REQUEST FOR PROPOSALS No. 24-001

Departure Bay Pumpstation and Forcemain: Collaborative Design and Construction – Designer Team Selection

ISSUED: January 31st, 2024

CLOSING DATE AND TIME:
Submissions must be received on or before:
3:00 PM (15:00 hrs) Local Time on February 29th, 2024

Submissions and Questions are to be directed to:

Gerald St. Pierre, P.Eng., PMP
Project Engineer, Capital Projects
Regional District of Nanaimo
Phone: 250-713-6957
Email: gstpierre@rdn.bc.ca

Questions are requested at least five (5) business days before the closing date.

REGIONAL DISTRICT OF NANAIMO

1. INTSTRUCTIONS TO PROPONENTS

a. Closing Date/Time/Submission Method

Submissions must be received on or before 3:00 PM (15:00 hrs), Local Time, on **February 29th, 2024**.

Submission Method:

By Email: In PDF format with "**24-001 - Departure Bay Pumpstation and Forcemain: Collaborative Design and Construction – Designer Team Selection**" as the subject line at this electronic address:

gstpierre@rdn.bc.ca

Please note: Maximum email file size limit is 20MB, or less. The RDN will not be liable for any technological delays of submissions.

Submissions received in any other manner will not be accepted.

b. Amendment to Proposals

Proposals may be amended in writing and sent via email to the RDN contact person identified on the cover page on or before the closing. Such amendments should be signed by the authorized signatory of the Proponent.

c. Addenda and Questions & Answers

If the RDN determines that an amendment or questions & answers are required for this RFP, the RDN will post the Addendum on the RDN (https://www.rdn.bc.ca/current-bid-opportunities) and BC Bid (https://bcbid.gov.bc.ca/) websites. Each addendum will be incorporated into and become part of the RFP. No amendment of any kind to the RFP is effective unless it is contained in a written addendum issued by the RDN. It is the sole responsibility of the Proponent to check and ensure all amendments are included prior to submitting their final Proposal submission.

d. Withdrawal of Proposals

The Proponent may withdraw their Proposal at any time by submitting a written withdrawal email to the RDN contact person identified on the cover page on or before the closing.

e. Unsuccessful Vendors

The Regional District will offer debriefings to unsuccessful Proponents, on request, at a mutually agreeable time.

2. *INTRODUCTION*

The Regional District of Nanaimo (RDN) invites qualified and experienced Designer Teams to submit Proposals to join a collaborative effort to complete the detailed design and construction for the above-noted Project.

A Contractor Team RFP will be posted in the near future.

This RFP contains capitalised terms referring to Integrated Project Delivery (IPD) methods. The terms are defined in **Appendix A** which contains two documents:

1. “Exhibit A – Definitions” from the sample contract “Hanson Bridgett Integrated Project Delivery (IPD) Agreement”, and;
2. A glossary taken from “Integrated Project Delivery: An Action Guide for Leaders”, available on the Integrated Project Delivery Alliance’s (IPDA) website at: https://www.ipda.ca/knowledge-competency/tools/integrated-project-delivery-an-action-guide-for-leaders/. The RDN does not represent or warrant the accuracy or completeness of any information contained within the above-referenced guide or the IPDA’s website.

“Exhibit A – Definitions” shall take precedent where a term is defined in both above documents.

This Request for Proposals (RFP) is issued to determine the most qualified and experienced team of service providers that can meet the RDN’s requirements, expectations, and timeline using the Integrated Project Delivery (IPD) model. The Respondent Team is expected to include a Lead Designer, Mechanical & Process Designer, Structural Designer, Linear Infrastructure (Civil) Designer, Electrical & Instrumentation Designer, Geotechnical Consultant, and Architect, who would be selected as a Team but who would engage with RDN as individual organizations and partners in the IPD process. It is possible that the Lead Designer may have the required mechanical, process, electrical and instrumentation, structural, civil, geotechnical, and architectural capabilities in-house. In this case, the Respondent shall identify this in their proposal. Together, the Owner, Designer Team and Contractor Team form the overall IPD Team.

The RDN, along with the City of Nanaimo, will review and evaluate the Team submissions received in response to this RFP and conduct interviews with 2 or more of the top-ranked Respondent Teams. The RDN will then proceed to negotiate with the overall top-ranked Team to perform the scope of work required to complete the Validation Report (the Work). Should these negotiations fail to result in an agreement for the Work, the RDN may then elect to negotiate with the next highest ranked Respondent Team and so on until an agreement is reached or the process is cancelled.

Following approval of the Validation Report, the RDN intends to enter into an IPD agreement using the Hanson Bridgett contract with the successful Respondents. This would indicate the start of the detailed design and construction phases of the project.

In any event, the RDN shall not be bound to enter into a contract with any Respondent to this RFP and, at its sole discretion, may elect to collapse this process. RDN Board approval is required prior to entering into any agreements referenced in this document.

3. BACKGROUND

The RDN operates four wastewater treatment facilities, 23 pump stations, and two septage receiving sites to transport and treat wastewater from more than 130,000 residents between Qualicum Beach and Duke Point.

The Departure Bay Pumpstation (DBPS) and Hammond Bay Forcemain (HBFM) were built in 1974 and are owned and operated by the Regional District of Nanaimo (RDN). The DBPS is located at 2936 Departure Bay Road in Nanaimo, B.C. and the forcemain runs from there to the Greater Nanaimo Pollution Control Centre (GNPCC) at 4600 Hammond Bay Road. The pumpstation provides conveyance of approximately 75% of the wastewater flows directed to GNPCC. Capacity constraints at the DBPS have resulted in back-ups within the interceptor and eventually overflows within the system. It is therefore necessary to upgrade the capacity of the pumpstation and the forcemain to handle future projected flows.

The project will be completed in multiple phases and will involve significant upgrades to the DBPS, construction of a new forcemain along Hammond Bay Road, and influent channel improvements at the GNPCC. There will also be substantial scope related to replacement and/or upgrades to City of Nanaimo owned water, sewer, and storm utilities (including a creek crossing) within the Hammond Bay Road corridor. City of Nanaimo staff will be active but non-signatory participants in this project.

The IPD Team will review the Project and complete a Validation Report that will include a Base Target Cost for the project base program and scope. Once approved, the Project would then proceed through detailed design and construction using the Hanson Bridgett IPD agreement. Reference **Appendix B** for a sample copy of the Hanson Bridgett IPD agreement.

***Note: Appendix B, containing the sample Hanson Bridgett IPD Agreement, will be added to this RFP as a forthcoming addendum.**

To help ensure success of the project for all IPD Team members, the RDN has engaged a third-party coach (Colliers Project Leaders) to facilitate and guide the IPD Team process.

Integrated Project Delivery is not a business-as-usual arrangement. The process is highly collaborative and requires commitment from all IPD Team members to establish an open, trusting relationship and joint project management processes to be successful. For those not familiar with IPD and the governing agreement, it is advised to research the project delivery model and carefully review the sample Hanson Bridgett IPD agreement in **Appendix B** prior to submitting a response to this RFP. Some suggested resources for more information on IPD and Lean construction are:

- Home | The Integrated Project Delivery Alliance (IPDA)

- Integrated Project Delivery for Construction - IPD (leanipd.com)
- About | Lean Construction Institute
- Lean Design Construction Canada

The above website links are provided for general information purposes only. The RDN does not represent or warrant the accuracy or completeness of any information contained within the websites.

4. PROJECT CHALLENGES

This project has some key challenges to consider and address, including:

a. The DBPS is located on Departure Bay Beach adjacent to a documented First Nations' village site.

b. Departure Creek, a fish bearing stream, runs underneath the DBPS property.

c. The existing DBPS must remain operational during the upgrades.

d. Hammond Bay Road is a key transportation corridor for City of Nanaimo residents/commuters as well as Emergency Services. The corridor contains many other underground utilities including sewer, water, storm, and natural gas.

5. PROJECT OBJECTIVES

The execution of both the design and construction of this Project must consider some specific objectives as follows:

a. Increase the capacity of the DBPS, HBFM, and GNPCC influent channel to meet the projected 2076 flows of 2460 L/s.

b. Design and Construct the DBPS to meet or exceed requirements related to sea level rise and seismic codes and provide high levels of back-up and redundancy.

c. Design and Construct replacements and/or upgrades to existing CoN utilities to meet the City's Manual of Engineering Standards and Specifications. Linked Here

d. Construction of the works should be designed and executed to mitigate disruption to existing pumpstation Operations, archeological values, the environment, and CoN residents.

6. SCOPE OF SERVICES

The general scope of services requested as part of this RFP includes the following:

a. Reliable in-person participation in Big Room activities using Lean IPD procedures, tools and techniques. The Big Room will be located in Parksville, BC.

b. Provide a representative for the Senior Management Team (SMT) per organization.

c. Provide an experienced representative for the Project Management Team (PMT) per organization.

d. Provide experienced technical and other experts for Project Implementation Teams (PITS), to engage in the key discipline areas of civil / structural, mechanical / process piping and electrical / instrumentation and associated project management and cost modelling / estimation. The proposed team should also include members with expert knowledge and/or relative experience in Building Information Modelling (BIM), specifically the use of Autodesk Plant 3D, Revit, Navisworks, and Civil 3D, including other types where applicable, in planning and executing the related scope of work.

e. Engage collaboratively with the Contractor and RDN in the project design to provide innovative ideas that improve construction operations across all aspects of work execution, including supply chain considerations and labour productivity, to adapt plans and continual estimates accordingly. The Design Team, as registered professionals, will take overall responsibility for design but the Contractor Team will assume responsibility for execution of a constructable design.

f. Jointly develop, with the other IPD Partners:

    i. the Expected Cost, the Base Target Cost, and standards for the integration of Project financial information from all Project Participants. This will include an appropriate Project Contingency (Risk & Opportunities balanced) and Allowances (including Escalation);

    ii. the associated Business Terms Sheet in the Hanson Bridgett IPD Agreement;

    iii. the financial management processes for the project including development of the Incentive Program;

    iv. the Baseline Milestone Schedule, engaging in adaptive, agile Lean planning processes;

    v. a Responsibility Matrix; and

    vi. the Validation Report, following the IPD team process.

g. Assuming Validation approval, and conditional upon execution of the IPD Agreement, work collaboratively with the other IPD Partners, and within the IPD processes and framework, for the remaining project execution including:

    i. the completion of detailed design, construction documentation and remaining procurement;

    ii. all logistics and supply chain planning and execution to prepare for construction operation;

iii. field leadership for the construction phase and the ongoing continuous improvement processes to meet or exceed performance expectations; and

iv. an integrated commissioning plan.

7. CONTEMPLATED SCHEDULE

The Validation phase is expected to take at least three months to complete. The IPD Team will determine the Validation phase schedule at the outset and the overall Project schedule in Validation. Below is an initial estimate of the Project timing, for guidance.

- Evaluate and Select IPD Team – First Quarter (Q1) 2024
- Onboarding for IPD Team – Q2 2024
- Pre-Validation Geotechnical Investigations – Q2 2024
- Commence Validation phase – Q2 2024
- Negotiate IPD Agreement – Q3 2024
- Complete Validation phase – Q3 2024
- **Proceeding beyond this point is dependent on outcome of the Validation Report, successful negotiation of an IPD agreement and Project approval by the RDN Board.**
- RDN Board approval – Q3 2024

Timing of the detailed design and construction phases will be dependent upon the IPD Team defined approach captured in the Validation Report. Note that the IPD Team will be expected to integrate work structuring that supports design-to-construction flow efficiency with Lean Project Delivery.

- Commence detailed design – Q4 2024
- Complete forcemain and influent channel detailed design & construction preparations – Q1 2025
- Commence forcemain and influent channel construction – Q2 2025
- Complete pumpstation detailed design & construction preparations – Q3 2025
- Commence pumpstation construction – Q4 2025

8. PROPOSAL SUBMISSION

The Proposal submission should include the information outlined in this section. To facilitate uniformity of presentation and ease of evaluation, the Proposal should be limited to a maximum of 50 pages, with a minimum 10-point font, (including appendices) and address the following evaluation items in order:

a. Executive Summary

i. One or two pages summarizing the Proposal and highlighting the Respondent Team's key attributes that addresses the qualifications and experience to successfully collaborate in this IPD project.

b. Project Methodology

i. Demonstrate an understanding of Lean principles, tools, and techniques and how they can be applied to the various stages of this project through completion.

ii. Discuss the Respondent Team's view regarding Big Room activities in the Validation, Design, Construction, Commissioning and Post-Commissioning phases of the project.

iii. Discuss the role of contractors and trades during design, and discuss the role of consultants during construction, with a focus on collaborative methodologies.

iv. Discuss the project challenges listed in Section 4 of this document and some of the strategies your team would recommend to address these challenges.

c. Resource Availability and Responsibilities

i. Provide an organization chart representing the multiple companies and roles involved, specific to the project, using a typical IPD structure. Identify only the team members that will be actively and directly contributing to the project. At a minimum, this must include SMT and PMT roles plus the primary design leadership roles representing each organization.

ii. Clearly identify each team member's role and include a Responsibility Matrix showing contributions at each phase of the IPD process.

iii. Describe methodology for crew planning during construction/commissioning. Include how your team will manage variation to respond to changes in labour reliability, work volumes or construction bottlenecks.

iv. Clearly identify current commitments (as a percentage) and availability for identified team members to be committed to this project.

d. Project Team Qualifications

i. For the team identified above, summarize how the team's technical and managerial experience on IPD projects, or other collaborative projects, will make them well suited to successfully complete this IPD project.

ii. For each of these key personnel, provide roles and responsibilities on three previous projects demonstrating experience related to their proposed role on this project.

iii. As a separate appendix, provide resumes including, but not limited to the following roles[1]:

- Senior Management Team Member (Must be Principal or President)
- Project Management Team Member (Proposed)
- Project Implementation Team Members (May include designers, project coordinator, site inspector, estimator, etc.)

[1] Respondents should anticipate that any personnel listed with resumes may be requested by the RDN to participate in the interview process. At a minimum, the RDN will require the SMT member and a PMT member for the interview.

REGIONAL DISTRICT OF NANAIMO

e. Project Management

i. Demonstrate understanding of the role of the Senior Management Team, Project Management Team and Project Implementation Teams including during field execution. Discuss how the team approach would maximize value to the project, reduce waste and improve efficiency.

ii. Demonstrate understanding of the IPD joint project management approach, particularly explaining the financial aspects including forecasting, open-book accounting, invoicing and change management processes.

iii. Discuss strategies for estimation including conceptual cost modelling, continuous estimation and risk/contingency integration practices that will support the IPD process.

iv. Provide methodology for civil / structural, mechanical / process piping and electrical / instrumentation design. Include any experience with the integration of technology and BIM.

v. Demonstrate an understanding of pull planning and adaptive/agile systems and their use in collaborative projects.

f. Project Firm Qualifications

i. Identify each of the firms comprising the Respondent's team, (clearly identifying any joint ventures or partnerships) and provide a brief history of each of the Respondent's firms, specifying the role and interest each firm has in participating in an IPD project.

ii. Based on each of the Respondent firm's roles and responsibilities (as identified in section c and d above), describe how the Respondent firm's corporate culture supports collaboration, transparency, and willingness to perform as part of a multi-disciplinary team.

iii. For each of the Respondent firms, describe the corporate qualifications, resources, and the ability of each firm to undertake this project.

g. References and Past Experience in Collaborative Projects

i. List and describe three collaborative (3) projects carried out by the Respondent Team that showcase the Design Team working together. Projects should be within the last ten (10) years and clearly demonstrate relevant experience and qualifications to design, construct, and commission projects similar in scope, value, and challenges to this Project. Include:

   a. Description of the projects demonstrating how they are similar to this Project and the collaborative tools and techniques used to complete them;

   b. Identification of the Delivery Method that was used to deliver the project;

   c. Date of completion, or if in progress, estimated date of completion and stage of the project;

   d. Outline which of the Respondent firms and key personnel were part of the project, and their role(s);

e. A summary of lessons learned with respect to the collaborative delivery aspects; and

f. A reference for each project. Include name, title, organization, phone number and email address.

h. Equity and Sustainability

i. A statement of your firm's approach to advancing equity and sustainability in corporate operations and service provision, including mention of official policies, achievements or standards met.

i. Financials

i. Provide a summary table, similar to the sample below, that is calculated in a manner consistent with Exhibit 'D' – Designer Chargeable Costs, provided in **Appendix C.**

Company	Employee	Role	BHWR	DPEM	DPE	Labour Cost

ii. Provide a summary table, similar to the sample below, to show:

a. your proposed overhead rate as per Section 2.2.3 (b) of Exhibit 'D' – Designer Chargeable Costs, provided in **Appendix C.**

b. your proposed Stipulated Profit Percentage as per Section 8.3 of the Sample Hanson Bridgett IPD Agreement included as **Appendix B**.

Company	Overhead Rate Proposed	Stipulated Profit Percentage Proposed

9. *EVALUATION*

a. Proposals will be initially evaluated by the RDN and the City of Nanaimo based on the above list and assigned a score out of 100, as per the matrix below.

Evaluation Item	Weighting
1. Executive Summary	**5**
2. Project Methodology	**20**
3. Resource Availability and Activities	**5**
4. Project Team Qualifications	**20**
5. Project Management	**15**
6. Project Firm Qualifications	**5**
7. References and Past Experience in Collaborative Projects	**15**
8. Equity and Sustainability	**5**
9. Financials	**10**
Total	**100**

b. The evaluation team will then conduct an in-person interview with 2 or more of the highest rated Respondents and assign each Respondent an interview ranking out of 50.

c. Following the interviews, the RDN will add up the proposal and interview scores and award the project to the highest overall rated Proponent, out of 150.

10. COMPENSATION

The successful Respondent Team firms will each be compensated for their Chargeable Costs (Ref. Exhibit 'D' in **Appendix C**) in the Validation Phase consistent with IPD pricing models, which separates and excludes profit. This will be negotiated with the highest rated Respondent.

Should the project be approved past Validation, this Profit-at-Risk pricing will be added and addressed accordingly and go through final negotiation for all IPD parties as per the Hanson Bridgett IPD Agreement.

Please note that during the Validation Phase, the RDN will conduct an audit of the Non-Owner Parties' financial records as per Section 9.2.1 of the Sample Hanson Bridgett IPD Agreement included as **Appendix B**.

11. GENERAL CONDITIONS

a. No Contract

By submitting a Request for Proposal and participating in the process as outlined in this RFP, proponents expressly agree that no contract of any kind is formed until a fully executed contract is in place.

b. Privilege Clause

The lowest priced or any proposal may not necessarily be accepted.

c. Acceptance and Rejection of Submissions

This RFP does not commit the RDN, in any way to select a preferred Proponent, or to proceed to negotiate a contract, or to award any contract. The RDN reserves the right in its sole discretion cancel this RFP, up until award, for any reason whatsoever.

The RDN may accept or waive a minor and inconsequential irregularity, or where applicable to do so, the RDN may, as a condition of acceptance of the Submission, request a Proponent to correct a minor or inconsequential irregularity with no change in the Submission.

d. Conflict of Interest

Proponents shall disclose in their Proposals any actual or potential Conflict of Interest and existing business relationships it may have with the RDN, its elected officials, appointed officials or employees.

e. Solicitation of Board Members and RDN Staff

Proponents and their agents will not contact any member of the RDN Board or RDN Staff with respect to this RFP, other than the RDN Contact named in this document.

f. Litigation Clause

The RDN may, in its absolute discretion, reject a Proposal submitted by Proponent, if the Proponent, or any officer or director of the Proponent is or has been engaged either directly or indirectly through another corporation in legal action against the RDN, its elected or appointed officers and employees in relation to:

a. any other contract for works or services; or

b. any matter arising from the RDN's exercise of its powers, duties, or functions under the Local Government Act, Community Charter or another enactment within five years of the date of this Call for Proposals.

In determining whether to reject a Proposal under this clause, the RDN will consider whether the litigation is likely to affect the Proponent's ability to work with the RDN, its consultants and representatives and whether the RDN's experience with the Proponent indicates that the RDN is likely to incur increased staff and legal costs in the administration of this Contract if it is awarded to the Proponent.

g. Exclusion of Liability

Proponents are solely responsible for their own expenses in preparing and submitting a Proposal and for any meetings, negotiations, or discussions with the RDN. The RDN will not be liable to any Proponent for any claims, whether for costs, expense, losses or damages, or loss of anticipated profits, or for any other matter whatsoever, incurred by the Proponent in preparing and submitting a Proposal, or participating in negotiations for a Contract, or other activity related to or arising out of this RFP. Except as expressly and specifically permitted in these Instructions to Proponents, no Proponent shall have any claim for compensation of any kind whatsoever, as a result of participating in this RFP, and by submitting a Proposal each Proponent shall be deemed to have agreed that it has no claim.

h. Ownership of Proposals

All Proposals, including attachments and any documentation, submitted to and accepted by the RDN in response to this RFP become the property of the RDN.

i. Freedom of Information

All submissions will be held in confidence by the RDN. The RDN is bound by the Freedom of Information and Protection of Privacy Act (British Columbia) and all documents submitted to the RDN will be subject to provisions of this legislation. The successful vendor and value of the award is routinely released.

12. LIST OF APPENDICIES

- Appendix A – Exhibit A – Definitions, and IPDA Guide Glossary
- Appendix B – Sample Hanson Bridgett IPD Agreement
- Appendix C – Sample Exhibit 'D' – Designer Chargeable Costs
- Appendix D –Departure Bay Pumpstation Upgrade Study, Associated Engineering, 2021
- Appendix E – Departure Bay Pumpstation Update to Pump Selections – Associated Engineering, 2023
- Appendix F – Hammond Bay Road – Corridor Topographic Survey, GeoVerra, 2023

Integrated Project Delivery Agreement
Exhibit A – Definitions

1. "**Achievement Event**" is an event described in Exhibit B-5.

2. "**Actual Net Recovery from Builder's Risk Insurance**" is the amount of actual funds received from the Builder's Risk insurance required by the Agreement, less any amount incurred to prosecute the Builder's Risk claim.

3. "**Added Value Incentive Items**" means those items set forth in Exhibit F.

4. "**Adverse Weather**" is a weather event having a statistical recurrence interval of 25 years or more in the geographical area where it occurs and which prevents or substantially impedes a Builder's ability to perform Construction Work resulting in a delay in the Contract Time beyond the number of lost days built into the Project Schedule for adverse weather. Construction work is substantially impeded if the Builder loses more than half of a planned and otherwise available workday except to the extent the delay is also caused by any fault, neglect, act, or omission of the Designers, Builders, or their respective employees, consultants, subcontractors, or suppliers.

5. "**Affiliate**" has the meaning provided in *Business Corporations Act*, SBC 2002, c 57, as amended from time to time.

6. "**Agreement**" is the Integrated Project Delivery Agreement executed by the Parties for this Project and all of the exhibits referenced in the Agreement.

7. "**Allowance**" is an estimated cost for a specific portion of the Work that is not at risk and does not contribute to shared savings. An Allowance is reconciled when it becomes an actual cost, or when the cost for the Allowance item can be reasonably estimated. If the reconciled amount is more or less than the estimated cost for the Allowance, then the Base Target Cost or Final Target Cost (depending on the Project Phase) is increased or decreased by the difference between the reconciled amount and the estimated cost.

8. "**Allowed Claim**" is defined in Section 12.1.2 of the Agreement.

9. "**Amendment**" is a document executed by the Parties amending the terms and/or conditions of the Agreement.

10. "**Anti-Corruption Laws**" means Applicable Laws, rules, or regulations concerning or relating to public or commercial bribery or corruption.

11. "**Applicable Law**" includes all local, provincial, and federal laws, rules, regulations, ordinances, building code, or other codes, statutes, or regulations, or lawful orders of Governmental Authorities that are relevant to any Party's rights or obligations under the Agreement. Applicable Laws include Anti-Corruption Laws.

12. "**Architect of Record**" ("**AOR**") is the Designer with primary responsibility for creating all architectural design documents and to sign and seal all architectural documents within its scope and in accordance with Applicable Law.

13. “**Base Target Cost**” is the amount agreed by the Parties at the conclusion of the Validation Phase per Section 5.4.17 of the Agreement.

14. “**Baseline Schedule**” is described in Section 5.4.10 of the Agreement.

15. “**BIM**” means Building Information Model.

16. “**BIM Execution Plan**” is described in Section 5.4.1 of the Agreement.

17. “**Builder**” means each Party who is responsible for performing the Construction Work in whole or part, among other things. The Contractor is a Builder.

18. “**Builders Lien Act**” means *Builders Lien Act*, SBC 1997 c 45, as amended from time to time.

19. “**Building Information Model**” is a parametric, computable representation of the Project design developed by the Designers, their consultants, and any Design-Build Trades, and will include construction details developed by the Parties and their respective consultants and subcontractors. As used in this Agreement, references to Building Information Model include the primary design model or models and all linked, related, affiliated, or subsidiary models developed for design, estimating, detailing, fabrication, or construction of the Project, or any portion or element of the Project. The portions of the BIM prepared by the Designers, their consultants, and the Design-Build Trades, and those portions prepared by the Builders under the responsible control of a licensed design professional, are Implementation Documents. The portions of the BIM prepared by the Builders or subcontractors (other than Design-Build Trades) to illustrate means and methods for constructing, fabricating, or installing portions of the Construction Work are Submittals, which are not Contract Documents or Implementation Documents.

20. “**Business Day**” is any Calendar Day other than Saturdays, Sundays, and legally recognized holidays in the jurisdiction where the Project is located.

21. “**Business Terms Sheet**” are the page(s) under that heading prior to Article 1 of the Agreement that sets forth the key business terms among the Parties.

22. “**Calendar Day**” is any day whether a Business Day or not.

23. “**Change Event**” has the meaning set forth in Section 11.1 of the Agreement.

24. “**Change Order**” is a mutually agreed written order between Parties adjusting the Base Target Cost, Final Target Cost, ICL, and/or Contract Time.

25. “**Change Order Percentage**” is the value, as applicable, set forth in the Business Terms Sheet.

26. “**Change Order Request**” is a written request for Change Order, which sets forth the nature of the change, the reason for the change, and the effect, if any, on the Base Target Cost or Final Target Cost, the Contract Time, or ICL.

27. “**Chargeable Cost**” is a cost incurred in the performance of the Work (excluding profit), specifically those defined in Exhibits D and E, and are chargeable against the Base Target Cost and Final Target Cost.

28. “**Co-location Plan**” is described in Section 6.6 of the Agreement.

29. “**Commissioning Phase**” is described in Section 5.4.2 of the Agreement.

30. “**Commissioning Plan**” is described in Section 5.4.3 of the Agreement.

31. “**Communication and Decision Plan**” is described in Section 5.4.4 of the Agreement.

32. “**Confidential Information**” means, with respect to a Party, any and all information and materials disclosed in furtherance of this Agreement or any Amendment hereto by or on behalf of the Party, its Affiliates, or any of their respective representatives to another Party or any of its representatives to the extent that the information:

    a. is marked or otherwise identified as confidential or proprietary information, or

    b. should, by its nature, or under the circumstances of its disclosure, reasonably be understood to be confidential or proprietary information of the Party.

    c. Without limiting the foregoing, Confidential Information includes:

    d. the Personal Information of any employee, officer, or director of a Party;

    e. Owner’s business, technical, and financial data, including Owner’s intellectual property;

    f. the trade secrets of a Party including existing and future products or service offerings, designs, business plans, business opportunities, finances, research, development, know-how, and other business, operational or technical information if the information satisfies the conditions of clause a or clause b, above, and

    g. the existence, pricing, and terms and conditions of this Agreement are not Confidential Information as between the Parties but are Confidential Information as to persons or organizations not a party to this Agreement.

33. “**Conformed Design Documents**” means the documents described in Section 6.5.1 of the Agreement.

34. “**Consequential Damages**” are unanticipated or indirect losses, including loss of anticipated profits, loss of business opportunities, loss of bonding capacity, unabsorbed or increased overhead except as otherwise provided in this Agreement, increased financing costs, increased insurance or bonding costs, inability to obtain insurance or bonding, loss of current or prospective projects, loss of markets, loss by reason of plant shutdown, non-operation or increased expense of operation of other equipment, or other consequential loss or damage of any nature arising from any cause whatever.

35. "**Construction Work**" includes all labour, materials, equipment, appurtenances, and services necessary for construction and commissioning of the Project in accordance with the Contract Documents performed by Builders or Builders' subcontractors.

36. "**Contract Documents**" include the Agreement (inclusive of all exhibits), the Building Information Model, the Implementation Documents, and all other documents issued by the Designers, their consultants, and Design-Build Trades for construction of this Project, any PMT Bulletins, SMT Bulletins, and/or Owner's Directives, and any subsequent Amendments or Change Orders. The Contract Documents include Submittals prepared by Design-Build Trades and those Submittals incorporated into the BIM. The documents included in the Contract Documents are complementary and what is required by one is required by all. If there are conflicting requirements within or between the various Contract Documents, the PMT will determine which requirements will better achieve the Project Objective and issue PMT Bulletins to that effect.

37. "**Contract Time**" is the date of Final Completion or, if Contract Time is stated as a duration, it is the number of Calendar Days between Notice to Proceed and Final Completion, either as set out in the Business Terms Sheet.

38. "**Contractor**" is the party identified as the Contractor in the Business Terms Sheet. The Contractor is a Builder that leads the other Builders and has overall responsibility for supervising and coordinating the Work of the Builders; advising the Parties on construction matters; providing overall coordination, scheduling, logistics, site safety, cost modeling, constructability, and information and document management; and managing Builder participation in the Target Value Design and pre-construction efforts.

39. "**COR**" means Change Order Request.

40. "**Cost Model**" is described in Section 5.4.5 of the Agreement.

41. "**day**" means a Calendar Day.

42. "**Deficiency List**" is a list of items that must be completed, repaired, or replaced prior to the Project or a Project Stage achieving Substantial Completion.

43. "**Design Consultants**" are specialty design or engineering that provide specialized Design Services, such as mechanical, electrical, structural, civil or other design or engineering specialties. Design Consultants may be Designers or subconsultants to a Party.

44. "**Design Materials**" are the latest issued construction drawings, including any changes made by RFI or Change Order, issued by a Designer, subsidiary drawings necessary for design and construction of the Project, and include the BIM, Record Model, the subsidiary BIM models necessary for design and construction of the Project, all electronic design data for the Project, any related two dimensional drawings, calculations, schedules or specifications, and any other design materials, created for the Project.

45. "**Design/Pre-construction Phase**" is described in Section 6.4 of the Agreement.

46. "**Design Services**" are those professional architectural and engineering services rendered by the Designers, their consultants, and any Design-Build Trades necessary to develop and

complete the Project design in accordance with the standard of care set forth in the Agreement and Applicable Law.

47. “**Design-Assist Trades**” are specialty contractors whose services include participation in the design effort but who are not Design-Build Trades. That participation includes provision of comments and recommendations on design elements and materials, preparation of cost opinions to inform design decisions, reviewing for constructability, trade coordination, and, where appropriate, execution of drafting efforts. Nothing in this Agreement requires the Design-Assist Trades to perform any Work outside their license or contrary to Applicable Laws. Design-Assist Trades may be Builders or subcontractors to a Party.

48. “**Design-Build Trades**” are specialty contractors that provide Design Services and Design Materials required for their respective portion of the Construction Work. Design-Build Trades have full architecture and engineering responsibility for their portion of the Work and will have their drawings and calculations signed and sealed by architects and/or registered professional engineers licensed in the jurisdiction where the Project is located in accordance with all Applicable Laws. Design-Build Trades may be Builders or subcontractors to a Party.

49. “**Designer**” means each Party who is responsible for performing the Design Services in whole or part, among other things, but do not include Design-Build Trades. The Lead Designer is a Designer. Designers are not responsible for providing Construction Work.

50. “**Effective Date**” is described in Section 1.2 of the Agreement.

51. “**Engineer of Record**” (“**EOR**”) is a Designer with primary responsibility for reviewing and coordinating Design Materials with respect to its discipline and will coordinate Submittals with the Lead Designer. It will also sign and seal all engineering documents within its scope and in accordance with Applicable Law.

52. “**Escalation Allowance**” is described in Section 11.6 of the Agreement.

53. “**Estimated Final Cost**” is the sum of incurred Chargeable Costs that have been actually incurred at the time the estimate is made plus the estimated Chargeable Costs that will be required to complete the Project.

54. “**Final Actual Cost**” is the sum of all incurred Chargeable Costs upon Final Completion of the Work.

55. “**Final Completion**” of the Project occurs when all the following have occurred:

a. the Builders have completed the Construction Work in full compliance with the Implementation Documents; all Final Deficiency List items have been completed and accepted by the PMT;

b. all final unconditional waivers and releases complying with Applicable Laws covering the Construction Work have been received by Owner except that with respect to any Construction Work for which Final Payment is being sought, Owner shall have received final conditional waivers and releases complying with Applicable Laws covering the Construction Work; if applicable,

c. if applicable, all final unconditional waivers and releases complying with Applicable Laws covering the Design Services have been received by Owner except that with respect to any Design Services for which Final Payment is being sought, Owner shall have received final conditional waivers and releases complying with Applicable Laws covering the Design Services; the Project has been commissioned;

d. all close-out documentation required under the Contract Documents has been transmitted to Owner;

e. a final certificate of occupancy has been issued by the Governmental Authority having jurisdiction over occupancy of the Project;

f. and the PMT has issued a certificate of Final Completion.

56. "**Final Deficiency List**" is the Deficiency List prepared after Substantial Completion and final inspections documenting all Construction Work that needs to be corrected or completed to achieve Final Completion.

57. "**Final Payment**" is Owner's payment of all amounts due and owing to the other Parties, including any ICL due after Final Completion of the Project.

58. "**Final Target Cost**" is described in Section 6.3.3 of the Agreement.

59. "**Force Majeure**" means natural disasters; named storms; labour strikes that cannot be resolved through a dual gate or other measures; disruptions in utility service and/or connections not caused by the Builders or those for whom they are responsible; Governmental Authority actions other than permitting, design review or inspection of construction; and civil disobedience; an act of terror; unavoidable casualties or catastrophic events, provided the above events are beyond the control, and not due to any act or omission of, the Designers, Builders, or anyone for whom they are responsible.

