34	32	33	65.73	500	110	Open	−14,763	0.87
36	33	35	73.14	500	110	Open	−14,763	0.87
38	35	37	49.39	500	110	Open	3,589	0.21
40	32	72	189.04	500	110	Open	6,714	0.4
45	40	41	187.67	225	110	Open	3,420	1
46	41	43	154.11	160	110	Open	−1,386	0.8
48	72	46	111.47	450	110	Open	6,714	0.49
50	46	45	101.35	225	110	Open	6,714	1.95
54	41	48	104.45	225	110	Open	3,846	1.12
55	48	49	155.62	225	110	Open	3,846	1.12
65	49	54	143.09	225	110	Open	3,846	1.12
66	45	51	417.79	225	110	Open	4,368	1.27
68	51	53	144.08	225	110	Open	3,408	0.99
82	54	64	138.9	225	110	Open	3,846	1.12
83	64	78	255.3	225	110	Open	2,886	0.84
85	78	77	252.69	90	110	Open	−48	0.09
86	53	77	391.46	225	110	Open	3,408	0.99
87	78	80	91.9	225	110	Open	2,934	0.85
88	80	81	285.79	225	110	Open	2,934	0.85
89	81	82	149.02	225	110	Open	2,934	0.85
90	82	83	489.98	225	110	Open	1,974	0.57
91	83	84	63.82	225	110	Open	3,649	1.06
92	84	85	194.61	225	110	Open	2,740	0.8
93	83	107	276.77	225	110	Open	−1,675	0.49
94	107	105	166.1	160	110	Open	725	0.42
96	85	90	24.11	160	110	Open	0	0
97	85	86	768.88	225	110	Open	1,826	0.53
98	86	89	27.93	160	110	Open	0	0
100	86	87	616.51	225	110	Open	1,008	0.29
101	87	94	61.35	160	110	Open	95	0.05
103	88	87	19.75	160	110	Open	0	0
104	94	93	110.6	160	110	Open	95	0.05
105	93	92	406.94	160	110	Open	483	0.28
107	84	104	788.69	160	110	Open	909	0.52
108	104	103	186.16	160	110	Open	425	0.24
109	103	102	122.52	160	110	Open	425	0.24
110	104	110	86.63	160	110	Open	484	0.28

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
111	110	86	125.24	160	110	Open	96	0.06
112	110	95	209.06	160	110	Open	388	0.22
113	95	96	107.46	160	110	Open	388	0.22
114	96	97	299.79	160	110	Open	388	0.22
115	97	93	92.22	160	110	Open	388	0.22
120	101	100	28.76	160	110	Open	431	0.25
121	100	99	149.53	160	110	Open	431	0.25
122	99	98	388.58	160	110	Open	431	0.25
123	102	101	241.09	160	110	Open	431	0.25
124	77	108	97.16	225	110	Open	3,360	0.98
126	108	109	79.98	225	110	Open	3,360	0.98
128	109	107	649.05	225	110	Open	2,400	0.7
129	105	111	210.69	160	110	Open	725	0.42
131	111	113	123.66	160	110	Open	725	0.42
132	113	115	260.86	160	110	Open	725	0.42
137	115	117	258.79	160	110	Open	725	0.42
138	117	118	44.16	250	110	Open	−194	0.05
139	118	119	39.5	250	110	Open	0	0
140	119	120	645.75	160	110	Open	0	0
141	117	102	504.75	160	110	Open	919	0.53
146	127	126	272.57	160	110	Open	2,643	1.52
147	126	125	102.72	160	110	Open	2,643	1.52
150	125	133	98.05	250	110	Open	2,643	0.62
151	127	132	221.07	160	110	Open	2,627	1.51
152	133	132	332.94	110	110	Open	−681	0.83
155	136	134	25.68	160	110	Open	5	0
156	133	134	604.2	250	110	Open	3,324	0.78
158	134	135	344.51	250	110	Open	2,370	0.56
159	143	135	66.74	160	110	Open	−601	0.35
160	135	137	258.04	250	110	Open	1,769	0.42
161	137	138	445.65	250	110	Open	1,489	0.35
162	138	118	1027.9	250	110	Open	1,108	0.26
163	137	142	212.46	160	110	Open	279	0.16
164	142	141	375.09	160	110	Open	279	0.16
165	141	140	289.84	160	110	Open	252	0.14
166	138	140	476.94	225	110	Open	−532	0.15
167	143	144	300.24	160	110	Open	601	0.35
168	144	141	410.99	110	110	Open	−27	0.03
169	144	145	413.28	160	110	Open	−332	0.19
171	128	147	598.71	160	110	Open	537	0.31
173	147	129	293.36	160	110	Open	−562	0.32
174	131	162	27.47	160	110	Open	1,840	1.06
175	162	163	272.14	160	110	Open	1,840	1.06
176	163	161	506.93	160	110	Open	1,762	1.01
177	161	129	53.84	160	110	Open	1,670	0.96
178	161	151	74.03	110	110	Open	93	0.11
182	129	130	681.68	160	110	Open	194	0.11
183	151	152	552.87	110	110	Open	93	0.11
184	152	153	686.29	110	110	Open	93	0.11
185	140	130	911.28	225	110	Open	−1,194	0.35
186	130	153	157	225	110	Open	−1,611	0.47
188	154	155	168.89	225	110	Open	−1,296	0.38
189	155	156	180.54	225	110	Open	−1,296	0.38
190	156	157	322.27	225	110	Open	−897	0.26
191	158	164	124.35	110	110	Open	85	0.1
195	167	166	503.36	160	110	Open	1,011	0.58
196	160	167	363.39	160	110	Open	1,354	0.78
197	167	168	362.07	110	110	Open	343	0.42
200	132	179	168.35	160	110	Open	1,946	1.12
201	179	128	401.89	160	110	Open	1,695	0.98

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
203	169	170	48.22	110	110	Open	−378	0.46
204	170	171	149.19	110	110	Open	−378	0.46
205	171	172	266	110	110	Open	−378	0.46
206	172	173	107.93	110	110	Open	−378	0.46
207	173	131	123.5	160	110	Open	−1,591	0.92
209	169	174	333.47	110	110	Open	378	0.46
210	174	175	119.64	160	110	Open	−1,291	0.74
211	173	180	167.26	160	110	Open	1,213	0.7
213	180	177	217.72	160	110	Open	1,213	0.7
215	177	176	72.45	160	110	Open	1,213	0.7
216	176	178	80.03	110	110	Open	−78	0.1
217	178	163	249.56	110	110	Open	−78	0.1
218	175	176	51.35	160	110	Open	−1,291	0.74
219	179	174	260.71	160	110	Open	−709	0.41
220	22	181	578.59	500	110	Open	14,950	0.88
221	181	131	25.02	150	110	Open	3,431	2.25
222	181	182	563.66	400	110	Open	10,558	0.97
230	193	191	349.77	160	110	Open	−399	0.23
231	130	195	22.34	160	110	Open	−302	0.17
232	156	193	31.21	160	110	Open	−399	0.23
233	157	191	126.11	225	110	Open	−897	0.26
234	191	192	31.85	250	110	Open	−1,296	0.31
235	194	221	634.06	225	110	Open	302	0.09
236	195	221	782.73	160	110	Open	−302	0.17
237	160	183	60.22	150	110	Open	−1,354	0.89
238	182	183	88.77	300	110	Open	7,698	1.26
239	183	184	286.9	300	110	Open	6,344	1.04
240	184	185	395.9	300	110	Open	6,864	1.12
241	185	158	16.02	150	110	Open	85	0.06
242	185	188	19.85	300	110	Open	5,865	0.96
243	188	186	285.51	300	110	Open	5,865	0.96
244	186	187	146.45	300	110	Open	5,865	0.96
250	187	192	137.55	300	110	Open	5,865	0.96
251	192	198	238.62	300	110	Open	3,656	0.6
252	198	199	290.5	160	110	Open	0	0
253	198	200	119.83	300	110	Open	3,656	0.6
254	200	219	460.49	300	110	Open	1,713	0.28
255	219	218	25.44	200	110	Open	799	0.29
256	214	218	353.29	160	110	Open	116	0.07
257	218	220	868.13	225	110	Open	915	0.27
259	214	215	33.75	160	110	Open	338	0.19
260	201	214	107.36	160	110	Open	454	0.26
261	200	201	28.28	200	110	Open	1,943	0.72
262	201	202	17.78	110	110	Open	168	0.2
263	202	204	632.9	110	110	Open	168	0.2
264	204	207	713.14	110	110	Open	260	0.32
266	203	204	199.48	160	110	Open	92	0.05
267	203	205	16.29	160	110	Open	−92	0.05
271	209	207	300.21	160	110	Open	783	0.45
272	207	210	374.55	110	110	Open	130	0.16
273	205	212	412.83	225	110	Open	343	0.1
274	205	223	203.47	160	110	Open	799	0.46
275	223	209	69.13	160	110	Open	783	0.45
276	223	211	406.91	110	110	Open	16	0.02
277	211	210	449.15	160	110	Open	784	0.45
278	212	211	203.44	160	110	Open	768	0.44
279	213	212	270.61	160	110	Open	425	0.24
280	201	216	126.42	225	110	Open	1,321	0.38
283	217	213	412.13	110	110	Open	87	0.11
286	182	224	35.61	225	110	Open	1,947	0.57

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
287	224	226	97.56	160	110	Open	1,427	0.82
290	227	229	653.56	160	110	Open	914	0.53
292	224	225	348.98	225	110	Open	520	0.15
293	225	184	1849.61	160	110	Open	520	0.3
302	242	24	658.31	160	110	Open	−50	0.03
303	240	241	173.51	160	110	Open	0	0
304	242	240	181.77	160	110	Open	−716	0.41
305	10	239	94.41	110	110	Open	1,069	1.3
306	239	240	251.41	160	110	Open	716	0.41
307	239	243	209.09	110	110	Open	194	0.24
308	243	242	216.99	90	110	Open	194	0.35
311	9	244	128.73	110	110	Open	910	1.11
315	220	250	526.13	160	110	Open	915	0.53
316	154	251	188.69	225	110	Open	1,821	0.53
317	251	153	69.35	225	110	Open	1,518	0.44
318	251	194	20.58	225	110	Open	302	0.09
319	16	252	193.95	600	110	Open	19,948	0.82
320	252	35	167.94	600	110	Open	19,311	0.79
42	17	259	94.34	160	110	Open	155	0.09
153	259	257	94.52	160	110	Open	155	0.09
193	257	252	111.05	160	110	Open	155	0.09
223	252	253	122.83	160	110	Open	791	0.46
321	253	256	170.34	160	110	Open	791	0.46
322	98	92	86.27	160	110	Open	431	0.25
323	235	237	381.35	160	110	Open	914	0.53
324	45	43	187.67	160	110	Open	1,386	0.8
326	244	11	496.38	160	110	Open	109	0.06
327	239	244	329.6	110	110	Open	159	0.19
328	235	234	55.05	160	110	Open	−513	0.3
329	234	233	167.35	160	110	Open	−513	0.3
330	233	232	182.39	160	110	Open	−513	0.3
332	164	165	207.25	110	110	Open	85	0.1
333	165	168	38.67	110	110	Open	85	0.1
334	168	166	157.76	110	110	Open	428	0.52
335	166	154	349.82	160	110	Open	1,438	0.83
338	237	12	802.56	160	110	Open	914	0.53
341	25	13	131.31	160	110	Open	1,314	0.76
342	13	34	43.17	160	110	Open	1,314	0.76
343	34	235	284.57	160	110	Open	1,314	0.76
11	226	50	126.42	160	110	Open	914	0.53
12	50	227	499.62	160	110	Open	914	0.53
20	226	52	280.96	160	110	Open	513	0.3
35	52	58	55.77	160	110	Open	513	0.3
39	58	232	243.77	160	110	Open	513	0.3
43	136	63	151.36	160	110	Open	−5	0
51	63	128	111.52	160	110	Open	−197	0.11
52	63	61	156.22	110	110	Open	192	0.23
53	61	60	211	110	110	Open	192	0.23
56	60	59	353.71	110	110	Open	192	0.23
58	145	59	90.41	110	110	Open	−332	0.4
59	59	147	162.77	110	110	Open	−140	0.17
60	215	65	318.75	160	110	Open	338	0.19
62	65	213	220	160	110	Open	338	0.19
67	216	66	49.94	225	110	Open	1,321	0.38
69	66	217	55.55	225	110	Open	1,321	0.38
70	217	67	46.22	225	110	Open	1,234	0.36
71	67	205	211.73	225	110	Open	1,234	0.36
27	127	22	128.62	300	110	Open	−5,270	0.86
28	11	28	658.78	300	110	Open	9,600	1.57
29	28	27	550.12	300	110	Open	6,400	1.05
30	27	19	633.7	300	110	Open	3,200	0.52
31	256	37	60.93	225	110	Open	−3,589	1.04
37	256	40	504.85	225	110	Open	3,420	1