60. "**General Conditions**" means the document provided in Exhibit K.

61. "**Governance Plans**" is described in Section 5.4 of the Agreement.

62. "**Governmental Authority**" means all crown, provincial, county, district or municipal boards, departments, courts, offices or agencies that have jurisdiction over the Project.

63. "**Hazardous Materials**" means any and all pollutants, wastes, flammables, explosives, radioactive materials, hazardous or toxic materials, hazardous or toxic wastes, hazardous or toxic substances or contaminants and all other materials governed by Applicable Law for environmental protection, occupational health and safety, or any substance or material that has been determined, or during the time of performance of the Construction Work is determined, to be capable of posing a risk of injury to health, safety, property or the environment by any Governmental Authority.

64. "**Holdback**" means the amount described in Section 4(1) of the Builders Lien Act or, if the statute is amended or replaced, any equivalent amount thereby established.

65. "**ICL**" means Incentive Compensation Layer.

66. “**ICL Percentage**” is described in Section 8.2 of the Agreement.

67. “**Implementation Documents**” consist of the BIM; plans, sections, and elevations extracted from the BIM; and any ancillary drawings, specifications, and construction details together with dimensions and layouts for civil, architectural, structural, mechanical, electrical, plumbing systems, and landscape design. The Implementation Documents will describe in detail the requirements for the Construction Work and provide information necessary and appropriate to obtain all necessary permits for construction of the Project.

68. “**Implementation Phase**” commences on the effective date of the Notice to Proceed with construction and ends at Final Completion.

69. “**Incentive Compensation Layer**” is described in Section 8.2 of the Agreement.

70. “**Incentive Program**” means the document attached in Exhibit I to the Agreement.

71. “**Joining Agreement**” is described in Section 1.5.4 of the Agreement.

72. “**Joint Site Investigation**” is a site investigation attended by the Parties during the Validation Phase for the purpose of reviewing existing information and investigating the Project Site to identify deficiencies and discrepancies, and to determine the extent of any additional investigations or testing required for proper design and construction of the Project.

73. “**Justified Delay**” is a critical path delay meeting one of the categories described in Section 11.2 of the Agreement.

74. “**Key Employees**” are those employees of the Non-Owner Parties listed in Exhibit J that may not be removed from the Project without Owner approval. (See Section 4.9 of the Agreement.)

75. “**Key Performance Indicator**” is described in Exhibit B-4.

76. “**Lead Designer**” is the party identified as the Lead Designer in the Business Terms Sheet.

77. “**Lean**” means principals, tools, and processes that maximize project value by optimizing effort and resource use by eliminating activity and waste that does not add value to the project. (See, www.leanconstruction.org.)

78. “**Lean Phase Plan**” is a plan for defining and integrating the necessary work, services, processes, and hand-offs among multiple firms and teams that are necessary to accomplish project Milestones while employing Lean objectives and values. The Lean Phase Plan is developed jointly by those that are responsible for carrying out the work or services referenced in the Lean Phase Plan.

79. “**Milestone**” means an events noted in Exhibit B-4.

80. “**Non-Owner Party**” is a Party to this Agreement that is not the Owner.

81. “**Non-Owner Parties**” are the Parties to this Agreement, except the Owner.

82. “**Notice of Final Completion**” means the notice described in Section 6.6.2 of the Agreement.

83. “**Notice of Substantial Completion**” means the notice described in Section 6.6.2 of the Agreement.

84. “**Notice to Proceed**” is a written document issued by the Owner or the PMT to initiate commencement of a certain Project Phase or Project Stage as set out in the said document.

85. “**OCIP Manual**” means the document provided in Exhibit L-4;

86. “**Owner**” is the entity identified as the Owner on the signature page at the end of the Agreement.

87. “**Owner-Elected Change**” is a material change directed by the Owner to the scope of the Work described in the Implementation Documents that (i) impacts either the Base Target Cost or Final Target Cost; (ii) requires Work that is not reasonably inferred from the Project Objective; and (iii) requires Work that is not due to (a) the failure of the Construction Work to be executed in conformance with the Implementation Documents, (b) the negligent acts, errors, or omissions in the design of the Project or its component systems; or (c) the repair, modification, or replacement of Construction Work that does not meet the functional and performance requirements of the Project Objective or Implementation Documents.

88. “**Owner’s Directive**” is a written directive from the Owner that overrides a decision by PMT or the SMT. An Owner’s Directive may be construed as an Owner-Elected Change if it affects the Base Target Cost or Final Target Cost and/or Contract Time.

89. “**Owner’s Separate Consultant**” is a design, technical, scientific, or other professional engaged directly by Owner to perform services that are related to the Project although not within the scope of the Agreement.

90. “**Owner’s Separate Contractor**” is a contractor engaged directly by Owner to perform work that is related to the Project although not within the scope of the Agreement.

91. “**Parties**” means, collectively, each Party;

92. “**Party**” means any entity that has executed the Agreement.

93. “**PCO**” means Proposed Change Order.

94. “**Personal Information**” means any information from which an individual may be identified, by direct or indirect means, that is provided to a Party by the Owner, or processed by a Party for or on behalf of the Owner, including without limitation an individual’s name, address, telephone number, social security number, driver’s license number, passwords, personal identification numbers (PIN), account numbers, account balances, account histories, and “personal information”, “nonpublic personal information”, “protected health information” (and other similar information, however described) as defined in any Applicable Laws protecting the Personal Information of a person.

95. “**PIT**” means Project Implementation Team.

96. “**PMT**” means Project Management Team.

97. “**PMT Bulletin**” is a written directive from the Project Management Team derived from a unanimous vote that affects design, cost, schedule, or allocation of the Work. A PMT Bulletin may affect the Project Objective.

98. “**Post Commissioning Phase**” is described in Section 6.8 of the Agreement.

99. “**Post Permit Change**” is a substantive change to a permit by a Governmental Authority or made necessary as a result of changes to Applicable Laws that impacts the Construction Work subsequent to the issuance of the affected permit provided that the changes are not due to (i) the failure of the Construction Work to be executed in conformance with the Implementation Documents, (ii) the negligent acts, errors or omissions in the design of the Project or its component systems; and (iii) the repair, modification, or replacement of Construction Work that does not meet the functional and performance requirements of the Project Objective or Implementation Documents and provided that the changes were not reasonably known or anticipated when the Base Target Cost was set.

100. “**Product Data**” are illustrations, standard schedules, performance charts, instructions, brochures, diagrams, and other information furnished by the Builders, or a subcontractor, tier-subcontractor, manufacturer, vendors, supplier, or distributor to illustrate materials or equipment for some portion of the Construction Work.

101. “**Project**” is the project described in Article 2 of the Agreement, and includes all activities that are undertaken pursuant to this Agreement.

102. “**Project Information**” has the meaning set forth in Section 15.2.6 of the Agreement.

103. “**Project Implementation Team**” is an interdisciplinary group of Project Participants organized by the PMT. PITs are part of the collaborative process to develop the Implementation Documents and other deliverables and may be formed temporarily or for the duration of the Project.

104. “**Project Management Information System**” (“**PMIS**”) is a digital system or interrelated systems for communicating amongst Project Participants and managing, distributing, and storing digital documents, files, logs, and communications. The PMIS contains detail of the Project Objective, including cost, time, scope, and quality; identifies the Project Participants, the people organizations, and their roles; manages agreements, including contracts, permits, approvals, and commitments; manages project control documents; is used to create reports and dashboards for the Project; and guides collaboration and communicates best practices with policies, workflow diagrams, and document management.

105. “**Project Management Team**” must include a representative of the Owner, a Designer, and a Builder, and may include additional members as jointly agreed by the Parties, who will act in a collaborative manner to provide management level leadership during the design and construction process in a concerted effort to achieve the Project Objective.

106. “**Project Manual**” means the document attached in Exhibit J to the Agreement.

107. “**Project Objective**” includes all Owner requirements, goals, and limitations documented in Exhibit B.

108. “**Project Participant**” is any person or entity that is providing material, equipment, work, or services for the Project.

109. “**Project Phase**” is a functional segregation of the Project into Validation Phase, Design/Preconstruction Phase, and Implementation Phase.

110. “**Project Requirements**” means the requirements set out in Exhibit B to the Agreement, particularly Exhibit B-1.

111. “**Project Schedule**” is the schedule for Project performance and completion as calculated at a specific date. The Project Schedule is initially based on the Baseline Schedule, but reflects modifications required due to occurrence of events, opportunities, and rescheduling.

112. “**Project Site**” is the physical location where the Project is being constructed and any adjacent laydown or storage areas dedicated to staging or storing material or equipment to be incorporated into the Project. In addition, the Project Site may include non-adjacent physical locations that are identified in writing if these locations are dedicated to providing or preparing for Construction Work.

113. “**Project Stage**” is a portion of the Project that is geographically or otherwise distinct.

114. “**Proposed Change Order**” is described in Section 11.3.1 of the Agreement.

115. “**QA**” means Quality Assurance.

116. “**Quality Assurance**” means a system of actions required to provide confidence that Work (or portion thereof) was performed in accordance with the Agreement.

117. “**QC**” means Quality Control.

118. “**Quality Control**” means the actions required to check, monitor, or inspect the Work (or portion thereof) to determine if it was performed in accordance with the Agreement.

119. “**Record Model**” is the version of the BIM that will be updated throughout construction to reflect the as-built condition of the Project and is turned over to the Owner upon Final Completion.

120. “**Representatives**” means a Party’s Affiliates and such Party’s and its Affiliates’ respective officers, board members, directors, partners, members, employees, agents and any other persons or entities (excluding the other Party or its Affiliates) who contribute to the performance of such Party’s obligations under this Agreement. For purposes of this Agreement, Designers’, Contractor’s, and Builders’ Representatives will include any and all consultants and subcontractors and such consultants’ and subcontractors’ directors, officers, employees, and agents. Owner’s Representatives will include its or its Affiliates’ collaborators and licensees.

121. “**Responsibility Matrix**” means the document provided in Exhibit C.

122. “**Risk and Opportunity Register**” is described in Section 5.4.11 of the Agreement.

123. “**Safety Plan**” is described in Section 5.4.13 of the Agreement.

124. “**Samples**” are physical examples that illustrate materials, equipment, or workmanship and establish standards by which the Construction Work will be judged.

125. “**Senior Management Team**” (“**SMT**”) includes a senior executive member from each Party, who will act in a collaborative manner to resolve any matters referred to it by the PMT either through consensus or, if a consensus is not reached, by a majority vote, subject to an Owner’s Directive.

126. “**Set Based Design**” is a design strategy that advances in parallel alternative design solutions that meet Project criteria and constraints until a decision is made to select one solution over the alternatives.

127. “**Shop Drawings**” are drawings, diagrams, schedules, and other data specially prepared for the Construction Work by a Builder or a subcontractor, manufacturer, supplier, or distributor to illustrate some portion of the Work.

128. “**SMT Bulletin**” is a written directive from the SMT derived from a majority vote of the SMT and is binding on all Project Participants unless vetoed or modified by an Owner’s Directive.

129. “**Staging Schedule**” is used if the Project will be performed in stages. At a minimum, the Staging Schedule defines the dates for commencement of construction, Substantial Completion, and Final Completion of each Project Stage.

130. “**Standard Consultant**” is a consultant engaged by a Designer or a Design-Build Trade that has not placed profit at risk and therefore is not eligible to share in the Agreement’s financial incentives, ICL, and mutual liability waivers. Standard Consultants are Project Participants but are not Parties to this Agreement.

131. “**Standard Subcontractor**” is a subcontractor, supplier, or vendor engaged by Contractor or a Builder that has not placed profit at risk and therefore is not eligible to share in the ICL and mutual liability waivers. Standard Consultants are Project Participants, but are not Parties to this Agreement.

132. “**Stipulated Overhead**” is described in Section 8.5 of the Agreement.

133. “**Stipulated Profit**” is described in Section 8.3 of the Agreement.

134. “**Submittals**” include Shop Drawings, Product Data, and Samples, but are not Contract Documents unless they are produced and stamped by a Design-Build Trade. To the extent required by the Contract Documents, all Submittals that are not produced by a Design-Build Trade only demonstrate how the Builders, including the Contractor if it performs any of the Construction Work, and subcontractors propose to execute the Construction Work shown by the Contract Documents.

135. “**Substantial Completion**” occurs on the date when the Project or Project Stage, as applicable, is substantially performed as defined in the *Builders Lien Act*, SBC 1997, c 45.

136. “**Target Value Design**” is a design discipline that requires project values, cost, schedule, and constructability to be basic components of the design criteria, and uses cost targets to drive innovation in designing a project to provide optimum value to an owner. Target Value Design uses constructability and cost information from the Designers and Builders before

design decisions are made to allow the design to progress within the Base Target Cost, Final Target Cost, and Contract Time.

137. "**Termination Date**" is described in Section 15.2.2 and 15.2.3 of the Agreement.

138. "**Unforeseen and Differing Site Conditions**" is the discovery of an unknown, subsurface or otherwise concealed physical condition at the Project Site that differs materially from those indicated in the Implementation Documents or the information obtained from the Joint Site Investigation; an unknown physical condition of an unusual nature at the Project Site that differs materially from those ordinarily found to exist and generally recognized as inherent in construction activities of the character and nature provided for in the Implementation Documents; or an unknown, pre-existing hazardous substance or condition at the Project Site that requires removal or remediation.

139. "**Unusual Material Escalation**" is an increase in the cost of materials that exceeds 5% per annum that could not reasonably have been anticipated when the Base Target Cost or Final Target Cost was set and which is caused by extreme and unusual fluctuation in the market cost of the material or materials.

140. "**Validation Phase**" is described in Section 6.2 of the Agreement.

141. "**Validation Report**" is defined and described in Section 5.4.17 of the Agreement.

142. "**Warranty Period**" is described in Section 14.2 of the Agreement.

143. "**Willful Default**" is any one of the following events:

a. actual or constructive abandonment of the Project;

b. persistent and repeated failure, after written notification, to correct Construction Work that significantly and materially deviates from the Implementation Documents or Applicable Law;

c. fraud, reckless disregard, or willful injury to the persons or property of another, or violation of the law, whether willful or negligent; or

d. willful and wanton misconduct.

Actual abandonment occurs if the Party, without justification, ceases performing Work for a period of 21 consecutive days or notifies one of the Parties that it is ceasing to perform Work on the Project.

Constructive abandonment occurs if the Party, without justification, expends so little effort on the Project that there is no meaningful progress on its scope of work for 21 consecutive days. The good faith exercise of any contractual suspension rights granted the Designers, Contractor, and Builders under this Agreement or under an applicable subcontract or consulting agreement is not an intentional or constructive abandonment.

144. "**Work**" includes all labour, materials, equipment, appurtenances, and services required to design, construct, and commission the Project in accordance with the Contract Documents. It includes Design Services and Construction Work.

145. “**Workers Compensation Act**” means Workers Compensation Act, RSBC 2019, c 1.

END OF EXHIBIT

GLOSSARY

A3

A one-page report on a single 11 x 17 sheet of paper, which uses PDCA thinking as it applies to collaborative problem solving, strategy development, or reporting. An A3 includes a problem statement, data and background information, analysis, proposed options, recommendations and agreements, actions, expected results, and follow-through. (*See Appendix 12 for an example of an A3.*)

A3 Thinking

A3 Thinking refers to the structured process of documenting a problem, solution, and action plan. The A3 Thinking process is undertaken collaboratively, with input from all stakeholders on the topic. It begins with consensus on the problem statement and arrives at consensus on a solution and path forward.

Actual Cost

The sum of the total cost of the work actually incurred by the project participants in connection with the performance of all phases of the project. Does not include owner expenses, such as fees for permit, inspection, or equipment. Depending on the contract form used, actual cost may be direct costs plus overhead or may be direct cost plus overhead plus profit.

Allowable Cost

The owner's absolute maximum project cost, based on the project business case, which is the subject of the validation study. The allowable cost includes all elements: direct costs, overhead, and profit (also called ICL).

Big Room

A space where all stakeholders in the team can come together and work, typically with visual documentation posted. Shared space can support communication and dialogue, resulting in greater efficiency and work product that is updated in real time, as well as less reworking and revising. Big Room setup, duration, and usage varies.

Building Information Model(ing) (BIM)

The product (model) and process (modeling) of generating and managing building data during the life cycle of a building. BIM uses three-dimensional building modeling software. BIM includes building geometry, spatial relationships, geographic information, and quantities and properties of building components.

Blended Rate

An average hourly rate that can be used for financial tracking when precise amounts are not needed. Typically used for trade partners when a range of hourly rates based on person-hours can be averaged to project costs. (See Appendix 23 for an example of how a blended rate was used to calculate costs based on hours.) Can also be used in situations when design partners may not wish to highlight differences in salaries for personnel who share the same job title. Averaging multiple people at the same title creates one rate that can be openly shared without revealing sensitive information.

Burn Rate

The rate at which project funds are expended. Typically tracked in a spreadsheet with budgeted versus actual cost for labor and materials, focusing on rate of expenditure over time. (*See Appendix 24 for an example of how the burn rate can be tracked.*)

Choosing by Advantages (CBA)

A structured decision-making system that compares the advantages of alternatives based on objective facts and transparently evaluated subjective preferences.

Co-location

Physically locating personnel in a single area, often referred to as the Big Room, to enable constant communication and integrated thinking, build relationships, and increase productivity. Co-location may be face-to-face 100% of the time or part-time. Virtual co-location, the commitment of the team to collaborate at specific dates and times through use of web-based collaboration technology, is another method of co-location.

Conditions of Satisfaction (CoS)

An explicit description by an owner and/or other members of the IPD team, stating all requirements that must be satisfied to deem the outcomes as successful. Distinct from a project charter, which typically focuses on team-behavioral goals. (*See Appendix 2 and Appendix 4 for examples of CoS.*)

Dashboard

Visual management system to track data and metrics important to the team, which highlights whether the project is on track and also prompts actions. (*See Appendix 14 for examples of dashboards and their use in the Big Room.*)

Design Assist

Builders providing design assist services offer suggestions, insight, costing, and constructability review, but do not take responsibility for design, which remains with a design professional unaffiliated with the builder. All builders that are within the IPD group typically provide design assist or design/build services. In some instances, trade contractors who are not in the IPD group may provide design assist services under their subcontracts.

Design/Build

Design/build can refer to a project delivery method or a method for delivering an element of a project, such as a mechanical system. As a project delivery method, the design/builder is responsible for the design and construction of the project. As a method for delivering an element of a project, the design/builder has the design and the construction responsibility for that element. Fire protection systems, for example, are often delivered as a design/build element within an IPD project.

Design Management

Design management brings order and structure to the development of the design through defining outcomes and decision-making processes and by identifying and optimizing information flow and pull planning.

Guaranteed Maximum Price (GMP)

A cost-type contract that compensates the contractor for actual costs incurred plus a fee subject to a ceiling price.

Huddle

Huddle (or "daily huddle") is a very short daily stand-up meeting that addresses the day's work. Huddles are a part of scrum but are also frequently used in lean construction. (*See also Scrum.*)

Incentive Compensation Layer (ICL)

The team's collective, at-risk profit. The ICL can increase or decrease based on the project outcome. An adjusted ICL is the ICL after adjustment based on project outcome.

IPD Agreement or Integrated Form of Agreement (IFoA)

In this guide, we use IPD agreement to reference the multiparty or poly-party agreement that includes, at minimum, the owner, design professional, and constructor as signatories to the same construction contract. Examples include custom agreements (such as those by the law firm Hanson Bridgett) and templates (such as CCDC-30, ConsensusDocs 300, and AIA-C191 or C195). An IPD agreement is synonymous with IFoA. An IFoA or IPD agreement may be a multiparty (three-party agreement) or a poly-party agreement that can have more than three parties. (*See also Multiparty Agreement and Poly-party Agreement.*)

Integrated Project Delivery (IPD)

IPD is a contractually based approach, which creates an environment that enhances collaboration, innovation, and value. IPD is characterized by early involvement of IPD team members, shared risk and reward based on project outcome, joint project management, liability reduction among IPD team members, and joint validation of project goals.

IPD Team

The IPD team is made up of the participants who have placed their profit at risk and have the opportunity for increased profitability, based on project outcome. Under a multiparty agreement, IPD team members who are not signatory to the multiparty agreement are engaged through appropriate subcontracts or subconsulting agreements that reflect the terms of the multiparty IPD agreement. Sometimes called the risk/reward team, parties, or the ICP participants.

Last Planner System (LPS)

The collaborative, commitment-based planning system that integrates pull planning, make-ready look-ahead planning with constraint analysis, weekly work planning based on reliable promises, and learning based upon analysis of PPC and reasons for variance. (*See Appendix 15 for an example of LPS statistics.*)

Lean

A culture based on a set of principles focused on creating more value for the customer through elimination of waste, streamlined processes, and continuous improvement (*See More Resources for more information on lean.*)

Level of Development (LOD)

The LOD specification is a product of the BIMForum. Based on the basic LOD definitions developed by AIA, it is used to clearly define and communicate to what level of completion work will be done in a BIM and by whom: who will be responsible for modeling which building elements to a specific level of detail at a particular point in time. (*See Appendix 13 for an example of a LOD matrix.*)

Likert Scale

A common means of psychological measurement used to gauge a person's opinions, values, and/or attitude along a range of responses. The range of responses usually consists of five to seven possible answers—for example, ranging from strongly disagree to strongly agree—with a number value corresponding to each response.

Logs/Registers

This family of tools includes constraint logs and risk and opportunity registers. These have multiple functions. They are used to track and mitigate risks and issues. The development and consistent usage of them builds team consensus and can drive accountability. (*For examples of logs and registers, please see Appendix 10 and Appendix 11.*)

MEP

Mechanical, electrical, and plumbing systems. These are often inclusive of fire protection and data cabling as well.

Milestone

An item on a master schedule that defines the end or beginning of a phase or a contractually required event.

Multiparty Agreement

Referencing a three-party IPD agreement between owner, designer, and builder. Though the prefix multi does not imply a specific number, it is industry standard that multiparty is a three-party agreement due to the history of the development of IPD agreements. (*See also IPD Agreement and Poly-party Agreement.*)

Non-Signatory

A company that is participating in the project that is not part of the IPD team. That is, they are not included in the IPD agreement with the shared risk/reward and other terms.

Off-Boarding

The deliberately planned process for removing team members or firms.

On-Boarding

The deliberately planned process for bringing new players onto the team. In IPD, there is a need to on-board and align the initial team and to have a process for on-boarding new players added later to the team.

One-Piece-Flow

A methodology used to address a process from end to end with all parties involved in order to identify which step(s) must be completed for the next step to occur without waiting or waste.

Overhead (Home Office Overhead)

The amount, which may be expressed as a percentage applied to costs or a fixed amount, to compensate a firm for items such as rent, executive salaries, and other non-project-specific costs. (*To see an example of how overhead can be calculated, see Appendix 27 for trade partners and Appendix 28 for designers*.)

Owner Controlled Insurance Program (OCIP)

An OCIP is an insurance program in which the owner obtains a policy to cover loss and liability during the project, reducing the coverages provided by other parties, such as the construction manager/general contractor and trade partners. An OCIP program has requirements for safety management, reporting, and the like, which must be incorporated into the IPD team's plan.

Owner's Project Requirements (OPR)

Developed by the owner, this is a project narrative defining the owner's requirements. The OPR is often used as a basis for the team to develop the CoS. In the context of a high-performance certification, this can include quantitative measures, such as meeting LEED or Petal standards. (*See Appendix 3 for an example of OPR.*)

Percent Plan Complete (PPC)

A basic measure of how well the planning system is working, calculated as the number of commitments completed by the time stated divided by the total number of commitments made for the time stated. It measures the percentage of assignments that are 100% completed as planned. (*For examples of how PPC is visually tracked, see Appendix 14 and Appendix 15.*)

Plan-Do-Check-Act (PDCA; also sometimes Plan-Do-Check-Adjust)

A four-step process intended to support continuous improvement in a product or process: plan, do, check, act. This is conceived of as a repeating and never-ending cycle, which creates a feedback loop for teams to assess their ability to achieve and improve outcomes.

Plus/Delta

Performed at the end of an activity, such as a meeting or a decision process. This review is used to evaluate the activity. Two questions are asked and discussed. Plus: what produced value during the session? Delta: what could we change to improve the process or outcome?

Poly-party Agreement

An IFoA that has more than three parties and generally includes, as parties, all members of the IPD team. The distinction between a multiparty (three party) and poly-party agreement is relevant to contract structure, governance, and insurance.

Project Charter

(*See also Conditions of Satisfaction.*)

Project Implementation Team (PIT)

PITs are nimble, multidisciplinary groups of project participants assigned by the PMT to conduct deep dives into specific project needs (e.g., building envelope, mechanical systems). PITs typically have an initial mission, a time frame in order to perform their work and report back, and the authority to incorporate the right people to perform the work. These are sometimes called clusters or cluster groups. PITs can include all members of the team—PMT, signatories, non-signatories, owners, architects, contractor, trades, and suppliers. Common PITs include structure, mechanical, electrical, envelope, etc. The specific number of PITs needed will be determined by the team. (*See also Project Management Team.*)

Project Management Team (PMT)

A team composed of representatives from each IPD contract party, with membership as defined by the specific IPD contract and subsequently others as jointly agreed by the parties. The PMT is charged to act in a collaborative manner to provide project management leadership during the design and construction process in a concerted effort to achieve the project's objectives. The PMT is the project's administrative workhorse, making the tough decisions and monitoring financials. Sometimes called the core group or core team. Interfaces with the SMT and PIT. (*See also Senior Management Team and Project Implementation Team.*)

Project Team

The totality of all firms participating in the project, regardless of their status in the risk/reward structure. For the purposes of this guide, the firms participating in risk/reward make up the IPD team. There may be firms working on the project that are not part of the risk/reward structure. These are referenced as non-signatory or the project team. The totality of all the individuals on the team is referenced as project participants. (*See also IPD Team and Non-Signatory Agreement*).

Pull

A method of advancing work when the next-in-line partner is ready to use it. A request from the partner signals that the work is needed and is pulled from the performer. In the pull method, work is released when the other members of the team are ready to use it.

Push

The opposite of pull. During push, an order is made from a central authority based on a schedule and advancing work based on a central schedule. Releasing materials, information, or directives possibly according to a plan but independent from whether or not the downstream process is ready to process them.

Request for Information (RFI)

A formal question asked by one party of the contract to another party. Typically, a request from the contractor to the designer.

Request for Proposals (RFP)

Owner's call for teams to submit proposals. In IPD this often includes how the team is going to handle collaboration and integration. (*See Appendix 1 for an RFP example.*)

Request for Qualifications (RFQ)

Typically includes relevant previous work, key personnel, and approach to work. In IPD this often includes demonstrations of lean and IPD experience.

Risk/Reward

A collectively agreed upon amount or percentage of final cost that will be distributed among the members of the IPD team (sometimes called risk/reward pool) if project goals are met. Sometimes called ICL or profit pool.

Rough Order of Magnitude (ROM)

Estimate of time or cost before details are known. A way to describe the impact and likelihood of an occurrence that could impact the project budget, positively or negatively. Calculated by taking possible cost or savings multiplied by the probability of occurrence. Typically used with risk logs or opportunity logs, sometimes combined into one format, sometimes weighted with probabilities and costs so that it can be managed in conjunction with contingency funds.

Scrum

Scrum is a term borrowed from agile project management, often used in software development, referring to a process involving small teams engaging in short, repeatable, sustainable "sprints," the outcome of which is a chunk of delivered value.

Senior Management Team (SMT)

A team composed of representatives from each IPD team member, typically the project executive of the firm. The SMT always handles dispute resolution and backs up the PMT as required. In many cases they also conduct contract negotiations and resolve questions of scope change, but this can alternatively be done by the PMT. The SMT is composed of one C-level executive from every party who signs the IPD agreement.

Target Cost (TC)

The cost goal established by the project team as the target for its design and delivery efforts, typically determined after the validation process. In some projects, there is only TC, which can be adjusted by the owner in the rare situations when that is appropriate. Other times, TC is broken into two measures:

- Base Target Cost: The TC amount that matches the base program in the project objective.
- Final Target Cost: The TC amount that matches the base program, plus any value added Items. Because the value added Items are funded from savings off of the base TC, the final TC must be less than or equal to the base TC (unless there are change orders).

Target Value Design (TVD)

A disciplined approach to design that requires project values, cost, schedule, and constructability to be basic components of the design criteria, and uses cost targets to drive innovation in designing a project to provide optimum value to an owner. TVD uses constructability and cost information from the owner and IPD team before design decisions are made to allow the design to progress within the base TC, final TC, and schedule. (*To see an example of PIT tracking during TVD, see Appendix 26*.)

Trade Partners

Trade partners are the IPD team members (signatories to the IFoA) who are the specialty contractors engaged to put the construction work in place. Trade partners typically include mechanical contractor, electrical contractor, structural steel contractor, and the like. Not to be confused with trade contractors, subcontractors, and trades, which are ambiguous terms that do not imply membership on the IPD team.

Validation

Validation is a process through which the IPD team establishes certainty for the project. It proves or disproves whether the team can meet the full range of the owner's CoS within the owner's constraints (including cost and schedule). Validation is not compressed schematic design. The project is developed only to the degree necessary to achieve certainty. Validation is a go/no-go gate, undertaken at the beginning of the project, and often has its own budget, schedule, prerequisites, and approvals. (*For an example of a validation checklist, see Appendix 8*.)

Virtual Design and Construction (VDC)

The use of BIM and other tools to optimize and coordinate design, virtually rehearse and manage construction, and/or operations.

Visual Management

Placing tools, parts, plans, schedules, measures, and performance indicators in plain view for transparency, allowing the system to be understood at a glance by everyone involved and actions taken locally in support of system objectives. (*For examples of dashboards and visual management in the Big Room, see Appendix 14.*)

Weekly Work Plan (WWP)

The commitment-level step of LPS, identifying the promised task completions agreed on by the project team. The WWP is used to determine the success of the planning effort and to determine what factors limit performance and is the basis of measuring PPC. (*See Appendix 16 for examples of WWPs*.)

Appendix B – Placeholder

Appendix B, containing the sample Hanson Bridgett IPD Agreement, will be added to this RFP as a forthcoming addendum.

Integrated Project Delivery Agreement
Exhibit D – Designer Chargeable Costs

1. DEFINITIONS

The following terms in this Exhibit D are defined as follows:

1.1 Billable Rates. Billable rates are the hourly rates that a Designer may charge for its Hourly Employees and Salaried Employees, as applicable, consistent with this Exhibit D and listed in the Designer's individual Exhibit D-1.

1.2 Stipulated Overhead Rate. A rate agreed to between Designer and Owner that compensates Designer for all of its Indirect Costs and is, depending on the option specified in the Business Terms Sheet, either included in Designer's Billable Rates or fixed fee.

1.3 Direct Salary Expense (**"DSE"**)**.** DSE is the amount actually paid by the Designer to an employee, exclusive of bonuses and profit sharing, and before any income tax, FICA (Federal Insurance Contribution Act) withholdings or equivalent State withholdings.

1.4 Base Hourly Wage Rate ("BHWR").

1.4.1 For Hourly Employees. The Base Hourly Wage Rate for Hourly Employees is the amount of DSE paid to the employee per working hour for non-overtime work.

1.4.2 For Salaried Employees. The Base Hourly Wage Rate for Salaried Employees is the amount of the employee's annual DSE divided by 2,080 hours.

1.5 Direct Personnel Expense (**"DPE"**)**.** DPE is the employer's contribution to the mandatory benefits provided to its Hourly Employees and Salaried Employees.

1.5.1 DPE only includes employment taxes, statutory employee benefits including workers' compensation insurance (net of premium discounts, dividends or rebates), and group insurance (including health, dental, term life and accidental death and dismemberment insurance, all net of employee contributions), sick pay, holidays, vacation actually earned and accrued, employer contributions to employee savings plans, and pension and profit sharing plans that are nondiscretionary, requiring equal distribution of benefits.

1.5.2 DPE does not include any charge for severance pay, tuition reimbursement, employee training, employee morale programs, employee bonuses, executive bonuses, provision of, or reimbursement for automobiles, computers, software, cellular phones and internet or telephone charges, liability insurance of any kind, or any non-mandatory employer contribution to employee compensation.

1.6 Direct Personnel Expense Multiplier ("DPEM"). DPEM is a multiplier, that when multiplied by an employee's BHWR, calculates the amount of DPE allocated to an hour of the employee's work.

Example				
BHWR	*	DPEM	=	DPE
$60	*	0.25	=	$15

1.7 Direct Costs. As defined in Section 2.1, below.

1.8 Indirect Costs. As defined in Section 2.2, below.

1.9 Chargeable Costs. As calculated in Section 2, below.

1.10 Hourly Employees. A Designer's employees that are directly engaged in the performance of Work on the Project that are non-salaried and whose compensation is paid on an hourly basis.

1.11 Salaried Employees. A Designer's employees that are directly engaged in the performance of Work on the Project that are paid a salary and whose compensation is not paid on an hourly basis.

2. CHARGEABLE COSTS. Chargeable Costs only include Designer's Direct Costs and Indirect Costs directly related to performing Design Services for the Project, but do not include profit. All Chargeable Costs are actual costs, without markup and are net of any credits, discounts or rebates.

2.1 Direct Costs. Designer's Direct Costs are the following:

2.1.1 Design Services.

(a) Labor Cost. The cost of Designer's employees directly performing Design Services on the Project calculated for each employee as follows:

Example				
BHWR	+	(BHWR * DPEM)	=	Labor Cost
$60	+	($60 * 0.25)	=	$75

(b) Limitation on Cost of Salaried Personnel. Charges for Design Services performed by Designer's salaried personnel in excess of the 40 hour work week are not allowable, unless agreed to by the PMT in writing prior to being incurred and only in an amount agreed to by the PMT as appropriate.

(c) Standard Consultants. Payments made by a Designer to its consultants will be in accordance with the requirements of their written consulting agreements.

2.1.2 Miscellaneous Expenses.

(a) Services. Actual costs for teleconferencing, video-conferencing, and express delivery or messenger services.

(b) Travel Expenses. All reasonably and actually incurred direct, non-salary, travel-related reimbursable expenses will be billed to Owner at actual cost without markup. Unless otherwise stated in Owner's travel guidelines, all air travel, regardless of domestic or international destination, will be at unrestricted coach class fare or other class, whichever is lowest. Mileage will be reimbursed at the IRS standard mileage rates for travel by Designer in its own vehicles.

(c) Models and Mock-ups. Actual cost of physical models and mock-ups requested by the PMT.

(d) Fees. License fees paid for the use of a particular design or process required by the Agreement and approved by the PMT. Filing or other fees paid for securing approval of Governmental Authorities for the design of the Project.

(e) Insurance. Insurance expenses for coverage specifically required of Designer by the Agreement and allocable to this Project that are incurred prior to Project Final Completion. Deductibles are a Chargeable Cost only to the extent specifically provided in Exhibit L-3 and Article 15 of the Agreement.

(f) Reproduction. The cost of oversize reproduction and printing (greater than 11x17) at actual cost.

(g) Cost of Repair/Correction. Cost of repairing or correcting deficient design work executed by a Designer, provided that (1) the costs are incurred prior to Final Completion and (2) the damaged or non-conforming work was not intentional or caused by Willful Default. Correction or repair of deficient or non-conforming work that was performed or installed by a Standard Consultant or Standard Subcontractor will be remedied at the Standard Consultant's or Standard Subcontractor's own expense and is not a Chargeable Cost.

(h) Other Incurred costs. Other costs incurred by Designer that are necessary for the Project, if approved by the PMT in writing prior to being incurred.

2.2 Indirect Costs or Overhead. Designer's Indirect Costs are the following:

2.2.1 Defined. Designer's Indirect Costs are costs, of any kind, other than Direct Costs and Excluded Costs. Designer's Indirect Costs customarily include the cost of personnel not working directly in connection with Designer's performance of its services, executive salaries, association dues and fees, depreciation on all property, equipment or other assets, payroll processing costs, corporate taxes or fees, business development costs, employee training, all home office infrastructure costs, general administrative personnel costs, risk management costs, interest expense, perquisites such as car allowances, home office expenses (including without limitation rent, utilities, telephones, faxes, and postal charges), software and computer hardware costs, accounting personnel, legal personnel, recruiting costs, cellular telephones and pagers, severance pay, and employee morale programs.

2.2.2 Overhead Rate. If Indirect Costs are paid under option 2.2.3(b), below, the Overhead Rate is a factor included in the Hourly Employees' or Salaried Employees' Billable Rate (as applicable).

2.2.3 Payment. Indirect Costs are paid as Chargeable Costs using one of the following methods selected when the Agreement is executed and indicated on the Business Terms Sheet:

(a) A fixed amount paid in equal monthly installments for a specified number of months, as indicated in the Business Term Sheet; or

(b) Included with the Designer's Hourly Employees' or Salaried Employees' Billable Rates calculated as (BHWR + (BHWR *DPEM)) * Overhead Rate;

3. EXCLUDED COSTS

3.1 Direct Costs. The following costs are excluded from Designer's Direct Costs.

3.1.1 Offsite Personnel. Salaries and other compensation of personnel stationed at any office or offices other than the Project Site office or the Designer's principal office identified in the Notices provision of the Business Terms Sheet, unless otherwise agreed in writing by the PMT.

3.1.2 Offsite Expenses. Expenses related to a firm's principal office and offices other than the Project Site office.

3.1.3 Business Licenses, Permits, and Taxes. All costs of business and/or operating permits, licenses, fees, and taxes required by any local, state, or federal Governmental Authorities to enable Designers or their consultants of any tier to be qualified to do business and/or perform services and/or any Design Services.

3.1.4 Costs Not Included in Direct Costs. Any cost not explicitly included as a Direct Cost in Section 2.1, above.

3.2 Chargeable Costs. The following costs are excluded from Chargeable Costs, and will not be paid by Owner.

3.2.1 Financing or Cost of Use of Money. Financing costs, cost of use of money, or other capital expenses, including interest on capital employed for the Design Services.

3.2.2 Bonuses and Incentive Programs. Employee bonuses or incentive program payments regardless of whether personnel are specifically assigned to this Project.

3.2.3 Fraud and Willful Default. Any cost resulting from fraud, Willful Default, or willful misconduct.

3.2.4 Stale Invoices. Work performed 75 days or more before the submittal date of the invoice to Owner, unless prior written approval is obtained from the PMT.

3.2.5 Costs incurred after Project Final Completion. Costs incurred for the Work after Project Final Completion.

[END OF EXHIBIT]

Associated Engineering | 75 YEARS

CONCEPT REPORT

Regional District of Nanaimo

Departure Bay Pump Station Upgrade Study

SEPTEMBER 2021

EXECUTIVE SUMMARY

Introduction

The Departure Bay Pump Station (DBPS) is owned and operated by the Regional District of Nanaimo (RDN). The DBPS is a wastewater pump station located at Departure Bay, within the City of Nanaimo. The DBPS is in its fifth decade of operation and has some underlying challenges; these challenges justify the consideration of a significant upgrade.

The RDN has engaged Associated Engineering (AE) to undertake an upgrade study for the DBPS. The study focuses on three primary drivers for the upgrade, as follows:

1. Capacity requirements;
2. Climate Change and Flood Risk;
3. Compliance with codes, regulations, and engineering best practices.

Overview of the DBPS

The DBPS is a critical piece of infrastructure in the RDN's wastewater system, as it handles approximately 75% of the wastewater flow to the Greater Nanaimo Pollution Control Centre (GNPCC). Failure of the station results in discharges of wastewater into Departure Bay at the Brechin Point overflow. The wastewater pumped from the DBPS flows through the Departure Bay Pipeline to the GNPCC. The four-kilometer alignment consists of a forcemain and gravity sewer.

The DBPS is split into a superstructure and a substructure. The superstructure provides space for equipment and spare parts storage as well as the necessary access into the substructure. The substructure is a multi-level concrete structure that consists of both a wet well and a dry well.

The lower-level Pump Floor houses the four wastewater pumps, suction pipes, discharge piping, valves and forcemain. The original pumps are Worthington model 10CFA-2. The "firm capacity" of the station (with the largest unit out of service) is 950 L/s.

The Motor Floor is located on an intermediate level between the Pump Floor and ground level. The Motor Floor contains the motors for all four pumps. This includes the motor drives for Pumps #1 through #3 and the combination drive for Pump #4. The diesel engine for Pump #4 is located in the southeast corner of the Motor Floor in the Diesel Room. The Motor Floor also houses much of the electrical and controls infrastructure. This includes the original eddy current drives for Pumps #2 through #3, the variable-frequency drive (VFD) for Pump #1, and the Motor Control Centre (MCC).

The wet well is split into two symmetrical sides. Each side can be isolated using gate valves that must be actuated above grade. There are two pump bays on each side, for a total of four pump bays. The approximate combined active storage volume of the wet well is 250 m^3.

Design Basis for Upgrades

The design criteria for the DBPS Upgrades can be summarized as follows:

- Flow Capacity
  - The full build-out flow capacity design basis for the upgrades is 1955 L/s. This value is based on InfoSWMM modeling of the Nanaimo Interceptor performed by GeoAdvice for the year 2073.
- Target Flood Design Level
  - The target flood design level (FDL) for the facility was assumed to be 5.41 m (geodetic). The RDN does not have an official flood construction level for the project site at this time. The target FDL represents a conservative design level. The grade of the DBPS at the ground floor is about 1.68 m below the target FDL.
- Regulatory Requirements
  - The regulatory requirements that must be considered in the design include, but, are not limited to, the following:
    - BC Municipal Wastewater Regulation;
    - Hydraulic Institute Standards for Pump Station Design;
    - NFPA 820 and the Canadian Electrical Code;
    - 2018 BC Building Code (BCBC);
    - Local Safety Regulators including WorkSafe BC and Technical Safety BC;
    - Environmental Regulations including the Fisheries Act, Water Sustainability Act, Species at Risk Act, Migratory Birds Convention Act, Wildlife Act, and any applicable municipal bylaws.
- Phased Approach and Constructability:
  - A phased approach to upgrades is preferred to spread out capital spending of major works.
  - Minimizing the need for bypass pumping will be key to keep operation costs low during construction.
  - Future design phases will need to take into account constructability.

Options and Upgrade Approach

Investigations have found that the existing downstream Departure Bay Pipeline has an existing flow capacity limit of approximately 1320 L/s. At flowrates higher than this value, the friction losses within the gravity forcemain would become too great, which would lead to flooding of wastewater at the existing stand pipe. Upgrades to this system are therefore required prior to and/or in parallel with upgrades at the DBPS.

AE developed three system curves for the Departure Bay Pipeline that represent potential alignment options to meet the capacity increase. The options are summarized as follows:

- **Option A** – The stand pipe connecting the forcemain to the gravity sewer along the Departure Bay Pipeline is removed, and the two lines are connected. This option requires the installation of wastewater air valves at the previous stand pipe location.
- **Option B** – The stand pipe is kept by twinning the gravity main (2 x 900 mm lines), thus removing the bottleneck to facilitate higher flow conditions.
- **Option C** – Building off of Option B, the upstream forcemain is also twinned (2 x 900 mm lines) to reduce friction and minor losses in the system.

Note that the RDN also provided a recommendation for an Option D (new forcemain along a marine alignment to Chinook Road). This option is discussed within the Comment Log of **Appendix C**.

Three potential options to mitigate against floods based on the FDL were reviewed. The selected option (Option 3) involves raising the entire superstructure above the FDL to prevent flood waters entering the dry well and wet well. This option was selected because it was deemed to be the most resilient option that has the least risk of failure when compared with the other two options. It should be noted that Option 3 was deemed to have the highest capital costs; however, the reduction in flood and safety risks and low operational requirements could offset the initial capital cost requirements in the long-term.

A site visit found that the existing building and process systems had many vulnerabilities that could fail during a distressing event such as an earthquake or major storm. Failure events could lead to undesirable or irreparable damage to the DBPS. In addition, the general aging of the existing infrastructure at the DBPS poses a risk in terms of reliability. Inherent safety concerns were also noted, including the lack of redundant egress from the lower levels of the DBPS. As a result, it was assumed that a significant upgrade would be needed to incorporate the latest codes and standards.

Phased Approach for Hydraulics and Pump Selection

A phased upgrade approach was developed for the hydraulic and pump design to meet the new capacity:

- <u>Phase 1</u>
  - Upgrade three of the existing pumps (Pumps #2, #3 and #4) to larger-capacity pumps. This will provide an increase in capacity to counter the capacity limitations of the existing system.
- <u>Phase 1a</u>
  - Twin the gravity sewer line to achieve flows above the existing bottleneck. Phase 1a follows the curve presented as Option B.
  - Complete this work concurrently with, or subsequent to, the Phase 1 upgrades at the DBPS, depending on the actual capacity of the gravity sewer.
- <u>Phase 1b</u>
  - Twin the forcemain to get further capacity out of the Phase 1 pumping system by reducing head requirements. Without the need to install any additional pumps, the RDN could get further capacity out of the pumping system by reducing the dynamic losses within the forcemain. Phase 1b follows the curve presented in Option C.
  - Complete Phase 1b prior to installation of additional flow capacity, as velocities through the system would become too high.
- <u>Phase 2</u>
  - Install two smaller pumps (replacing Pump #1) to bring the DBPS system to a firm capacity of 1955 L/s.

The conceptual pump selections are summarized in **Table E-1**.

Table E-1
Preliminary Pump Selection

	Model	Rated Power	Impeller Diameter	Rated Speed	No. of New Units in Phase 1	No. of New Units in Phase 2
Large Pump (56 MLD)	Flygt CT 3351/936	765 hp	625 mm	1200 rpm	3 units (Pumps #2, #3 and #4)	0
Small Pump (28 MLD)	Flygt NT 3312/936	385 hp	530 mm	1200 rpm	No units	2 units (Pump #1)

Conceptual Facility Upgrades

The conceptual design is presented in Sections 5 and 6 of this report. The upgrades involve, but are not limited to, the following:

- Ground Floor Elevation will be lifted 1.7 m above grade to combat flooding. This involves the full replacement of the superstructure/building, and bringing the substructure walls up to the new level.
- Extension of the Motor Floor and Ground Floor along the north end of the building. The extension is to allow for the addition of a new enclosed staircase. To comply with BCBC 2018 and safety regulations.
- Structural enhancements to meet seismic design requirements.
- Installation of a new header along the west wall on the Pump Floor. This new header will accommodate flows from the new 56 MLD pumps.
- Relocation of the existing header to make room for a new enclosed staircase.
- New piping and valving for the new upsized pump suction and discharge lines. It is proposed that the level of automation in the pump station be increased with the upgrades.
- Floor modifications on the Pump Floor to facilitate the new suction line assembly for new smaller pumps (Phase 2).
- Installation of new pipe and pump supports, new equipment pads, new crane equipment and restraints, new base for outdoor transformer and switch gear, fuel tank area upgrades, and replacement of grating.
- Retrofit or replacement of the new surge anticipation system. New valves and assembly may be required to meet the capacity increase in the system.
- Replacement of bulk heads that separate the dry well from the wet well to accommodate the larger-diameter suction pipe.
- Replacement of the existing ferric chloride dosing and storage system.
- Minor modifications to wet well to meet additional hydraulic capacity.
- Extension of the grated square openings that exist for pump motor access to facilitate the installation and removal of the new larger-capacity pumps.
- New forced-air HVAC system. Additional cooling and air exhaust will be required in the proposed electrical and generator room.
- General plumbing upgrades throughout the building.
- Retrofit or replacement of the existing odour control system.
- Upgrades to the power distribution system to accommodate new peak power demands. It is anticipated that the power distribution system will need to be upgraded to support a 2500 Amp service at 600 VAC. This will involve the replacement of:
    - The existing unit substation with a 2500 kVA unit substation,
    - The existing genset, and
    - The existing automatic transfer switch.
- The new genset will consist of two or three diesel generators wired in parallel. The generators shall be located within a new generator room, equipped with a new ventilation system.
- New 600 VAC distribution equipment (Motor Control Centre, motor starters, cables and raceway).
- Three 765 HP, normal-duty VFDs, with active harmonic filtering, for flow control (Phase 1). The new VFDs to be located in their own freestanding enclosures/cabinets to reduce the overall space requirements as compared to a single MCC lineup. The existing VFD for Pump #1 to be reused during Phase 1.
- Relocation of identified existing electrical equipment to the Ground Floor in a new dedicated Electrical Room.
- New lighting throughout the building and wet well with energy-efficient light-emitting diode (LED) fixtures.
- Full upgrade to the process control system. This includes the replacement of instrumentation and a new facility PLC control panel.

Opinion of Probable Cost for Phase 1

A Class C opinion of probable cost was prepared for the DBPS Phase 1 Upgrade. The cost estimate summary is presented in **Table E-2**. The total capital works with direct and indirect costs are estimated at $21.3 million.

The cost estimate excludes the necessary upgrade works to the downstream forcemain and gravity sewer. These costs will be significant and need to be considered independently of this assignment.

Table E-2
Opinion of Probable Capital Cost Summary

	Capital Cost
Direct + Indirect Costs	$15,952,000
Contingency (30%)	$4,786,000
Escalation to 2022 (2.5%)	$519,000
Total Project Cost	$21,257,000

Recommendations

AE recommends that the RDN proceed forward with upgrading the capacity of the DBPS to meet current and future demands. Recommendations have been separated into four categories (capacity, climate change, regulatory and planning and financial).

ACKNOWLEDGEMENTS

Associated Engineering would like to thank the Regional District of Nanaimo for their overall management and direction for this phase of the project. We would also like to acknowledge the efforts of the following Regional District of Nanaimo project staff and operational staff for providing background data and operational and maintenance information.

From the engineering team, Gerald St. Pierre (Project Engineer) and Duncan Taylor (Manager of Engineering Services). From operations, Ian Lundman (Superintendent of Wastewater Services) and Robert Skwarcynski (Chief Operator at the Greater Nanaimo Pollution Control Centre (GNPCC)), Jeff Singbeil (Wastewater Operator) and Jeremy Kaye (Senior Instrumentation Technician for Wastewater Services).

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AE	Associated Engineering
ANSI	American National Standards Institute
BCBC	British Columbia Building Code
BCEC	British Columbia Electrical Code
CEC	Canadian Electrical Code
CSA	Canadian Standard Association
DBPS	Departure Bay Pump Station
EL	Elevation
FCL	Flood Construction Level
FDL	Flood Design Level
FRP	Fibreglass Reinforced Plastic
GNPCC	Greater Nanaimo Pollution Control Centre
HI	Hydraulic Institute
hp	Horsepower
HWL	High Water Level
Hz	Hertz
Kg	Kilogram
L/s	Litres per Second
LWL	Low Water Level
LWMP	Liquid Waste Management Plant
m	Metre
m^3	Cubic Metre
MCC	Motor Control Centre
mm	Millimetre
MWR	Municipal Wastewater Regulation
O&M	Operations and Maintenance
PLC	Programmable Logic Controller
PWWF	Peak Wet Weather Flow
RDN	Regional District of Nanaimo
SCADA	Supervisory Control and Data Acquisition
TDH	Total Dynamic Head
VFD	Variable Frequency Drive

1 INTRODUCTION

1.1 Background and Objective

The Regional District of Nanaimo (RDN) owns and operates the Departure Bay Pump Station (DBPS). The DBPS is a wastewater pump station located at Departure Bay in the City of Nanaimo. The DBPS was built in 1974, and although the facility has undergone a variety of upgrades, the station is essentially in its original form. As the facility is in its fifth decade of operation, the DBPS has some underlying challenges. These challenges justify the consideration of a significant upgrade. The RDN has engaged Associated Engineering (AE) to undertake an upgrade study for the DBPS. The study focuses on three primary drivers for the upgrade as follows:

4. Capacity requirements
    a. In recent years, the DBPS has not always been able to keep up with flow capacity during peak flow conditions. During peak events, all pumps must operate at full capacity. In addition, on some occasions, peak flow has caused overflowing of the wastewater collection system. This overflowing has occurred at Brechin Point. Through its Liquid Waste Management Plan (LWMP), the RDN has identified the need to increase the capacity of the DBPS to eliminate overflows.[1]
5. Climate change
    a. As the climate changes, the DBPS can expect to have new challenges. The most significant challenge is likely sea level rise. Sea level rise in combination with storm surge events increases the risk of an extreme flooding event at the DBPS. The upgrades to the DBPS should consider the necessary improvements to adapt for future climatic requirements.
6. Compliance with codes, regulations, and engineering best practices
    a. Due to its age, some existing infrastructure of the DBPS will not be in compliance with current codes, regulations, and engineering best practices. The upgrades need to consider the latest codes and regulations as they are applicable. One area of concern is seismic design requirements. The RDN would like to consider the necessary upgrades to bring the pump station up to the current BC Building Code standards. The upgrades should also meet as applicable: the Occupational Health and Safety Regulation, Technical Safety BC, British Columbia Electrical Code, Environmental Regulations and energy standards.

The objective of the upgrade is to extend the life of the pump station by another 50 years. The study is to consider conceptual level design and typical budget requirements.

The intent of this report is to document the study and present the upgrade options. The study is based on background information provided by the RDN, including target flood levels, future capacity requirements, probable forcemain upgrades, and other relevant studies.

1.2 Overview of Facility

The DBPS is situated adjacent to the ocean at the northwest end of Departure Bay, within the City of Nanaimo. Since it was commissioned in 1974, the station has conveyed municipal wastewater to the Greater Nanaimo Pollution Control Centre (GNPCC). The DBPS is a key component in the overall system as it handles approximately 75% of the wastewater flow to the GNPCC.

[1] Regional District of Nanaimo (2020) Liquid Waste Management Plan: 2019 Annual Report

The DBPS has a traditional wet well and dry well arrangement. The station features four 350 hp centrifugal wastewater pumps. There is a back-up generator at the station, which provides power to the station in the event of a power outage.

1.3 Previous Upgrades and Recent Studies

Since commissioned in 1974, the DBPS has undergone some improvements and upgrades. Previous major upgrades at the DBPS include but are not limited to the following:

- Addition of a 1.4 MW standby generator and installation of buried diesel storage tank adjacent to the DBPS building in 1997.
- Shaft replacement of Pumps #2 and #3 in 1999. This upgrade followed recommendations made in Pump Vibration Remediation Study Report (Associated Engineering, 1999).
- A full control upgrade in 2000. This upgrade included the addition of level transmitters (LE-801 and LE-802) and two wet wells.
- Addition of a ferrous chloride storage and feed system in 2002 to control odour and corrosion.
- Odour control upgrade in 2008. This upgrade added an ionizer system that ionizes outdoor air and disperses it throughout the wet well.
- Pump #1 upgrade in 2016. Pump #1 was replaced with a Flowserve 12MNZ24B, which has a similar capacity and model to existing pumps. As a part of this upgrade, the eddy-current drive was replaced with a variable frequency drive (VFD).

Recent studies include:

- Departure Bay Pump Station Upgrade Study (Associated Engineering, 2006).
- Departure Bay Pump Station Upgrade Study – System Head Testing (Associated Engineering, 2008).
- Departure Bay Forcemain Transient Analysis (AECOM, 2020).
- Nanaimo Interceptor Hydraulic Model Update and Capacity Analysis (GeoAdvice, 2020).

2 FACILITY DESCRIPTION

2.1 Overview

The DBPS is located on the northwest shore of Departure Bay and receives wastewater flows from the City of Nanaimo. The station pumps the wastewater to the GNPCC via a 900 mm diameter forcemain and gravity sewer. The pumping station is a key component in the overall system as it handles approximately 75% of the wastewater flow to the GNPCC. Failure of the station results in discharges of wastewater into Departure Bay. Upstream of the DBPS are five sanitary overflows along the Nanaimo Interceptor. The one directly upstream of the DBPS is Brechin Point (located at the Departure Bay Ferry Terminal), with an overflow elevation of 2.34 m.

The Departure Bay Pipeline is a 4.0 km forcemain and gravity sewer. The pipeline runs from the DBPS to Hammond Bay Interceptor. From this location, it flows to the GNPCC. The pipeline was installed in 1974, at the same time as the DBPS. The forcemain and gravity sewer comprise 900 mm (ID) steel with coal tar enamel coated and lined. The forcemain is asbestos-wrapped.

2.2 Structure

2.2.1 Superstructure and Ground Floor

The facility superstructure provides a structure and cover over most of the substructure. The superstructure provides space for storage as well as the necessary access into the substructure and dry well. The superstructure has steel framing with cinder block construction.

Record drawings for the facility show the entrance level at an elevation of 3.73 m (12.25 ft)[2].

The superstructure has two roll-up doors located on the south side of the building, which provide access for large equipment and chemicals. An additional access door is located on the east side of the building. This access door is used for personnel entrance to the DBPS.

The ground floor contains the existing unit substation, main switchgear (includes Main Breaker, Automatic Transfer Switch (ATS), etc.) and a washroom. It also provides access to the two lower floors.

The existing ventilation system for the substructure comprises an air intake and large open duct. This duct is located in the northwest corner of the building.

A floor opening is located on the east side of the building, which extends all the way down to the lowest level of the station. This opening provides access to the lower level for movement of large equipment. It also provides movement of air between the different levels.

Four square hatches above the pumps provide access to the pump motors located on the intermediate level.

[2] Elevations from the Departure Bay Pump Station are assumed to be geodetic datum. No datum is referenced in the drawings. Geodetic datum is referenced on the drawings for the Departure Bay Pipeline, which was constructed at a similar time.

2.2.2 Substructure

The substructure is a multi-level concrete structure that consists of both a wet well and dry well. The substructure extends approximately 12.1 m (39.75 ft) below grade.

2.2.2.1 Dry Well Lower Level: Pump Floor

The lower level Pump Floor is a split level with the main floor at an elevation of-5.6 m (-18.35 ft) and a trench at an elevation of -7.3 m (-24 ft). The Pump Floor houses the four wastewater pumps, suction pipes, discharge piping, valves and forcemain. On the discharge header, an air-operated pinch valve is configured to prevent pressure surges in the forcemain. Compressors that provide pressurized air are located on the south wall.

The DBPS was originally designed with four centrifugal pumps. All four pumps were provided with extended steel shafts. Pumps #1 through #3 have 350 hp induction motors. Pump #4 has a combination drive, with an induction motor and 425 hp diesel engine. Pumps #1 through #3 had eddy-current drives to provide flow variability, while Pump #4 had an across the line starter. The original pumps are Worthington model 10CFA-2.

The most notable upgrade to the pumps was the replacement of the steel shafts of Pumps #2 and #3 to composite shafts in 1999. In addition, Pump #1 was replaced in 2016 with a newer Flowserve model and VFD. These upgrades are referenced in Section 1.3.

Table 2-1 provides a summary of the pump models and major replacement and upgrades since 1974. The firm capacity of the station with the largest unit out of service is 950 L/s.

Table 2-1
Pumps at the DBPS

	Pump Model	Replacement & Upgrades
Pump #1	Flowserve Model 12MN24B	Original pump replaced in 2016
Pump #2	Worthington Model 10CFA-2	Composite shaft replacement circa 2000
Pump #3	Worthington Model 10CFA-2	Composite shaft replacement circa 2000
Pump #4	Worthington Model 10CFA-2 (c/w combination angle-drive)	Original pump, shaft and drive

The wet well suction lines penetrate from the two wet wells through to the dry well. In the dry well, the suction lines are in dedicated trenches. The penetrations between the wet well and dry well are provided as removeable bulkheads.

The Pump Floor has a work bench along the west side of the room. This area is also used for storage of spare parts.

2.2.2.2 Dry Well Intermediate Level: Motor Floor

The Motor Floor is located on an intermediate level between the Pump Floor and ground level. The Motor Floor contains the motors for all four pumps. This includes the motor drives for Pumps #1 through #3 and the combination drive for Pump #4. The diesel engine for Pump #4 is located in the southeast corner of the Motor Floor in the Diesel Room.

The Motor Floor also houses much of the electrical and controls infrastructure. This includes the original eddy current drives for Pump #2 and #3, the VFD for Pump #1, and the Motor Control Centre (MCC).

The Motor Floor also has an Office and Controls Room.

2.2.2.3 Wet Well

The wet well is split into two symmetrical sides. Each side can be isolated using gate valves that must be actuated above grade. There are two pump bays on each side, for a total of four pump bays.

The wet well shares a common wall with the dry well.

The approximate combined active storage volume of the wet well is 250 m^3. This active storage volume is based on the following wet well elevations:

- High Water Elevation – 6.2 m (20.5 ft)
- Low Water elevation – 2.4 (8.0 ft)

It should be noted that this approximate volume is a conservative approximation. This volume does not account for storage within the Nanaimo Interceptor. In addition, it was difficult to measure the exact volume of the wet well, as the wet well has complex geometry.

The wet well is ventilated using ionized air. As mentioned, this upgrade was completed in 2008. Ionizers are used to add ionized air to the wet well for odour control.

3 DESIGN CRITERIA FOR UPGRADES

The following design criteria for the DBPS Upgrades are described below:

- Flow Capacity
- Target Flood Design Level
- Regulatory Requirements
- Phased Approach and Constructability

3.1 Flow Capacity

3.1.1 Existing Station Capacity Limitations

Based on preliminary discussions with the RDN, the existing station has capacity limitations that needed to be addressed. To better understand these limitations, a review of the existing system capacity was undertaken. This review also provided an understanding of low-flow periods to the station.

Historical flowmeter data from the DBPS were reviewed for the year 2020. The effluent flowmeter is located on the forcemain discharge header downstream of the four pumps.

Figure 3-1 shows the diurnal flow pattern on an average dry-weather day through the DBPS. Under these conditions, the nighttime dry-weather flow is as low as 80 L/s. The daytime peak is about 275 L/s. This curve is typical of wastewater collection systems that experience higher water use during peak daytime hours.

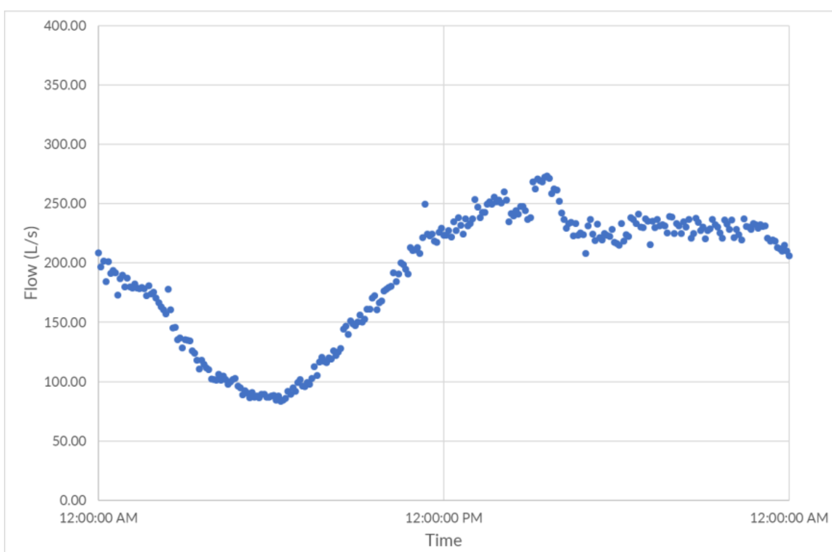


Figure 3-1
Dry Summer Flow Diurnal Trend

Figure 3-2 shows the diurnal pattern during a peak flow event in 2020 that lasted approximately one and a half days. This curve shows that the flowrate through the DBPS was sustained at 1100 L/s. This represents the maximum capacity of the system with all four pumps in operation. This sustained period lasted for over 12 hours.

AE also reviewed flow meter data from a high-flow event that occurred between the afternoon of January 28 and the early morning of January 30, 2018. During this time period (more than 24 hours), all four pumps were operating at full speed, with flows ranging from 1000 L/s to 1100 L/s. The RDN noted that the wet well flooded above the maximum high-water level during this event.

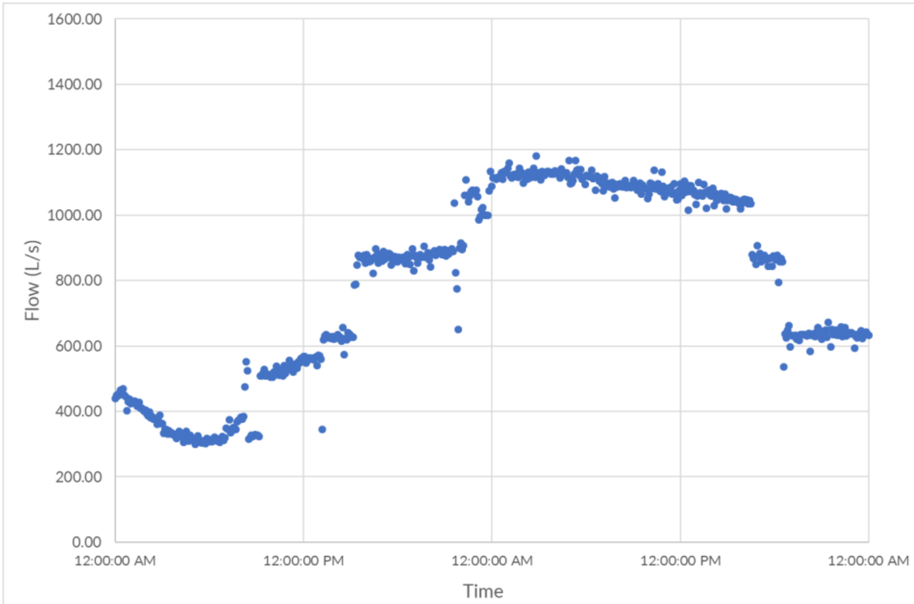


Figure 3-2
Peak Flow / Winter Week

Based on the reviewed data and the conversations with the RDN, it is apparent that the system does not have sufficient pumping capacity. Operating all four pumps in parallel was not the intended purpose of the station, as this offers no redundancy in the event of a pump failure. This lack of redundancy could increase the consequences of a peak event, if a pump were to fail during this time.

3.1.2 Design Basis for Upgrades

Previous modelling of the Nanaimo Interceptor was completed by GeoAdvice Engineering,[3] which provides the design basis for the capacity upgrades. The upgrades will be designed to the 2073 peak wet weather flow (PWWF) scenario based on the InfoSWMM model. This model incorporated the effects of a five-year 24-hour storm event with climate change impacts.

A summary of the model results is presented in **Table 3-1**. The full build-out flow capacity design basis for the upgrades is 1955 L/s.

[3] GeoAdvice Engineering Inc. (2020) Regional District of Nanaimo – Nanaimo Interceptor Hydraulic Model Update and Capacity Analysis Final Report.

Table 3-1
Flow Capacity Design Basis

Design Condition	Flow Rate	Source
2043 Peak Design Flow	1720 L/s	GeoAdvice, 2020: InfoSWMM model
2073 Peak Design Flow	1955 L/s	GeoAdvice, 2020: InfoSWMM model

It is a priority to provide consistent flow from the DBPS. This is because the DBPS accounts for over 70% of the flow to the GNPCC. Maintaining flow to the treatment processes at the GNPCC is required for optimal performance of the process units and systems. As a result, the pump selection and operating philosophy must consider the wide range of flows from the present-day summer nighttime low flow of 80 L/s to the future PWWF of 1955 L/s. The upgrades should limit start and stop operation of the pumps and should provide the ability for influent flow-matching.

3.1.3 Downstream Impacts to Increased Flow Capacity

3.1.3.1 Forcemain and Gravity Sewer

With the flow capacity of the pump station increasing, consideration must be given to downstream infrastructure, specifically the Departure Bay Pipeline.