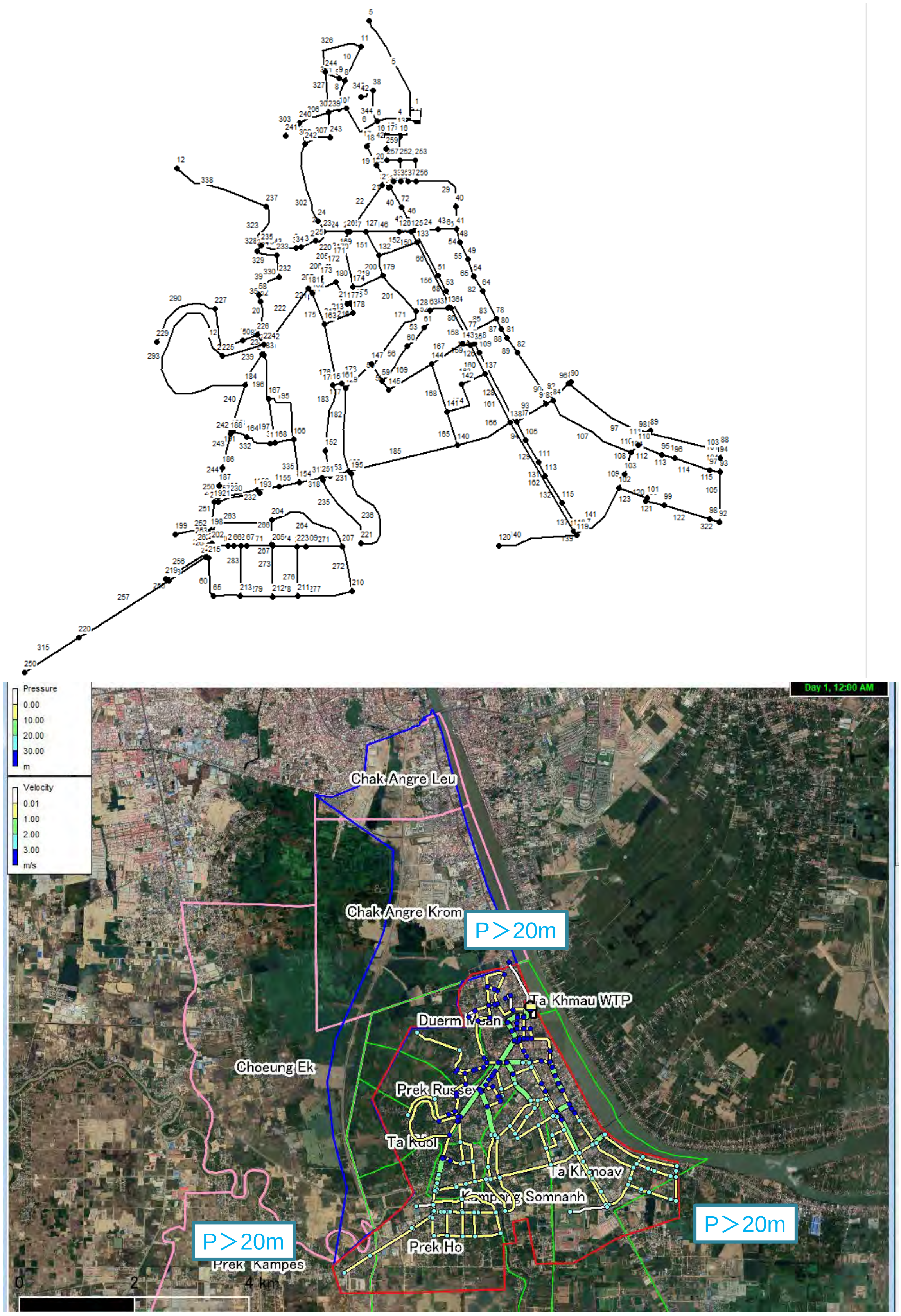


図 **A6.6** 水理計算管網モデルと管網計算結果（**Pipe Expansion Plan in 2030**）

表 A6.9　管網計算結果（節点）（Pipe Expansion Plan in 2030）

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
2	0	41.7	41.7
3	0	41.7	41.7
4	0	41.6	41.6
5	0	41.7	41.7
6	0	41.6	41.6
7	0	41.6	41.6
8	0	41.6	41.6
9	0	41.2	41.2
10	0	40.3	40.3
11	0	41.6	41.6
14	0	41.0	41.0
15	0	40.7	40.7
16	0	41.0	41.0
17	0	40.7	40.7
18	650	40.0	40.0
20	0	39.6	39.6
21	650	39.0	39.0
22	650	36.6	36.6
23	0	35.5	35.5
24	0	35.6	35.6
25	0	34.3	34.3
26	0	36.5	36.5
31	0	39.8	39.8
32	0	39.9	39.9
33	0	40.1	40.1
35	650	40.3	40.3
37	0	40.3	40.3
40	0	37.5	37.5
41	650	36.6	36.6
43	0	37.8	37.8
45	650	39.3	39.3
46	0	39.6	39.6
48	0	35.9	35.9
49	0	34.9	34.9
51	650	38.7	38.7
53	0	38.6	38.6
54	0	33.9	33.9
64	650	33.0	33.0
72	0	39.8	39.8
77	0	38.2	38.2
78	0	32.1	32.1
80	0	31.6	31.6
81	0	30.1	30.1
82	650	29.3	29.3
83	0	28.1	28.1
84	0	27.3	27.3
85	715	25.9	25.9
86	715	23.0	23.0
87	715	22.3	22.3
88	0	22.3	22.3

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
89	0	23.0	23.0
90	0	25.9	25.9
92	715	21.6	21.6
93	0	22.3	22.3
94	0	22.3	22.3
95	0	22.8	22.8
96	0	22.7	22.7
97	0	22.4	22.4
98	0	21.7	21.7
99	0	22.0	22.0
100	0	22.1	22.1
101	0	22.1	22.1
102	715	22.3	22.3
103	0	22.6	22.6
104	0	23.1	23.1
105	0	28.4	28.4
107	0	29.4	29.4
108	0	36.8	36.8
109	650	35.6	35.6
110	0	23.0	23.0
111	0	27.2	27.2
113	0	26.4	26.4
115	0	24.9	24.9
117	0	23.4	23.4
118	715	23.3	23.3
119	0	23.3	23.3
120	0	23.3	23.3
125	0	27.4	27.4
126	0	29.8	29.8
127	0	36.1	36.1
128	650	24.8	24.8
129	715	24.4	24.4
130	715	24.4	24.4
131	0	33.7	33.7
132	0	30.9	30.9
133	0	27.2	27.2
134	650	24.8	24.8
135	0	24.1	24.1
136	0	24.8	24.8
137	0	23.8	23.8
138	715	23.5	23.5
140	715	23.5	23.5
141	0	23.6	23.6
142	0	23.7	23.7
143	0	24.0	24.0
144	650	23.5	23.5
145	0	23.7	23.7
147	650	24.0	24.0
151	0	24.9	24.9
152	0	24.8	24.8

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
153	0	24.7	24.7
154	715	25.4	25.4
155	0	25.7	25.7
156	0	26.1	26.1
157	0	26.4	26.4
158	0	30.5	30.5
160	0	31.7	31.7
161	0	24.9	24.9
162	0	33.4	33.4
163	0	30.3	30.3
164	0	30.1	30.1
165	0	29.5	29.5
166	0	28.2	28.2
167	0	29.9	29.9
168	0	29.4	29.4
169	0	30.4	30.4
170	0	30.6	30.6
171	0	31.2	31.2
172	0	32.2	32.2
173	0	32.6	32.6
174	650	29.2	29.2
175	0	29.9	29.9
176	0	30.2	30.2
177	0	30.6	30.6
178	0	30.2	30.2
179	650	28.7	28.7
180	0	31.7	31.7
181	650	35.0	35.0
182	715	32.3	32.3
183	0	32.1	32.1
184	0	31.5	31.5
185	715	30.5	30.5
186	0	28.5	28.5
187	0	27.5	27.5
188	0	30.4	30.4
191	0	26.5	26.5
192	715	26.5	26.5
193	0	26.1	26.1
194	0	24.8	24.8
195	0	24.4	24.4
198	0	25.9	25.9
199	0	25.9	25.9
200	0	25.6	25.6
201	0	25.4	25.4
202	0	25.4	25.4
203	0	24.6	24.6
204	0	24.6	24.6
205	0	24.6	24.6
207	715	22.7	22.7
209	0	23.7	23.7

Node ID	Demand (m3/d)	Head (m)	Pressure (m)
210	715	22.4	22.4
211	0	23.9	23.9
212	0	24.6	24.6
213	0	24.9	24.9
214	0	25.3	25.3
215	0	25.3	25.3
216	0	25.2	25.2
217	0	25.0	25.0
218	0	25.2	25.2
219	715	25.3	25.3
220	0	24.5	24.5
221	0	24.8	24.8
223	0	23.9	23.9
224	0	32.2	32.2
225	0	32.2	32.2
226	0	31.3	31.3
227	0	28.6	28.6
229	715	25.7	25.7
232	0	30.6	30.6
233	0	30.4	30.4
234	0	30.1	30.1
235	715	30.1	30.1
237	0	28.4	28.4
239	0	38.2	38.2
240	0	37.0	37.0
241	0	37.0	37.0
242	650	36.1	36.1
243	0	37.7	37.7
244	650	40.1	40.1
250	715	22.2	22.2
251	0	24.8	24.8
252	0	40.6	40.6
253	0	40.3	40.3
256	650	39.9	39.9
257	0	40.6	40.6
259	0	40.6	40.6
12	715	24.8	24.8
13	0	33.1	33.1
34	0	32.7	32.7
38	0	41.6	41.6
42	0	41.6	41.6
50	0	30.8	30.8
52	0	31.0	31.0
58	0	30.9	30.9
59	0	23.9	23.9
60	0	24.3	24.3
61	0	24.6	24.6
63	0	24.8	24.8
65	0	25.0	25.0
66	0	25.1	25.1
67	0	25.0	25.0

表 A6.10　管網計算結果（管）（Pipe Expansion Plan in 2030）

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
2	2	3	27.18	800	110	Open	44,824	1.03
3	3	4	10.87	700	110	Open	42,268	1.27
4	3	6	312.42	500	110	Open	2,556	0.15
5	2	5	900.16	250	110	Open	0	0
6	6	7	385.89	500	110	Open	2,556	0.15
7	7	10	56.56	110	110	Open	1,028	1.25
8	7	8	240.17	400	110	Open	1,529	0.14
9	8	9	46.95	110	110	Open	610	0.74
10	8	11	305.7	300	110	Open	919	0.15
13	4	14	244.18	700	110	Open	42,268	1.27
14	14	16	13.83	600	110	Open	23,323	0.95
15	14	15	105.74	500	110	Open	18,945	1.12
16	15	17	20.74	150	110	Open	208	0.14
17	15	18	210.31	500	110	Open	18,737	1.1
19	18	20	169.63	500	110	Open	17,697	1.04
21	20	21	184.4	500	110	Open	17,697	1.04
22	21	22	458.88	500	110	Open	25,569	1.51
23	22	26	18.79	160	110	Open	1,229	0.71
24	26	23	193.56	160	110	Open	1,229	0.71
25	23	24	98.95	160	110	Open	−476	0.27
26	23	25	125.34	160	110	Open	1,705	0.98
32	31	21	76.83	300	110	Open	8,913	1.46
33	31	32	17.8	300	110	Open	−8,913	1.46
34	32	33	65.73	500	110	Open	−18,488	1.09
36	33	35	59.29	500	110	Open	−18,488	1.09
38	35	37	63.39	500	110	Open	3,197	0.19
40	32	72	189.04	500	110	Open	9,575	0.56
45	40	41	185.54	225	110	Open	2,963	0.86
46	41	43	152.5	160	110	Open	−1,576	0.91
48	72	46	111.47	450	110	Open	9,575	0.7
50	46	45	101.34	400	110	Open	9,575	0.88
54	41	48	106.9	225	110	Open	3,499	1.02
55	48	49	155.62	225	110	Open	3,499	1.02
65	49	54	143.09	225	110	Open	3,499	1.02
66	45	51	417.79	400	110	Open	6,959	0.64
68	51	53	144.07	400	110	Open	5,919	0.55
82	54	64	138.9	225	110	Open	3,499	1.02
83	64	78	255.3	225	110	Open	2,459	0.72
85	78	77	252.69	90	110	Open	−628	1.14
86	53	77	391.46	400	110	Open	5,919	0.55
87	78	80	91.9	225	110	Open	3,087	0.9
88	80	81	285.79	225	110	Open	3,087	0.9
89	81	82	149.02	225	110	Open	3,087	0.9
90	82	83	489.98	225	110	Open	2,047	0.6
91	83	84	63.82	225	110	Open	4,958	1.44
92	84	85	194.61	225	110	Open	3,691	1.07
93	83	107	276.77	225	110	Open	−2,911	0.85
94	107	105	166.1	160	110	Open	1,340	0.77
96	85	90	24.11	160	110	Open	0	0
97	85	86	768.88	225	110	Open	2,547	0.74
98	86	89	27.93	160	110	Open	0	0
100	86	87	616.51	225	110	Open	1,325	0.39
101	87	94	61.35	160	110	Open	181	0.1
103	88	87	19.75	160	110	Open	0	0
104	94	93	110.6	160	110	Open	181	0.1
105	93	92	406.94	160	110	Open	691	0.4
107	84	104	788.69	160	110	Open	1,267	0.73
108	104	103	186.16	160	110	Open	835	0.48
109	103	102	122.52	160	110	Open	835	0.48
110	104	110	86.63	160	110	Open	432	0.25

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
111	110	86	125.24	160	110	Open	−78	0.04
112	110	95	209.06	160	110	Open	510	0.29
113	95	96	107.46	160	110	Open	510	0.29
114	96	97	299.79	160	110	Open	510	0.29
115	97	93	92.22	160	110	Open	510	0.29
120	101	100	28.76	160	110	Open	453	0.26
121	100	99	149.53	160	110	Open	453	0.26
122	99	98	388.58	160	110	Open	453	0.26
123	102	101	241.09	160	110	Open	453	0.26
124	77	108	97.16	225	110	Open	5,291	1.54
126	108	109	79.98	225	110	Open	5,291	1.54
128	109	107	649.05	225	110	Open	4,251	1.24
129	105	111	210.69	160	110	Open	1,340	0.77
131	111	113	123.66	160	110	Open	1,340	0.77
132	113	115	260.86	160	110	Open	1,340	0.77
137	115	117	258.79	160	110	Open	1,340	0.77
138	117	118	44.16	250	110	Open	578	0.14
139	118	119	39.5	250	110	Open	0	0
140	119	120	645.75	160	110	Open	0	0
141	117	102	504.75	160	110	Open	762	0.44
146	127	126	272.57	160	110	Open	2,785	1.6
147	126	125	102.72	160	110	Open	2,785	1.6
150	125	133	98.06	250	110	Open	2,785	0.66
151	127	132	221.07	160	110	Open	2,794	1.61
152	133	132	332.95	110	110	Open	−709	0.86
155	136	134	25.68	160	110	Open	−80	0.05
156	133	134	604.2	250	110	Open	3,494	0.82
158	134	135	344.51	250	110	Open	2,374	0.56
159	143	135	66.74	160	110	Open	−650	0.37
160	135	137	258.04	250	110	Open	1,725	0.41
161	137	138	445.65	250	110	Open	1,416	0.33
162	138	118	1027.9	250	110	Open	566	0.13
163	137	142	212.46	160	110	Open	309	0.18
164	142	141	375.09	160	110	Open	309	0.18
165	141	140	289.84	160	110	Open	240	0.14
166	138	140	476.94	225	110	Open	−294	0.09
167	143	144	300.24	160	110	Open	650	0.37
168	144	141	410.99	110	110	Open	−69	0.08
169	144	145	413.28	160	110	Open	−322	0.19
171	128	147	598.71	160	110	Open	585	0.34
173	147	129	293.36	160	110	Open	−571	0.33
174	131	162	27.47	160	110	Open	1,918	1.1
175	162	163	272.14	160	110	Open	1,918	1.1
176	163	161	506.93	160	110	Open	1,832	1.05
177	161	129	53.84	160	110	Open	1,764	1.02
178	161	151	74.03	110	110	Open	68	0.08
182	129	130	681.68	160	110	Open	49	0.03
183	151	152	552.87	110	110	Open	68	0.08
184	152	153	686.29	110	110	Open	68	0.08
185	140	130	911.28	225	110	Open	−1,198	0.35
186	130	153	157	225	110	Open	−1,929	0.56
188	154	155	168.89	225	110	Open	−1,800	0.52
189	155	156	180.54	225	110	Open	−1,800	0.52
190	156	157	322.27	225	110	Open	−1,245	0.36
191	158	164	124.35	110	110	Open	351	0.43
195	167	166	503.36	160	110	Open	992	0.57
196	160	167	363.39	160	110	Open	1,217	0.7
197	167	168	362.07	110	110	Open	225	0.27
200	132	179	168.35	160	110	Open	2,084	1.2
201	179	128	401.89	160	110	Open	1,751	1.01