As mentioned, the pipeline is divided into two sections, a pumped forcemain and a gravity sewer. The forcemain extends just over 2 km from the DBPS before reaching a stand pipe. From this location, gravity flow is achieved for the remainder of the alignment (approximately 2 km) to Hammond Bay Road.

At present, the gravity portion of the alignment has the potential to be the biggest restriction. The original Departure Bay Pipeline drawings show that at a flow of 1300 L/s, the hydraulic grade line will exceed the elevation of the stand pipe. At this flowrate, the dynamic losses in the gravity sewer become too high and the system has the potential to flood at the stand pipe.

An additional challenge with the existing forcemain is that the existing air valves at the high point along Sherwood Drive are not operational at this time. One of the recommendations from the 2020 AECOM Departure Bay Forcemain Transient Analysis Report was to bring these air valves back in operation.

The conceptual study considered upgrades to both the forcemain and the gravity sewer, including either twinning or replacing areas of the forcemain and gravity sewer to keep velocities within a desirable range.

The RDN has confirmed that there are future plans to either twin or replace the forcemain, depending on the results of a condition assessment. For the purpose of this study, AE assumes that upgrade work on the forcemain and gravity line will be completed as necessary to achieve the design flows, including replacement of air valves, as required. The pump selection process has considered the anticipated changes throughout the build-out.

3.1.3.2 Greater Nanaimo Pollution Control Centre

In addition to the forcemain and gravity sewer, it is important to consider how the increased capacity will affect the GNPCC.

There are two pump stations that feed the GNPCC, the Departure Bay Pump Station and the Wellington Pump Station. The Wellington Pump Station has an existing capacity of 208 L/s with a predicted maximum flow of 390 L/s in 2043.

The RDN confirmed that the existing capacity of the headworks equipment at the GNPCC is 2,240 L/s, which could be increased to 3,360 L/s through the addition of a fourth screen. Notwithstanding, the existing influent channel is limiting, and a capacity upgrade to this channel needs to be considered in parallel with the upgrades that will increase the DBPS capacity.

3.2 Flood Design Level

At the time of writing, the RDN has yet to officially adopt a flood construction level (FCL) for the project site. For the purpose of the conceptual study, the RDN has advised on a conservative future target flood design level (FDL). The target FDL is presented in **Table 3-2**.

Table 3-2
Target Flood Design Level for the Conceptual Upgrades

Parameter	Value
Target Flood Design Level	5.41 m

Assuming the 1974 drawings are at geodetic datum, the Ground Level of the DBPS is at 3.73 m (12.25 ft). This is approximately 1.68 m below the target FDL. This difference is not insignificant when the impacts of a flooding event are considered. It will be imperative that the design includes options for mitigating against flooding.

Prior to subsequent design stages, the RDN should complete a survey to confirm elevations of critical infrastructure. In addition, the RDN should confirm the official FCL.

Flooding potential of Departure Creek, which runs in a culvert beneath the access road was not considered during this study. Potential impacts to the Creek as a result of the upgrades should be considered at subsequent design phases.

3.3 Regulatory Requirements

Although the intent of this study is to provide conceptual level design of the upgrades to the DBPS, it is important to consider the impact of regulatory bodies on project design and construction. The following provides an overview (but not a complete list) of important regulations that will need to be considered during the next phases of the upgrades. It should be noted that the study has not considered these requirements in detail.

3.3.1 BC Municipal Wastewater Regulation

As mentioned, the RDN has an approved LWMP that provides management over the wastewater conveyance and treatment systems within the region. The RDN has Operational Certificates in place for its WWTPs, which provide an alternative to registration and authorization under the British Columbia Municipal Wastewater Regulation (MWR). Notwithstanding, the MWR provides guidance for redundancy for pump stations, which should be followed.

The MWR advises the following for lift stations with multiple pumps:

- The station must have sufficient capacity to pump peak design flow when the largest pump is out of service.
- An on-site generator must be available for standby power, and standby power must be capable of being activated before the hydraulic capacity of the pump station is exceeded.

The original design of the DBPS met the pump redundancy requirements, with three pumps able to meet peak demands. Although a backup generator was not a part of the original design, the angle-drive pump provided power redundancy in the event of a sustained electrical outage. However, as wastewater flows steadily increased over time, the RDN has lost redundancy in the pumping system. At present, all four pumps are required during peak flows, and overflows are occurring.

The DBPS currently meets the requirements for standby power. As previously mentioned, the onsite backup generator was installed in 1997. This generator will likely become limited when upgrades are considered.

For the purpose of the conceptual upgrades, the MWR requirements will be used as guidance. As a result, the upgrades must provide adequate redundancy in both capacity (i.e., redundant units) and power for the future.

3.3.2 Hydraulic Institute Standards for Pump Station Design

Hydraulic Institute Standards (ANSI/HI) provide standard requirements and best practices for design, construction and commissioning elements involved with pump stations. These include specific requirements for pump intake design, pump selection and operation, and other hydraulic principals. The upgrades should follow the guidance provided by the Hydraulic Institute.

3.3.3 BC Electrical Code

The upgrades must comply with the BC Electrical Code (BCEC). Refer to the Electrical Regulations and Regulatory Notices as stipulated by Technical Safety BC.

3.3.4 Identification of Hazardous Locations

The upgrades must comply with the BC Electrical Code (BCEC). The wet well location is classified as a hazardous location in accordance with the CSA C22.1 Canadian Electrical Code, Part 1. Hazardous area classifications should consider and comply with the principles of NFPA 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities for areas not clearly defined in CSA 22.1.

3.3.5 2018 BC Building Code

The upgrades must be compliant with the 2018 BC Building Code (BCBC) and other relevant codes and bylaws. A detailed review of code compliance has not been undertaken for this study. However, for purposes of the study, assumptions have been made regarding the level of upgrades required. The two main considerations are seismic upgrades and safe access / egress.

3.3.6 Safety Regulations

The upgrades should be designed to meet all current applicable codes and safety standards in accordance with the Occupational Health and Safety Regulation and Technical Safety British Columbia.

3.3.7 Environmental Regulations

During the project construction, environmental permitting will be required to comply with applicable legislation. This may include requirements contained within the *Fisheries Act*, *Water Sustainability Act*, *Species at Risk Act*, *Migratory Birds Convention Act*, *Wildlife Act*, and any applicable municipal bylaws. Environmental services may include construction environmental management planning work, permit preparation, wildlife salvages, and environmental monitoring.

It should be noted that Departure Creek runs through the project site within a culvert beneath the main access road to the DBPS. Departure Creek is a fish-bearing watercourse that originates in the Nanaimo Golf Club area and runs southeast for 3 km down to Departure Bay[4]. Only the last 860 m of the watercourse is accessible to fish due to natural barriers further upstream[5]. Salmonids including Chum Salmon, Coho Salmon, Cutthroat Trout and Coastal Cutthroat Trout have been recorded in Departure Creek. The Departure Creek Streamkeepers & Harbour City River Stewards operate a community watershed monitoring program on Departure Creek and, in partnership with the Departure Bay Neighbourhood Association, initiated habitat restoration works in the Departure Creek watershed in 2020.

It is not anticipated that the creek will be disturbed during construction, as the extent of the upgraded area does not include the main access road. Notwithstanding, Departure Creek should be assessed during preliminary and detailed design. Any modification to the creek or work done below top of bank will require Provincial and/or Federal permits. Encroachment on the creek should be considered a potential constraint and avoided during the design phase.

3.4 Phased Approach and Constructability

A phased approach to upgrades is preferred to spread out capital spending of major works. The conceptual design should consider how phasing can be achieved.

Another important consideration is constructability. The DBPS conveys a large portion of the wastewater flow to the GNPCC. As a result, the pump station will need to be operable for the duration of the project. This may be achieved through a temporary bypass of the station when needed. However, bypassing for long durations would be challenging and onerous. Further design phases must consider construction sequencing such that impacts on operation of the existing station are minimized.

[4] Government of British Columbia. 2021. HabitatWzard Web Application. Available at: https://maps.gov.bc.ca/ess/hm/habwiz/ Accessed August 2021

[5] D.R. Clough Consulting. 2016. Departure Creek Habitat Assessment Report. Consultants report prepared for the Departure Bay Neighbourhood Association, Nanaimo BC. Available at: https://www.rdn.bc.ca/sites/default/files/inline-files/Departure%20Creek%20Habitat%20Assessement%202016.pdf

4 OPTIONS AND UPGRADE APPROACH

As outlined in Section 1.1, the three main challenges that the DBPS is facing are the lack of capacity and redundancy, the risks of climate change flooding, and the lack of compliance with regulations and code.

The following sections outline these challenges and related consequences, followed by mitigation options and the selected approach for the conceptual design.

4.1 Capacity and Redundancy

4.1.1 Challenges and Consequences

As described in Section 3.1, the DBPS does not have sufficient pumping capacity nor redundancy under peak flow conditions. The maximum capacity, with all four pumps in operation (and no redundancy), is 1100 L/s, which is less than the current peak flows that are conveyed through the Nanaimo Interceptor.

Upgrading the DBPS to the future capacity targets is not straightforward as there are many downstream and upstream impacts that require consideration. The potential limitations in the system are as follows:

- Electrical Infrastructure Limitations
  - Electrical infrastructure such as the unit substation, transfer switch, and generator may be limited if higher capacity pumps are installed.
- Wet Well Capacity Limitations
  - The wet well was originally designed for future capacity upgrades, as evidenced by the use of removal bulkheads between the dry and wet wells and the capacity for a new header on the Pump Level. Notwithstanding, the upgrades need to consider the wet well capacity.
- Pipeline Limitations
  - The forcemain and gravity line are aging, and the RDN is undertaking further investigation of its condition. As described previously, the original design shows that at flow rates above 1300 L/s, the capacity of the gravity line would be exceeded.
- GNPCC Capacity Limitations
  - Capacity of the GNPCC needs to be considered, specifically the hydraulic capacity of the headworks equipment. As noted in Section 3.1.2.3, there are plans to upgrade the GNPCC to handle future peak flows. This consideration will not be reviewed in further detail in this report but should be a consideration for future design phases.

The main consequences of lack of capacity at the DBPS are potential damage to infrastructure, risk to public safety, and negative impacts to the environment resulting from overflows. At peak flows, the sewer upstream of the DBPS has overflowed directly into Departure Bay at Brechin Point. In addition, the peak flow event in 2018 resulted in flooding of the DBPS wet well above the high-water level. These events are significant concerns of operations staff.

The lack of pumping redundancy increases the capacity risks. Without adequate standby capacity, if a pump were to fail during a peak flow event, further flooding would result. As the pumps and components age over time, it may become more difficult to maintain pumping capacity, and the risk of failure increases.

Although peak flow events mainly occur under severe winter storms, it can be anticipated that the frequency and duration of these events may continue to increase as climate changes. Overall wastewater flows are also projected to increase over time as population density increases. This will further intensify the capacity challenges experienced at the station.

The lack of capacity and redundancy at the DBPS is problematic, and the impacts have the potential to worsen with time. The RDN has made a commitment to eliminate the use of overflows as part of their LWMP. To achieve this goal, the RDN must upgrade the capacity at the DBPS.

4.1.2 Mitigation Options and Selected Approach

To achieve the desired 2073 PWWF of 1955 L/s (presented in **Table 3-1**), it is necessary to consider how the downstream system may change over the next 50 years. In addition, a main priority is to consider how pump upgrades could be phased. This includes phasing of pumps, but also phasing of the upgrades with the forcemain and gravity sewer.

4.1.2.1 System Hydraulics

As part of this study, it was necessary to consider how the downstream forcemain and gravity sewer will have an impact on pump selection. For the purposes of this study, three forcemain scenarios were considered:

- **Option A** – The stand pipe connecting the forcemain to the gravity sewer along the Departure Bay Pipeline is removed, and the two lines are connected. This option requires the installation of wastewater air valves at the previous stand pipe location.
- **Option B** – The stand pipe is kept by twinning the gravity main (2 x 900 mm lines), thus removing the bottleneck to facilitate higher flow conditions.
- **Option C** – Building off of Option B, the upstream forcemain is also twinned (2 x 900 mm lines) to reduce friction and minor losses in the system.

Figure 4-1 presents the system curves for Options A, B and C. The three curves were produced using forcemain alignment information from the Departure Bay Forcemain Record Drawings. The Hazen-Williams equation was used to estimate friction losses in the system, which was the same approach undertaken during the previous upgrade study conducted by AE. Minor losses were estimated using standard loss coefficients for fittings, valves and other restrictions. It's important to note that the Hazen-Williams equation can be limiting in its accuracy, depending on Reynold's number. Verification using the Darcy-Weisbach equation is typically recommended but was not undertaken during the conceptual design. The previous upgrade work conducted by AE acted as a basis for the system curve development.

As seen in **Figure 4-1**, Options A and B follow the same curve for flowrates between zero and 1300-1400 L/s. This lower part of the curve follows the existing system, as neither Option A nor Option B require any updates to the existing forcemain. For Option A, the curve starts to steepen at higher flows, which is due to the increase in dynamic losses from the conversion of the previous gravity line to Hammond Bay Road. It should be noted that Option A was the original design intent back in the 1970s, and it was noted at this time that the requirement to connect the forcemain and gravity sewer would be needed at 30 MGD (1320 L/s). Option A is a low-cost option to achieving higher flows through the system, as it only requires the removal of the stand pipe, and the addition of wastewater air valves at the high point. However, this option has disadvantages. At the higher flowrates, velocities experienced are significantly more than what would be recommended. This can be noted through the steep slope of the system curve, representing the high losses in the system at the higher flow rates. With a steeper system curve, a larger sized pump would be required to achieve the required headloss of the system (in comparison to the other options), which could add significantly to power upgrade and operation costs. In addition, this option is contingent that the existing condition of the forcemain and gravity sewer are able to accept the higher-pressure ratings required with the system.

The Option B curve is essentially an extension of the existing system curve to higher flow rates. With this option, the gravity sewer is twinned such that this portion of the alignment can remain gravity-based flow at higher flow rates. Twinning the gravity line is not a small endeavour, and it is possible that only portions may need to be twinned (note that the Option B system curve shown assumes that the entire alignment is twinned). It is recommended that the connection point to the twin line be at a higher elevation, such that flow remains through a single gravity line at lower flow rates (thus, keeping scour velocities). At higher flow rates, both lines would be used as the hydraulic grade line reaches the elevation of the twinned line connection. The use of an inverted siphon at this connection point is also recommended to allow the twinned line to flow full. Although this curve is less steep that Option A, velocities through the forcemain are still very high. This curve would likely not be a feasible option at the peak flow rates required for the final build out of the station.

Option C involves the twinning of the forcemain, which results in a reduction in the dynamic losses as evidenced by the flattening of the system curve. This option assumes that Option B (twinning of the gravity line) has already been undertaken. Although a large capital investment, twinning of the forcemain significantly reduces the system losses, which will reduce the size and number of pumps required to reach the full flow build-out. It is inevitable that the RDN will need to either upsize or twin the forcemain to achieve these higher flows in the future.

The RDN also noted that an additional fourth option (Option D) exists where a new forcemain is constructed from the DBPS along a marine alignment. The forcemain would connect to the existing gravity main at Chinook Road. Further details regarding this option are discussed in the comment log of **Appendix C**.

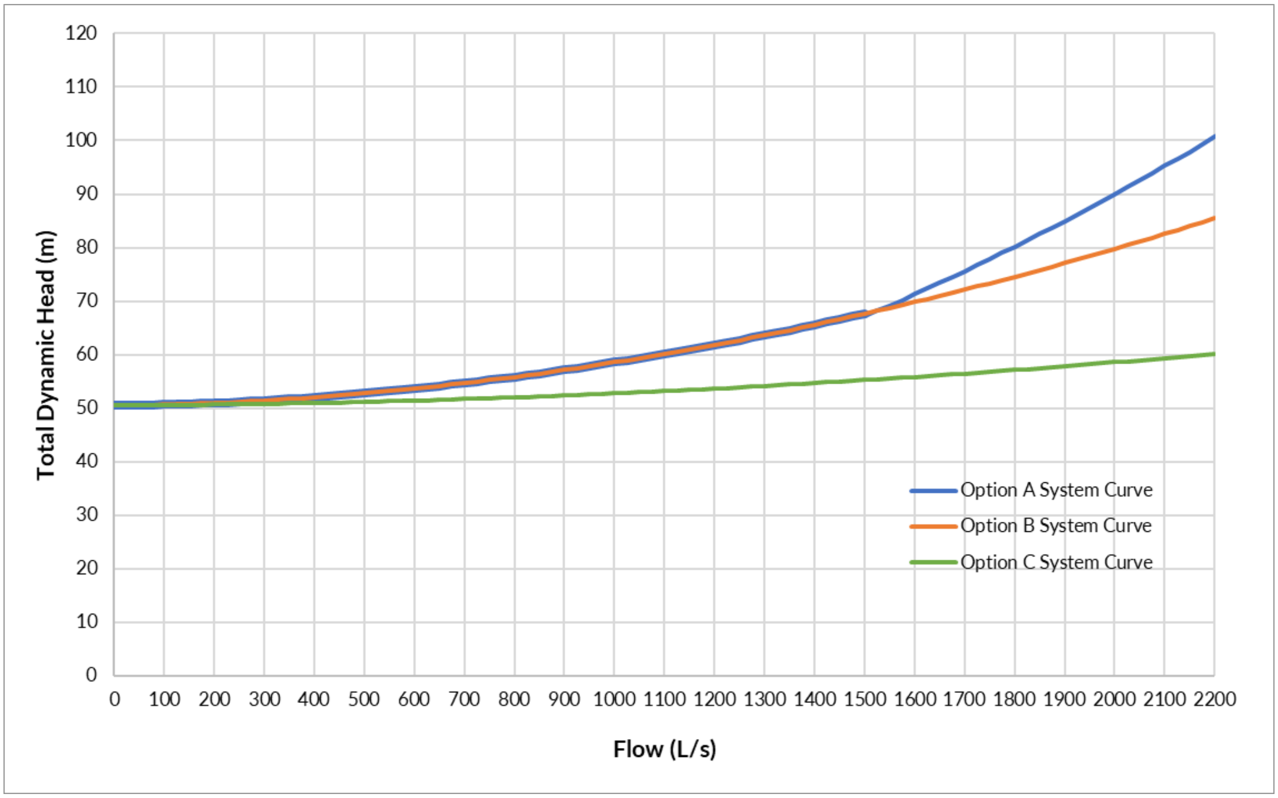


Figure 4-1
System Curve for the Departure Bay Forcemain Under Different Options

After reviewing the system curves, a phased upgrade approach was developed for the upgrades to meet the new design capacity. For the purpose of the upgrade study, the following basis is being proposed:

- **Phase 1**
  - Upgrade three of the existing pumps (Pumps #2, #3 #4) to larger capacity pumps. This will provide an increase in capacity to counter the capacity limitations of the existing system.
- **Phase 1a**
  - Twin the gravity sewer line to achieve flows above the existing bottleneck. Phase 1a follows the curve presented as Option B.
  - Complete this work concurrently with or follow the Phase 1 upgrades at the DBPS, depending on the actual capacity of the gravity sewer.
- **Phase 1b**
  - Twin the forcemain to get further capacity out of the Phase 1 pumping system by reducing head requirements. Without the need to install any additional pumps, the RDN could get further capacity of the pumping system by reducing the dynamic losses within the forcemain. Phase 1b follows the curve presented in Option C.
  - Complete Phase 1b prior to installation of additional flow capacity, as velocities through the system would become too high.

- **Phase 2**
  - Install two smaller pumps (replacing Pump #1) to bring the DBPS system to a full capacity of 1955 L/s, with full redundancy.

Although these scenarios are being used for the purpose of this study, the RDN should develop a plan for forcemain and gravity sewer improvement prior to finalizing the design of the upgrades to the DBPS.

4.2 Climate Change and Flood Target Level

4.2.1 Challenges and Consequences

Climate change is projected to impact infrastructure within the RDN. A major impact of global temperature increases is the resulting increase in sea levels. With the DBPS situated directly on the coast, it is imperative that future upgrades consider the potential impacts from sea level rise and storm surge.

As described in Section 3.2, the target design flood level is above the existing grade at the DBPS (difference of approximately 1.7 m). Under the current condition, the entire station including critical infrastructure would flood, resulting in a system-wide failure.

There is potential for severe and potentially catastrophic consequences if the DBPS flooded. Possible outcomes include:

- Mechanical and electrical equipment become damaged beyond repair.
- Irreparable structural damage to station.
- The Nanaimo Interceptor may back up to street level causing wastewater flooding in streets and/or homes.

These consequences could shut down the facility for months, and equipment will require replacement. The cost implications with such an event are severe.

4.2.2 Mitigation Options and Selected Approach

Three potential options to mitigate against floods based on the FDL were reviewed:

1. Raising only water-sensitive equipment above the FDL.
2. Constructing a dyke around the site to prevent sea level and storm surge from entering the existing structure.
3. Raising the entire superstructure above the FDL to prevent from floods entering the dry well and wet well.

Option 1 would require modifying the existing superstructure (i.e., adding an additional higher level) such that all electrical equipment can be placed above the new flood construction level. This would include new required switch gear, MCC, control panel, and standby generator(s). In addition, all pumps would need to be replaced with immersible style pumps. This is because the existing pumps would not be operable in flooded conditions as the motor is not enclosed. Immersible style pumps offer a solution, with an enclosed motor directly connected to the pump.

Option 1 may appear to be a low-cost option since it does not involve changing the substructure; however, there are some disadvantages and risks with Option 1. These disadvantages include:

- The need to construct a new higher level above the FDL would likely require replacement of the superstructure.
- None of the existing pumps could be maintained, as immersible pumps would be required in the event of a flood.
- The wet well could still be susceptible to flooding if no amendments are made.

- Access to pumps or equipment during a flooding event would not be possible. This could exasperate the problem if a pump fails while the station is flooded.

Option 2 would involve construction of a dyke around the perimeter of the site. This structure would prevent flooding of the building and substructure by containing the flood. With installation of perimeter berms, stormwater would need to be managed on site. A new drainage system would be required for this purpose.

The benefits of implementing Option 2 are that there would be minimal changes required to the existing structure. However, the disadvantages are that this option would have high maintenance for the installed drainage equipment that protects against flooding. In addition, this system has a higher risk of failure under a severe weather event or storm surge. If the berms or drainage pumps fail, the entire station would no longer be protected from the flood, resulting in catastrophic failure.

Option 3 would involve raising the entire superstructure above the FDL to prevent flooding of the entire station. The superstructure would be raised and replaced. The wet well would need to be sealed such that water could not penetrate into the structure during a flood event. This would involve sealing the wet well cover and connecting ducts.

Option 3 is the most resilient option that has the least risk of failure compared to the other two options. With this option, the risk of flood is eliminated through flood-proofing of the entire structure. With reduced risk, the RDN would have better assurance of infrastructure reliability during a severe storm event.

The main challenge with Option 3 is that it requires the most amount of disturbance to the existing facility. Capital costs are expected to be the highest in comparison to the other options. Notwithstanding, the reduction in flood and safety risks and low operational requirements associated with Option 3, could offset the initial capital investment.

For these reasons, the conceptual design will be based on Option 3 for the purpose of flood mitigation.

4.3 Code Compliance and Age of Infrastructure

4.3.1 Challenges and Consequences

The DBPS is in its fifth decade of operation, and with its age comes challenges with infrastructure condition and compliance with current best practices. If significant upgrades are required to the structure due to flood mitigation (as presented in Section 4.2), the need to achieve compliance with current codes and standards may become a requirement, and failure to do so could leave the RDN at significant risk.

To better understand the challenges with the existing station, a site investigation was conducted on February 11, 2021. During this visit, a limited assessment of the facility was undertaken. The condition assessment was limited to visual observations and discussion. No measurements or tests were conducted during this visit.

The general finding was that the existing building and process systems did not have seismic design elements that would provide resiliency following an earthquake (e.g., the lack of pipe restraints on some piping systems). Within the dry pit (**Figures 4-2** through **Figure 4-4**), the lack of seismic restraints on either of the swing arms of the one-ton cranes (**Figure 4-3**), and even lack of seismic bracing within the general framing of the superstructure.

Failure of any of these components or systems during a seismic event could lead to undesirable or irreparable damage to the DBPS. Similar to a flooding event, an earthquake could leave the station out of service for many weeks to months, resulting in significant impact to liquid waste services within the RDN. Although the probability of such an event occurring is low, the consequences would be severe.

The general aging of infrastructure also poses a risk in terms of reliability. For example, through on-site discussions with the RDN, the operations team noted that the vertical riser on the forcemain has had some recent upgrade work due to thinning of pipe material over time. It is believed that the presence of rocks and other hard material was slowly eroding away at the steel pipe. Although no severe impacts occurred, this example provides evidence of how the aging infrastructure can become an increasing liability. This is especially true for components that are within corrosive or abrasive environments, that may experience more wear over time. It should be noted that normal wear is managed by the RDN on a regular basis through maintenance and replacement of parts. Notwithstanding, some components may be approaching their end of their service life and a condition assessment may be warranted.

The existing structure also has inherent safety concerns. One main concern is the lack of safe egress from the lower levels of the DBPS. The Pump and Motor Floors of the station only have a single point of egress, which is through an open staircase to the Ground Level. In the event of an explosion or fire, this point of egress may not provide suitable protection needed for a worker to escape.

Figure 4-2
Piping Not Restrained

Figure 4-3
Lack of Seismic Restraints on Swing Arm of the Cranes

Figure 4-4
Vertical Riser

4.3.2 Mitigation Options and Selected Approach

It is difficult to establish how codes and regulations will impact the upgrades at a conceptual level. Detailed structural analysis and a code consultant would be required at preliminary and detailed design to review the upgrade plans and determine what systems need to be upgraded.

For the purpose of this study, it is assumed that there will be significant structural and architectural work to bring the structure in closer compliance with BCBC 2018 and other best practices. It is also proposed that a new enclosed staircase be added on the north side of the building. Further discussion on proposed structural improvements is provided in Section 6.2.

5 PROCESS DESIGN

5.1 Wastewater Pumping

5.1.1 Pump Selection

Pump selection was based on the full build-out scenario at 1955 L/s. This flow rate will be achieved during the Phase 2 upgrades as presented in Section 4.1.2.1. To meet the capacity of 1955 L/s, a total of five pumps will be provided: three pumps at a nominal capacity of 650 L/s and two pumps at a nominal capacity of 325 L/s. It is suggested that all of the pumps will be provided with variable frequency drives (VFDs).

The five-pump solution will allow:

- The pump station to provide a firm capacity of 1955 L/s with any pump out of service for maintenance.
- The station to meet the full range of flows down to 80 L/s.

For the purposes of this study, Xylem immersible dry well pumps have been selected. The details on the proposed pump selections are provided in **Table 5-1**. Further details on the pumping units can be found on the pump specification sheets provided in **Appendix A**.

Table 5-1
Preliminary Pump Selection

	Model	Rated Power	Impeller Diameter	Rated Speed	No. of New Units in Phase 1	No. of New Units in Phase 2
Large Pump (56 MLD)	Flygt CT 3351/936	765 hp	625 mm	1200 rpm	3 (replacing Pumps #2, #3 and #4)	0
Small Pump (28 MLD)	Flygt NT 3312/936	385 hp	530 mm	1200 rpm	0	2 (replacing Pump #1)

5.1.2 Pump Hydraulics

The following section reviews the pump selections in relation to the system curves for each of the phases presented in Section 4.1.2.1. For the purpose of this study, it is assumed that the RDN will complete upgrades to the gravity sewer and forcemain, as required to meet capacity of the system (as presented in Section 4.1.2).

5.1.2.1 Existing System

Figure 5-1 shows the existing system, including the existing four pumps. The existing system curve stops at approximately 1400 L/s. This flow rate, as previously mentioned, is the expected capacity of the existing downstream gravity sewer line.

Pump curves for the existing installation were obtained from the original manufacturer. The manufacturer indicated that they were not able to retrieve the pump curve for the newly installed Pump #1. However, they noted that the pump installed had the same duty point as the existing pumps, so an approximate curve was assumed. The intersection of the combined pump curve (four pumps in operation) with the system curve shows that the duty point approximates to the anticipated capacity of the existing system (i.e. 1100 L/s).

Table 5-2 summarizes the combined duty point of the system, with and without redundancy (i.e., three pumps and four pumps in operation, respectively).

Table 5-2
Capacity for the Existing System With and Without Redundancy

	Flow (L/s)	Head (m)
Capacity (largest unit out of service)	900	58
Capacity (all units in service)	1100	60

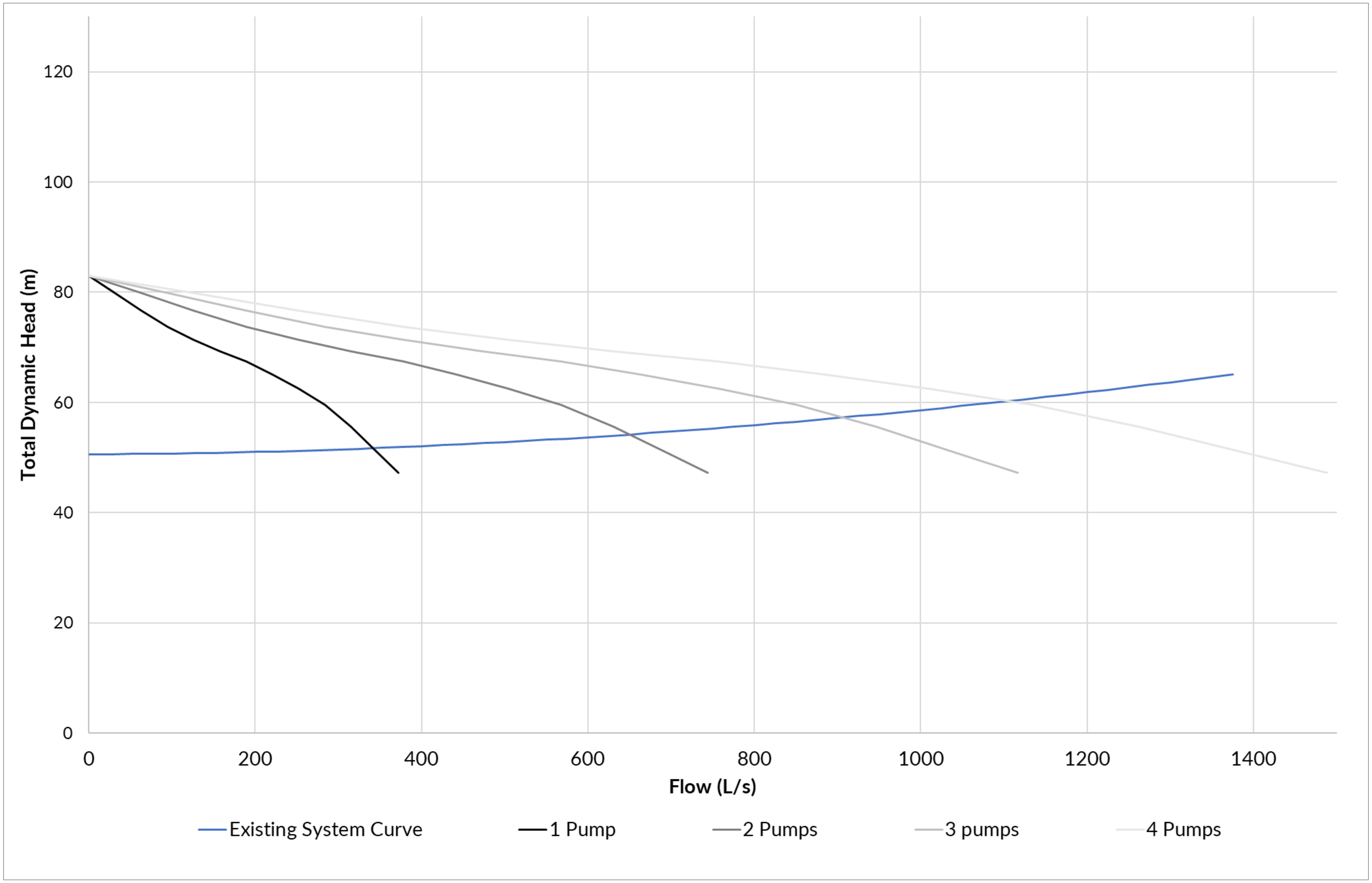


Figure 5-1
System Curve with Existing Pumps – Existing System

5.1.2.2 Phase 1 / Phase 1a

Figure 5-2 shows the Phase 1 system with three new 56 MLD units (Pumps #2, #3 and #4) and one existing unit (Pump #1). **Figure 5-2** assumes that the gravity sewer is twinned (i.e. Phase 1a). This is why the system curve extends beyond 1400 L/s. This curve is Option B introduced in Section 4.1.2.1.

The pump curves for the large pumps (Flygt CT 3351/936) were provided by the manufacturer. Variable speed curves are shown for the large pumps. These curves show the high operational flexibility of the system. For low flows, the existing pump would be used as per current practice.

Table 5-3 summarizes the combined capacity of the system, with and without redundancy. This upgrade will provide additional needed capacity to meet the current limitations in the system. The maximum capacity without redundancy is up to 1600 L/s, providing relief during extreme wet-weather flows.

Table 5-3
Capacity for Phase1a

	Flow (L/s)	Head (m)
Capacity (largest unit out of service)	1400	66
Capacity (all large units in service)	1600	70

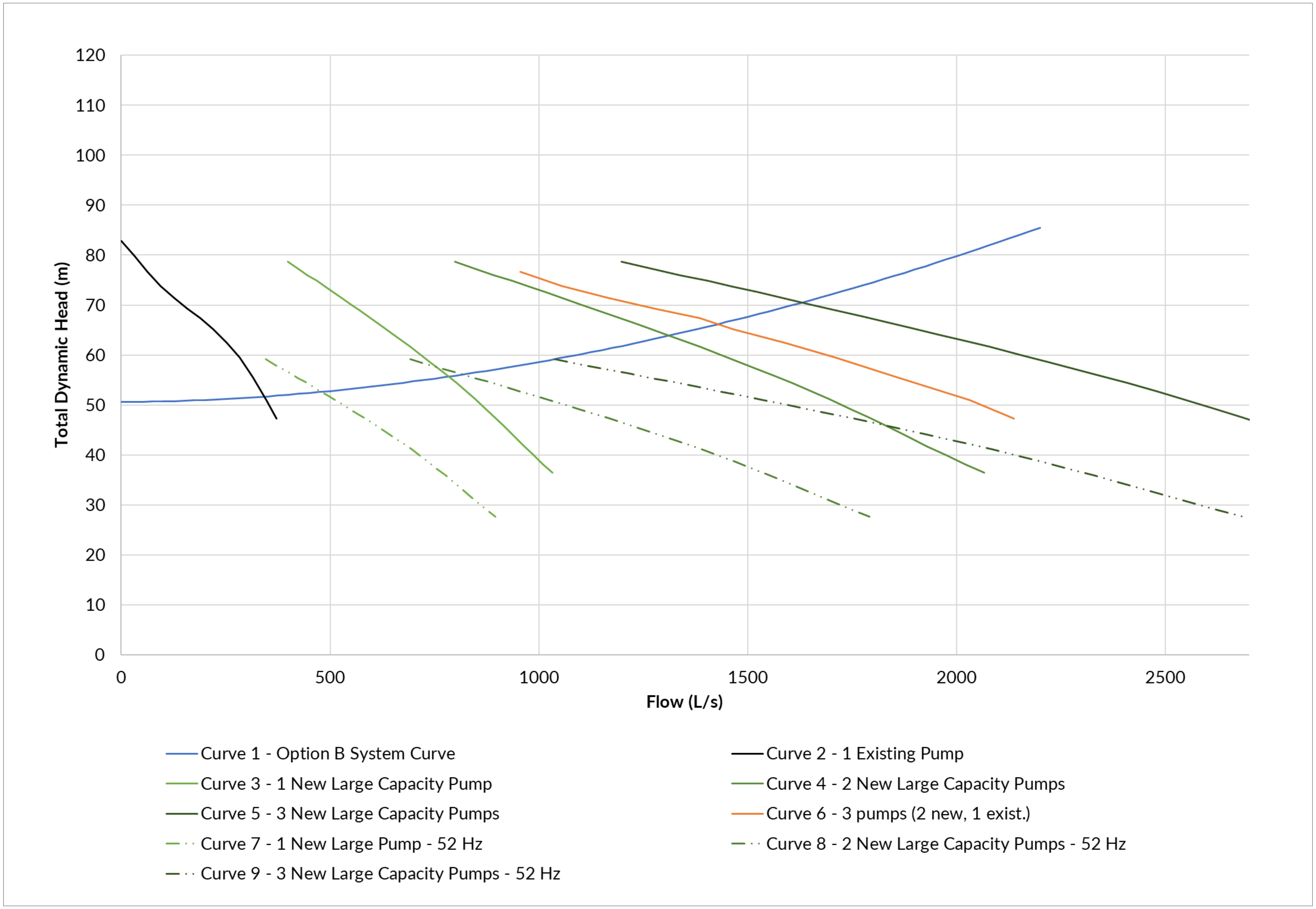


Figure 5-2
System Curve and Selected Pumps – Phase 1 / Phase1a

5.1.2.3 Phase 1b

Figure 5-3 shows the Phase 1b system. As previously stated, this intermediate phase does not involve any changes to the pumping system, but instead requires that the forcemain is either replaced or twinned. The curve presented in **Figure 5-3** shows the system with a twinned line. The system curve is Option C introduced in Section 4.1.2.1.

Table 5-3 summarizes the combined capacity of the system (extracted from **Figure 5-3**), with and without redundancy. Without adding any more pumps, this scenario shows that the RDN would be able to meet higher capacity requirements by reducing the dynamic losses in the forcemain. This interim step would likely be required within the next 20 years to meet increases in peak flow requirements. Without redundancy, this scenario should provide up to the 2073 PWWF.

Table 5-4
Capacity for Phase 1b

	Flow (L/s)	Head (m)
Capacity (largest unit out of service)	1800	58
Capacity (all large units in service)	2150	60

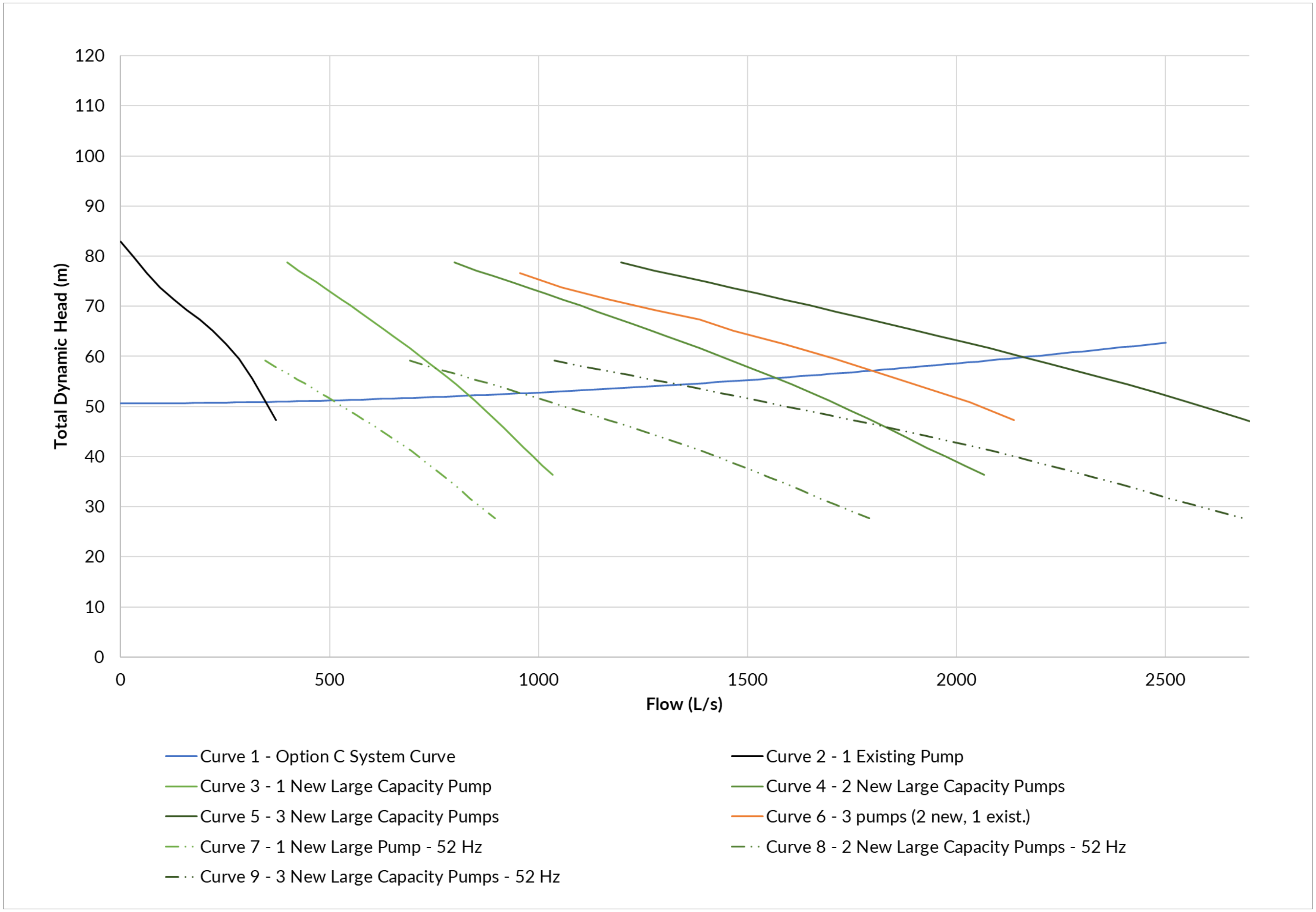


Figure 5-3
System Curve with Selected Pumps – Phase 1b (Forcemain is twinned)

5.1.2.4 Phase 2

Figure 5-4 shows the Phase 2 system, which includes the addition of the two new 28 MLD pumps (replacing Pump #1). This scenario represents the final build-out of the upgrades to the DBPS. The system curve shown in **Figure 5-4** is Option C and assumes that Phase 1b (twinning of the forcemain) precedes the Phase 2 installation.

The pump curves for the two 28 MLD pumps (Flygt NT 3312/936) were provided by the manufacturer. **Figure 5-4** shows the variable speed curves for the full build-out. These curves illustrate that the system has the capability to accommodate the entire flow range from 80 L/s to over 2000 L/s (with full operational redundancy).

Table 5-4 summarizes the combined duty point of the system, with redundancy (i.e., three pumps 56 MLD pumps in operation and the two 28 MLD pumps as standby). This condition exceeds the 2073 PWWF design condition.

Table 5-5
Capacity for Phase 2

	Flow (L/s)	Head (m)
Capacity (largest unit out of service)	2150	60

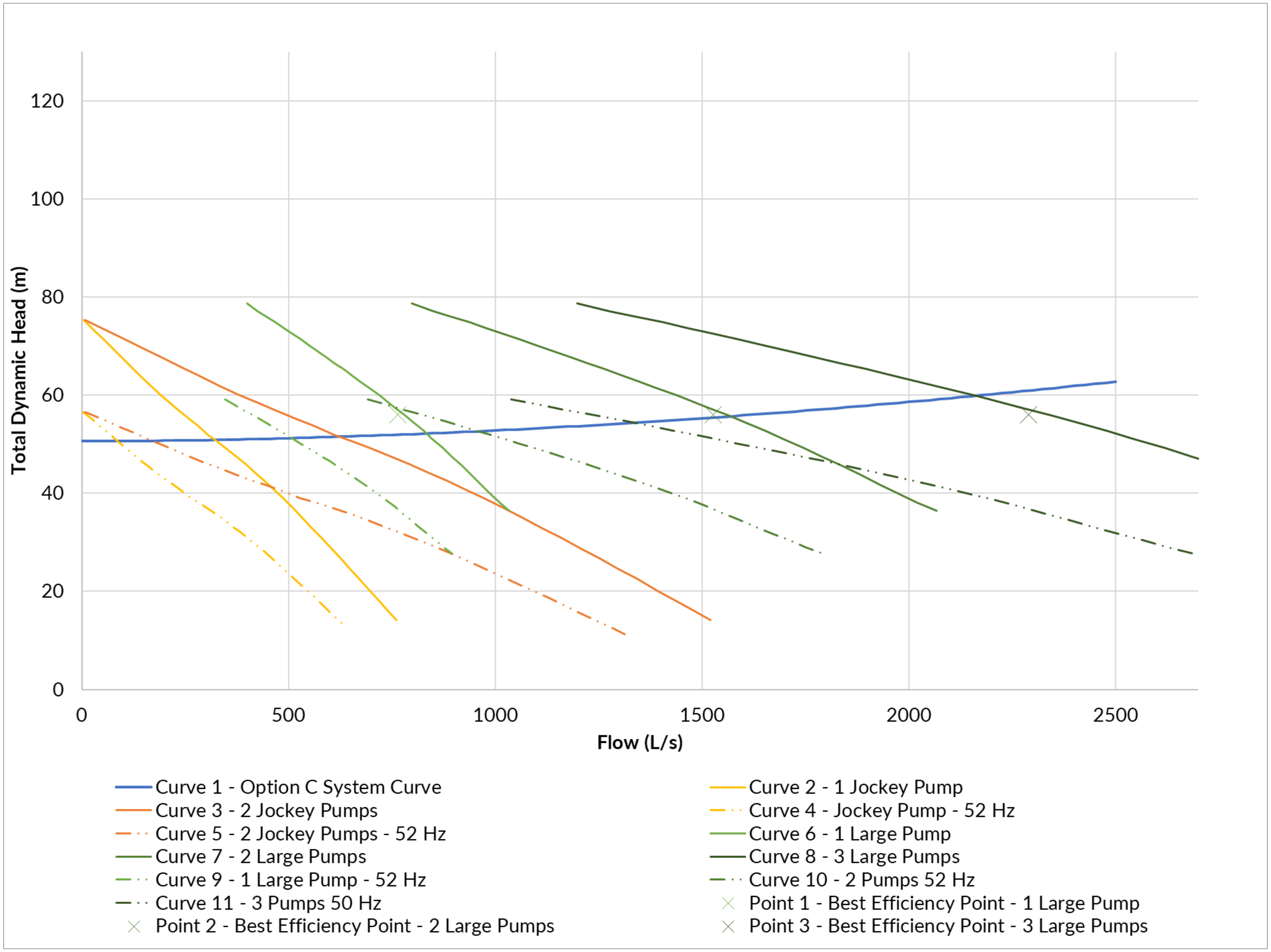


Figure 5-4
System Curve with Selected Pumps – Phase 2

5.2 General Arrangement

5.2.1 Proposed Pump Floor Plan Upgrades

Figure 5-5 shows the proposed general arrangement of the wastewater pumps on the Pump Floor for both Phase 1 and Phase 2. Phase 1 will involve most of the modifications to the floor plan, while Phase 2 includes modifications necessary for installation of the remaining pumps.

Figure 5-6 shows the proposed plan view for the intermediate Motor Floor and the Ground Floor. These arrangements are furthered referenced and discussed in Section 6.

It is important to note the proposed layouts are provided as examples of what the arrangements could look like and provides the basis for the conceptual design. Optimization of the layouts to best suit the RDN's requirements can be done during preliminary design.

The following sections review the proposed changes to the process systems during Phases 1 and 2.

5.2.2 Piping and Valves

As was the original design intent back in the 1970s, it is proposed that a new header be installed along the west wall of the building. This new header will accommodate flows from the new 56 MLD pumps. Under Phase 1, the three new 56 MLD capacity pumps (Pumps #2, #3 and #4) will be installed on this header.

Due to the installation of a new enclosed staircase at the north end of the building (to be discussed further in Section 6.2), the existing header will need to be replaced and relocated. It is proposed this upgrade will occur during the Phase 1 upgrade. During Phase 2, this header could be modified to accept the discharge lines from the two 28 MLD pumps (that will replace Pump #1).

This study assumes that the new piping will be provided as coated carbon steel. New supports and hangers for piping systems will be required. These will be designed to meet the seismic requirements. It is anticipated that stanchion supports will be required on the pump suction and discharge lines.

As shown in **Figure 5-5**, new valving will be required on the new upsized pump suction and discharge lines. This study assumes that two new check valves and five new knife-gate valves will be provided. It is proposed that main isolation and check valves continue to be located within the dry-well. For Phase 2, additional valving would be required for the installation of the remaining pumps.

The existing trench for the supply pipes and valving is considered a confined space and requires special entry requirements. The design intent is to remove the need for confined space entry for day to day operation. Options include removing the confined space classification or making changes to design such that operators do not need to access the space for regular maintenance activities.

It is proposed that the level of automation in the pump station be increased with the upgrades. This includes that all significant valves be equipped with actuators for remote control operation. In addition, the Control Philosophy can be expanded to incorporate process automation and allow operators to have more flexible control in pump operation.

A process hazard analysis must be considered in the future design stages, including valve isolation and lock-out procedures.

5.2.3 Surge Anticipation System

This study assumes that the air-operated pinch valve and compressor system that provides surge protection should be kept. New valves and assembly may be required to meet the capacity increase in the system.

Depending on condition and capacity requirements, the existing compressors may be reused, or new ones installed.

Note that the surge anticipation system is currently not shown in the general arrangement in **Figure 5-5**, however, this system could be located in the same general location as the existing system. Relocation of the compressors to the intermediate Motor Floor may be an option, with reclaimed space from the previous Diesel Room.

5.2.4 Specialty Fittings

The suction line bell mouths will require upsizing for the new larger capacity pumps. In addition, the bulk heads that separate the dry well from the wet well will need to be replaced on the new pump suction lines to accommodate the larger diameter suction pipe.

5.2.5 Chemical Dosing

AE has assumed that the existing ferric chloride dosing system will need to be replaced during the upgrades. Storage of chemicals on the Ground Floor is preferred for easy loading and access.

5.2.6 General Mechanical

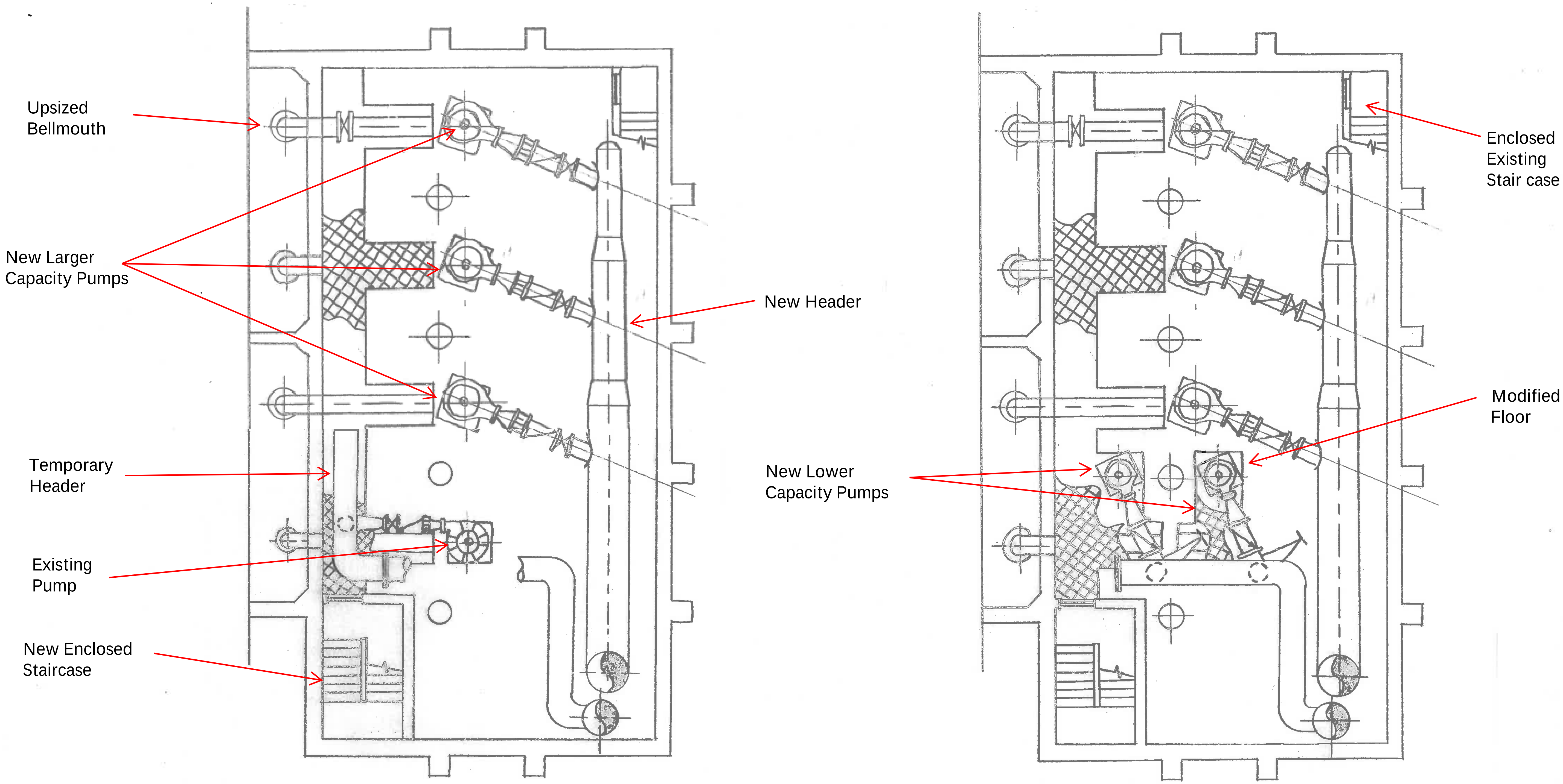
Some miscellaneous mechanical work will be required during the upgrades. This includes items such as removal and storage of old mechanical equipment, replacement of the sump pump, rotation of the two existing pumps (Pumps #1 and #3), and installation of two new larger capacity pumps (Pumps #2 and #4).

5.3 Wet Well

The existing wet well was assessed using principles from the Hydraulic Institute's Pump Intake Design standards. The initial investigations indicate that the wet well is likely adequate for future expansion. Desktop investigations looked at the approach velocity and submergence under current and future peak flow conditions.

Notwithstanding the above findings, the RDN should conduct hydraulic modelling of the wet well under the new peak flow condition of 1955 L/s. This modelling should be developed at the preliminary design phase to confirm these findings.

Minor upgrade works may be required in the wet well depending on the outcome of the results of the hydraulic model study. The cost estimate includes an allowance for minor modifications in the wet well.



Phase 1 Layout

Phase 2 Layout

Figure 5-5 Proposed Layouts for Pump Floor Level for the Phase 1 and Phase 2 Upgrades

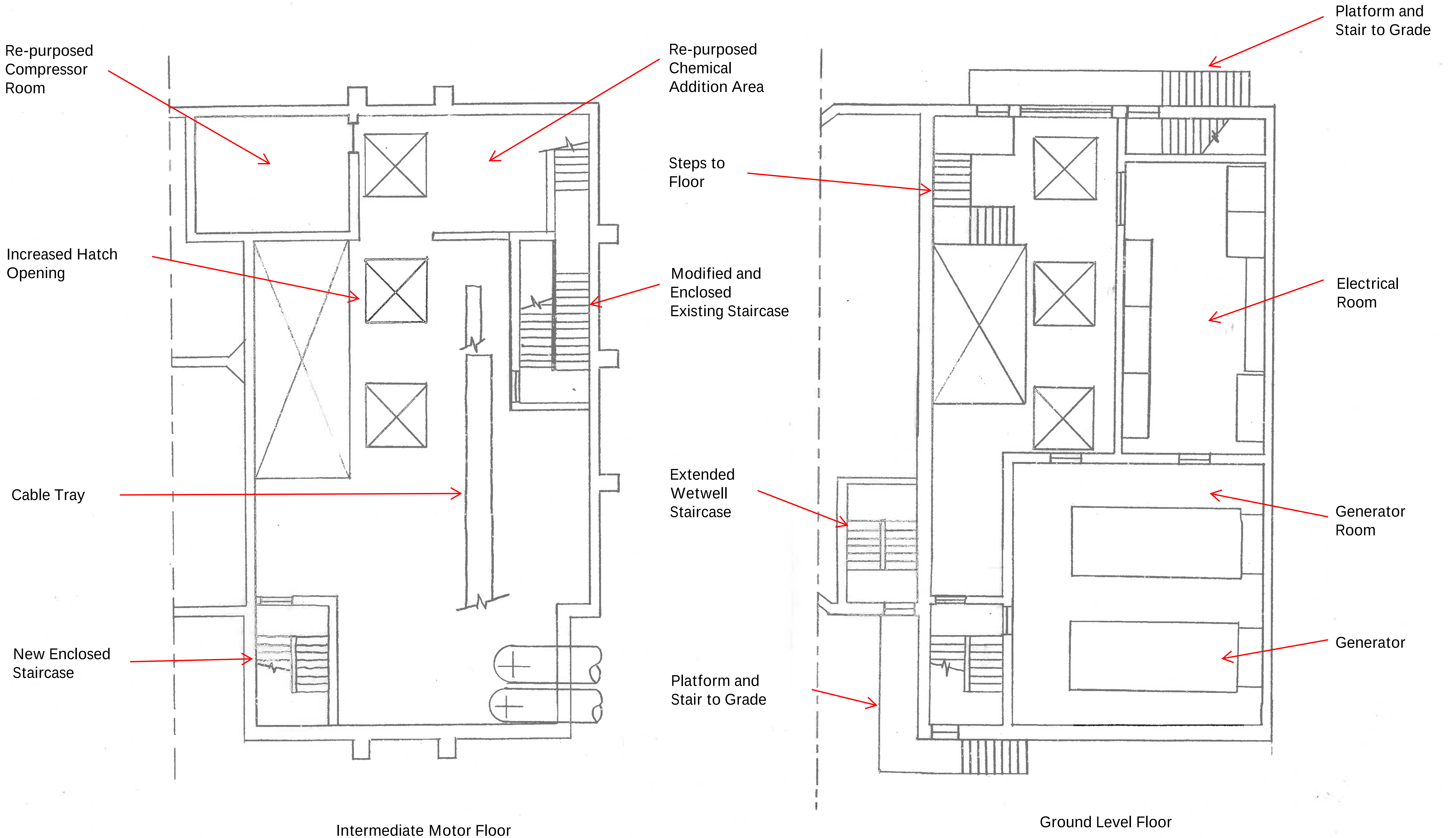


Figure 5-6 Proposed Layouts for Intermediary Motor Floor and Ground Level Floor

6 SUPPORTING DISCIPLINES

The following sections provide an overview of the anticipated works at the DBPS during the Phase 1 and Phase 2 upgrades

6.1 Civil / Site Works

6.1.1 Demolition

The Phase 1 demolition will include the superstructure and internal components. The demolition will facilitate the proposed flood proofing and retrofits of the existing structure. In general, it is challenging to estimate demolition costs, as there may be some salvage value for components that are no longer needed by the RDN.

Demolition work will likely also be needed for the electrical service into the facility.

It is anticipated that minimal demolition will be required during Phase 2. The exception being the removal of retired pumps and process mechanical equipment.

6.1.2 Site Grading, Surfacing and Drainage

During Phase 1, some site grading will be required. This grading will be limited to areas that are impacted by the construction works. At the end of construction, some asphalt surfacing is anticipated.

A topographic site survey should first be conducted during preliminary design to confirm existing grade and elevations of structures. A site survey is also required to confirm that elevations are based on the geodetic datum.

6.1.3 Utilities and Site Flood Proofing

Existing utilities and site infrastructure need to be addressed during Phase 1 to prevent flooding of the wet well. This will include sealing of belowground ducting systems, sealing of manholes and valve operator boxes, and retrofitting the existing site drainage system.

In addition to flood proofing at the DBPS, upstream infrastructure may need flood-proofing. The RDN should investigate the elevation of offsite manholes along the Nanaimo Interceptor and conduct a flood risk evaluation within the wastewater collection system.

6.1.4 Forcemain Tie-Ins

Some work would be required to tie-in the new forcemain with the existing alignment during the Phase 1 upgrades.

6.1.5 Fencing, Landscaping and Tree Protection

Following the major upgrades to the superstructure, new fencing and landscaping will be required. In addition, protection of existing trees on site may be required during construction.

6.2 Structural and Architectural

6.2.1 Existing Substructure Retrofits for Flood Mitigation

It is proposed that the Ground Floor Elevation be lifted 1.7 m above grade to combat flooding during Phase 1. These upgrades will require significant structural analysis and design. Flood water has the potential to impose a considerable new force on the existing structure that will need to be reviewed. In addition, detailed analysis needs to be undertaken in the design of the connection between the new flood wall and the existing substructure.

The existing superstructure has masonry walls. The new superstructure should avoid heavy materials such as concrete and masonry, to minimize seismic weight and load demand on the existing substructure below. The new superstructure, including any steel columns/bracing, base plates, and anchor bolt details, would need to account for the limited curb width of the existing structure.

6.2.2 Modifications for Code Compliance

As outlined in Section 4.3, modifications to the building envelope and structure are recommended to comply with current codes, regulation and standards. **Figure 5-6** shows the proposed floor plans for the intermediate Motor Floor and the Ground Floor.

One of the most significant changes to the structure during Phase 1 is the extension of the Motor Floor and Ground Floor from Bay Line E to Bay Line F. The Pump Floor is already built out to this length. This extension will provide additional indoor capacity without the need to excavate in a new area on site. Foundation walls will be required between the Motor Floor and Ground Floor to support the new superstructure footprint. A new ground floor slab is also required in this area.

The extension of the building to this length will allow for the addition of a new staircase, as shown in **Figure 5-6**. As described previously, this enclosed egress may be required to meet compliance with the BCBC 2018 and safety regulations. A code consultant should be retained during preliminary design to confirm requirements.

The existing structure will likely not meet current seismic standards in its current condition. A detailed analysis will be required to identify the deficiencies. Prior to this analysis, a geotechnical report will be required for the site. Existing perimeter shear walls will require strengthening using fibreglass reinforced plastic (FRP) or additional reinforced concrete layer for in-plane capacity. Exterior walls may also require strengthening to enhance out-of-plane resistance against dynamic soil loads.

At the wet-well, a new enclosed stair case that is accessed above the flood design level will continue to provide operator access to the wet-well.

6.2.3 Modifications for Pump Configuration

On the Ground and Motor Floors, the grated square openings that exist for pump motor access will need to be increased to facilitate the installation and removal of the new larger capacity pumps. This structural change will require analysis to ensure that seismic diaphragm stresses can be mitigated. The slab around the openings may need strengthening to conform with seismic requirements.

Structural input and analysis will also be required for replacement of the bulk heads between the wet well and the dry well.

In addition, as shown in **Figure 5-5**, floor modifications on the Pump Floor will be required to facilitate the new suction line assembly for the two 28 MLD pumps. Since installation of the 28 MLD will occur during Phase 2, it is not recommended that this work be completed during the Phase 1 upgrades.

6.2.4 Other Structural Works

Miscellaneous structural work required during Phase 1 may include installation of new pipe and pump supports, new equipment pads, new crane equipment and restraints, new base for an outdoor unit substation, fuel tank area upgrades, and replacement of grating.

6.2.5 Other Architectural Works

The new superstructure will require architectural design and input. This includes items such as exterior and interior finishing, roofing, and doors. A new roll-up door will be required for movement of chemicals and equipment to and from the building.

In addition, the RDN may require speciality architectural features for the new structure to fit in with the existing neighbourhood, which is in a public-facing location.

The architectural works will be required during the Phase 1 upgrades.

6.3 Building Mechanical

Significant upgrades to the building mechanical systems will be required during Phase 1. The intent is to meet the BCBC 2018.

The new generator room will require a new ventilation system for the new generators. Specific air requirements for the generators should be addressed in preliminary design. Due to the installation of new VFDs, additional cooling in the electrical room will be required. For the rest of the building, a new forced air ducting system will be required to replace the existing passive system. The new ventilation system would require installation of new fans, intake louvers, dampers, ducting, and HVAC controls.

Depending on its condition and performance, the existing odour control mitigation system that ionizes air entering the wet well will need to be retrofitted or upgraded to mitigate against flooding. The existing ionizers could be replaced to a foul air treatment system such as a single-stage granular activated carbon unit.

A general plumbing upgrade will be required throughout the building; however, it is not anticipated that a fire suppression system will be required.

Depending on local bylaws, code requirements and preferences of the RDN, a noise attenuation system may consider for site features, including the generators and fans.

6.4 Electrical, Instrumentation and Controls

6.4.1 Current Pump Station Capacity

During the site visit, it was confirmed that the facility's single line diagram provides a good overview of what is installed on site. The facility is fed by a 1000 kVA unit substation that feeds a 1600Amp rated Automatic Transfer Switch (ATS) that toggles the power source between the utility feed and an onsite standby generator. The ATS ultimately feeds a 600 VAC, 3 phase, 3 wire, MCC located on the Motor floor. Nameplate information regarding the MCC could not be found on site; however, based on documentation available it is assumed that the MCC's bus is rated for 1200 Amps. The MCC is protected by a 1600Amp power circuit breaker found on the load side of the ATS. While the setpoints adjustments of the breaker are visible, the rating plug of the device could not be determined by observing the front panel, it is assumed that the breaker does not exceed a value of 1200 Amps. The MCC does not have a power meter, as such no trend data (e.g., peak demands, harmonic content) for the facility is available. Utility bills (from BC Hydro) can be utilized to determine the actual peak power demand of the facility, in particular bills from months of high use.

Supplying stand-by power to the facility is a 1400 kW, 600 VAC, 3 phase, 0.8 pf, standby diesel generator that is protected by a 1600Amp molded case circuit breaker (MCCB).

Pump #1 is driven by a 350HP Allen Bradley VFD that was installed in 2016. As previously discussed, Pumps #2 and #3 are still driven by eddy current drives while Pump #4 is started across-the-line. Based on discussions with operators on site, all motor starters are working without issue.

6.4.2 Proposed Pump Station Upgrade Options

6.4.2.1 Phase 1

To operate three 765hp pumps simultaneously, it is anticipated that the distribution system will need to accommodate a peak demand of 2460 kVA (1939 kW). To achieve this, the facility's power distribution system will need to be upgraded to support a 2500 Amp service at 600VAC. This will involve the replacement of:

- The existing unit substation with a 2500kVA unit substation,
- The existing genset, and
- The existing automatic transfer switch.

In addition to the cost of the new unit substation, there will likely be a contribution factor applied by BC Hydro to upgrade the power network to the site.

New 600VAC distribution equipment (MCC, Motor starters, etc.) and supporting infrastructure (Cables and raceway) will need to be installed. **Figure 5-6** provides an outline as to how the new system could be configured.

As the unit substation will need to be replaced, additional grounding will likely be required to reduce touch and step hazards, and to bring up the installation to BC Hydro requirements. To limit the extent of the modifications, the unit substation should be relocated to an outside area and away from the generator(s).

As the existing main bus/MCC is sized for 1200 Amps, it cannot be reused as the main bus; however, it should not be demolished as it will provide a means to keep the pumps operational during construction. As previously mentioned, new 2500 Amp, 600VAC, 3-phase, 3-wire, 42kAIC Motor Control Centre will be required to feed the three pumps and miscellaneous station loads. Per discussions on site, best engineering practices for arc-flash mitigation should be taken into consideration. To understand the potential arc-flash hazardous of the new system, a Power System Study will need to be conducted. For the purposes of this study and the cost estimate, it is assumed the new MCC will be equipped with:

- An arc-flash maintenance mode switch on its main protective device,
- Insulated busses, and
- A means to trip and energize the main breaker away from the arc flash boundary.

Other mitigation options to consider during detailed design include:

- Arc resistant gear (we have provided anticipated cost in our estimate),
- Auto-racking, and
- Automatic Vertical Bus Shutters.