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
203	169	170	48.22	110	110	Open	−395	0.48
204	170	171	149.19	110	110	Open	−395	0.48
205	171	172	266	110	110	Open	−395	0.48
206	172	173	107.93	110	110	Open	−395	0.48
207	173	131	123.5	160	110	Open	−1,660	0.96
209	169	174	333.47	110	110	Open	395	0.48
210	174	175	119.64	160	110	Open	−1,351	0.78
211	173	180	167.26	160	110	Open	1,265	0.73
213	180	177	217.72	160	110	Open	1,265	0.73
215	177	176	72.45	160	110	Open	1,265	0.73
216	176	178	80.03	110	110	Open	−86	0.1
217	178	163	249.56	110	110	Open	−86	0.1
218	175	176	51.35	160	110	Open	−1,351	0.78
219	179	174	260.71	160	110	Open	−706	0.41
220	22	181	578.59	500	110	Open	17,722	1.04
221	181	131	25.02	150	110	Open	3,578	2.34
222	181	182	563.66	400	110	Open	13,104	1.21
230	193	191	349.77	160	110	Open	−555	0.32
231	130	195	22.34	160	110	Open	−363	0.21
232	156	193	31.21	160	110	Open	−555	0.32
233	157	191	126.11	225	110	Open	−1,245	0.36
234	191	192	31.85	250	110	Open	−1,800	0.42
235	194	221	634.06	225	110	Open	363	0.11
236	195	221	782.73	160	110	Open	−363	0.21
237	160	183	60.22	150	110	Open	−1,217	0.8
238	182	183	88.77	400	110	Open	9,916	0.91
239	183	184	286.9	400	110	Open	8,699	0.8
240	184	185	395.9	400	110	Open	9,016	0.83
241	185	158	16.02	150	110	Open	351	0.23
242	185	188	19.85	300	110	Open	7,520	1.23
243	188	186	285.51	300	110	Open	7,520	1.23
244	186	187	146.45	300	110	Open	7,520	1.23
250	187	192	137.55	300	110	Open	7,520	1.23
251	192	198	238.62	300	110	Open	4,576	0.75
252	198	199	290.5	160	110	Open	0	0
253	198	200	119.83	300	110	Open	4,576	0.75
254	200	219	460.49	300	110	Open	2,143	0.35
255	219	218	25.44	200	110	Open	999	0.37
256	214	218	353.29	160	110	Open	145	0.08
257	218	220	868.13	225	110	Open	1,144	0.33
259	214	215	33.75	160	110	Open	423	0.24
260	201	214	107.36	160	110	Open	568	0.33
261	200	201	28.28	200	110	Open	2,433	0.9
262	201	202	17.78	110	110	Open	211	0.26
263	202	204	632.9	110	110	Open	211	0.26
264	204	207	713.14	110	110	Open	326	0.4
266	203	204	199.48	160	110	Open	115	0.07
267	203	205	16.29	160	110	Open	−115	0.07
271	209	207	300.21	160	110	Open	980	0.56
272	207	210	374.55	110	110	Open	162	0.2
273	205	212	412.83	225	110	Open	429	0.13
274	205	223	203.47	160	110	Open	1,000	0.58
275	223	209	69.13	160	110	Open	980	0.56
276	223	211	406.91	110	110	Open	20	0.02
277	211	210	449.15	160	110	Open	982	0.57
278	212	211	203.44	160	110	Open	961	0.55
279	213	212	270.61	160	110	Open	532	0.31
280	201	216	126.42	225	110	Open	1,654	0.48
283	217	213	412.13	110	110	Open	109	0.13
286	182	224	35.61	225	110	Open	2,044	0.59

Pipe ID	Node start	Node end	Length (m)	Diameter (mm)	C value	Status	Flow(m3/day)	Velocity (m/s)
287	224	226	97.56	160	110	Open	1,727	0.99
290	227	229	653.56	160	110	Open	1,144	0.66
292	224	225	348.98	225	110	Open	317	0.09
293	225	184	1849.61	160	110	Open	317	0.18
302	242	24	658.31	160	110	Open	476	0.27
303	240	241	173.51	160	110	Open	0	0
304	242	240	181.77	160	110	Open	−1,193	0.69
305	10	239	94.41	110	110	Open	1,028	1.25
306	239	240	251.41	160	110	Open	1,193	0.69
307	239	243	209.09	110	110	Open	323	0.39
308	243	242	216.99	90	110	Open	323	0.59
311	9	244	128.73	110	110	Open	610	0.74
315	220	250	526.13	160	110	Open	1,144	0.66
316	154	251	188.69	225	110	Open	2,225	0.65
317	251	153	69.35	225	110	Open	1,861	0.54
318	251	194	20.58	225	110	Open	363	0.11
319	16	252	193.95	600	110	Open	23,323	0.95
320	252	35	167.94	600	110	Open	22,725	0.93
42	17	259	94.34	160	110	Open	208	0.12
153	259	257	94.52	160	110	Open	208	0.12
193	257	252	111.05	160	110	Open	208	0.12
223	252	253	122.83	160	110	Open	806	0.46
321	253	256	170.34	160	110	Open	806	0.46
322	98	92	86.27	160	110	Open	453	0.26
323	235	237	381.35	160	110	Open	1,144	0.66
324	45	43	187.67	160	110	Open	1,576	0.91
326	244	11	496.38	160	110	Open	−919	0.53
327	239	244	329.6	110	110	Open	−489	0.6
328	235	234	55.05	160	110	Open	−583	0.34
329	234	233	167.35	160	110	Open	−583	0.34
330	233	232	182.39	160	110	Open	−583	0.34
332	164	165	207.25	110	110	Open	351	0.43
333	165	168	38.67	110	110	Open	351	0.43
334	168	166	157.76	110	110	Open	577	0.7
335	166	154	349.81	160	110	Open	1,569	0.9
338	237	12	802.56	160	110	Open	1,144	0.66
341	25	13	131.31	160	110	Open	1,705	0.98
342	13	34	43.17	160	110	Open	1,705	0.98
343	34	235	284.57	160	110	Open	1,705	0.98
344	6	38	262.11	160	110	Open	0	0
346	38	42	143.69	160	110	Open	0	0
11	226	50	126.42	160	110	Open	1,144	0.66
12	50	227	499.62	160	110	Open	1,144	0.66
20	226	52	280.96	160	110	Open	583	0.34
35	52	58	55.77	160	110	Open	583	0.34
39	58	232	243.77	160	110	Open	583	0.34
43	136	63	151.36	160	110	Open	80	0.05
51	63	128	111.52	160	110	Open	−125	0.07
52	63	61	156.22	110	110	Open	205	0.25
53	61	60	211	110	110	Open	205	0.25
56	60	59	353.71	110	110	Open	205	0.25
58	145	59	90.41	110	110	Open	−322	0.39
59	59	147	162.77	110	110	Open	−116	0.14
60	215	65	318.75	160	110	Open	423	0.24
62	65	213	220	160	110	Open	423	0.24
67	216	66	49.94	225	110	Open	1,654	0.48
69	66	217	55.55	225	110	Open	1,654	0.48
70	217	67	46.22	225	110	Open	1,545	0.45
71	67	205	211.73	225	110	Open	1,545	0.45
27	127	22	128.62	300	110	Open	−5,578	0.91
28	256	37	65.6	225	110	Open	−3,197	0.93
29	256	40	490.73	225	110	Open	2,963	0.86

資　料 6.3　河川からの取水許可に関する資料

MRC からの承認レター

ព្រះរាជាណាចក្រកម្ពុជា
ជាតិ សាសនា ព្រះមហាក្សត្រ

PHNOM PENH WATER SUPPLY AUTHORITY
Planning and Project Department
1 3 SEP 2019
BY ៣៤៧ PMU

គណៈកម្មាធិការជាតិទន្លេមេគង្គកម្ពុជា

លេខ: ៤២០ គ.ជ.ទ.ម.ក

ព.ស ២៥៦៣

រាជធានីភ្នំពេញ, ថ្ងៃទី ១១ ខែ កញ្ញា ឆ្នាំ ២០១៩

រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ
លេខាធិការដ្ឋាន
ចូល លេខ: 2815
ថ្ងៃទី 12 9 19
បញ្ជូនទៅ DG

ប្រធានគណៈកម្មាធិការជាតិទន្លេមេគង្គកម្ពុជា
សូមជម្រាបជូន
ឯកឧត្តម អគ្គនាយករដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ

រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ
ការិយាល័យ រដ្ឋបាល
ចូល លេខ: 218
ថ្ងៃទី 12/9/19 ម៉ោង 10:25

កម្មវត្ថុ:ករណីសុំអនុញ្ញាតឱ្យរដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ យកទឹកទន្លេបាសាក់ ត្រង់ចំណុចទីតាំងសាខាចែកចាយទឹកតាខ្មៅ ទៅធ្វើប្រព្រឹត្តកម្មទឹកស្អាត នៅរោងចក្រផលិតទឹកស្អាតតាខ្មៅ សង្កាត់ដើមមៀន ក្រុងតាខ្មៅ ខេត្តកណ្តាល ។

យោង: លិខិតលេខ ៦៨៣ លស ចុះថ្ងៃទី២៨ ខែសីហា ឆ្នាំ២០១៩ របស់រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ។

សេចក្តីដូចមានចែងក្នុងកម្មវត្ថុ និងយោងខាងលើ ខ្ញុំសូមជម្រាបជូន **ឯកឧត្តម អគ្គនាយក** ជ្រាបថា គណៈកម្មាធិការជាតិទន្លេមេគង្គកម្ពុជា ពុំជំទាស់ទៅនឹងសំណើខាងលើនេះទេ ដោយផ្អែកលើចំណុចមួយចំនួនដូចខាងក្រោម៖

- គម្រោងនេះមានការឯកភាពពីប្រមុខរាជរដ្ឋាភិបាលកម្ពុជា និងមានភ្ជាប់មកជាមួយនូវផែនទីបច្ចេកទេសនៃការសិក្សាត្រង់ចំណុចទីតាំង
- គម្រោងនេះសម្រួលដល់ការប្រើប្រាស់ទឹកទន្លេបាសាក់ នៅតំបន់គោលដៅដែលមានក្នុងផែនការមេសម្រាប់ការផ្គត់ផ្គង់ទឹកស្អាត ក្នុងការសម្រេចឱ្យបាននូវគោលនយោបាយទឹកស្អាត របស់រាជរដ្ឋាភិបាល
- លទ្ធផលនៃការសិក្សាបានបង្ហាញថា ពុំមានផលប៉ះពាល់ដល់លំហូរទឹកគិតជាមធ្យមប្រចាំឆ្នាំ និងលំហូរទឹកអប្បបរមានៅរដូវប្រាំង និងបរិស្ថានទន្លេបាសាក់ និងពុំរំខានដល់ការធ្វើនាវាចរណ៍តាមដងទន្លេបាសាក់ ព្រមទាំងជួយកាត់បន្ថយ ឬទប់ស្កាត់ការបាក់ច្រាំងទន្លេបាសាក់ដោយសារទឹកជំនន់ទន្លេ
- ដូចការវិភាគ ក្នុងចំណុចទី៤ នៃលិខិតយោងខាងលើ និងស្របតាមស្មារតីនៃកិច្ចព្រមព្រៀងមេគង្គឆ្នាំ១៩៩៥ បរិមាណទឹកដែលត្រូវយកមកធ្វើប្រព្រឹត្តកម្មទឹកស្អាត មានតិចតួចដែលមិនមានឥទ្ធិពលប៉ះពាល់ធំដុំដល់ធារទឹក នៃទន្លេបាសាក់ ឬ ទន្លេមេគង្គឡើយ។

សូម **ឯកឧត្តមអគ្គនាយក** ទទួលនូវការរាប់អានពីខ្ញុំ។

ប្រធាន

លឹម_កានហោ

ចម្លងជូន៖
- ក្រសួងធនធានទឹក និងឧតុនិយម
- ឯកសារ-កាលប្បវត្តិ

អគារលេខ 576, ផ្លូវជាតិលេខ២ សង្កាត់ចាក់អង្រែក្រោម ខណ្ឌមានជ័យ រាជធានីភ្នំពេញ កម្ពុជា ប្រអប់សំបុត្រ 2214 ភ្នំពេញ 3
ទូរស័ព្ទ : (855-23) 216 514 ទូរសារ : (855-23) 218 506 អ៊ីម៉ែល : cnmcs@cnmc.gov.kh Website : www.cnmc.gov.kh

MOWRAM からの承認レター

ព្រះរាជាណាចក្រកម្ពុជា
ជាតិ សាសនា ព្រះមហាក្សត្រ

រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ
លេខាធិការដ្ឋាន
ចូល លេខ: 3263
ថ្ងៃទី 28/10/19 ម៉ោង 15:50
បញ្ជូនទៅ DG

ក្រសួងធនធានទឹក និងឧតុនិយម

លេខ ២៩០៤ ធទឧ

ថ្ងៃ ព្រហស្បតិ៍ ១១ កើត ខែ កត្តិក ឆ្នាំ កុរ ឯកស័ក ព.ស ២៥៦៣
រាជធានីភ្នំពេញ, ថ្ងៃទី ២៤ ខែ តុលា ឆ្នាំ ២០១៩

រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ
ការិយាល័យ រដ្ឋបាល
ចូល លេខ: 823
ថ្ងៃទី 28/10/19 ម៉ោង 15:40
បញ្ជូនទៅ [illegible]

30 [illegible]
DY ៤៣២ PMU

រដ្ឋមន្ត្រីក្រសួងធនធានទឹក និងឧតុនិយម
ជម្រាបជូន
ឯកឧត្តម អគ្គនាយករដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ

កម្មវត្ថុ ៖ សំណើសុំលិខិតអនុញ្ញាត សម្រាប់ដកយកទឹកទន្លេបាសាក់ ត្រង់ចំណុចទីតាំងសាខាចែកចាយទឹកស្អាតតាខ្មៅ ទៅធ្វើប្រព្រឹត្តកម្មទឹកស្អាតនៅរោងចក្រផលិតទឹកស្អាតតាខ្មៅ សង្កាត់ដើមមៀន ក្រុងតាខ្មៅ ខេត្តកណ្ដាល ។

យោង ៖ លិខិតលេខ ៧៦៧ ល.ស ចុះថ្ងៃទី ២៥ ខែ កញ្ញា ឆ្នាំ ២០១៩ របស់រដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ

សេចក្ដីដូចមានចែងក្នុងកម្មវត្ថុ និងយោងខាងលើ សូមជម្រាបឯកឧត្តម អគ្គនាយករដ្ឋាករទឹកស្វយ័តក្រុងភ្នំពេញ ជ្រាបថា ក្រសួងធនធានទឹក និងឧតុនិយម អនុញ្ញាតឲ្យទាញយកទឹកដើម្បីផលិតទឹកស្អាតចំនួន ៣០,០០០ម៣/ថ្ងៃ តាមសំណើសុំខាងលើ ដោយផ្អែកលើចំណុចមួយចំនួនដូចខាងក្រោម ៖