Phase 1 will require three, 765HP normal duty VFDs to be installed to provide the appropriate control over flow rates. Given the size/rating of the drives, they will need to be paired with some form of active harmonic filtering to lessen impacts to the station's generators and to meet BC Hydro's requirements. This can be achieved with either VFDs with active front end's or with a stand alone active harmonic filter. Depending on the manufacturer, the active harmonic filter could be staged in an attempt to reduce upfront costs. This decision ultimately depends on the timeline between phases and market conditions.

If the harmonics of the drives are not filtered, the generators will likely need to be up-sized to accommodate the harmonic load on the system and will increase the overall cost of the project.

The new VFDs should be separated into their own freestanding enclosures/cabinets to reduce the overall space requirements as compared to a single MCC lineup.

Under Phase 1, the existing VFD for Pump #1 will be re-used and will be relocated to the Ground Floor.

With all of the electrical equipment relocated to the Ground Floor, HVAC requirements for the building will need to be reanalyzed, in particular cooling loads as the new VFDs will dissipate approximately 29-38 kW of heat when in operation. Note that a cooling load of 120 kW was assumed in our demand calculations.

At 1400 kW, the existing generator will at most be able to run two of the 765HP duty pumps at full speed. For the purposes of this study, we have assumed that the generator will need to power all three large duty pumps during a power outage. To accomplish this, 2250 kW worth generation will need to be installed. Upon consultation with a local generator manufacturer, we estimate that either three 750kW or two 1250kW generator units will be required to provide enough power for this run case. The new generators will require a large floorspace which greatly exceeds the existing generator room. **Figure 5-6** shows the new proposed location for the new generators. For the cost estimate, we have assumed that the generators will come in skin-tight, 79 dbA sound attenuated enclosures, with a separate cabinet housing its control and distribution equipment.

To operate two 765hp and two 385hp pumps simultaneously during Phase 2, we anticipate that the distribution system will need to accommodate a peak demand of 2402 kVA (1946 kW).

6.4.3 Lighting Upgrades

New lighting throughout the building and wet well will need to be considered as apart of the Phase 1 installation. Lighting levels will need to be reviewed to ensure that the installation meets the guidelines set out by IESNA and WorkSafe BC. All lights will be replaced with energy efficient light-emitting diode (LED) fixtures to reduce maintenance requirements and improve energy efficiency.

6.4.4 Controls

The conceptual design assumes that a full upgrade to the control system will be required. This includes replacement of instrumentation, including level meters within the wet well and new flowmeters on the discharge headers. In addition, a new control panel (1 rack, 17 slot chassis) for the station has been assumed.

An allowance was made for programming of the control system as well as integration with the RDN's communication network. In addition, new software for either local or remote access may be installed.

7 OPINION OF PROBABLE COST

A Class C opinion of probable cost was prepared for the DBPS Phase 1 Upgrade. The cost estimate was based on the guidelines set out by Engineers and Geoscientists British Columbia (EGBC).

The cost estimate summary is presented in **Table 7-1**. The total capital works with direct and indirect costs are estimated at 21.3 million. A more detailed breakdown of the cost estimate is provided in **Appendix B**.

The cost estimate for the upgrades was developed using pricing quotes from equipment suppliers, and provisional sums for areas where it was not possible to obtain a quote or perform quantity take-offs at this level of design. This estimate includes an overall contingency of 30%.

The cost estimate was based on the RDN pre-purchasing major equipment including the pumps, unit substation, and generators. Contractor overhead and profit were not applied to these items.

A cost estimate for the Phase 2 upgrades was excluded from this work. Phase 2 will not likely take place within the next 10 years. In addition, the cost estimate excludes the necessary upgrade works to the downstream forcemain and gravity sewer. These costs will be significant and need to be considered independently of this assignment.

Table 7-1
Opinion of Probable Capital Cost Summary

	Capital Cost
DIRECT COSTS	
Site Development	$110,000
Site Works	$450,000
Structural and Architectural	$3,480,000
Mechanical	$1,550,000
Electrical, Instrumentation & Controls	$3,883,000
Major Equipment Supply	$2,929,000
Contractor Overhead and Profit (10%, excluding Site Development)	$937,000
Insurance and Fees (1%)	$123,000
INDIRECT COSTS	
Engineering (Design and Construction) (12%)	$1,616,000
Other Allowances and Owner Overhead	$874,000
SUBTOTAL – DIRECT+ INDIRECT	$15,952,000
Contingency (30%)	$4,786,000
Escalation to 2022 (2.5%)	$519,000
TOTAL PROJECT COST ESTIMATE	$21,257,000

8 RECOMMENDATIONS

The RDN is required to perform upgrades to the DBPS to address the major challenges at the station. AE recommends that the RDN move forward with the next phase of this project. The recommendations have been separated into four categories, summarized below. Undertaking these steps prior to or during the next phase of project development will help ensure the effective management of the project.

8.1 Capacity Increase

AE recommends that the RDN proceed forward with upgrading the capacity of the DBPS to meet current and future demands. As outlined in the study, a phased approach is recommended. The following actions are important to progress the project to the next phase:

- Develop a plan for forcemain and gravity sewer improvement prior to finalizing the design of the upgrades to the DBPS. The selection of pumps is a significant decision and should be based on current information for these alignments.
- Develop a plan for capacity upgrade work at the GNPCC that coincides with upgrades at the DBPS.
- Initiate discussions with BC Hydro regarding the expected increase in power to site and determine what the anticipated contribution factor will be for BC Hydro to upgrade power to the site.
- Complete a detailed hydraulic model on the wet well to determine if retrofits can allow for better hydraulic flow through the pump station.

8.2 Climate Change / Flood Control

AE recommends proceeding with raising the building above the target flood construction level (presented as Option 3). This option provides the most resiliency and least amount of risk, once construction is complete. The following actions are recommended to proceed with this option:

- Confirm whether the RDN is planning to adopt an official Flood Construction Level prior to the next phase of upgrades.
- Complete a detailed topographic survey of the site, including major structural points and confirm datum of drawings.
- Undertake an investigation of the elevation of offsite manholes along the Nanaimo Interceptor and conduct a flood risk evaluation within the wastewater collection system.

8.3 Building Upgrades and Code / Regulatory Compliance

As significant upgrades are required to bring the building up to the new flood construction level, undertaking actions to bring the existing structure up to code should be a priority for the RDN. The following actions are recommended to begin with this process:

- Require that a code consultant be used during preliminary and detailed design.
- Require that a noise consultant be used during preliminary and detailed design. The RDN may want to start taking background noise levels at the DBPS to better understand the noise output of the existing system. This baseline could be used to set noise targets for the upgrades.
- Undertake geotechnical investigations at the location of the building expansion (between Bay Lines E to F). A geotechnical report is required for the detailed structural analysis.

8.3.1 Planning and Financial

Internal financial and planning is required to continue to move the project through to preliminary design, detailed design and construction. The following are some of the actions the RDN should undertake prior to the next phase of the project:

- Update financial plans and determine potential sources in funding. This may include seeking out opportunities for grant funding or looking into borrowing requirements. It is not anticipated that a public referendum will be required for borrowing, since the RDN has an approved LWMP.
- Update the LWMP by following the relevant plan monitoring processes, as applicable. This may include undertaking stakeholder and public engagement for the new project or setting implementation targets.
- Consider and review procurement options for design and construction services. This includes reviewing options for overall project delivery (traditional or alternate delivery). In addition, the RDN may want to consider the use of social procurement policies and equipment pre-purchase.

CERTIFICATION PAGE

This report presents our findings regarding the Regional District of Nanaimo Departure Bay Pump Station Upgrade Study. The services provide by Associated Engineering (B.C.) Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Associated Engineering (B.C.) Ltd.
Engineers & Geoscientists BC Permit Number 1000163

Prepared by:

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Reviewed by:

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
S. BOLONGARO
24970
Sep 16, 2021

Sean Bolongaro, C.Eng., P.Eng.
Division Manager, Water

SW/SB/fd

APPENDIX A - PUMP DATA SHEETS

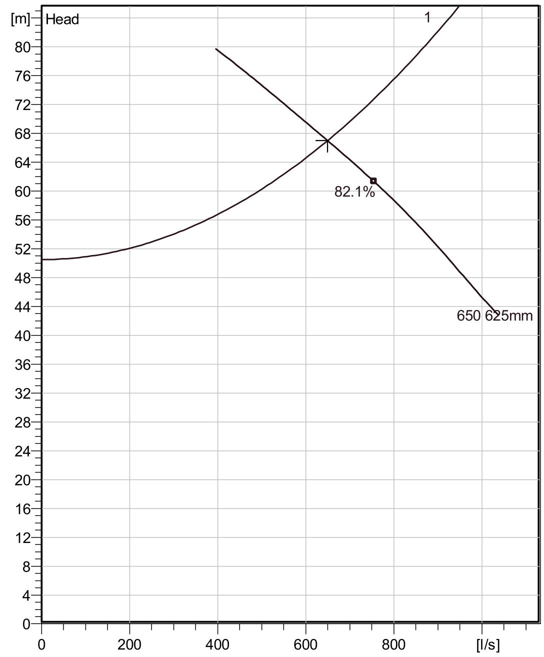
CT 3351/936 3~ 650

Shrouded single or multi-channel impeller pumps with large throughlets and single volute pump casing for liquids containing solids and fibres. Cast iron design with double sealing technology. Some models available as stainless steel versions.

FLYGT
a xylem brand

Technical specification

Curves according to: Water, pure ,4 °C,62.42 lb/ft³,1.6891E-5 ft²/s



Curve: ISO 9906

Configuration

Motor number
C0936.000 66-66-6IE-D IE3 765hp

Installation type
T - Vertical Permanent, Dry

Impeller diameter
625 mm

Discharge diameter
0.35 m

Pump information

Impeller diameter
625 mm

Discharge diameter
0.35 m

Inlet diameter
450 mm

Maximum operating speed
1195 rpm

Number of blades
3

Throughlet diameter
110 m

Max. fluid temperature
40 °C

Materials

Impeller
Grey cast iron

Project		**Created by**	Marius Bocu
Block	0	**Created on**	6/3/2021 **Last update** 6/3/2021

CT 3351/936 3~ 650

Technical specification

Motor - General

Motor number	Phases	Rated speed	Rated power
C0936.000 66-66-6IE-D IE3 765hp	3~	1195 rpm	765 hp
Approval	**Number of poles**	**Rated current**	**Stator variant**
No	6	725 A	3
Frequency	**Rated voltage**	**Insulation class**	**Type of Duty**
60 Hz	600 V	H	
Version code			
000			

Motor - Technical

Power factor - 1/1 Load	Motor efficiency - 1/1 Load	Total moment of inertia	Starts per hour max.
0.78	96.8 %	29 kg m²	0
Power factor - 3/4 Load	**Motor efficiency - 3/4 Load**	**Starting current, direct starting**	
0.72	96.8 %	4950 A	
Power factor - 1/2 Load	**Motor efficiency - 1/2 Load**	**Starting current, star-delta**	
0.61	96.3 %	1650 A	

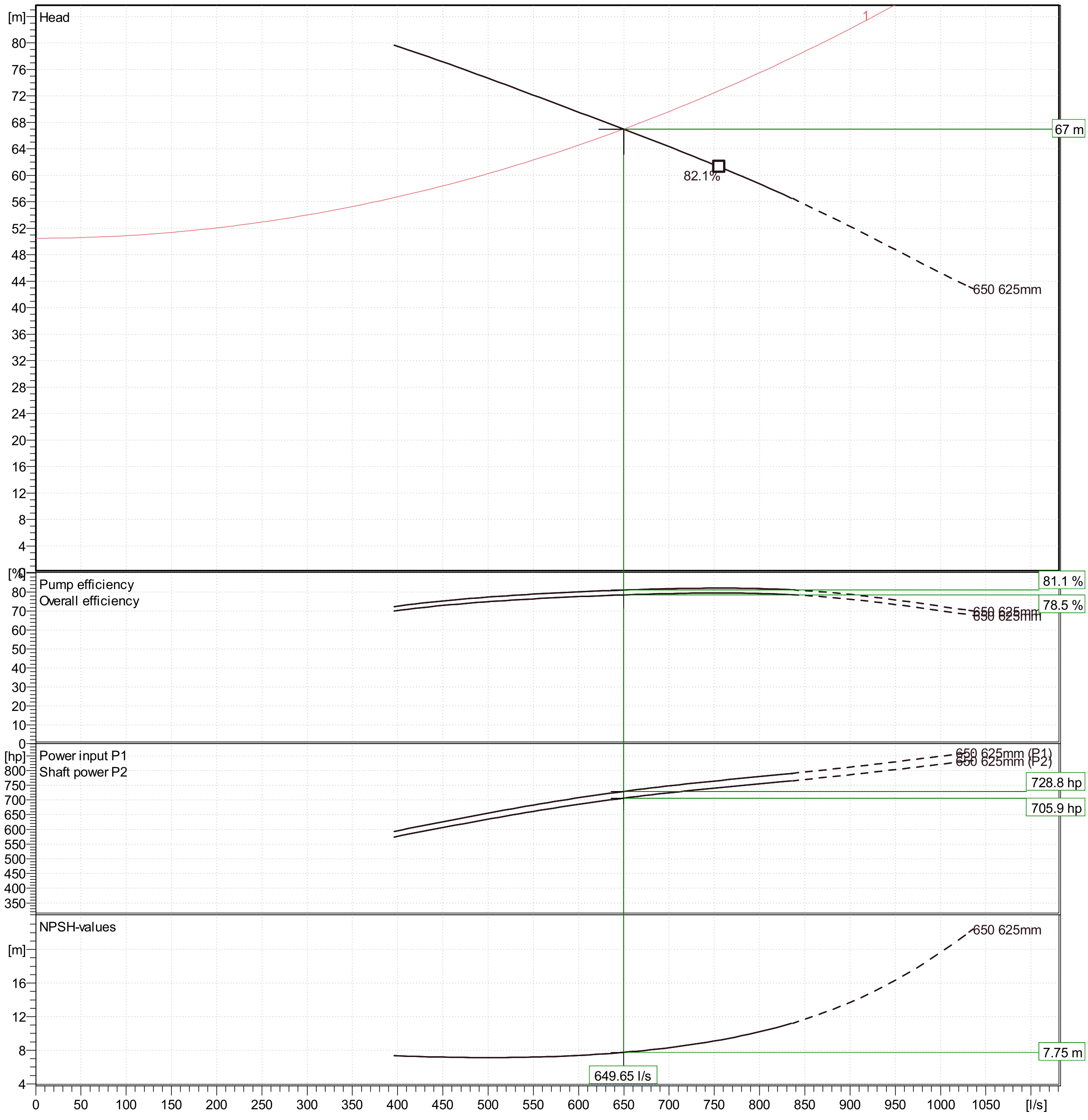
CT 3351/936 3~ 650

Performance curve

Duty point

Flow	Head
650 l/s	67 m

Curves according to: Water, pure 4 °C, 62.42 lb/ft³, 1.6891E-5 ft²/s



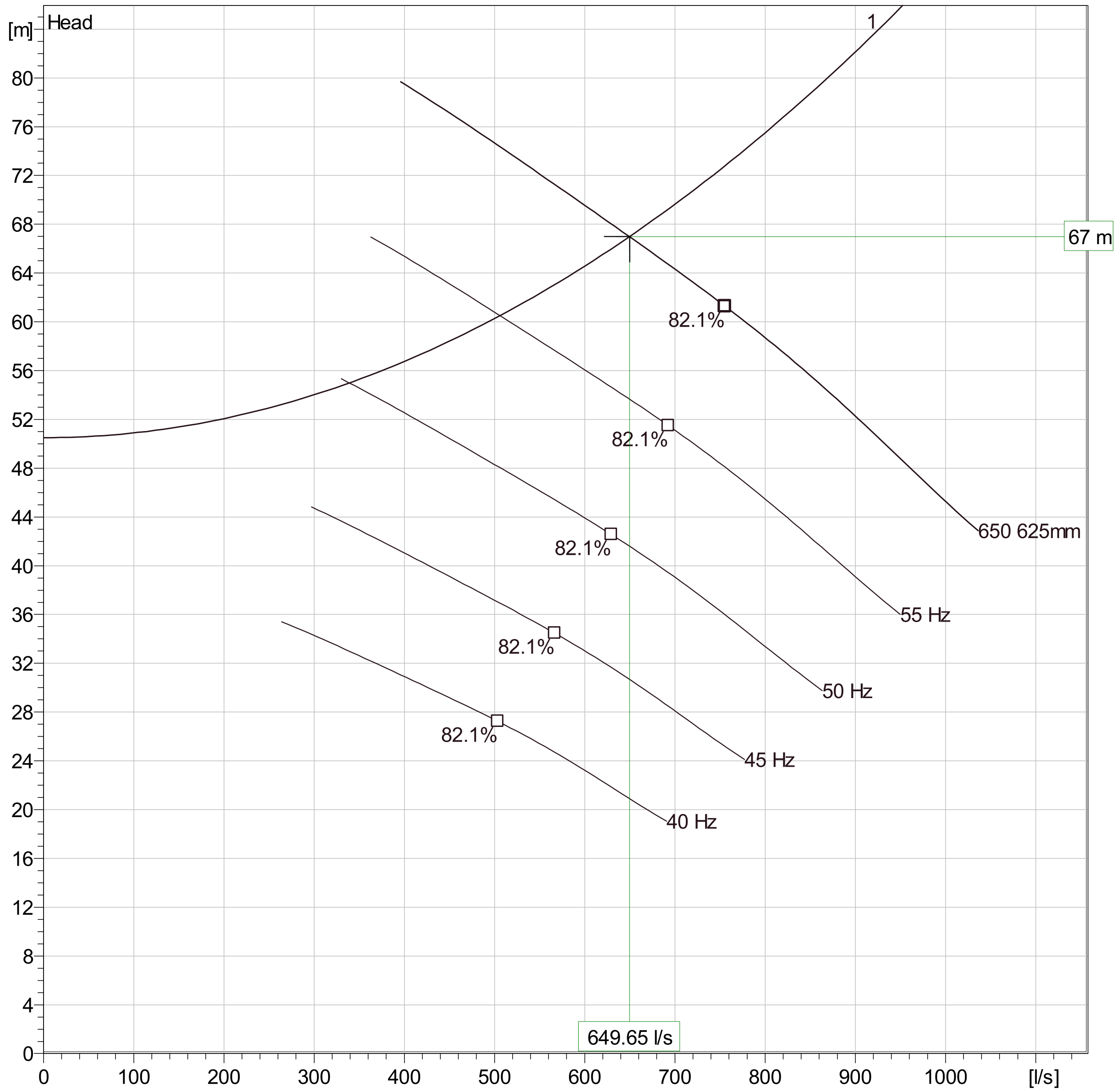
Curve: ISO 9906

Project		**Created by**	Marius Bocu		
Block	0	**Created on**	6/3/2021	**Last update**	6/3/2021

CT 3351/936 3~ 650

Duty Analysis

Curves according to: Water, pure ,4 °C,62.42 lb/ft³,1.6891E-5 ft²/s



Operating characteristics

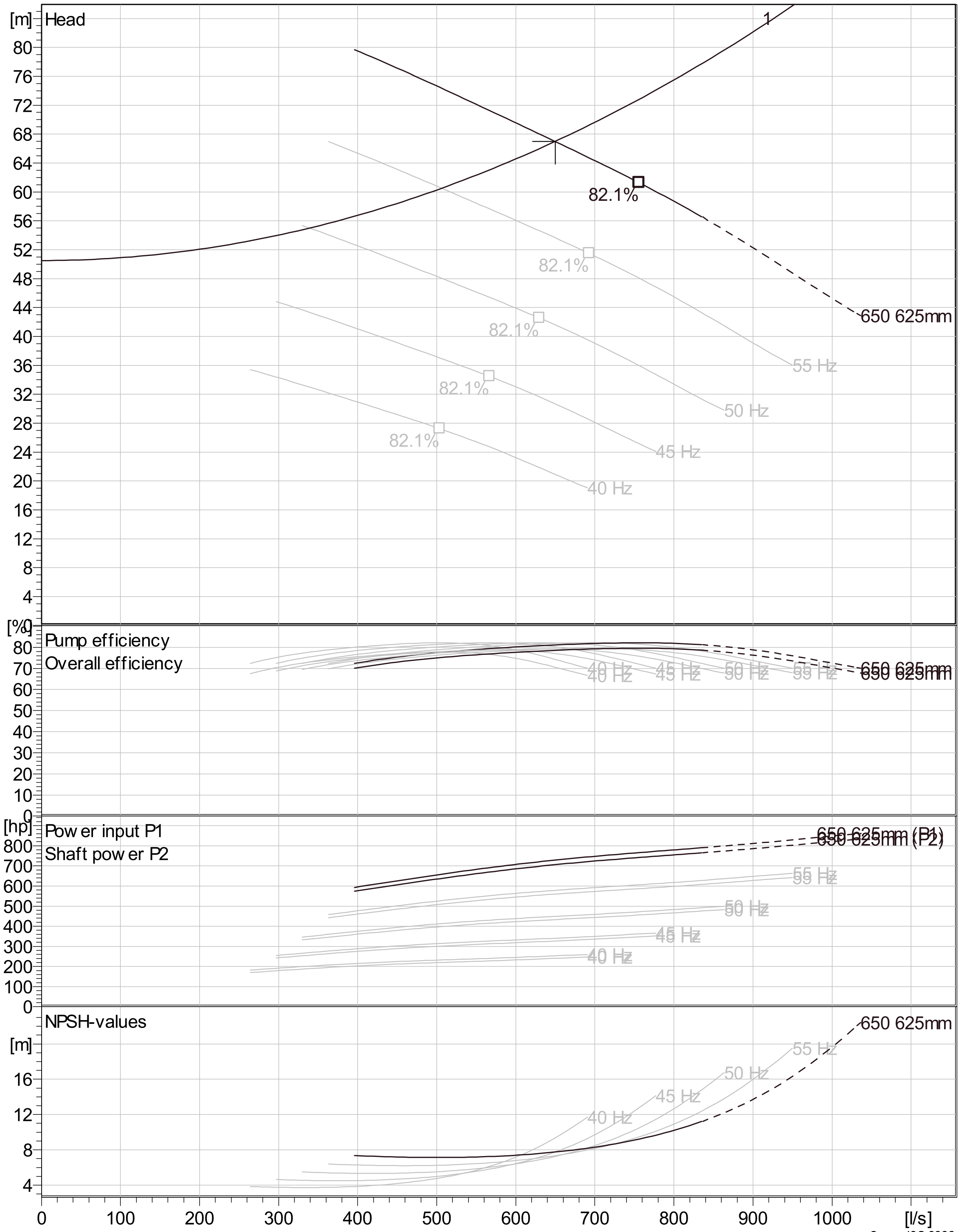
Pumps / Systems	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific Energy	NPSHre
1	650 l/s	67 m	706 hp	650 l/s	67 m	706 hp	81.1 %	0.000232 kWh	7.75 m

Project		**Created by**	Marius Bocu		
Block	0	**Created on**	6/3/2021	**Last update**	6/3/2021

CT 3351/936 3~ 650

VFD Curve

Curves according to: Water, pure , 4 °C, 62.42 lb/ft³, 1.6891E-5 ft²/s

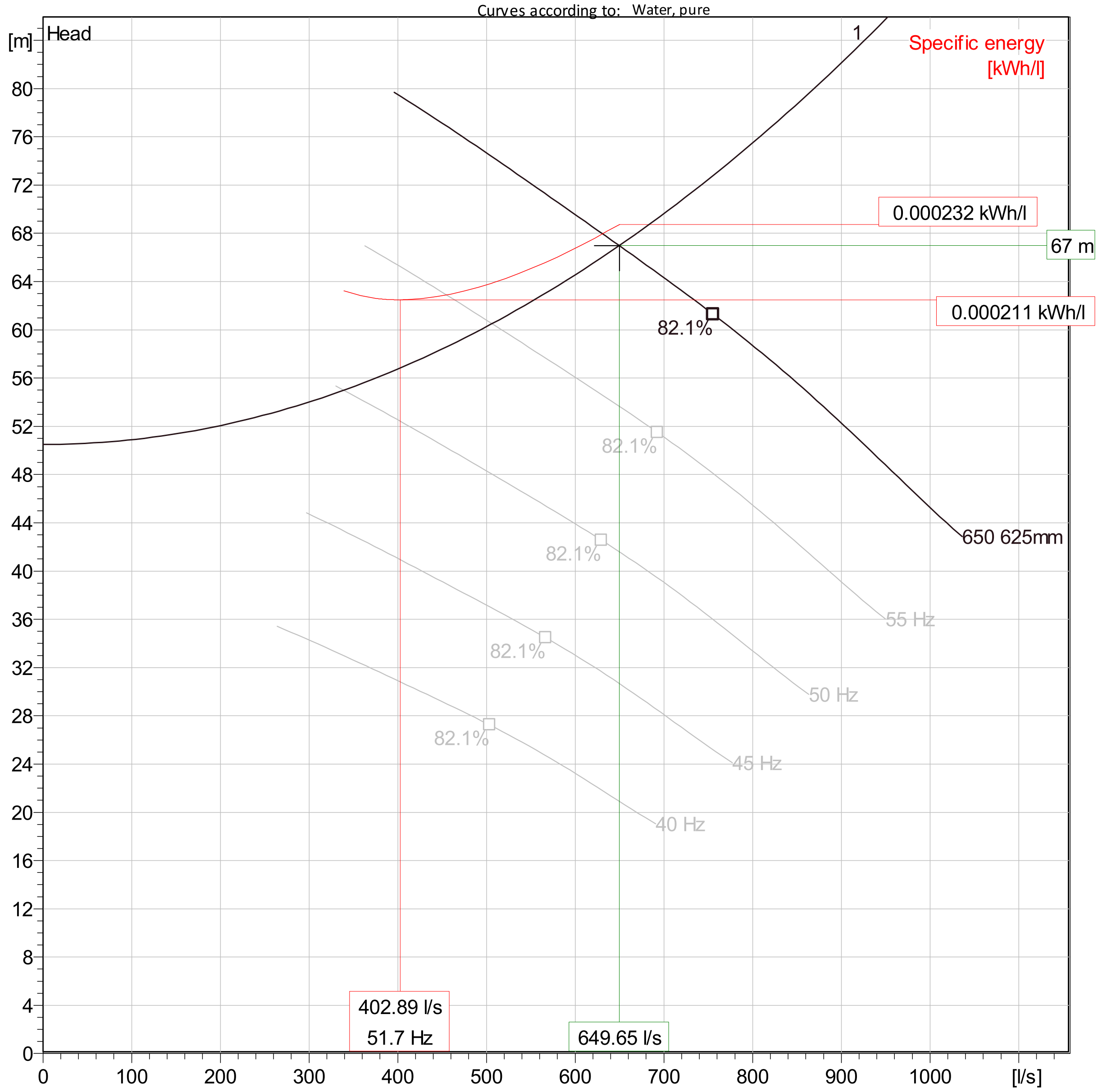


Curve: ISO 9906

Project		**Created by**	Marius Bocu		
Block	0	**Created on**	6/3/2021	**Last update**	6/3/2021

CT 3351/936 3~ 650

VFD Analysis



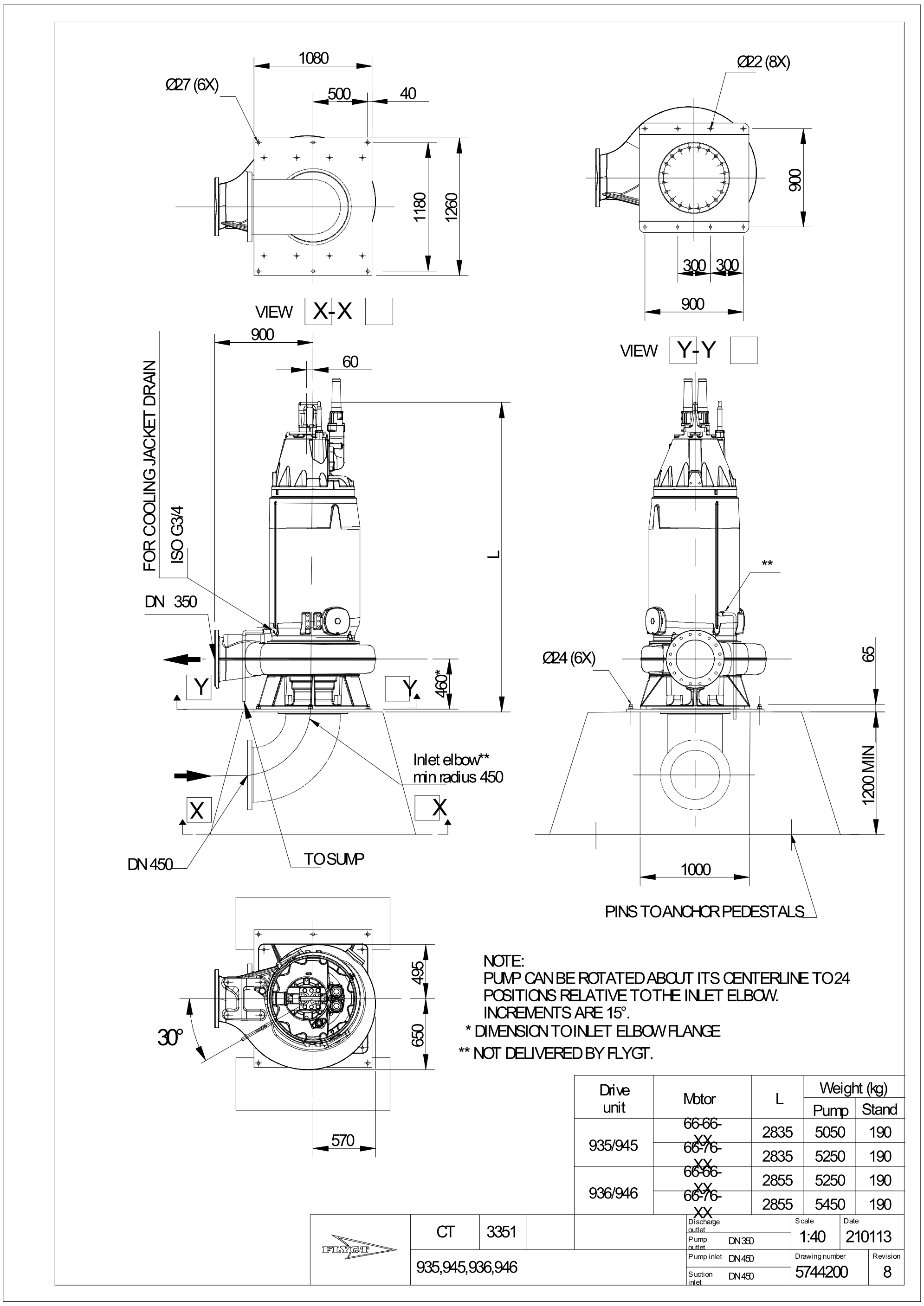
Operating characteristics

Pumps / Systems	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific Energy	NPSHre
1	60 Hz	650 l/s	67 m	706 hp	650 l/s	67 m	706 hp	81.1 %	0.000232 kWh	7.75 m
1	55 Hz	507 l/s	60.5 m	511 hp	507 l/s	60.5 m	511 hp	79 %	0.000216 kWh	6.27 m
1	50 Hz	340 l/s	55 m	336 hp	340 l/s	55 m	336 hp	73.1 %	0.000214 kWh	5.46 m
1	45 Hz									
1	40 Hz									

Project		**Created by**	Marius Bocu		
Block	0	**Created on**	6/3/2021	**Last update**	6/3/2021

CT 3351/936 3~ 650

Dimensional drawing



Project		**Created by**	Marius Bocu
Block	0	**Created on**	6/3/2021 **Last update** 6/3/2021

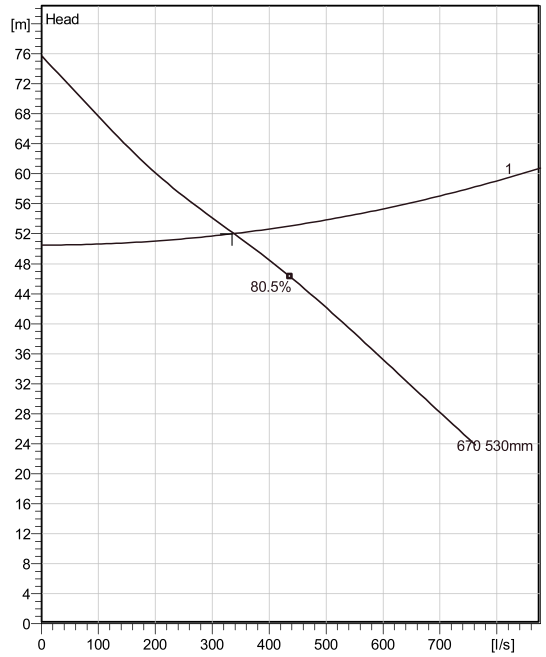
NT 3312/836 3~ 670

Patented self cleaning semi-open channel impeller, ideal for pumping in most waste water applications. Possible to be upgraded with Guide-pin® for even better clogging resistance. Modular based design with high adaptation grade.