- គម្រោងនេះមានការឯកភាពពីប្រមុខរាជរដ្ឋាភិបាលកម្ពុជា និងមានភ្ជាប់មកជាមួយនូវផែនទីបច្ចេកទេស នៃការសិក្សាត្រង់ចំណុចទីតាំង
- គម្រោងនេះសម្រួលដល់ការប្រើប្រាស់ទឹកទន្លេបាសាក់ នៅតំបន់គោលដៅដែលមានក្នុងផែនការមេសម្រាប់ផ្គត់ផ្គង់ទឹកស្អាត ក្នុងការសម្រេចឲ្យបាននូវគោលនយោបាយទឹកស្អាត របស់រាជរដ្ឋាភិបាល
- លទ្ធផលនៃការសិក្សាបានបង្ហាញថា ពុំមានផលប៉ះពាល់ដល់លំហូរទឹកគិតជាមធ្យមប្រចាំឆ្នាំ និងលំហូរទឹកអប្បបរមានៅរដូវប្រាំង និងបរិស្ថានទន្លេបាសាក់ និងពុំរំខានដល់ការធ្វើនាវាចរណ៍តាមដងទន្លេបាសាក់
- ដូចការវិភាគ ក្នុងចំណុចទី៤ នៃលិខិតលេខ ៦៨៣ លស ចុះថ្ងៃទី ២៨ ខែ សីហា ឆ្នាំ ២០១៩ និងស្របតាមស្មារតីនៃកិច្ចព្រមព្រៀង មេគង្គឆ្នាំ ១៩៩៥ បរិមាណទឹកដែលត្រូវយកមកធ្វើប្រព្រឹត្តកម្មទឹកស្អាត មានតិចតួចដែលមិនមានឥទ្ធិពលប៉ះពាល់ធំដុំដល់ធារទឹកនៃទន្លេបាសាក់ ឬ ទន្លេមេគង្គឡើយ ។

សូមឯកឧត្តមអគ្គនាយកទទួលនូវការរាប់អានដ៏ស្មោះពីខ្ញុំ ។

រដ្ឋមន្ត្រី

លឹម_គានហោ

ចម្លងជូន៖
-ថ្នាក់ដឹកនាំក្រសួងធនធានទឹក និងឧតុនិយម
-អគ្គនាយកក្រសួង
-អគ្គាធិការ
-ខុទ្ទកាល័យឯកឧត្តមរដ្ឋមន្ត្រី
"ដើម្បីជូនជ្រាប"
-ឯកសារ-កាលប្បវត្តិ

• អគារលេខ: ៣៦៤ មហាវិថី ព្រះមុនីវង្ស សង្កាត់ ផ្សារដើមថ្កូវ ខណ្ឌ ចំការមន រាជធានីភ្នំពេញ ទូរស័ព្ទលេខ: (៨៥៥) ២៣ ២១៦ ៦៧០

資　料 6.4　モニタリング フォーム

モニタリング フォーム（案）(工事中)

The latest results of the below monitoring items should be submitted to JICA Cambodia Office as part of Quarterly Progress Report throughout the construction phase.

1. Response/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
Number and contents of formal comments made by the public	
Number and contents of responses from government agencies (such as MoE etc.)	

2. Pollution

2.1 Water Quality

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	To be meet the requirements instructed by PPWSA	Measurement Point	Frequency
pH	-					To be confirmed	2 points (1 at upstream of WTP intake, 1 at downstream of the WTP intake) for intake construction	Preconstruction: 1 time/point Construction: 1 time/point
SS	mg/L					To be confirmed		
Turbidity	mg/L					To be confirmed		
COD	mg/L					To be confirmed		
NH_4-N	mg/L					To be confirmed		
Coliform	MPN/100mL					To be confirmed		
SS	mg/L			120	80	120	1 point (at the discharge point to existing sewerage system) for sewage management in construction site	1 time/point/month
BOD	mg/L			80	40	80		
COD	mg/L			100	40	100		

2.2 Air Quality

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
CO	mg/m^3			20	20	20	1 point (1 at the WTP site)	Preconstruction: 1 time/point Construction:
NO_2				0.1	0.04	0.1		
SO_2				0.3	0.04	0.3		

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
O_3				0.2	0.06	0.2		1 time/point/6 months
Pb				0.005	-	0.005		
TSP				0.33	0.1	0.33		
PM_{10}				0.005	-	0.005		
$PM_{2.5}$				0.025	0.015	0.025		

2.3 Noise and Vibration and Solid Waste

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Waste Disposal Method	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
Equivalent continuous A sound level (Laeq, 10)	dB(A)			-	75 (6:00-18:00)	70	75	2 points (1 at the WTP, 1 at western boundary of the WTP)	Preconstruction: 1 time/point Construction: 1 time/point/6 months
Vibration level (Lv10)	dB(A)			-	-	65 (8:00-19:00)	65	2 points (1 at the WTP, 1 at western boundary of the WTP)	Preconstruction: 1 time/point Construction: 1 time/point/6 months
Volume of wastes (waste soil)	m^3				-	-	-	2 points (1 at Gate of the WTP, 1 at Boeng Tompun Lagoon)	1 time (24 hr)/month
Volume of wastes (other construction wastes)	m^3				-	-	-	2 points (1 at Gate of the WTP, 1 at existing Dangkor landfill site by 2021 or new landfill sit after 2021)	1 time (24 hr)/month

モニタリング フォーム（案）(供与時)

3.1 Water Quality

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
SS	mg/L			120	80	120	1 point (at the discharge point to existing sewerage system)	1 time/point/month
BOD	mg/L			80	40	80		
COD	mg/L			100	40	100		

3.2 Air Quality

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Cambodian Standards	Japanese Standards	Standards for Contract	Measurement Point	Frequency
CO	mg/m^3			20	20	20	1 point (1 at the WTP site)	Preconstruction: 1 time/point Construction: 1 time/point/6 months
NO_2				0.1	0.04	0.1		
SO_2				0.3	0.04	0.3		
O_3				0.2	0.06	0.2		
Pb				0.005	-	0.005		
TSP				0.33	0.1	0.33		
PM_{10}				0.005	-	0.005		
$PM_{2.5}$				0.025	0.015	0.025		

3.3 Solid Waste

Parameter	Unit	Measures Value (Average)	Measures Value (Max.)	Sludge Disposal Method	Cambodian Standards	Standards for Contract	Measurement Point	Frequency
Volume of sludge	m^3			[1] Landfill [2] Reuse for backfilling [3] Other	-	-	2 points (1 at Gate of the WTP, 1 at new landfill site or reuse site)	1 time (24 hr)/6 months

資　料 6.5　環境チェックリスト

環境チェックリスト

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1. Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process?	Y	(a) Initial Environmental Impact Assessment (IEIA) report has been prepared and submitted to Ministry of Environment (MoE) in the end of August, 2019.
		(b) Have EIA reports been approved by authorities of the host country's government?	N	(b) The IEIA report is currently under review by MoE. It is expected that MoE will issue approval letter on the IEIA report by the end of November, 2019.
		(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?	N	(c) The IEIA report is currently under review by MoE.
		(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	N	(d) In addition to the above approvals, a permit for water intake is required. On Sep. 12, 2019, approval letter for the water extraction right was issued by Cambodia National Mekong Committee (CNMC) signed by Chief of Committee, H.E. LIM Kean Hor (Minister of Water Resources and Meteorology).
	(2) Explanation to the Public	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the local stakeholders?	Y	(a) Stakeholder consultation meetings were held in Derm Mien Village on June 22, 2019 and in Kandal Provincial Department of Environment (DoE) on July 18, 2019. During the meetings, the project contents and the potential impacts are explained to the local stakeholders. Understanding was obtained from the local stakeholders considering the discussion and comments collected from them during the meetings. In addition, information disclosure has been also carried out through local authorities and NGOs.
		(b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	Y	(b) Local residents required to increase house connection, regular water supply, appropriate water tariff and lower price of house connection. These comments and requirements have been reflected in the project design (increasing service population from current 48,000 to 120,000, providing 24 hours water supply, providing subsidized connections and tariff for low income households.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	Y	(a) Three alternative studies (without project, conventional treatment and advanced treatment) have been examined. In order to avoid land acquisition and resettlement, conventional treatment method is selected.
2. Mitigation Measure	(1) Air Quality	(a) Is there a possibility that chlorine from chlorine storage facilities and chlorine injection facilities will cause air pollution?	N	(a) On-site sodium hypochlorite generation system with high safety will be applied. Therefore, chlorine gas will not be used in the WTP and leakage of chlorine is not expected.
		(b) Do chlorine concentrations within the working environments comply with the country's occupational health and safety standards?	Y	(b) In the on-site sodium hypochlorite generation system, the disinfectant is produced and stored in liquid form. Therefore, there is no danger of gas leaks from high-pressure chlorine cylinders. In addition, in Cambodia there are no regulations on chlorine concentrations within working environments..

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Water Quality	(a) Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	Y	(a) During construction period: Domestic wastewater generated from construction site at Ta Khmau WTP will be discharged into existing sewerage system. During operation period: Wastewater from the WTP administration building will be treated at wastewater treatment facility before being discharged into existing sewerage system. SS, BOD, COD of effluents discharged from the WTP will comply with Cambodia effluent standards to sewerage system (Sub-decree No. 27 on the Water Pollution Control; SS<120 mg/L, BOD<80 mg/L and COD<100 mg/L).
	(3) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed in accordance with the country's regulations?	N	(a) In Cambodia, there are no laws or regulations on WTP sludge disposal. During construction phase: part of construction waste soil (app. 1,000 m^3) will be reused for backfilling at construction site. The remaining waste soil (app. 1,000 m^3) will be reused for backfilling of Boeng Tompun (lagoon, 3 km far from the WTP). During operation period: WTP sludge will be collected and transported to new landfill site by PPWSA who is conducting a detailed survey on the reuse of sludge for backfilling. In addition, the amount of the sludge is limited (app. 3 tDS/day).
	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as pumping stations comply with the country's standards?	Y	(a) During construction period: Current noise levels around the WTP are 57 to 69 dB(A). During construction, the noise level at boundary of the WTP is estimated to be 78-87 dB(A) due to construction equipment and vehicles operation, which exceeds the standard (75 dB) slightly. However, no sensitive facilities have been identified around the WTP site. In addition, EMP has been prepared and contractor will follow the EMP to minimize noise and vibration during construction period. Current vibration levels (equivalent levels) at the project area are 17 to 26 dB, which are much lower than that of Japanese standards (65 dB). Therefore, it is estimated that vibration levels during construction period will comply with Japanese standards (no vibration standards in Cambodia). During operation period: All pumps will be installed within pump stations, therefore, the noise and vibration level in outside of pump stations is considered to be same as the background level of the site.
	(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	N	(a) During construction period and operation period, no groundwater will be extracted. Therefore, the impacts of subsidence are not expected.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
3. Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	N	(a) The project sites are not located in protected area or environmentally sensitive areas designated by Cambodia laws or international treaties. In addition, all proposed treatment facilities will be located within the existing WTP site. Therefore, there is no possibility that the project will affect the protected areas.
	(2) Ecosystem and Biota	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	N	(a) The project site doesn't encompass primeval forests, tropical rain forests, and ecologically valuable habitats.
		(b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	N	(b) Within the project site, there are no protected habitats of endangered species designated by Cambodia laws or international treaties and conventions.
		(c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?	N	(c) It is not anticipated to cause significant ecological impacts because there are no protected habitats in the area of the WTP site.
		(d) Is there a possibility that the amount of water (e.g., surface water, groundwater) used by the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	Y	(d) Raw water of 0.38 m^3/s will be intaken from Bassac River, which is much less than low flow (40 m^3/s) of the River. Therefore, the impacts of the project on aquatic environments of Bassac River are considered to be not significant. In addition, an approval letter has been obtained from Cambodia National Mekong Committee. PPWSA will prepare water supply plan during dry period in cooperation with MoE in order to ensure suitable environmental flow of Bassac River in the future.
	(3) Hydrology	a) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect surface water and groundwater flows?	N	(a) Compared with low flow (40 m^3/s) of Bassac River, intake volume (33,000 m^3/d or 0.38 m^3/s) will not have significant impacts on surface water and groundwater flow. In addition, an approval letter has been obtained from Cambodia National Mekong Committee.
4. Social Environment	(1) Resettlement	a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?	N	(a) Because the considerations for avoiding resettlement are made and the WTP will be constructed within existing WTP site of PPWSA, there is no resettlement caused by the project.
		(b) Is adequate explanation on compensation and resettlement given to affected people prior to resettlement?	N	(b) For the proposed project, no resettlement will take place.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	N	(c) For the proposed project, neither resettlement nor land acquisition will take place. Therefore, preparation of resettlement plan including compensation is not needed.
		(d) Is the compensations going to be paid prior to the resettlement?	N	(d) For the proposed project, neither resettlement nor land acquisition will take place. Therefore, no compensations will be necessary for the resettlement.
		(e) Is the compensation policies prepared in document?	N	(e) For the proposed project, neither resettlement nor land acquisition will take place. Therefore, preparation of compensation policies is not expected.
		(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	N	(f) For the proposed project, there is no resettlement or land acquisition.
		(g) Are agreements with the affected people obtained prior to resettlement?	N	(g) For the proposed project, there is no resettlement and land acquisition. Therefore, it is not necessary to get agreement with the affected people.
		(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	N	(h) For the proposed project, there is no resettlement and land acquisition.
		(i) Are any plans developed to monitor the impacts of resettlement?	N	(i) For the proposed project, alternative studies have been carried out to avoid resettlement. As the results, there is no resettlement or land acquisition will be required. Therefore, it is not necessary to monitoring the impacts of resettlement.
		(j) Is the grievance redress mechanism established?	N	(j) For the proposed project, there is no resettlement or land acquisition. Thus, it is not necessary to establish grievance redress mechanism.
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	N	(a) All proposed facilities will be located within the existing WTP site and will not affect the living environment of the land other than the construction site. The project is expected to improve the living environment as the water supply rate increases. Fishing activity is prohibited from July 1 to November 30 each year because this is the breeding season for all kinds of fish. Therefore, the impacts of the construction on fishing activity are not expected during this period. During fishing season, the construction of the WTP may create impacts on fishing activity. However, fishing activity can be conducted at upstream or downstream (500m or more) of intake construction site. Therefore, the impacts on fishing activity are low and mitigable