FLYGT
a xylem brand

Technical specification

Curves according to: Water, pure ,4 °C,62.428 lb/ft³,1.6889E-5 ft²/s



Curve: ISO 9906

Configuration

Motor number
N0836.000 54-52-6ID-D IE3 385hp

Installation type
T - Vertical Permanent, Dry

Impeller diameter
530 mm

Discharge diameter
0.3 m

Pump information

Impeller diameter
530 mm

Discharge diameter
0.3 m

Inlet diameter
350 mm

Maximum operating speed
1190 rpm

Number of blades
3

Max. fluid temperature
40 °C

Materials

Impeller
Grey cast iron

Project		**Created by**	Marius Bocu		
Block	0	**Created on**	6/3/2021	**Last update**	6/3/2021

NT 3312/836 3~ 670

Technical specification

Motor - General

Motor number N0836.000 54-52-6ID-D IE3 385hp	**Phases** 3~	**Rated speed** 1190 rpm	**Rated power** 385 hp
Approval No	**Number of poles** 6	**Rated current** 335 A	**Stator variant** 2
Frequency 60 Hz	**Rated voltage** 600 V	**Insulation class** H	**Type of Duty**
Version code 000			

Motor - Technical

Power factor - 1/1 Load 0.86	**Motor efficiency - 1/1 Load** 96.3 %	**Total moment of inertia** 9.02 kg m²	**Starts per hour max.** 0
Power factor - 3/4 Load 0.82	**Motor efficiency - 3/4 Load** 96.7 %	**Starting current, direct starting** 2430 A	
Power factor - 1/2 Load 0.73	**Motor efficiency - 1/2 Load** 96.7 %	**Starting current, star-delta** 810 A	

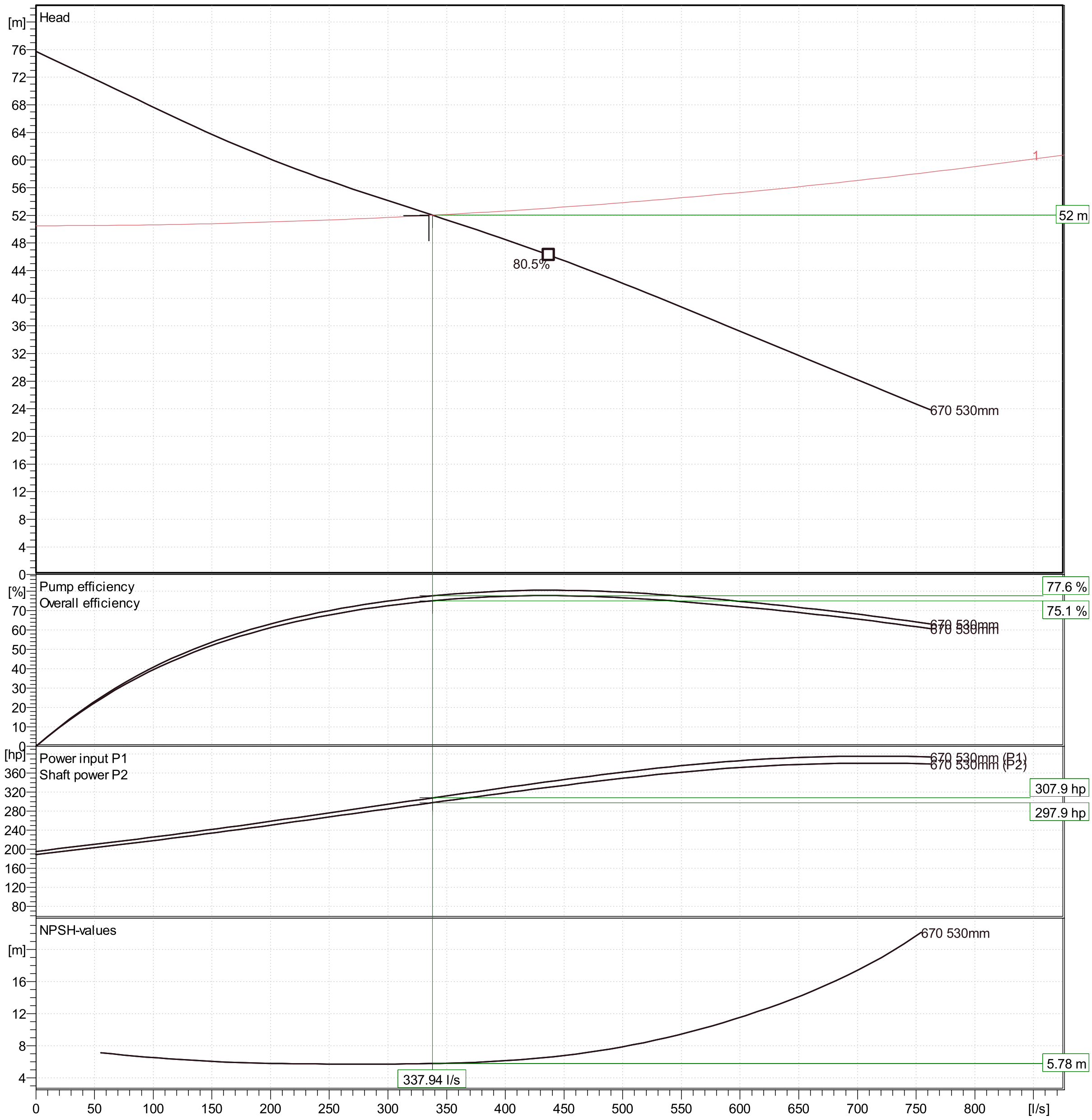
NT 3312/836 3~ 670

Performance curve

Duty point

Flow	Head
335 l/s	52 m

Curves according to: Water, pure 4 °C, 62.428 lb/ft³, 1.6889E-5 ft²/s



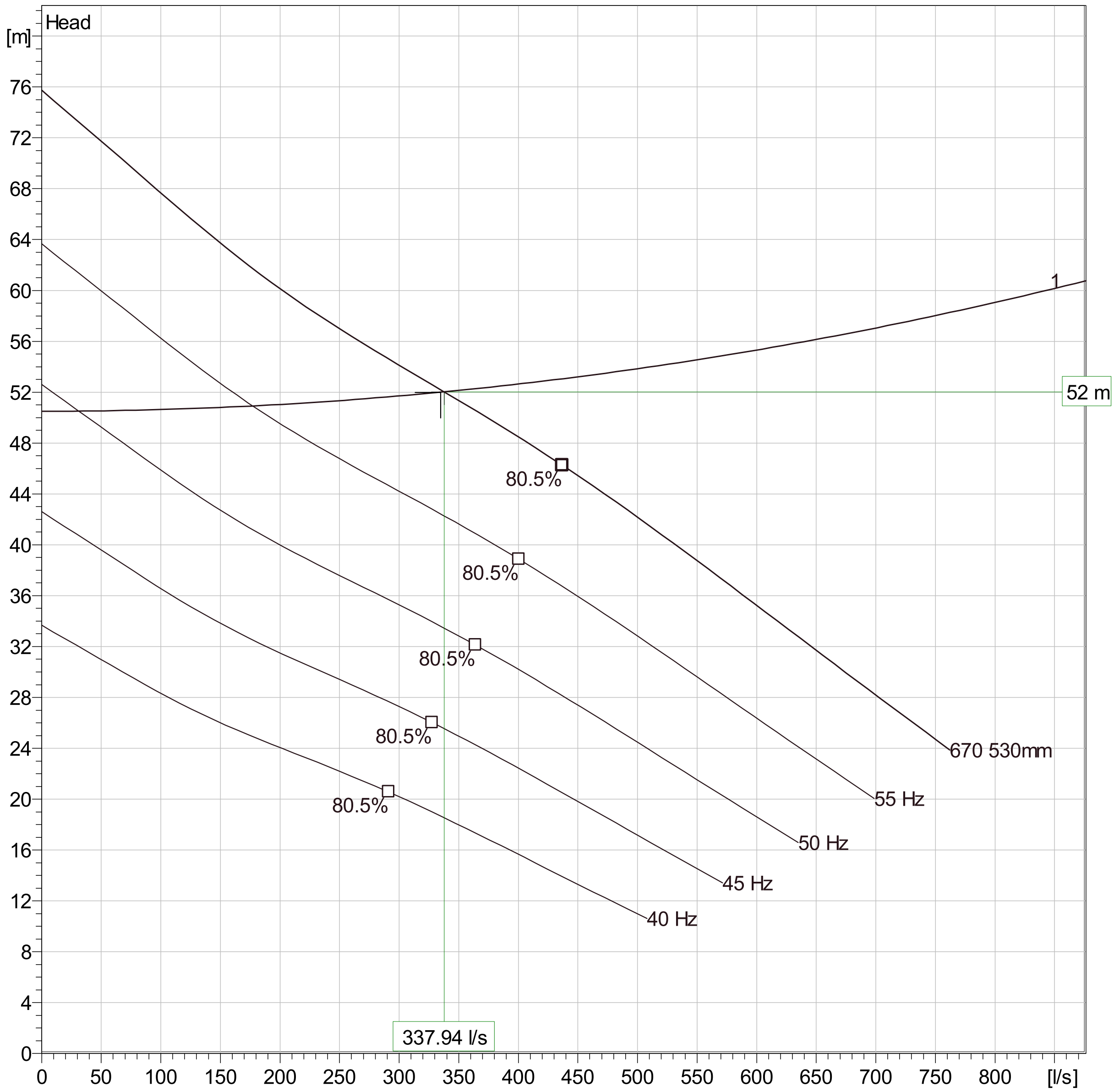
Curve: ISO 9906

Project		**Created by**	Marius Bocu		
Block	0	**Created on**	6/3/2021	**Last update**	6/3/2021

NT 3312/836 3~ 670

Duty Analysis

Curves according to: Water, pure ,4 °C,62.428 lb/ft³,1.6889E-5 ft²/s



Operating characteristics

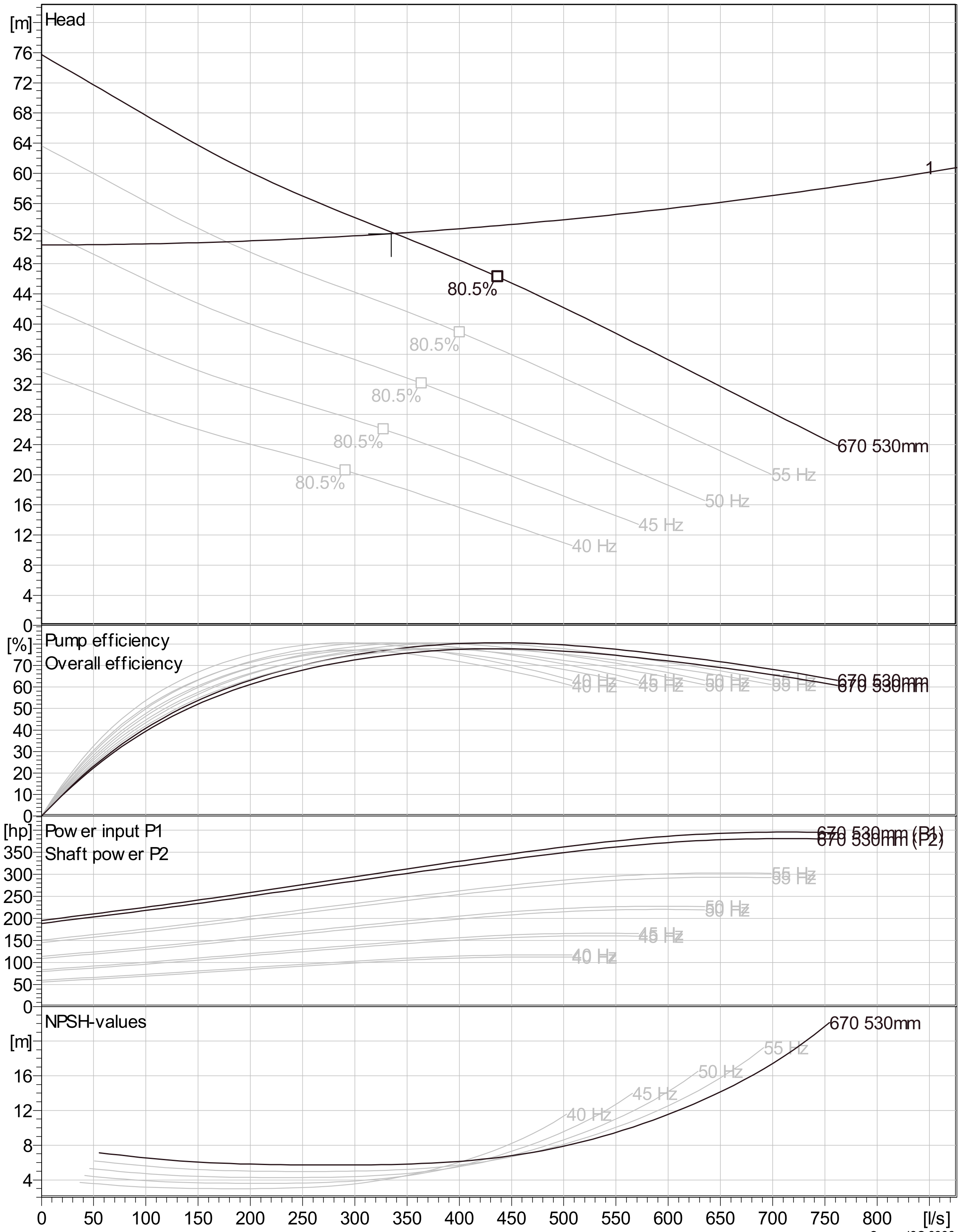
Pumps / Systems	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific Energy	NPSHre
1	335 l/s	52 m	297 hp	335 l/s	52 m	297 hp	77.5 %	0.00019 kWh/	5.78 m

Project		**Created by**	Marius Bocu		
Block	0	**Created on**	6/3/2021	**Last update**	6/3/2021

NT 3312/836 3~ 670

VFD Curve

Curves according to: Water, pure , 4 °C, 62.428 lb/ft³, 1.6889E-5 ft²/s



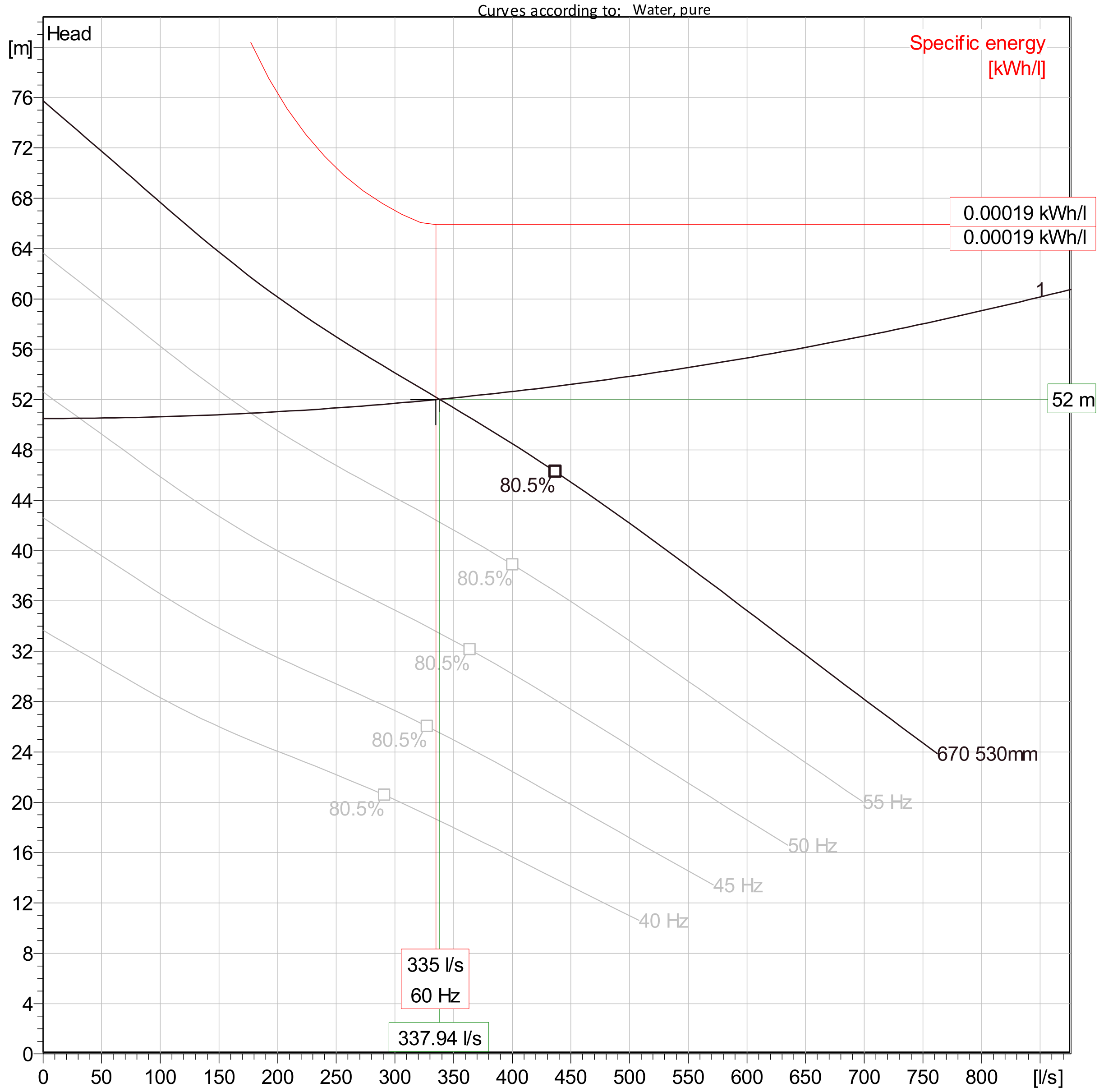
Curve: ISO 9906

Project		**Created by**	Marius Bocu		
Block	0	**Created on**	6/3/2021	**Last update**	6/3/2021

NT 3312/836 3~ 670

VFD Analysis

a xylem brand



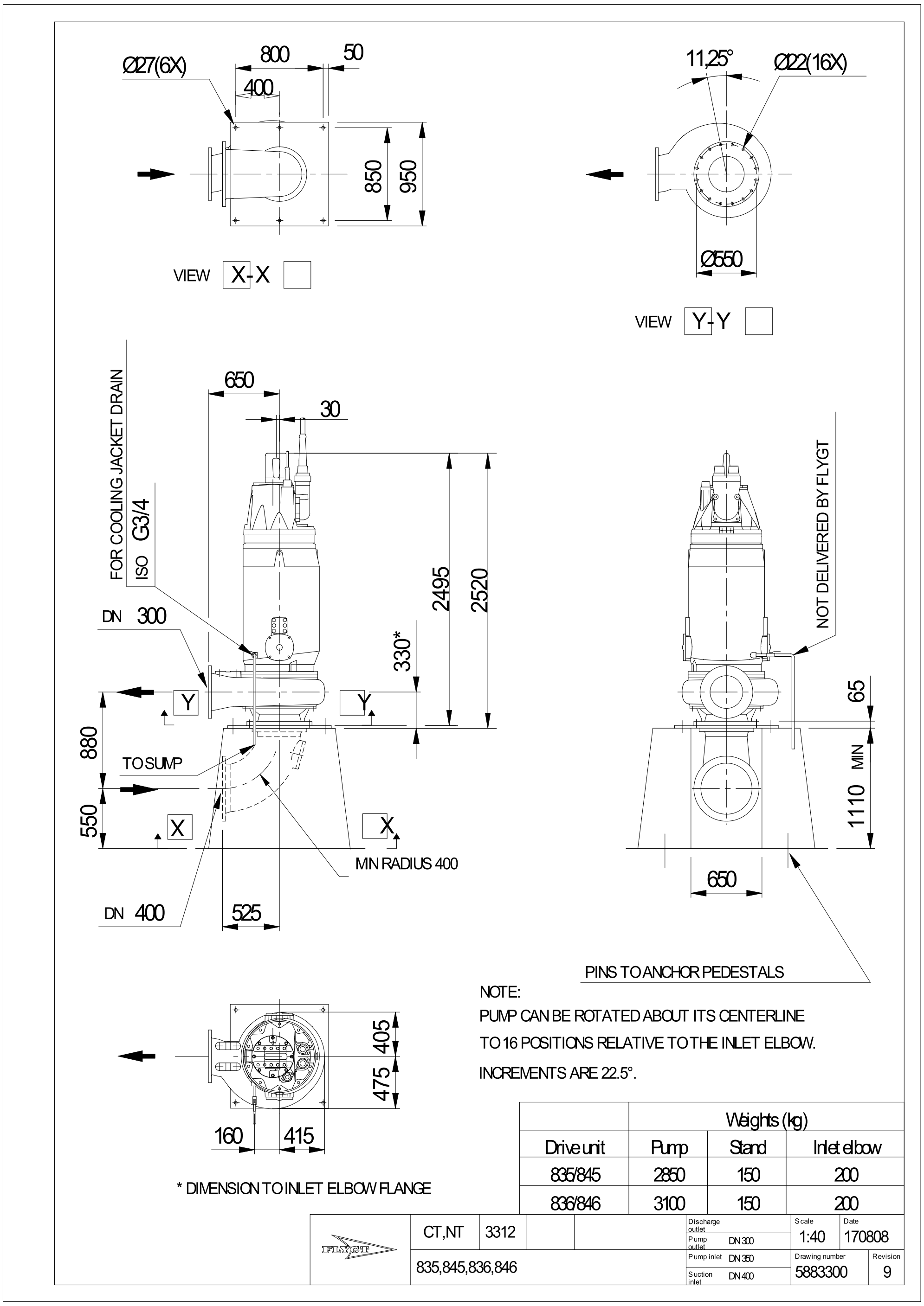
Operating characteristics

Pumps / Systems	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific Energy	NPSHre
1	60 Hz	335 l/s	52 m	297 hp	335 l/s	52 m	297 hp	77.5 %	0.00019 kWh	5.78 m
1	55 Hz	177 l/s	50.9 m	191 hp	177 l/s	50.9 m	191 hp	62 %	0.000231 kWh	5.08 m
1	50 Hz	31.3 l/s	50.5 m	116 hp	31.3 l/s	50.5 m	116 hp	18 %	0.000797 kWh	
1	45 Hz									
1	40 Hz									

Project		**Created by**	Marius Bocu
Block	0	**Created on**	6/3/2021 **Last update** 6/3/2021

NT 3312/836 3~ 670

Dimensional drawing



	Weights (kg)		
Drive unit	Pump	Stand	Inlet elbow
835/845	2850	150	200
836/846	3100	150	200

Project		**Created by**	Marius Bocu	
Block	0	**Created on**	6/3/2021	**Last update** 6/3/2021

APPENDIX B - COST ESTIMATE BREAKDOWN

Class C Cost Estimate (Note 1)

Client: Regional District of Nanaimo
Subject: Departure Bay Pump Station Phase 1 Upgrades

Date: 10-Sep-21
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

Cost Estimate Summary

1	**DIRECT COSTS**				Note 2
1.1	**SITE DEVELOPMENT**		$	110,000	
1.2	**SITE WORKS**		$	450,000	
1.3	**STRUCTURAL AND ARCHITECTURAL**		$	3,480,000	
1.4	**MECHANICAL**		$	1,550,000	
1.5	**ELECTRICAL, INSTRUMENTATION & CONTROLS**		$	3,883,000	
1.6	**MAJOR EQUIPMENT SUPPLY**		$	2,929,000	
1.7	**CONTRACTOR OH&P**	10%	$	937,000	Note 3
1.8	**INSURANCE AND FEES**	1%	$	123,000	Note 4
	Subtotal Direct Costs		$	13,462,000	
2	**INDIRECT COSTS**				
2.1	**Engineering (Design and Construction)**	12%	$	1,616,000	
2.2	**Environmental Requirements**		$	100,000	Note 5
2.3	**Allowances for Indirect Items During Construction**		$	100,000	Note 6
2.4	**Owner Overhead**	5%	$	674,000	Note 7
2.5	**Finance Costs**	0%			Note 8
	Subtotal Indirect Costs		$	2,490,000	
	Subtotal (Indirect + Direct)		$	15,952,000	
	Contingency	30%	$	4,786,000	Note 9
	Escalation (to 2022)	2.5%	$	519,000	Note 10
	TOTAL PROJECT COST ESTIMATE		**$**	**21,257,000**	

NOTES:
1. Class C Cost Estimate defined as per Engineering and Geoscientists British Columbia (EGBC)
2. GST has been excluded from the estimate. PST has been included, where applicable.
3. A 10% rate on Items 1.2 through 1.6 was applied to cover Contractor Overhead and Profit (OH&P).
4. A 1% rate on Items 1.2 through 1.6 was applied to cover Contractor insurance, bonding and other fees.
5. Provisional sum intended for environmental professional services during the design and construction of the upgrades.
6. Indirect allowances include items such as fuel for bypass pumping, and other temporary works required by RDN during construction.
7. Costs include Owner Project Management and Coordination, Administration Services, Review of Deliverables, and Owner's Training Costs. and Owner Operations
8. Assumes that the RDN is not borrowing money for the project.
9. Percentage is per CSA recommendations for a complex Class D estimate. For many items, provisional sums have been instituted. For the pumps and VFDs, quotes were obtained from suppliers.
10. Escalation to account for inflation of the construction market between 2021 and 2022, the estimated project start.

Cost Estimate

Client: **Regional District of Nanaimo**
Subject: **Departure Bay Pump Station Phase 1 Upgrades**

Date: Sep 10, 2021
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

Site Development

Item	Description	Qty.	Units	Unit Price	Extension
1	BC Hydro Electrical Upgrade Contribution	1	LS	100,000	100,000
2	Telus / Communications Service	1	LS	10,000	10,000
3		0	ea	1	-
4		0	ea	1	-
5		0	ea	1	-
6		0	ea	1	-
7		0	ea	1	-
8		0	ea	1	-
9		0	ea	1	-
10		0	ea	1	-
11		0	ea	1	-
12		0	ea	1	-
13		0	ea	1	-
14		0	ea	1	-
15		0	ea	1	-
16		0	ea	1	-
17		0	ea	1	-
18		0	ea	1	-
19		0	ea	1	-
20		0	ea	1	-
	Subtotal				**$ 110,000**

Associated Engineering | GLOBAL PERSPECTIVE LOCAL FOCUS.

Cost Estimate

Client: **Regional District of Nanaimo**
Subject: **Departure Bay Pump Station Phase 1 Upgrades**

Date: Sep 10, 2021
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

Site Works

Item	Description	Qty.	Units	Unit Price	Extension
1	Site Grading, surfacing (asphalt), and other site drainage	1	allowance	100,000	100,000
2	Fencing, Landscaping and Tree Protection	1	allowance	40,000	40,000
3	Demolition	1	allowance	150,000	150,000
4	Sealing / replacement of ducting systems	1	allowance	20,000	20,000
5	Sealing of manholes and valve operator boxes	1	allowance	20,000	20,000
6	Forcemain tie-ins	1	allowance	100,000	100,000
7	Venting Requirements	1	allowance	20,000	20,000
8		0	ea	1	-
9		0	ea	1	-
10		0	ea	1	-
11		0	ea	1	-
12		0	ea	1	-
13		0	ea	1	-
14		0	ea	1	-
15		0	ea	1	-
16		0	ea	1	-
17		0	ea	1	-
18		0	ea	1	-
19		0	ea	1	-
20		0	ea	1	-
	Subtotal				**$ 450,000**

Associated Engineering GLOBAL PERSPECTIVE LOCAL FOCUS.

Cost Estimate

Client: **Regional District of Nanaimo**
Subject: **Departure Bay Pump Station Phase 1 Upgrades**

Date: Sep 10, 2021
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

Structural and Architectural

Item	Description	Qty.	Units	Unit Price	Extension
1	Extending substructure to new FCL (dry well and wet-well access)	1	allowance	625,000	625,000
2	Structural modifications of Sub-Structure to meet code (stairs and seismic)	1	allowance	750,000	750,000
3	Structural modifications for pump configuration	1	allowance	75,000	75,000
4	Structural modifications to extend bay width	920	allowance	500	460,000
5	Misc. Structural Works	1	allowance	100,000	100,000
6	New Superstructure	1	allowance	1,020,000	1,020,000
7	Specialty Architectural Items	1	allowance	50,000	50,000
8	Grating and Steel Work	1	allowance	50,000	50,000
9	Crane Equipment	1	allowance	100,000	100,000
10	Painting and Finishing	1	allowance	30,000	30,000
11	Doors	1	allowance	40,000	40,000
12	Transformer and switchgear base	1	allowance	30,000	30,000
13	Fuel Tank Base + Corral	1	allowance	150,000	150,000
14					
15					
16					
17					
18					
19					
20					
	Subtotal				**$ 3,480,000**

Associated Engineering GLOBAL PERSPECTIVE LOCAL FOCUS.

Cost Estimate

Client: **Regional District of Nanaimo**
Subject: **Departure Bay Pump Station Phase 1 Upgrades**

Date: Sep 10, 2021
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

Process Mechanical

Item	Description	Qty.	Units	Unit Price	Extension
1	Piping	1	allowance	300,000	300,000
2	Valves	1	allowance	250,000	250,000
3	Specialty fittings	1	allowance	50,000	50,000
4	Misc. Supports and Hangers	1	allowance	55,000	55,000
5	Surge Anticipation and Other Speciality Valves	1	allowance	50,000	50,000
6	Sump Pump System	1	allowance	20,000	20,000
7	Alum Dosing system	1	allowance	30,000	30,000
8	Compressors	1	allowance	20,000	20,000
9	Misc. Mechanical Equipment	1	allowance	25,000	25,000
10	General Mechanical	1	allowance	150,000	150,000
11	Fuel Storage System Allowance	1	allowance	150,000	150,000
12		0	ea	1	-
13		0	ea	1	-
14		0	ea	1	-
15		0	ea	1	-
16		0	ea	1	-
17		0	ea	1	-
18		0	ea	1	-
19		0	ea	1	-
20		0	ea	1	-
	Subtotal				**$ 1,100,000**

Associated Engineering GLOBAL PERSPECTIVE LOCAL FOCUS.

Cost Estimate

Client: **Regional District of Nanaimo**
Subject: **Departure Bay Pump Station Phase 1 Upgrades**

Date: Sep 10, 2021
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

Building Mechanical

Item	Description	Qty.	Units	Unit Price	Extension
1	Emergency Equipment	1	allowance	10,000	10,000
2	Generator Room Venitllation System	1	allowance	100,000	100,000
3	General Ventillation System	1	allowance	180,000	180,000
4	Odour Control System	1	allowance	60,000	60,000
5	Plumbing Installation	1	allowance	25,000	25,000
6	General Building Mechanical Items	1	allowance	50,000	50,000
7	Noise attenuation system	1	allowance	25,000	25,000
8		0	ea	1	-
9		0	ea	1	-
10		0	ea	1	-
11		0	ea	1	-
12		0	ea	1	-
13		0	ea	1	-
14		0	ea	1	-
15		0	ea	1	-
16		0	ea	1	-
17		0	ea	1	-
18		0	ea	1	-
19		0	ea	1	-
20		0	ea	1	-
	Subtotal				**$ 450,000**

Cost Estimate

Client: **Regional District of Nanaimo**
Subject: **Departure Bay Pump Station Phase 1 Upgrades**

Date: Sep 10, 2021
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

Electrical

Item	Description	Qty.	Units	Unit Price	Extension
1	Motor Control Centre	1	ea	463,252	464,000
2	VFDs	1	ea	1,004,701	1,005,000
3	General Electrical Installation	1	allowance	2,203,500	2,204,000
4		0	ea	1	-
5		0	ea	1	-
6		0	ea	1	-
7		0	ea	1	-
8		0	ea	1	-
9		0	ea	1	-
10		0	ea	1	-
11		0	ea	1	-
12		0	ea	1	-
13		0	ea	1	-
14		0	ea	1	-
15		0	ea	1	-
16		0	ea	1	-
17		0	ea	1	-
18		0	ea	1	-
19		0	ea	1	-
20		0	ea	1	-
	Subtotal				**$ 3,673,000**

Associated Engineering GLOBAL PERSPECTIVE LOCAL FOCUS.