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(b) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	N	(a) Comparing with low flow (40 m^3/s) of Bassac River, intake amount (33,000 m^3/d or 0.38 m^3/s) will not have significant impacts on the existing water uses and water area uses. In addition, an approval letter has been obtained from Cambodia National Mekong Committee.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	N	(a) Ta Khmau WTP site is located within existing WTP site. Thus, the impact is considered to be negligible.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	N	(a) The WTP is located within the existing WTP site, and area is small (o.45 ha). In addition, tree planting will be conducted in the WTP.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?	Y	(a) There is no ethnic minority or indigenous group in the project area. In addition, water service rate will be increased up to 100%.
		(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	Y	(b) Ditto
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?	Y	(a) Cambodian laws and ordinances (such as Labor Law 1997 and amendment Law 2018, the Law on Social Security, Sub-Decree 11/16, on Health Care Scheme etc.) associated with working conditions (such as wage and hours of work etc.) will be followed by the project proponent during construction works and operation of the project based on Environmental Management Plan (EMP).
		(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?	Y	(b) Safety considerations will be taken during construction works and operation of the project based on the EMP prepared (such as ear protection equipment must be provided to workers when a noise level exceeds 80 dB(A) in the WTP construction site or within pump station). In addition, inspections of PPWSA and other authorities on safety will be conducted.
		(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?	Y	(c) Safety and health program and safety training for workers will be planned and implemented during construction works and operation of the project based on EMP prepared. (such as wearing safety shoes and elements during construction, following Standard Operation Procedures for the works during operation)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	Y	(d) Appropriate measures will be taken based on EMP prepared. (such as specific security guards will be assigned by contractor and PPWSA will conduct regular inspection during construction and operation)
5. Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?	Y	(a) Mitigation measures on utilization of local resources (fishing), water usage/water right, traffic control, poor households, accidents (such as safety plan preparation, O/M manual etc.), air pollution (such as covering trucks and spraying exposed areas with water etc.), water pollution, wastes (sludge reuse methods etc.), noise and vibrations (such as application of reasonable construction schedule and methods etc.) have been proposed.
		(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts?	Y	(b) All construction works of Ta Khmau WTP will be carried out within the existing WTP site. Therefore, the impacts on the natural environment (ecosystem) will be very limited.
		(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	Y	(c) Before construction starts, information will be delivered to fisherman via commune and village chiefs in advance. A detailed traffic control plan will be prepared. In addition, proper construction schedule and methods to reduce traffic disruption and traffic accident. Education of staff/workers on the safety and fire will also be conducted to reduce impacts.
		(d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	Y	(d) Proper construction plan of the WTP and traffic control plan will be prepared before construction,
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?	Y	(a) Environmental monitoring program has been prepared in the IEIA report based on the recommendations from the JICA Survey Team.
		(b) What are the items, methods and frequencies of the monitoring program?	Y	(b) The items, methods and frequencies of the monitoring program have been proposed and presented in Preparatory Survey Report. Basically, air quality (CO, NO_2, SO_2, O_3, Pb TSP PM_{10} and $PM_{2.5}$): time/6 months; basin water quality (pH, temperature, TDS, TSS, DO, BOD, COD, Oil and Grease, NO_3, T-N, T-P, As, Hg, Total Coliform etc. 17 parameters): time/two weeks, noise and vibration: time/6 months, traffic (along National Highway 102): regularly.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?	Y	(c) Monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework) has been prepared.
		(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	Y	(d) Monitoring format has been proposed.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Dam and River Projects checklist should also be checked.	N	(a) Not necessary.
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	Y	(b) Not necessary.

資　料 6.6　環境管理計画

環境管理計画（案）

Impacts	Mitigation Measures	Implementing Organization	Responsible Organization	Cost
Before / During Construction				
Traffic	1) Prepare a detailed traffic control plan and to coordinate with local government. 2) Prepare proper construction schedule and methods to reduce traffic disruption and traffic accident. 3) Assign traffic control person at the entrance of the WTP while construction is taking place.	Contractor	PPWSA	Included in the construction cost
Air Pollution	1) Cover stored materials with plastic or other materials. 2) Cover trucks, and to spray exposed areas with water. 3) Wash vehicles before going out the construction site. 4) Minimize traffic over freshly exposed surfaces. 5) Install barrier walls for limiting wind dispersing if necessary. 6) Prepare air quality monitoring plan and carry out it during construction. 7) Update the Environmental Monitoring Plan during Detailed Design	Contractor	PPWSA	2,000 USD/year (Included in the construction cost)
Waste	1) Prepare reasonable plan for solid waste disposal, especially for excavated soil. 2) Install temporary toilet at the construction site for workers, and set sanitary bins for domestic wastes. 3) PPWSA has a plan to sell the surplus waste soil to buyer as backfilling materials. 4) Dispose solid wastes appropriately	Contractor	PPWSA	Included in the construction cost
Noise	1) Prepare a detailed plan for noise control and coordinate with local government. 2) Prepare proper construction schedule and methods. 3) Set speed limits for vehicles and train workers on mitigation measures for environmental impacts. 4) Use low noise level equipment, if necessary. 5) Prepare noise monitoring plan and carrying out monitoring during construction.	Contractor	PPWSA	1,000 USD/year (Included in the construction cost)
Water Pollution	1) The embankment will be constructed to prevent land erosion during the rainfall. 2) Carry out water quality monitoring. 3) Install wastewater treatment system within the WTP to treat domestic wastewater during construction and operation.	Contractor	PPWSA	1,000 USD/year (Included in the construction cost)
During Operation				
Air quality	1) Preparing air quality monitoring plan. 2) Implementation of air quality monitoring.	Operator	PPWSA	1,000 USD/year (Included in the O&M cost)
Waste	1) Monitoring on volume of sludge and solid wastes from the WTP. 2) Implementation of EMP for operation of the WTP.	Operator	PPWSA	Included in the O&M cost
Water pollution	1) Preparing water quality monitoring plan. 2) Implementation of water quality monitoring at downstream of the WTP.	Operator	PPWSA	2,000 USD/year (Included in the O&M cost)

資　料 6.7　各浄水場の月次生産量及び生産要素データ

(1) 2014 年の各浄水場の月次生産量及び生産要素データ

សរុបការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីតាមរោងចក្រទាំងបួន
TOTAL OF RAW MAETERIAL AND POWER CONSUMPTION FOR THE FOURTH WTPS

Month	រោងចក្រភូមិព្រែក Phum Prek WTP		រោងចក្រជ្រោយចង្វារ Chrouy Chang War WTP		រោងចក្រចំការមន Cham Car Morn WTP		រោងចក្រនិរោធ Niroth WTP		សរុប Total	
	150,000 m³/day		130,000 m³/day		20,000 m³/day		130,000 m³/day		430,000 m³/day	
	ទឹកល្អក M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកល្អក M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកល្អក M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកល្អក M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកល្អក M³ Raw water	ទឹកស្អាត M³ Treated water
1	4,889,105	4,644,650	3,735,430	3,660,670	66,608	63,152	3,218,754	3,118,172	11,909,897	11,486,644
2	4,392,031	4,172,428	3,719,260	3,638,060	38,819	39,026	2,965,998	2,877,592	11,116,108	10,727,106
3	5,034,693	4,782,960	4,604,290	4,491,770	292,178	284,034	3,223,174	3,111,673	13,154,335	12,670,437
4	4,818,431	4,577,511	4,082,120	3,986,860	295,495	283,914	2,907,946	2,804,014	12,103,992	11,652,299
5	5,391,261	5,121,699	4,719,890	4,610,330	345,661	329,815	3,277,651	3,209,035	13,734,463	13,270,879
6	4,921,961	4,675,862	4,440,790	4,329,060	346,570	328,155	3,741,662	3,663,442	13,450,983	12,996,519
7	4,418,604	4,205,752	3,985,980	3,886,440	406,116	393,317	4,863,949	4,701,050	13,674,649	13,186,559
8	4,434,160	4,223,007	4,163,840	4,041,700	431,962	419,618	4,706,760	4,519,509	13,736,722	13,203,834
9	3,895,602	3,700,818	3,716,980	3,605,010	357,689	355,315	4,257,365	4,111,350	12,227,636	11,772,493
10	4,453,437	4,230,762	4,005,610	3,915,890	416,311	406,531	4,612,314	4,516,030	13,487,672	13,069,213
11	4,224,289	4,013,411	4,020,400	3,929,410	408,715	395,125	4,277,910	4,201,560	12,931,314	12,539,506
12	4,407,892	4,187,497	4,121,050	4,030,970	422,586	402,147	4,457,639	4,355,992	13,409,167	12,976,606
សរុបរួម Total	55,281,466	52,536,357	49,315,640	48,126,170	3,828,710	3,700,149	46,511,122	45,189,419	154,936,938	149,552,095
មធ្យម AVG		4,378,030		4,010,514		308,346		3,765,785		12,462,675
អតិបរមា MAX		5,121,699		4,610,330		419,618		4,701,050		13,270,879

សរុបការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីតាមរោងចក្រទាំងបួន
TOTAL OF RAW MAETERIAL AND POWER CONSUMPTION FOR THE FOURTH WTPS

Month	PAC		សាច់ជូរ Alum		កំបោរ Lime		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**80,675**	7.02	-	-	-	-	**33,055**	2.9	**3,029,686**	264
2	**71,300**	6.65	-	-	-	-	**30,448**	2.8	**2,917,099**	272
3	**88,625**	6.99	-	-	540.000	0.0	**37,642**	3.0	**3,512,135**	277
4	**79,800**	6.85	-	-	-	-	**30,569**	2.6	**3,263,394**	280
5	**107,650**	8.11	-	-	-	-	**31,686**	2.4	**3,813,178**	287
6	**64,150**	4.94	-	-	-	-	**30,055**	2.3	**3,613,740**	278
7	**130,950**	9.93	-	-	-		**29,904**	2.3	**3,273,347**	248
8	**96,950**	7.34	-	-	-	-	**27,859**	2.1	**3,139,008**	238
9	**62,600**	5.32	5,550	0.471	-	-	**24,503**	2.1	**2,718,870**	231
10	**63,825**	4.88	5,250	0.402	-	-	**28,824**	2.2	**3,121,149**	239
11	**56,000**	4.47	-	-	-	-	**28,497**	2.3	**3,141,935**	251
12	**58,150**	4.48	-	-	-	-	**31,521**	2.4	**3,374,510**	260
សរុបរួម Total	**960,675**	6.42	10,800	0.07	540.000	0.00	**364,563**	2.4	**38,918,051**	260.2
មធ្យម AVG	**80,056**	**6.42**	-	-	-	-	**30,380**	**2.45**	**3,243,171**	**260**
អតិបរមា MAX	**130,950**	**9.93**	-	-	-	-	**37,642**	**2.97**	**3,813,178**	**287**

ការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីរោងចក្រភូមិព្រែក
RAW MAETERIAL AND POWER CONSUMPTION FOR PHUM PREK WTP

Month	PAC		សាច់ជូរ Alum		កំបោរ Lime		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**43,200**	9.3	-	-	-	-	**14,620**	3.1	**1,203,019**	259
2	**41,600**	10.0	-	-	-	-	**13,557**	3.2	**1,121,864**	269
3	**60,000**	12.5	-	-	-	-	**17,418**	3.6	**1,308,693**	274
4	**63,200**	13.8	-	-	-	-	**15,139**	3.3	**1,299,120**	284
5	**90,800**	17.7	-	-	-	-	**14,610**	2.9	**1,519,066**	297
6	**31,200**	6.7	-	-	-	-	**12,914**	2.8	**1,340,299**	287
7	**48,000**	11.4					**9,053**	2.2	**1,053,787**	251
8	**30,400**	7.2	-	-	-	-	**7,839**	1.9	**1,010,989**	239
9	**17,600**	4.8	-	-	-	-	**8,290**	2.2	**854,827**	231
10	**19,200**	4.5	-	-	-	-	**9,199**	2.2	**1,008,397**	238
11	**20,000**	5.0	-	-	-	-	**9,188**	2.3	**996,430**	248
12	**22,400**	5.3	-	-	-	-	**10,164**	2.4	**1,086,757**	260
សរុបរួម Total	**487,600**	9.28	-	-	-	-	**141,991**	2.70	**13,803,248**	263
មធ្យម AVG	**40,633**	**9.02**					**11,833**	**2.67**	**1,150,271**	**261**
អតិបរមា MAX	**90,800**	**17.73**					**17,418**	**3.64**	**1,519,066**	**297**

ការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីរោងចក្រជ្រោយចង្វារ
RAW MAETERIAL AND POWER CONSUMPTION FOR CHROY CHANG WA WTP

Month	PAC		ស ច់ជូរ Alum		កំបោរ Lime		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកត (g)	គិតជា (Kg)	ឯកត (g)	គិតជា (Kg)	ឯកត (g)	គិតជា (Kg)	ឯកត (g)	គិតជា (Kwh)	(wh)
1	11,575	3.2	-	-	-	-	6,530	1.8	968,230	264.5
2	7,000	1.9	-	-	-	-	6,670	1.8	1,002,380	275.5
3	6,500	1.4	-	-	-	-	7,850	1.7	1,263,690	281.3
4	5,500	1.4	-	-	-	-	7,210	1.8	1,112,930	279.1
5	9,050	2.0	-	-	-	-	8,730	1.9	1,319,140	286.1
6	17,075	3.9	-	-	-	-	8,250	1.9	1,208,130	279.1
7	36,000	9.3					8,600	2.2	973,750	250.6
8	28,225	7.0	-	-	-	-	8,670	2.1	974,030	241.0
9	19,100	5.3	-	-	-	-	7,180	2.0	836,640	232.1
10	17,650	4.5	-	-	-	-	7,400	1.9	934,090	238.5
11	13,950	3.6	-	-	-	-	7,490	1.9	976,960	248.6
12	12,150	3.0	-	-	-	-	7,330	1.8	1,035,270	256.8
សរុប Total	183,775	3.82	-	-	-	-	91,910	1.91	12,605,240	262
មធ្យម AVG	15,315	3.87	-	-	-	-	7,659	1.91	1,050,437	261
អតិបរមា MAX	36,000	9.26	-	-	-	-	8,730	2.21	1,319,140	286

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រចំការមន
RAW MAETERIAL AND POWER CONSUMPTION FOR CHAMCAR MORN WTP

Month	PAC		សច់ជូរ Alum		កំបោរ Lime		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**400**	6.3	-	-	-	-	**137**	2.2	**24,150**	382
2	**200**	5.1	-	-	-	-	**113**	2.9	**16,350**	419
3	**1,875**	6.6	-	-	-	-	**765**	2.7	**88,270**	311
4	**1,725**	6.1	-	-	-	-	**588**	2.1	**88,546**	312
5	**1,800**	5.5	-	-	-	-	**650**	2.0	**103,802**	315
6	**3,000**	9.1	-	-	-	-	**598**	1.8	**102,196**	311
7	**5,200**	13.2					**661**	1.7	**112,600**	286
8	**4,325**	10.3	-	-	-	-	**703**	1.7	**115,940**	276
9	**900**	2.5	5,550	15.6	-	-	**645**	1.8	**97,685**	275
10	**975**	2.4	5,250	12.9	-	-	**891**	2.2	**112,337**	276
11	**2,300**	5.8	-	-	-	-	**872**	2.2	**113,128**	286
12	**2,600**	6.5	-	-	-	-	**901**	2.2	**119,144**	296
សរុបរួម Total	**25,300**	**6.84**	**10,800**	**2.9**	-	-	**7,524**	**2.03**	**1,094,148**	**296**
មធ្យម AVG	**2,108**	**6.62**	-	-	**-**	**-**	**627**	**2.12**	**91,179**	**312**
អតិបរមា MAX	**5,200**	**13.22**	-	-	**-**	**-**	**901**	**2.90**	**119,144**	**419**

ការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីរោងចក្រនិរោធ
RAW MAETERIAL AND POWER CONSUMPTION FOR NIROTH WTP

Month	PAC		ស ចជូរ Alum		កំបោរ Lime		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គីតជា (Kg)	ឯកតា (g)	គីតជា (Kg)	ឯកតា (g)	គីតជា (Kg)	ឯកតា (g)	គីតជា (Kg)	ឯកតា (g)	គីតជា (Kwh)	(wh)
1	**25,500**	8.2	-	-	-	-	**11,768**	3.8	**834,287**	268
2	**22,500**	7.8	-	-	-	-	**10,108**	3.5	**776,505**	270
3	**20,250**	6.5	-	-	540	0.2	**11,609**	3.7	**851,482**	274
4	**9,375**	3.3	-	-	-	-	**7,632**	-	**762,798**	272
5	**6,000**	1.9	-	-	-	-	**7,696**	2.4	**871,170**	271
6	**12,875**	3.5	-	-	-	-	**8,293**	2.3	**963,115**	263
7	**41,750**	8.9					**11,590**	2.5	**1,133,210**	241
8	**34,000**	7.5	-	-	-	-	**10,647**	2.4	**1,038,049**	230
9	**25,000**	6.1	-	-	-	-	**8,388**	2.0	**929,718**	226
10	**26,000**	5.8	-	-	-	-	**11,334**	2.5	**1,066,325**	236
11	**19,750**	4.7	-	-	-	-	**10,947**	2.6	**1,055,417**	251
12	**21,000**	4.8	-	-	-	-	**13,126**	3.0	**1,133,339**	260
សរុបរួម Total	**264,000**	5.84	-	-	540	0.01	**123,138**	2.72	**11,415,415**	253
មធ្យម AVG	**22,000**	**5.75**	-	-	-	-	**10,262**	**2.56**	**951,285**	**255**
អតិបរមា MAX	**41,750**	**8.88**	-	-	-	-	**13,126**	**3.77**	**1,133,339**	**274**

(2) 2015 年の各浄水場の月次生産量及び生産要素データ

សរុបការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីតាមរោងចក្រទាំងបួន
TOTAL OF RAW MAETERIAL AND POWER CONSUMPTION FOR THE FOURTH WTPS

Month	រោងចក្រភូមិព្រែក Phum Prek WTP		រោងចក្រជ្រោយចង្វារ Chrouy Chang War WTP		រោងចក្រចំការមន Cham Car Morn WTP		រោងចក្រនិរោធ Niroth WTP		សរុប Total	
	150,000 m³/day		130,000 m³/day		20,000 m³/day		130,000 m³/day		430,000 m³/day	
	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water
1	4,249,549	**4,037,072**	4,271,650	**4,164,180**	427,459	**408,034**	4,320,213	**4,239,902**	**13,268,871**	**12,849,188**
2	4,134,854	**3,928,111**	3,747,480	**3,678,720**	382,936	**369,722**	3,950,521	**3,853,475**	**12,215,791**	**11,830,028**
3	4,733,305	**4,496,638**	4,447,870	**4,358,080**	426,838	**415,813**	4,811,165	**4,683,329**	**14,419,178**	**13,953,860**
4	4,157,193	**3,949,334**	4,080,600	**3,998,580**	370,176	**360,630**	4,281,749	**4,172,015**	**12,889,718**	**12,480,559**
5	4,871,906	**4,628,310**	4,666,360	**4,573,290**	457,182	**436,693**	4,845,710	**4,747,404**	**14,841,158**	**14,385,697**
6	4,707,758	**4,472,370**	4,734,240	**4,657,460**	396,870	**376,092**	4,541,140	**4,437,350**	**14,380,008**	**13,943,272**
7	5,047,070	**4,794,719**	4,707,280	**4,585,810**	404,895	**384,074**	4,709,739	**4,548,199**	**14,868,984**	**14,312,802**
8	5,217,167	**4,956,310**	4,589,690	**4,444,820**	390,770	**369,121**	4,635,860	**4,408,290**	**14,833,487**	**14,178,541**
9	4,985,729	**4,736,440**	4,536,880	**4,375,370**	393,515	**372,926**	4,629,869	**4,353,620**	**14,545,993**	**13,838,356**
10	4,773,497	**4,534,821**	4,318,410	**4,188,560**	355,160	**335,940**	4,325,580	**4,151,679**	**13,772,647**	**13,211,000**
11	4,862,419	**4,619,297**	4,643,070	**4,472,360**	345,162	**326,649**	4,385,439	**4,268,500**	**14,236,090**	**13,686,806**
12	4,915,921	**4,670,123**	4,910,650	**4,796,890**	370,982	**354,409**	4,828,040	**4,657,569**	**15,025,593**	**14,478,991**
សរុបរួម Total	56,656,368	**53,823,545**	53,654,180	**52,294,120**	4,721,945	**4,510,103**	54,265,025	**52,521,332**	169,297,518	**163,149,100**
មធ្យម AVG		4,485,295		4,357,843		375,842		4,376,778		13,595,758
អតិបរមា MAX		4,956,310		4,796,890		436,693		4,747,404		14,478,991

សរុបការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីតាមរោងចក្រទាំងបួន
TOTAL OF RAW MAETERIAL AND POWER CONSUMPTION FOR THE FOURTH WTPS

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	64,125	4.99	33,927	2.64	3,418,630	266
2	68,575	5.80	34,034	2.88	3,207,459	271
3	68,750	4.93	39,477	2.83	3,769,991	270
4	38,050	3.05	28,602	2.29	3,271,907	262
5	40,150	2.79	33,108	2.30	3,882,382	270
6	48,275	3.46	33,235	2.38	3,663,044	263
7	119,525	8.35	35,063	2.45	3,695,201	258
8	123,975	8.74	31,467	2.22	3,408,921	240
9	106,825	7.72	28,843	2.08	3,270,833	236
10	86,825	6.57	28,012	2.12	3,068,444	232
11	97,275	7.11	33,309	2.43	3,420,200	250
12	104,925	7.25	37,717	2.60	3,795,937	262
សរុបរួម Total	967,275	5.93	396,794	2.43	41,872,949	257
មធ្យម AVG	80,606	5.90	33,066	2.44	3,489,412	257
អតិបរមា MAX	123,975	8.74	39,477	2.88	3,882,382	271

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រភូមិព្រែក
RAW MAETERIAL AND POWER CONSUMPTION FOR PHUM PREK WTP

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	28,800	7.1	11,731	2.9	1,068,380	264.6
2	40,800	10.4	14,389	3.7	1,060,344	269.9
3	33,600	7.5	17,872	4.0	1,231,169	273.8
4	11,200	2.8	12,148	3.1	1,051,815	266.3
5	10,400	2.2	12,824	2.8	1,259,000	272.0
6	12,800	2.9	13,328	3.0	1,195,069	267.2
7	29,600	6.2	15,679	3.3	1,256,664	262.1
8	36,800	7.4	12,507	2.5	1,200,456	242.2
9	28,800	6.1	10,576	2.2	1,126,201	237.8
10	19,600	4.3	10,170	2.2	1,039,598	229.2
11	34,400	7.4	11,156	2.4	1,151,105	249.2
12	43,200	9.3	13,078	2.8	1,235,297	264.5
សរុបរួម Total	330,000	6.13	155,458	2.89	13,875,098	258
មធ្យម AVG	27,500	6.14	12,955	2.90	1,156,258	258
អតិបរមា MAX	43,200	10.39	17,872	3.97	1,259,000	274

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រប្រព្រោយចង្វារ

RAW MAETERIAL AND POWER CONSUMPTION FOR CHROY CHANG WA WTP

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គីឡូ (Kg)	ឯកតា (g)	គីឡូ (Kg)	ឯកតា (g)	គីឡូ (Kwh)	(wh)
1	8,700	2.1	7,640	1.8	1,105,890	265.6
2	7,100	1.9	7,460	2.0	1,005,360	273.3
3	8,300	1.9	8,940	2.1	1,195,950	274.4
4	6,900	1.7	7,600	1.9	1,071,010	267.8
5	8,700	1.9	9,110	2.0	1,295,500	283.3
6	12,200	2.6	9,320	2.0	1,274,660	273.7
7	46,400	10.1	9,090	2.0	1,221,790	266.4
8	39,500	8.9	8,880	2.0	1,098,470	247.1
9	32,000	7.3	8,410	1.9	1,057,360	241.7
10	27,150	6.5	8,020	1.9	1,009,180	240.9
11	24,550	5.5	8,700	1.9	1,158,960	259.1
12	12,050	2.5	9,490	2.0	1,305,280	272.1
សរុបរួម Total	233,550	4.47	102,660	1.96	13,799,410	264
មធ្យម AVG	19,463	4.41	8,555	1.96	1,149,951	264
អតិបរមា MAX	46,400	10.12	9,490	2.05	1,305,280	283

ការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីរោងចក្រចំការមន
RAW MAETERIAL AND POWER CONSUMPTION FOR CHAMCAR MORN WTP

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**3,000**	7.4	**869**	2.1	**122,206**	299.5
2	**2,675**	7.2	**741**	2.0	**111,685**	302.1
3	**2,850**	6.9	**802**	1.9	**124,342**	299.0
4	**1,950**	5.4	**636**	1.8	**107,342**	298
5	**2,300**	5.3	**858**	2.0	**130,062**	297.8
6	**3,025**	8.0	**759**	2.0	**110,475**	293.7
7	**6,150**	16.0	**753**	2.0	**111,722**	290.9
8	**7,675**	20.8	**710**	1.9	**103,970**	281.7
9	**7,775**	20.8	**665**	1.8	**103,922**	278.7
10	**5,200**	15.5	**625**	1.9	**93,886**	279.5
11	**3,450**	10.6	**655**	2.0	**93,690**	286.8
12	**4,525**	12.8	**706**	2.0	**103,085**	290.9
សរុបរួម Total	50,575	11.21	8,779	1.9	1,316,387	291.9
មធ្យម AVG	**4,215**	**11.39**	**732**	**1.94**	**109,699**	**292**
អតិបរមា MAX	**7,775**	**20.85**	**869**	**2.13**	**130,062**	**302**

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រនិរោធ
RAW MAETERIAL AND POWER CONSUMPTION FOR NIROTH WTP

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកត (g)	គិតជា (Kg)	ឯកត (g)	គិតជា (Kwh)	(wh)
1	23,625	5.6	13,687	3.2	1,122,154	264.7
2	18,000	4.7	11,444	3.0	1,030,070	267.3
3	24,000	5.1	11,863	2.5	1,218,530	260.2
4	18,000	4.3	8,218	2.0	1,041,740	249.7
5	18,750	3.9	10,316	2.2	1,197,820	252.3
6	20,250	4.6	9,828	2.2	1,082,840	244.0
7	37,375	8.2	9,541	2.1	1,105,025	243.0
8	40,000	9.1	9,370	2.1	1,006,025	228.2
9	38,250	8.8	9,192	2.1	983,350	225.9
10	34,875	8.4	9,197	2.2	925,780	223.0
11	34,875	8.2	12,798	3.0	1,016,445	238.1
12	45,150	9.7	14,443	3.1	1,152,275	247.4
សរុបរួម Total	353,150	6.72	129,897	2.47	12,882,054	245
មធ្យម AVG	29,429	6.71	10,825	2.48	1,073,505	245
អតិបរមា MAX	45,150	9.69	14,443	3.23	1,218,530	267

(3) 2016 年の各浄水場の月次生産量及び生産要素データ

សរុបការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីតាមរោងចក្រទាំងបួន
TOTAL OF RAW MAETERIAL AND POWER CONSUMPTION FOR THE FOURTH WTPS

Month	រោងចក្រភូមិព្រែក Phum Prek WTP		រោងចក្រជ្រោយចង្វារ Chrouy Chang War WTP		រោងចក្រចំការមន Cham Car Morn WTP		រោងចក្រនិរោធ Niroth WTP		សរុប Total	
	150,000 m³/day		130,000 m³/day		20,000 m³/day		260,000 m³/day		560,000 m³/day	
	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water	ទឹកឆៅ M³ Raw water	ទឹកស្អាត M³ Treated water
1	5,070,463	**4,816,940**	4,776,660	**4,670,860**	354,703	**333,174**	4,897,659	**4,733,190**	15,099,485	**14,554,164**
2	4,735,286	**4,498,520**	4,474,850	**4,372,600**	284,498	**267,053**	4,542,620	**4,382,719**	14,037,254	**13,520,892**
3	5,274,968	**5,011,220**	5,166,900	**5,027,120**	372,596	**354,283**	4,989,929	**4,821,820**	15,804,393	**15,214,443**
4	5,015,430	**4,763,707**	4,860,280	**4,709,020**	310,529	**296,255**	4,498,920	**4,366,859**	14,685,159	**14,135,841**
5	5,603,398	**5,323,227**	5,207,500	**5,107,090**	467,425	**447,421**	5,005,859	**4,906,040**	16,284,182	**15,783,778**
6	5,158,940	**4,900,993**	4,939,790	**4,840,520**	463,819	**438,368**	4,821,770	**4,732,549**	15,384,319	**14,912,430**
7	5,526,306	**5,249,990**	5,065,190	**4,960,680**	426,861	**399,976**	-	**4,707,890**	11,018,357	**15,318,536**
8	5,684,534	**5,400,305**	5,025,320	**4,918,050**	410,648	**385,772**	5,049,730	**4,825,070**	16,170,232	**15,529,197**
9	5,304,177	**5,038,966**	4,754,510	**4,651,530**	383,813	**358,413**	4,643,849	**4,429,690**	15,086,349	**14,478,599**
10	5,323,036	**5,056,887**	4,573,490	**4,441,100**	294,951	**275,451**	5,042,380	**4,948,720**	15,233,857	**14,722,158**
11	5,229,221	**4,967,760**	4,339,139	**4,191,190**	143,236	**135,539**	5,644,200	**5,495,420**	15,355,796	**14,789,909**
12	5,221,021	**4,959,970**	4,461,810	**4,319,360**	156,643	**147,922**	5,954,230	**5,846,840**	15,793,704	**15,274,092**
សរុបរួម Total Year	63,146,780	**59,988,485**	57,645,439	**56,209,120**	4,069,722	**3,839,627**	55,091,146	**58,196,807**	179,953,087	**178,234,039**
មធ្យម AVG		**4,999,040**		**4,684,093**		**319,969**		**4,849,734**		**14,852,837**
អតិបរមា MAX		**5,400,305**		**5,107,090**		**447,421**		**5,846,840**		**15,783,778**

សរុបការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីតាមរោងចក្រទាំងបួន
TOTAL OF RAW MAETERIAL AND POWER CONSUMPTION FOR THE FOURTH WTPS

Month	PAC		ក្លរ Chlorine		ក្លរទឹក Sodium Hypochlorite Solution			ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (L)	ឯកតា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)
1	135,650	9.32	38,068	2.62	–	–	–	3,847,847	264
2	123,600	9.14	35,099	2.60	–	–	–	3,596,639	266
3	77,425	5.09	38,602	2.54	–	–	–	4,046,540	266
4	36,400	2.58	32,533	2.30	–	–	–	3,619,563	256
5	32,575	2.06	36,689	2.32	–	–	–	4,082,603	259
6	63,650	4.27	33,393	2.24	–	–	–	3,887,880	261
7	163,725	10.69	28,861	1.88	41,800	992.35	0.06	3,902,148	255
8	129,750	8.36	22,033	1.42	57,750	1498.04	0.10	3,924,127	253
9	125,900	8.70	19,754	1.36	55,500	1358.40	0.38	3,522,991	243
10	107,550	7.31	27,960	1.90	23,000	475.56	0.03	3,531,386	240
11	110,575	7.48	30,928	2.09	6,000	205.23	0.01	3,709,943	251
12	127,150	8.32	25,012	1.64	65,500	1,876.22	0.12	4,041,298	265
សរុបរួម Total Year	1,233,950	6.92	368,932	2.07	249,550	6,405.81	0.11	45,712,965	256
មធ្យម AVG	102,829	6.94	30,744	2.08	20,796	534	0.06	3,809,414	256
អតិបរមា MAX	163,725	10.69	38,602	2.62	65,500	1,876	0	4,082,603	266

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រភូមិព្រែក
RAW MAETERIAL AND POWER CONSUMPTION FOR PHUM PREK WTP

Month	PAC		ក្លរ Chlorine		ក្លររាវទឹក Sodium Hypochlorite Solution			ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (L)	ឯកតា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)
1	72,800	15.1	15,150	3.1	-	-	-	1,254,306	260.4
2	76,000	16.9	16,656	3.7	-	-	-	1,165,706	259.1
3	33,200	6.6	18,692	3.7	-	-	-	1,302,116	259.8
4	8,400	1.8	15,069	3.2	-	-	-	1,174,477	246.5
5	6,800	1.3	15,896	3.0	-	-	-	1,347,116	253.1
6	12,400	2.5	13,374	2.7	-	-	-	1,262,949	257.7
7	56,000	10.7	7,262	1.4	41,800	992.3	0.19	1,329,291	253.2
8	48,000	8.9	1,160	0.2	57,750	1,498.0	0.28	1,382,944	256.1
9	44,800	8.9	0.00	0.00	55,500	1,358.4	0.27	1,221,715	242.5
10	33,600	6.6	6,952	1.4	23,000	475.6	0.09	1,180,206	233.4
11	38,400	7.7	8,700	1.8	6,000	205.2	0.04	1,190,133	239.6
12	41,600	8.4	0.00	0.00	65,500	1,876.2	0.38	1,312,464	264.6
សរុបរួម Total Year	472,000	7.87	118,911	1.98	249,550.0	6,405.8	0.11	15,123,423	252
មធ្យម AVG	39,333	7.95	9,909	2.02	20,795.8	533.8	0.10	1,260,285	252
អតិបរមា MAX	76,000	16.89	18,692	3.73	65,500.0	1,876.2	0.38	1,382,944	265

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រជ្រោយចង្វារ
RAW MAETERIAL AND POWER CONSUMPTION FOR CHROY CHANG WA WTP

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	11,050	2.4	9,130	2.0	1,302,530	278.9
2	8,800	2.0	8,530	2.0	1,247,780	285.4
3	9,600	1.9	9,900	2.0	1,431,910	284.8
4	8,400	1.8	9,350	2.0	1,301,960	276.5
5	8,700	1.7	10,040	2.0	1,425,080	279.0
6	28,100	5.8	9,210	1.9	1,358,010	280.6
7	52,450	10.6	9,520	1.9	1,338,070	269.7
8	38,600	7.8	9,540	1.9	1,295,420	263.4
9	34,050	7.3	9,090	2.0	1,172,700	252.1
10	33,250	7.5	8,670	2.0	1,108,450	249.6
11	24,550	5.9	8,680	2.1	1,073,720	256.2
12	25,250	5.8	8,840	2.0	1,163,720	269.4
សរុបរួម Total Year	282,800	5.03	110,500	1.97	15,219,350	270.8
មធ្យម AVG	23,567	5.04	9,208	1.97	1,268,279	
អតិបរមា MAX	52,450	10.57	10,040	2.07	1,431,910	

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រចំការមន
RAW MAETERIAL AND POWER CONSUMPTION FOR CHAMCAR MORN WTP

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	4,300	12.9	712	2.1	98,696	296.2
2	4,050	15.2	532	2.0	79,878	299.1
3	3,000	8.5	693	2.0	105,644	298.2
4	1,100	3.7	582	2.0	87,893	297
5	1,700	3.8	909	2.0	132,800	296.8
6	3,275	7.5	897	2.0	131,205	299.3
7	7,400	18.5	806	2.0	117,513	293.8
8	5,150	13.3	764	2.0	109,423	283.6
9	5,175	14.4	705	2.0	99,836	278.6
10	2,475	9.0	595	2.2	77,720	282.2
11	1,250	9.2	372	2.7	40,440	298.4
12	1,300	8.8	447	3.0	44,524	301.0
សរុបរួម Total Year	40,175	10.5	8,014	2.09	1,125,572	293.1
មធ្យម AVG	3,348	10.40	668	2.17	93,798	293.65
អតិបរមា MAX	7,400	18.50	909	3.02	132,800	301.00

ការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីរោងចក្រនិរោធ
RAW MAETERIAL AND POWER CONSUMPTION FOR NIROTH WTP

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	47,500	10.0	13,076	2.8	1,192,315	251.9
2	34,750	7.9	9,381	2.1	1,103,275	251.7
3	31,625	6.6	9,317	1.9	1,206,870	250.3
4	18,500	4.2	7,532	1.7	1,055,233	241.6
5	15,375	3.1	9,844	2.0	1,177,607	240.0
6	19,875	4.2	9,912	2.1	1,135,716	240.0
7	47,875	10.2	11,273	2.4	1,117,274	237.3
8	38,000	7.9	10,569	2.2	1,136,340	235.5
9	41,875	9.5	9,959	2.2	1,028,740	232.2
10	38,225	7.7	11,743	2.4	1,165,010	235.4
11	46,375	8.4	13,176	2.4	1,405,650	255.8
12	59,000	10.1	15,725	2.7	1,520,590	260.1
សរុបរួម Total Year	438,975	7.5	131,507	2.26	14,244,620	245
មធ្យម AVG	36,581	7.5	10,959	2.25	1,187,052	244
អតិបរមា MAX	59,000	10.2	15,725	2.76	1,520,590	260

(4) 2017 年の各浄水場の月次生産量及び生産要素データ

ផលិតកម្មទឹកស្អាតសរុបតាមរោងចក្រ
TOTAL PRODUCTION FOR EACH WTPS

Month	រោងចក្រភូមិព្រែក Phum Prek WTP (150,000m3/day)		រោងចក្រជ្រោយចង្វារ Chrouy Chang War WTP (130,000m3/day)		រោងចក្រចំការមន Cham Car Morn WTP		រោងចក្រនិរោធ Niroth WTP		សរុប Total	
	150,000 m3/day		130,000 m3/day		20,000 m3/day		260,000 m3/day		560,000 m3/day	
	ទឹកឆៅ M^3 Raw water	ទឹកស្អាត M^3 Treated water	ទឹកឆៅ M^3 Raw water	ទឹកស្អាត M^3 Treated water	ទឹកឆៅ M^3 Raw water	ទឹកស្អាត M^3 Treated water	ទឹកឆៅ M^3 Raw water	ទឹកស្អាត M^3 Treated water	ទឹកឆៅ M^3 Raw water	ទឹកស្អាត M^3 Treated water
1	5,107,620	**4,852,239**	4,432,320	**4,225,900**	180,267	**169,588**	6,138,570	**5,989,039**	15,858,777	**15,236,766**
2	4,697,249	**4,462,387**	4,142,060	**4,025,740**	398,309	**381,343**	5,458,579	**5,352,040**	14,696,197	**14,221,510**
3	5,200,286	**4,940,272**	4,620,870	**4,503,470**	420,195	**402,685**	6,758,649	**6,589,629**	17,000,000	**16,436,056**
4	4,602,424	**4,372,303**	4,004,280	**3,875,280**	330,434	**314,794**	6,304,700	**6,167,740**	15,241,838	**14,730,117**
5	5,285,421	**5,021,150**	4,383,900	**4,231,449**	295,158	**279,779**	7,165,579	**6,953,759**	17,130,058	**16,486,137**
6	5,010,717	**4,760,181**	4,652,030	**4,491,510**	184,206	**174,900**	7,097,259	**6,840,929**	16,944,212	**16,267,520**
7	4,980,234	**4,731,222**	4,891,440	**4,727,438**	188,458	**171,940**	7,669,940	**7,370,240**	17,730,072	**17,000,840**
8	4,999,848	**4,749,856**	4,761,290	**4,619,120**	104,235	**98,561**	8,061,879	**7,778,959**	17,927,252	**17,246,496**
9	4,516,125	**4,290,319**	4,378,300	**4,241,920**	-	**-**	7,362,769	**7,117,509**	16,257,194	**15,649,748**
10	4,965,708	**4,717,423**	4,522,650	**4,377,800**	-	**-**	8,683,150	**8,422,699**	18,171,508	**17,517,922**
11	4,776,216	**4,537,407**	4,414,480	**4,280,520**	-	**-**	7,851,608	**7,661,319**	17,042,304	**16,479,246**
12	4,891,574	**4,646,995**	4,424,120	**4,305,000**	-	**-**	8,043,170	**7,813,480**	17,358,864	**16,765,475**
សរុបរួម Total	59,033,421	**56,081,754**	53,627,740	**51,905,147**	2,101,262	**1,993,590**	86,595,852	**84,057,342**	201,358,275	**194,037,833**
មធ្យម AVG		**4,673,480**		**4,325,429**		**166,133**		**7,004,779**		**16,169,819**
អតិបរមា MAX		**5,021,150**		**4,727,438**		**402,685**		**8,422,699**		**17,517,922**

សរុបការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីតាមរោងចក្រទាំងបួន
TOTAL OF RAW MAETERIAL AND POWER CONSUMPTION FOR THE FOURTH WTPS

PAC		កំបោរ Lime		ក្លរ Chlorine		អំបិល Salt	ក្លរទឹក Sodium Hypochlorite Solution			ថាមពលអគ្គិសនី Electricity	
គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	គិតជា (L)	ឯកតា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
130,125	8.54	**600**	0.10	**27,982**	1.84	**64,150**	**2,200,810**	15,405.67	3.17	**4,177,576**	274
126,800	8.92			**26,264**	1.85	**32,000**	**1,739,213**	12,174.49	2.73	**3,969,267**	279
112,850	6.87			**24,394**	1.48	**50,000**	**2,171,242**	15,198.69	3.08	**4,721,093**	287
75,250	5.11			**19,926**	1.35	**45,000**	**2,117,788**	14,824.52	3.39	**4,219,971**	286
81,500	4.94			**22,704**	1.38	**34,500**	**1,996,100**	13,972.70	2.78	**4,788,070**	290
183,750	11.30			**26,358**	1.62	**41,750**	**1,906,834**	400.58	0.08	**4,560,773**	280
191,525	11.27			**29,947**	1.76	**35,000**	**1,451,753**	10,162.27	2.15	**4,580,759**	269
168,525	9.77			**28,851**	1.67	**25,750**	**1,379,226**	9,654.58	2.03	**4,487,384**	260
128,550	8.21			**24,495**	1.57	**28,500**	**1,258,801**	8,472.46	1.97	**4,009,688**	256
122,725	7.01			**30,077**	1.72	**31,000**	**1,353,687**	9,219.67	1.95	**4,712,887**	269
108,850	6.61			**32,725**	1.99	**37,375**	**1,525,594**	10,679.16	2.35	**4,659,482**	283
110,575	6.60			**31,398**	1.87	**54,250**	**1,960,947**	13,726.63	2.95	**4,819,874**	287
1,541,025	**7.94**	**600**	**0.10**	**325,121**	**1.68**	**479,275**	**21,061,995**	**133,891.42**	**2.39**	**53,706,824**	**277**
128,419	**7.93**			**27,093**	**1.67**	**39,940**	**1,755,166**	**11,158**	**2.39**	**4,475,569**	**277**
183,750	**11.30**			**27,982**	**1.85**	**64,150**	**2,200,810**	**15,405.67**	**3.39**	**4,788,070**	**290**

ការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីរោងចក្រភូមិព្រែក
RAW MAETERIAL AND POWER CONSUMPTION FOR PHUM PREK WTP

Month	PAC		ក្លរ Chlorine		អំបិល Salt	ក្លរទឹក Sodium Hypochlorite Solution			ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	គិតជា (L)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**52,000**	10.72	**-**	-	**64,150**	**2,200,810**	**15,406**	3.17	**1,376,962**	284
2	**64,000**	14.34	**2,026**	0.45	**32,000**	**1,739,213**	**12,174**	2.73	**1,265,369**	284
3	**68,800**	13.93	**624**	0.13	**50,000**	**2,171,242**	**15,199**	3.08	**1,414,888**	286
4	**39,200**	8.97	**-**	-	**45,000**	**2,117,788**	**14,825**	3.39	**1,230,482**	281
5	**26,000**	5.18	**258**	0.05	**34,500**	**1,996,100**	**13,973**	2.78	**1,410,391**	281
6	**54,400**	11.43	**277**	0.06	**41,750**	**1,906,834**	**401**	0.08	**1,307,576**	275
7	**52,800**	11.16	**1,726**	0.36	**35,000**	**1,451,753**	**10,162**	2.15	**1,256,282**	266
8	**43,200**	9.10	**995**	0.21	**25,750**	**1,379,226**	**9,655**	2.03	**1,274,984**	268
9	**28,800**	6.71	**-**	-	**28,500**	**1,258,801**	**8,472**	1.97	**1,128,638**	263
10	**24,800**	5.26	**291**	0.06	**31,000**	**1,353,687**	**9,220**	1.95	**1,292,187**	274
11	**26,400**	5.82	**1,979**	0.44	**37,375**	**1,525,594**	**10,679**	2.35	**1,267,362**	279
12	**30,000**	6.46	**-**	-	**54,250**	**1,960,947**	**13,727**	2.95	**1,296,895**	279
សរុប Total	**510,400**	**9.10**	**8,176**	**0.15**	**479,275**	**21,061,995**	**133,891**	**2.39**	**15,522,016**	**277**
មធ្យម AVG	**50,733**	**10.76**	**531**	**0.11**	**44,567**	**1,755,166**	**11,996.11**	**2.54**	**1,334,278**	**282**
អតិបរមា MAX	**68,800**	**14.34**	**2,026**	**0.45**	**64,150**	**2,200,810**	**15,405.67**	**3.39**	**1,414,888**	**286**

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រជ្រោយចង្វារ
RAW MAETERIAL AND POWER CONSUMPTION FOR CHROY CHANG WA WTP

Month	PAC		ក្លរ Chlorine (Cl_2)		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**14,250**	3.37	**9,370**	2.22	**1,168,470**	277
2	**6,800**	1.69	**8,630**	2.14	**1,119,830**	278
3	**5,800**	1.29	**9,680**	2.15	**1,297,960**	288
4	**5,750**	1.48	**8,560**	2.21	**1,122,960**	290
5	**14,450**	3.41	**9,180**	2.17	**1,268,900**	300
6	**47,800**	10.64	**10,000**	2.23	**1,261,610**	281
7	**49,050**	10.38	**10,400**	2.20	**1,271,310**	269
8	**40,700**	8.81	**10,340**	2.24	**1,178,540**	255
9	**27,250**	6.42	**9,560**	2.25	**1,066,940**	252
10	**29,600**	6.76	**9,890**	2.26	**1,135,690**	259
11	**23,800**	5.56	**9,830**	2.30	**1,136,250**	265
12	**17,850**	4.15	**9,960**	2.31	**1,189,350**	276
សរុបរួម Total	**283,100**	**5.45**	**115,400**	**2.22**	**14,217,810**	**274**
មធ្យម AVG	**15,808**	**5.33**	**9,617**	**2.22**	**1,184,818**	**274**
អតិបរមា MAX	**47,800**	**10.64**	**10,400**	**2.31**	**1,297,960**	**300**

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រចំការមន
RAW MAETERIAL AND POWER CONSUMPTION FOR CHAMCAR MON WTP

Month	PAC		ក្លរ Chlorine		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	1,750	10.32	549	3.24	50,284	297
2	4,375	11.47	1,069	2.80	111,158	291
3	4,125	10.24	1,061	2.63	119,215	296
4	2,550	8.10	782	2.48	94,039	299
5	2,675	9.56	636	2.27	83,869	300
6	3,425	19.58	409	2.34	52,067	298
7	4,425	25.74	523	3.04	51,417	299
8	1,625	16.49	262	2.66	29,270	297
9	ផ្អាកដំណើរការផលិត					
10						
11						
12						
សរុបរួម Total	24,950	12.52	5,291	2.65	591,319	297
មធ្យម AVG	3,119	13.94	661	2.68	73,915	297
អតិបរមា MAX	4,425	25.74	1,069	3.24	119,215	300

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រនីរោធ
RAW MAETERIAL AND POWER CONSUMPTION FOR NIROTH WTP

Month	PAC		កំបោរ Lime		ក្លរ Chlorine		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**62,125**	10.37	**600**	0.10	**18,063**	3.02	**1,581,860**	264
2	**51,625**	9.65			**14,539**	2.72	**1,472,910**	275
3	**34,125**	5.18			**13,029**	1.98	**1,889,030**	287
4	**27,750**	4.50			**10,584**	1.72	**1,772,490**	287
5	**38,375**	5.52			**12,630**	1.82	**2,024,910**	291
6	**78,125**	11.42			**15,672**	2.29	**1,939,520**	284
7	**85,250**	11.57			**17,298**	2.35	**2,001,750**	272
8	**83,000**	10.67			**17,254**	2.22	**2,004,590**	258
9	**72,500**	10.19			**14,935**	2.10	**1,814,110**	255
10	**68,325**	8.11			**19,896**	2.36	**2,285,010**	271
11	**58,650**	7.66			**20,916**	2.73	**2,255,870**	294
12	**62,725**	8.03			**21,438**	2.74	**2,333,629**	299
សរុបរួម Total	**722,575**	**8.60**	**600**	**0.10**	**196,254**	**2.33**	**23,375,679**	**278**
មធ្យម AVG	**60,215**	**8.57**			**16,355**	**2.34**	**1,947,973**	**278**
អតិបរមា MAX	**85,250**	**11.57**			**21,438**	**3.02**	**2,333,629**	**299**

(5) 2018 年の各浄水場の月次生産量及び生産要素データ

ផលិតកម្មទឹកស្អាតសរុបតាមរោងចក្រ
TOTAL PRODUCTION FOR EACH WTPS

Month	Phum Prek WTP (150,000m3/day)		Chrouy Chang War WTP (130,000m3/day)		Cham Car Morn WTP		Niroth WTP		សរុប Total	
	150,000 m3/day		130,000 m3/day		20,000 m3/day		260,000 m3/day		560,000 m3/day	
	Raw water M³	Treated water M³	Raw water M³	Treated water M³	Raw water M³	Treated water M³	Raw water M³	Treated water M³	Raw water M³	Treated water M³
1	5,250,093	**5,000,088**	4,524,040	**4,407,600**	-	-	7,775,098	**7,595,949**	17,549,231	**17,003,637**
2	4,717,122	**4,481,266**	4,174,400	**4,055,270**	-	-	6,685,140	**6,491,999**	15,576,662	**15,028,535**
3	5,439,983	**5,167,984**	5,110,750	**4,980,660**	-	-	7,487,630	**7,295,220**	18,038,363	**17,443,864**
4	4,917,283	**4,671,419**	4,907,240	**4,781,270**	-	-	7,094,378	**6,908,009**	16,918,901	**16,360,698**
5	5,318,096	**5,052,191**	5,141,820	**5,045,699**	-	-	7,871,380	**7,693,489**	18,331,296	**17,791,379**
6	5,102,323	**4,847,207**	4,920,820	**4,784,110**	-	-	8,044,300	**7,866,729**	18,067,443	**17,498,046**
7	5,271,664	**5,008,081**	4,984,790	**4,849,320**	-	-	8,244,808	**8,031,279**	18,501,262	**17,888,680**
8	5,378,461	**5,109,538**	5,087,420	**4,963,480**	-	-	8,554,830	**8,318,710**	19,020,711	**18,391,728**
9	5,269,909	**5,006,414**	4,927,590	**4,774,590**	-	-	8,467,738	**8,256,849**	18,665,237	**18,037,853**
10	5,210,659	**4,950,126**	4,918,410	**4,774,400**	-	-	7,933,410	**7,777,849**	18,062,479	**17,502,375**
11	5,362,680	**5,094,546**	4,811,570	**4,702,700**	-	-	8,214,499	**8,064,359**	18,388,749	**17,861,605**
12	5,189,816	**4,930,325**	5,332,919	**5,216,720**	-	-	8,145,904	**7,949,274**	18,668,639	**18,096,319**
សរុបរួម Total	62,428,089	59,319,185	58,841,769	57,335,819			94,519,115	92,249,715	215,788,973	208,904,719
មធ្យម AVG		4,943,265		4,777,985				7,687,476		17,408,727
អតិបរមា MAX		5,167,984		5,216,720				8,318,710		18,391,728

សរុបការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីតាមរោងចក្រទាំងបួន
TOTAL OF RAW MAETERIAL AND POWER CONSUMPTION FOR THE FOURTH WTPS

Month	PAC		Chlorine		Salt	Sodium Hypochlorite Solution			Electricity	
	(Kg)	(g)	(Kg)	(g)	(Kg)	(L)	(Kg)	(g)	(Kwh)	(wh)
1	**113,250**	6.66	**36,042**	2.12	**45,000**	**1,341,208**	9,388	1.88	**4,967,329**	292
2	**89,925**	5.98	**30,824**	2.05	**47,500**	**2,017,379**	14,122	3.15	**4,492,937**	299
3	**103,200**	5.92	**30,632**	1.76	**68,750**	**2,436,304**	17,054	3.30	**5,152,590**	295
4	**89,300**	5.46	**24,419**	1.49	**52,000**	**1,854,252**	12,980	2.78	**4,844,429**	296
5	**82,700**	4.65	**25,731**	1.45	**58,000**	**1,953,693**	13,676	2.71	**5,243,876**	295
6	**121,100**	6.92	**24,864**	1.42	**52,750**	**2,008,185**	14,057	2.90	**5,057,060**	289
7	**177,100**	9.90	**26,897**	1.50	**48,000**	**1,725,731**	12,080	2.41	**4,783,748**	267
8	**161,100**	8.76	**30,331**	1.65	**37,500**	**1,487,042**	10,409	2.04	**4,562,617**	248
9	**142,300**	7.89	**28,820**	1.60	**43,000**	**1,573,041**	11,011	2.20	**4,294,062**	238
10	**102,700**	5.87	**24,231**	1.38	**46,500**	**1,672,908**	11,710	2.37	**4,194,475**	240
11	**106,225**	5.95	**31,262**	1.75	**62,000**	**1,966,799**	13,768	2.70	**4,784,755**	268
12	**127,000**	7.02	**32,252**	1.78	**75,000**	**2,434,442**	17,041	3.46	**5,048,944**	279
សរុបរួម Total	1,415,900	6.78	346,305	1.66	636,000	22,470,984	157,297	2.65	57,426,822	275
មធ្យម AVG	117,992	6.75	28,859	1.66	53,000	1,872,582	13,108	2.66	4,785,569	276
អតិបរមា MAX	177,100	9.90	36,042	2.12	75,000	2,436,304	17,054.13	3.46	5,243,876	299

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រភូមិព្រែក
RAW MAETERIAL AND POWER CONSUMPTION FOR PHUM PREK WTP

Month	PAC		ក្លរ Chlorine		អំបិល Salt	ក្លរទឹក Sodium Hypochlorite Solution			ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	គិតជា (L)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**45,200**	9.04	**3,408**	0.68	**45,000**	**1,341,208**	**9,388**	1.88	**1,418,699**	284
2	**45,600**	10.18	**3,522**	0.79	**47,500**	**2,017,379**	**14,122**	3.15	**1,298,177**	290
3	**65,600**	12.69	**4,002**	0.77	**68,750**	**2,436,304**	**17,054**	3.30	**1,448,470**	280
4	**51,200**	10.96	**856**	-	**52,000**	**1,854,252**	**12,980**	2.78	**1,307,429**	280
5	**27,200**	5.38	**766**	0.15	**58,000**	**1,953,693**	**13,676**	2.71	**1,437,666**	285
6	**32,000**	6.60	**-**	-	**52,750**	**2,008,185**	**14,057**	2.90	**1,381,160**	285
7	**46,400**	9.27	**-**	-	**48,000**	**1,725,731**	**12,080**	2.41	**1,339,688**	268
8	**45,600**	8.92	**-**	-	**37,500**	**1,487,042**	**10,409**	2.04	**1,282,547**	251
9	**32,800**	6.55	**-**	-	**43,000**	**1,573,041**	**11,011**	2.20	**1,246,152**	249
10	**26,400**	5.33	**-**	-	**46,500**	**1,672,908**	**11,710**	2.37	**1,230,165**	249
11	**35,200**	6.91	**-**	-	**62,000**	**1,966,799**	**13,768**	2.70	**1,387,926**	272
12	**45,600**	9.25	**-**	-	**75,000**	**2,434,442**	**17,041**	3.46	**1,371,574**	278
សរុបរួម Total	**498,800**	**8.41**	**12,554**	**0.21**	**636,000**	**22,470,984**	**157,297**	**2.65**	**16,149,653**	**272**
មធ្យម AVG	**41,567**	**8.42**	**1,046**	**0.20**	**53,000**	**1,872,582**	**13,108.07**	**2.66**	**1,345,804**	**272**
អតិបរមា MAX	**65,600**	**12.69**	**4,002**	**0.79**	**75,000**	**2,436,304**	**17,054.13**	**3.46**	**1,448,470**	**290**

ការប្រើប្រាស់វត្ថុធាតុដើម និងចរន្តអគ្គិសនីរោងចក្រជ្រោយចង្វារ
RAW MAETERIAL AND POWER CONSUMPTION FOR CHROY CHANG WA WTP

Month	PAC		ក្លរ Chlorine		អំបិល Salt	ក្លរទឹក Sodium Hypochlorite Solution			ថាមពលអគ្គិសនី Electricity	
	គតជ (Kg)	ឯកត (g)	គតជ (Kg)	ឯកត (g)	គតជ (Kg)	គតជ (L)	គតជ (Kg)	ឯកត (g)	គតជ (Kwh)	(wh)
1	**12,550**	2.85	**9,870**	2.24					**1,266,830**	287
2	**7,200**	1.78	**8,940**	2.20					**1,216,220**	300
3	**8,400**	1.69	**10,320**	2.07					**1,517,220**	305
4	**8,100**	1.69	**9,340**	1.95					**1,460,610**	305
5	**17,250**	3.42	**10,180**	2.02					**1,524,970**	302
6	**39,350**	8.23	**9,750**	2.04					**1,375,960**	288
7	**55,450**	11.43	**10,380**	2.14					**1,289,460**	266
8	**44,000**	8.86	**10,910**	2.20					**1,272,080**	256
9	**34,250**	7.17	**10,790**	2.26					**1,219,540**	255
10	**26,800**	5.61	**9,420**	1.97					**1,205,550**	253
11	**22,775**	4.84	**10,510**	2.23					**1,249,930**	266
12	**19,850**	3.81	**4,940**	0.95	**29,075**	**949,934**	**6,533**	1.25	**1,470,460**	282
សរុប Total	**295,975**	**5.16**	**115,350**	**2.01**					**16,068,830**	**280**
មធ្យម AVG	**24,665**	**5.12**	**9,613**	**2.02**					**1,339,069**	**280**
អតិបរមា MAX	**55,450**	**11.43**	**10,910**	**2.26**					**1,524,970**	**305**

ការប្រើប្រាស់វត្ថុធាតុដើម និងថាមពលអគ្គិសនីរោងចក្រនិរោធ
RAW MAETERIAL AND POWER CONSUMPTION FOR NIROTH WTP

Month	PAC		ក្លរ Chlorine		ថាមពលអគ្គិសនី Electricity	
	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kg)	ឯកតា (g)	គិតជា (Kwh)	(wh)
1	**55,500**	7.31	**22,764**	3.00	**2,281,800**	300
2	**37,125**	5.72	**18,362**	2.83	**1,978,540**	305
3	**29,200**	4.00	**16,310**	2.24	**2,186,900**	300
4	**30,000**	4.34	**14,223**	2.06	**2,076,390**	301
5	**38,250**	4.97	**14,785**	1.92	**2,281,240**	297
6	**49,750**	6.32	**15,114**	1.92	**2,299,940**	292
7	**75,250**	9.37	**16,517**	2.06	**2,154,600**	268
8	**71,500**	8.60	**19,421**	2.33	**2,007,990**	241
9	**75,250**	9.11	**18,030**	2.18	**1,828,370**	221
10	**49,500**	6.36	**14,811**	1.90	**1,758,760**	226
11	**48,250**	5.98	**20,752**	2.57	**2,146,899**	266
12	**61,550**	7.74	**27,312**	3.44	**2,206,910**	278
សរុបរួម Total	**621,125**	**6.73**	**218,401**	**2.37**	**25,208,339**	**273**
មធ្យម AVG	**51,760**	**6.65**	**18,200**	**2.37**	**2,100,695**	**275**
អតិបរមា MAX	**75,250**	**9.37**	**27,312**	**3.44**	**2,299,940**	**305**