Cost Estimate

Client: **Regional District of Nanaimo**
Subject: **Departure Bay Pump Station Phase 1 Upgrades**

Date: Sep 10, 2021
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

Instrumentation & Controls

Item	Description	Qty.	Units	Unit Price	Extension
1	New flowmeters	2	allowance	10,000	20,000
2	Level instruments	1	allowance	20,000	20,000
3	Control Panel	1	allowance	30,000	30,000
4	Programming and Integration	1	allowance	100,000	100,000
5	Computer and Software	1	allowance	20,000	20,000
6	Misc. instruments	1	allowance	20,000	20,000
7		0	ea	1	-
8		0	ea	1	-
9		0	ea	1	-
10		0	ea	1	-
11		0	ea	1	-
12		0	ea	1	-
13		0	ea	1	-
14		0	ea	1	-
15		0	ea	1	-
16		0	ea	1	-
17		0	ea	1	-
18		0	ea	1	-
19		0	ea	1	-
20		0	ea	1	-
	Subtotal				**$ 210,000**

Cost Estimate

Client: **Regional District of Nanaimo**
Subject: **Departure Bay Pump Station Phase 1 Upgrades**

Date: Sep 10, 2021
Project Number: 2020-2083
Prepared By: SW/SB
Checked by: AM
Type of Estimate: Conceptual

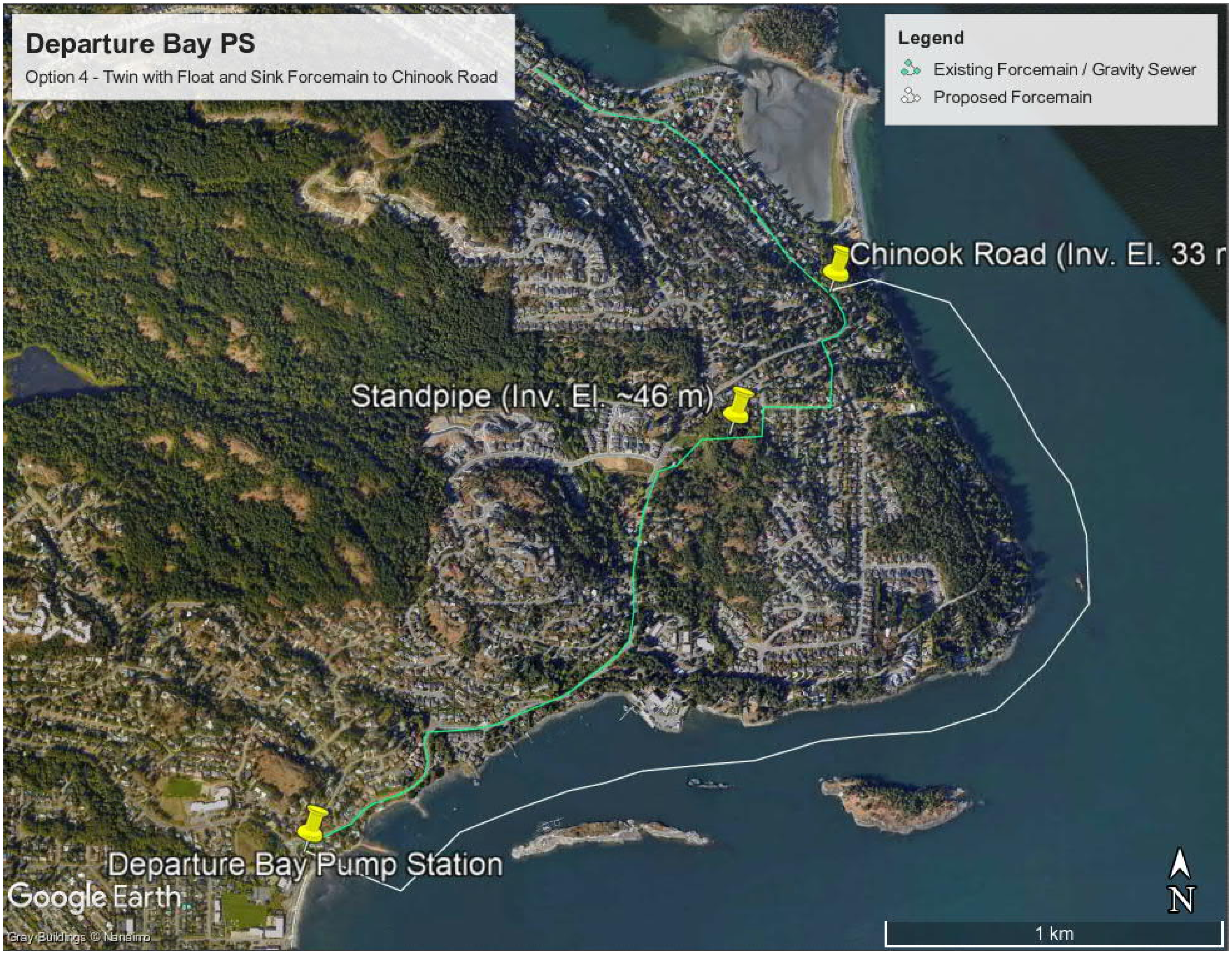
Equipment Supply

Item	Description	Qty.	Units	Unit Price	Extension
1	Flygt CT 3351.936 DU 650 impeller (625mm) 765HP 600V 3phase, closed	3	allowance	522,963	1,569,000
2	Generators	2	allowance	530,000	1,060,000
3	Unit Substation Upgrade	1	allowance	300,000	300,000
4		0	ea	1	-
5		0	ea	1	-
6		0	ea	1	-
7		0	ea	1	-
8		0	ea	1	-
9		0	ea	1	-
10		0	ea	1	-
11		0	ea	1	-
12		0	ea	1	-
13		0	ea	1	-
14		0	ea	1	-
15		0	ea	1	-
16		0	ea	1	-
17		0	ea	1	-
18		0	ea	1	-
19		0	ea	1	-
20		0	ea	1	-
	Subtotal				**$ 2,929,000**

APPENDIX C - COMMENT LOG

Comment Log		
Page Number (of DRAFT PDF)	Comment	Response
14/47	Please confirm with Ops if Pump #4 has an ECD	RDN confirmed that the starter for Pump 4 is a direct "across the line" starter. Associated updated the report.
19	Confirm that the GNPCC existing headworks capacity is 1,800 L/s	RDN confirmed that the headworks has a design PWWF capacity of 2240 l/s, which can be increased to 3360 l/s through the addition of a fourth screen. However, the influent channel capacity will be the limiting factor in achieving these flows. A comment was added that a capacity upgrade should be considered with the design of the upgrades at the DBPS
21	Add word "be" between to and operable	Comment Addressed.
23/24	Add Option D Twin the upstream forcemain with float and sink alignment making landfall at Chinook Road. (~32 m elevation and tie-in) This would follow twinning of the gravity main from this future connection point. How will this system curve effect required pump sizing and power requirements? Estimated GHG reductions over the lifespan of the PS? Additional permitting and other requirements?	Option D is a possible route that should be evaluated during future work by the RDN. Attached hereto is some considerations regarding Option D, as well as the benefits and disadvantages. Looking at this option in greater detail will be undertaken separate to this work.
24	Add word "of" in between use and an	Comment Addressed.
24/25	What is the recommendation for the air relief valve at Hammond Bay and Friar Tuck? Will repair of this valve in any way affect the forcemain hydraulics? Will replacing the standpipe with an air valve increase capacity as well?	The forcemain upgrade work was not looked at in great detail. Associated has added comments that these valves should be considered in future phases of work as per the 2020 AECOM Transient Analysis project.
25	Ops reports that Pump #3 needs replacing as well, in Phase 1.	Associated has updated the report text and cost estimate to reflect this change.
26/45	How does the location and potential flooding of Departure Creek get addressed in these options?	Departure Creek was not considered in great detail. A note was added that the design should consider flooding potential of Departure Creek in the context of the upgrade work. In terms of construction, language was added that environmental monitoring requirements for the creek / riparian zone need to be considered .
27	How will access to the wet well be maintained for maintenance? (in regards to raising the entire superstructure above the FCL)	New staircase from the FCL down to the wet-well would provide access for maintenance. Note was added in report.
28	Can a staircase to the lower pipe chase be added to remove the confined space classification?	It may be quite costly to do this, and actions could be undertaken to limit the need to go into this area. For example, valve operators could be brought up to floor level. Associated has added a note clarifying the design intent for this space.
28	The existing bridge crane will need to be upgraded to allow for better and safer lifting access	Yes, this was the intention and additional language has been added.
40	Primary isolation valves should be located within the PS	Yes, this was the intention and additional language has been added.
40	What kind of check valves are we proposing, and how will all the new valves be controlled?	Details for valve type to be confirmed at a later phase.
41	Remote control of the wet well gates?	We have added a general note about increasing automation and remote control of valves. We have also added a note regarding future requirement to perform a process hazard analysis in future design phases.
48	Add "e" in word separate	Comment Addressed.
48	Will air monitoring be required in this generator area?	Significant ventilation in generator room will be required. We have assumed that no air monitoring will be required. . Other options that can reduce ventilation requirements including use of water-cooled generators. We have added a comment that air requirements for the generators will be addressed in preliminary design.
48	Existing wet well lighting requires upgrade	Note added.

OPTION D – NEW MARINE FORCEMAIN TO CHINOOK ROAD



Options and Advantages and Disadvantages for Proposed New Marine Forcemain to Chinook Road

Option No. and Description	Advantages	Disadvantages

Option D1
New marine line to Chinook Road is used as the primary pumping forcemain for low to medium flows.
During peak flows, flow is split between new forcemain and existing forcemain.
	• Can size for optimum flowrates in the new forcemain for scour velocities.
	• Better hydraulics at lower flows (less static lift)
	  • Lower operational costs
	  • Lower installation costs (assumed, may not be the case)
		• May require different pumps to accommodate higher heads at peak flows (using both forcemains, both static and dynamic losses would increase)
		• Permitting requirements for marine work could be challenging. Untreated wastewater would be in the forcemain (not treated effluent like in an outfall). Environmental risk needs to be considered.
		• Failure of the forcemain (e.g. seismic event) would be very challenging. Repair would be difficult, and pumping capacity would be lost for months.

Option D2 New marine forcemain to Chinook Road is installed, but flow is split between the existing and new forcemain under normal operating conditions.	• Gives the most flexibility for operation (lower risk)	• Would lose the hydraulic advantage because the systems are coupled, and the pumps would be designed for the higher hydraulic requirements • Permitting requirements for marine work could be challenging. Untreated wastewater would be in the forcemain (not treated effluent like in an outfall). Environmental risk needs to be considered. • Failure of the forcemain (e.g. seismic event) would be very challenging. Repair would be difficult, and pumping capacity would be lost for months.
Option D3 New marine forcemain to Chinook Road would be used as the Primary Pumping forcemain for all flow conditions	• Energy savings at lower flows	• At the higher flow, TDH would be significant with the need to meet scour velocities at lower flow. Extra pumping units may be required for higher flows.

Option No. and Description	Advantages	Disadvantages
This existing forcemain would be mothballed.		• Permitting requirements for marine work could be challenging. Untreated wastewater would be in the forcemain (not treated effluent like in an outfall). Environmental risk needs to be considered. • Failure of the forcemain (e.g. seismic event) would be very challenging. Repair would be difficult, and pumping capacity would be lost for months. Risk would be higher than Options D1 and D2 since the existing system would be mothballed. • Capital costs would go up (assuming that different pumps will be required at peak flows). Pump station may need to be bigger as a result.
Option D4 Two new marine forcemains to Chinook Road (twinned). One forcemain is used under low and average flow conditions. Two forcemains are used during peak flow conditions. The existing forcemain would be mothballed.	• Energy savings at low and average flows. • One set of pumps for low, average and peak flows • Flexibility	• Capital cost would be the high (construction of two forcemains, instead of one) • Permitting requirements for marine work could be challenging. Untreated wastewater would be in the forcemain (not treated effluent like in an outfall). Environmental risk needs to be considered. • Failure of the forcemain (e.g. seismic event) would be very challenging. Repair would be difficult, and pumping capacity would be lost for months. Risk would be higher than Options D1 and D2 since the existing system would be mothballed.

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TECHNICAL MEMORANDUM

Issue Date:	August 30, 2023	**File No.:**	2022-2483.01
To:	Gerald St. Pierre, P.Eng., PMP	**Previous Issue Date:**	N/A
From:	Shane Duggan, B. Eng., M. Eng.	**Project No.:**	2022-2483
Client:	Regional District of Nanaimo		
Project Name:	Departure Bay Pump Station		
Subject:	Departure Bay Pump Station Update to Pump Selections		

1 INTRODUCTION

The Departure Bay Pump Station (DBPS) and associated force main are owned and operated by the Regional District of Nanaimo (RDN). The DBPS is a wastewater pump station located at Departure Bay, within the City of Nanaimo. The infrastructure is in its fifth decade of operation and is requiring replacement/upgrading to address the aging infrastructure and to meet current demands.

In 2021, Associated Engineering (B.C) Ltd. (Associated) prepared a Departure Bay Pump Station Upgrade Study, which proposed two phases of upgrades at the DBPS to achieve a firm capacity at peak wet weather flow (PWWF) conditions in 2073 of 1,955 L/s.

The objective of this memorandum is to revise the pump replacement selection for the DBPS with consideration of the following:

- The Nanaimo Interceptor Hydraulic Capacity Analysis (GeoAdvice Engineering Inc. 2023) has set a new design basis for the upgrades in the PWWF for the year 2076 of 2,460 L/s.
- The Hammond Bay Options Analysis Report (Associated Engineering 2022) provides updated options for the required force main upgrades that will support the pump upgrades.

With the pump updates, the RDN is interested in confirming any changes to the required power needs to support the BC Hydro power supply application process. This report will detail the revised pump selection, the reasoning for their selection, and the new pump's cost and power requirements. Please refer to **Section 4**.

2 BACKGROUND

2.1 DBPS and Previous Work

The DBPS pumps wastewater through an existing 900 mm, 4 km long force main, along Hammond Bay Road, from the Departure Bay Pump Station to the Hammond Bay Interceptor Sewer, which directs the effluent to the downstream Greater Nanaimo Pollution Control center for treatment.

The DBPS was built in 1974, and although the facility has undergone a variety of upgrades, the station is essentially in its original form. As the facility is in its fifth decade of operation, the DBPS has some underlying challenges. In recent years, the DBPS has not always been able to keep up with flow capacity during peak flow conditions. During peak events, all pumps must operate at full capacity. In addition, on some occasions, peak flow has caused overflowing of the wastewater collection system.

In 2013, AECOM evaluated routing options for a replacement line. Five routing options were developed and costed. In early February 2022, RDN evaluated and refined the 2013 options to the following:

- Twinning the force main along its existing alignment.
- Twinning the force main along an extended marine float and sink route, making landfall at Chinook Road.

Associated's 2022 Hammond Bay Option's Analysis considered both the Marine Route and Land Route. For this assessment, it was decided to proceed only with the land route due to some significant advantages – e.g., relatively easy access to the force main for operation and maintenance and lower capital construction costs.

Based on preliminary hydraulic analysis, the new force main pipe diameter of 1050 mm, and HDPE DR17 were selected, to address modifications in the alignment and capacity.

The Departure Bay Pump Station Upgrade Study proposed three 56 MLD pumps, and two 28 MLD pumps to handle the previously assessed capacity of 1,955 L/s. These pumps were rated at 765 hp and 385 hp, respectively. To operate these pumps, it was determined that the facility's power distribution system would need to accommodate a peak operating demand of approximately 2,460 kVA (1,939 kW). To achieve this, Associated recommended the following upgrades:

- Obtain a new electrical service from BC Hydro. Either a primary metered 2.5 MVA unit substation or a secondary metered, 2,500 Amp service (at 600 VAC).
- Upgrade distribution system to support a 2,500 Amp service at 600 VAC.
- Replace the existing genset with either 3 x 750 kW or 2 x 1,250 kW paralleled standby generators.

2.2 Updated Design Basis for Upgrades

The revised design criteria for the DBPS Upgrades can be summarized as follows:

- Flow Capacity.
  - The full build-out flow capacity design basis for the upgrades is 2,460 L/s. This value is based on InfoSWMM modelling of the Nanaimo Interceptor performed by GeoAdvice for the year 2076.
  - Upgrade the Departure Bay Pump Station force main to a minimum diameter of 1,050 mm and a maximum of 1,650 mm.
  - A minimum force main velocity of 1.1 m/s and a maximum force main velocity of 3 m/s is considered under the 2076-PWWF25 with Climate Change, Hydraulic Design Sizing Criteria.
- Redundancy Requirements.
  - The station must have sufficient capacity to pump peak design flow when the largest pump is out of service.

3 HYDRAULIC ANALYSIS

This section of the report describes the approach and results of hydraulic analyses conducted for the Land Route option for the new Hammond Bay Force main. The intent of the hydraulic analyses was primarily to determine and confirm appropriate pump selection and force main pipe sizing.

The analyses were conducted through SewerGems using the GVF-Convex (SewerCAD) active numerical solver, steady-state time analysis type. The pump, pump station, and wet well characteristics were inputted into the software. The 900 mm, 1,050 mm force main, and 1,350 mm gravity connector stations and corresponding pipe invert and ground elevations were also inputted. This represents a further refinement and holistic review of the conceptual force main system to obtain a reliable power supply size estimate under the updated design criteria.

The analysis considers the three large pumps installed under Phase 1, with the redundancy being provided by the two small pumps installed as part of Phase 2, both, together acting with the largest pump out of service.

3.1 Hydraulic Analysis at PWWF

This section has been revised to assess whether the 1050 mm force main operating in isolation, can meet the design basis of 2,460 L/s. The findings for the existing 900 mm force main operating in conjunction with the new land-based 1050 force main for higher flow conditions are also presented.

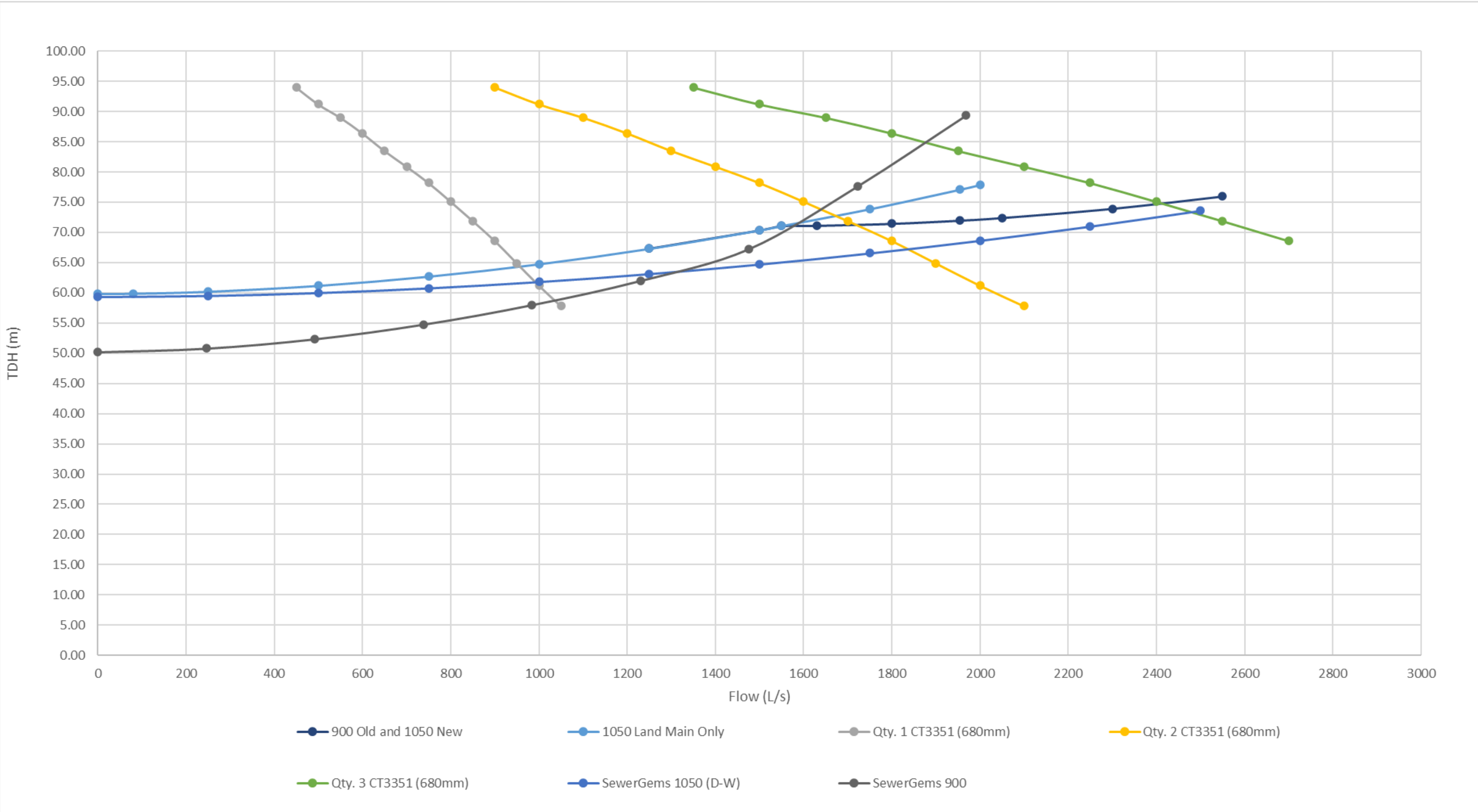
1050 mm DR17 HDPE has an inside pipe diameter of 934 mm. For this analysis, the Darcy-Weisbach gravity friction method within SewerGems was used. Operating as a single force main in conjunction with the DBPS, this new force main has the following system curve characteristics at the PWWF of 2,460 L/s:

- Static head: 59.9 m.
- Pump Station Losses: 1.65 m.
- Force main frictional losses: 16.32 m.

Refer to **Figure 3-1** for the developed system curve. Three pumps operating to deliver the PWWF of 2,460 L/s, through the 1,050 mm force main, would be sized at 820 L/s at 72 m TDH. The nominal pumping energy required would be 1,756 kW assuming a pump hydraulic efficiency of 82.8%.

The scenario in which the existing 900 mm force main would operate in conjunction with the new land-based 1,050 force main for higher flow conditions is also presented but is no longer required, given the 1,050 mm force main can meet the design basis. The value of using the two mains is limited from a hydraulics or energy efficiency perspective as the extreme high flows would be an infrequent occurance. The availability of the existing 900 mm steel force main as a backup to the new force main still provides an advantage in terms of system resiliency.

Figure 3-1 Developed System Curve for Land Routes



The hydraulic profile for the two force mains under max flow conditions are shown below. The X-axis, Station (m), indicates chainage distance along the pipe's routing. The Y-Axis, Elevation (m), accounts for the pipe invert elevation and corresponding ground elevation, at a given station.

Figure 3-2 illustrates three pumps operating through the 1,050mm force main only to overcome the high point in the system at Stn. 2,250 m. A siphon break is proposed at the high point at Stn. 2,250 m following which the pipe runs partially full between Stn. 2,250 m and 2,525 m.

Figure 3-2 HGL – 1050mm FM only with 3 Pumps Operating

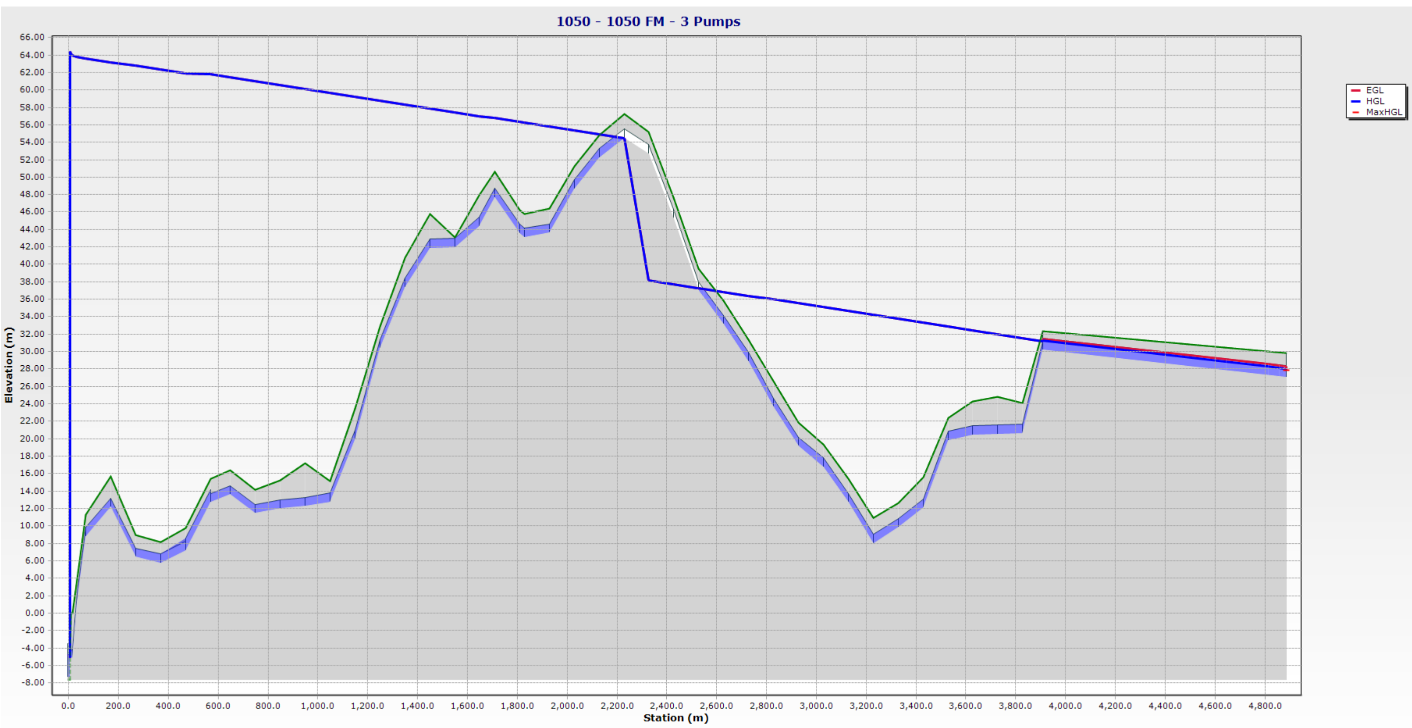


Figure 3-3 illustrates the HGL through the 1,050 mm force main for three pumps operating and both force mains open, overcoming the high point in the system at Stn. 2,250 m. A siphon break is proposed at the high point at Stn. 2,250 m following which the pipe runs partially full between Stn. 2,250 m and 2,525 m.

Figure 3-4 illustrates three pumps operating through the 900 mm force main, with both force mains open, overcoming the high point in the system at Stn. 2,050 m. A siphon break is proposed at the high point at Stn. 2,050 m following which the pipe runs partially full between Stn. 2,050 m and 2,650 m.

The 900 mm force main routing has a lower highpoint (45 m), than the proposed 1,050mm force main routing highpoint (55 m).

Figure 3-3 HGL – 1050mm FM Route w/ both Force mains open & 3 Pumps Operating

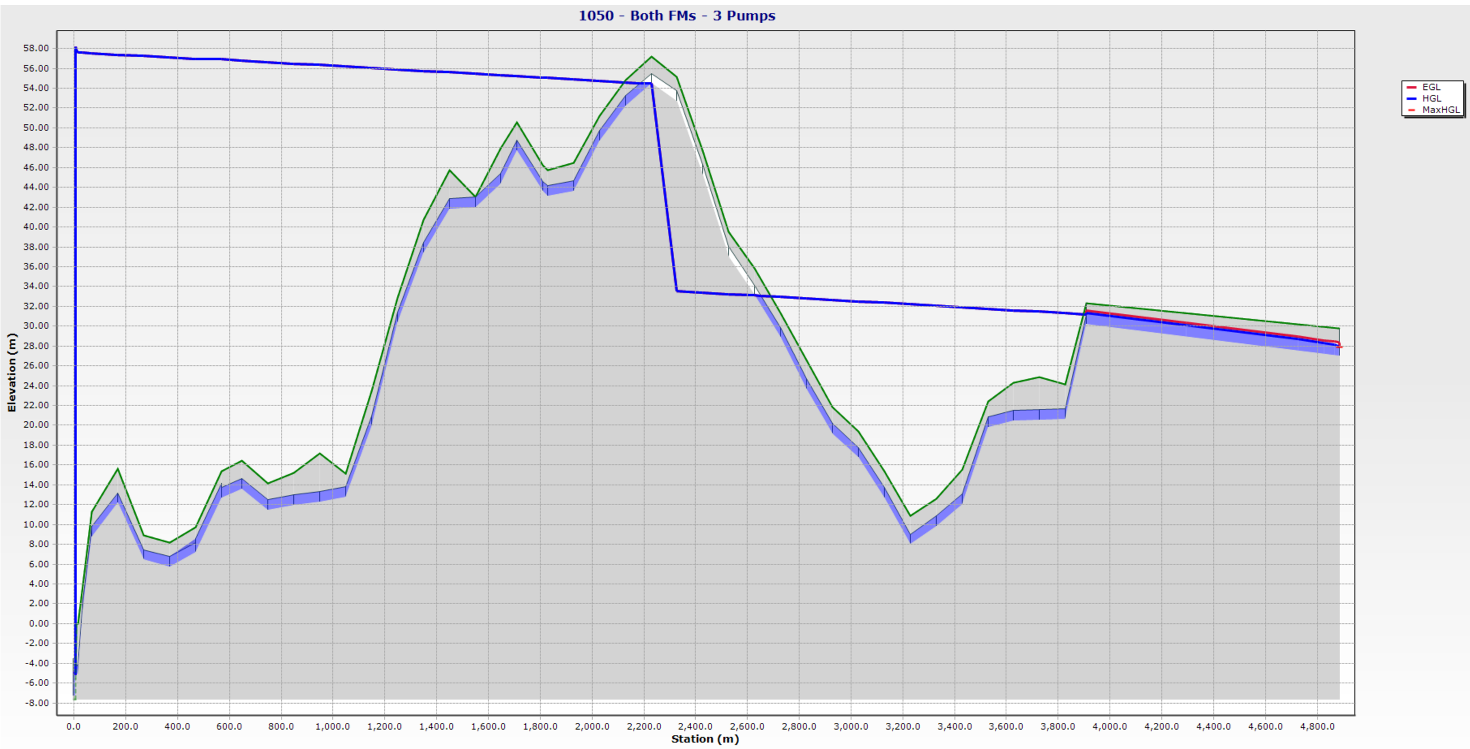
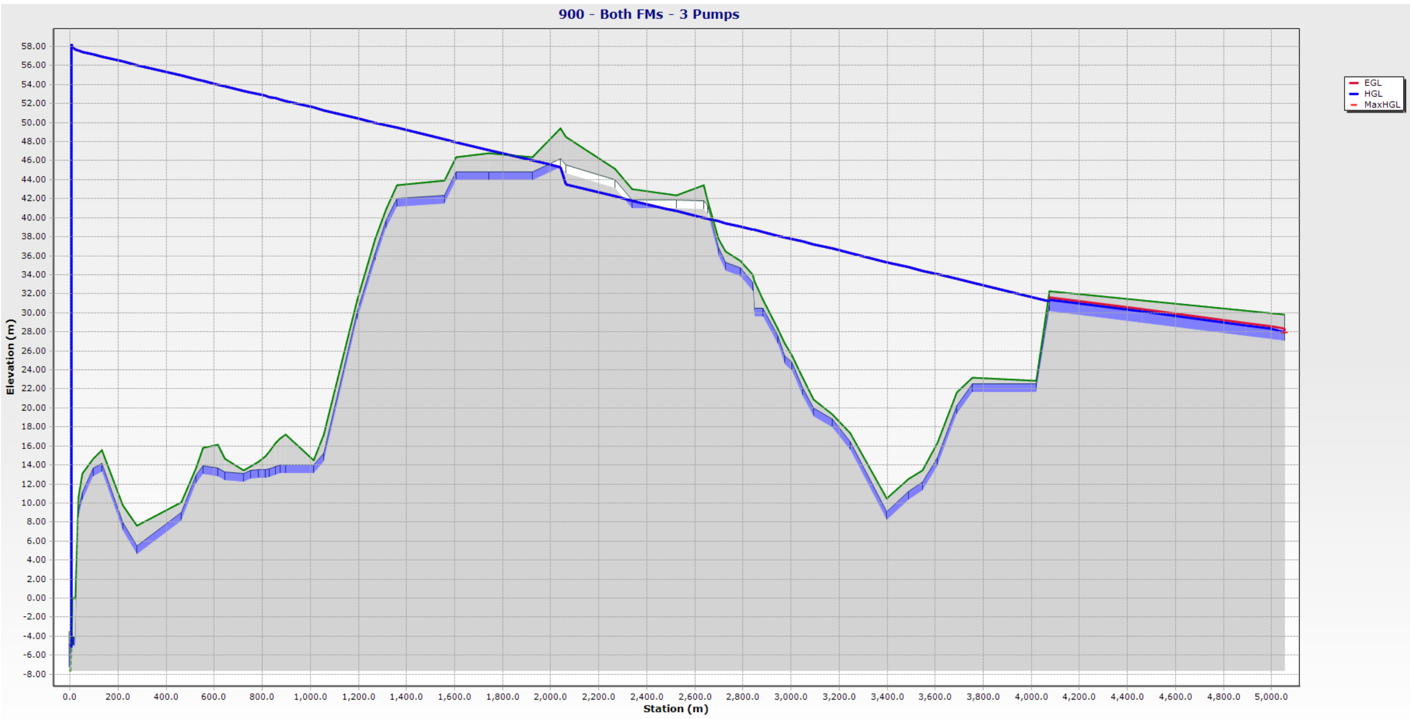


Figure 3-4 HGL – 900mm FM Route w/ both Force mains open & 3 Pumps Operating



The new 1050mm FM is able to convey the target flows, however, the 900 mm force main could be selected to operate in isolation during low flow conditions, given it is the smaller diameter pipe providing higher flow velocities for cleansing action during operation. The operational considerations of both the 900 mm and 1,050 mm force mains, individually, and/or together, are to be considered in later design stages. Further, the potential of installing two smaller pipes close together instead of one large pipe in support of preventing odour issues and maintenance concerns will also have to be assessed in subsequent design stages.

4 WASTEWATER PUMPING

4.1 Pump Selection

Pump selection was based on the full build-out scenario at 2,460 L/s. This flow rate will be achieved during the Phase 2 upgrades. To meet the capacity of 2,460 L/s, a total of five pumps will be provided: three pumps (Phase 1) at a nominal capacity of 820 L/s and two pumps (Phase 2) at a nominal capacity of 410 L/s. It is suggested that all the pumps will be provided with variable frequency drives (VFDs).

The five-pump solution will allow:

- The pump station is to provide a firm capacity of 2,460 L/s with any pump out of service for maintenance.
- The station to meet the full range of flows down to 80 L/s.

For the purposes of this study, Xylem Flygt immersible dry well pumps have been selected. The details on the proposed pump selections are provided in **Table 4-1**. Further details on the pumping units can be found on the pump specification sheets provided in **Appendix A**. Updated costing for the selected pumps is provided in **Section 4.2**.

Table 4-1 Pump Selection

	Model	Rated Power	Impeller Diameter	Rated Speed	No. of New Units Phase 1
Large Pump	CT 3351/965	1040 HP	680 mm	1195 RPM	3

*Phase 1 Pumps, only, are selected for the purpose of this analysis.

4.2 Pump Cost Comparison

Table 4-2 outlines a cost comparison between the newly selected pumps, for the purpose of this memo, and the previously selected pumps, from the 2021 Pump Station Upgrade Study.

Table 4-2 Pump Cost Comparison

Pump	Description	Qty.	Unit Price	Total
New Selection	Flygt CT3351.965 1040HP 625 mm impeller	3	$717,360	$2,153,000
Previous Selection	Flygt CT3351.936 765HP 680 mm impeller	3	$522,963	$1,569,000

4.3 Pump Layouts, Physical Size Limitations

The new CT 3351/965 pumps are of similar size to the existing Worthington model 10CFA-2 pumps, in terms of length, width, and height. The new pumps are about 300 mm and 240 mm bigger in length and width, as well as slightly taller than the existing pumps. Height constraints are not a concern as the new pumps are 3 m tall, while the pump room itself is 4 m tall.

4.4 Electrical Impact Relevant to BC Hydro Feed Application

Based on the updated pump sizes, it is anticipated that the facility will have a peak operating demand of approximately 2,900 kVA (2,600 kW), to operate all three pumps, building loads, and other miscellaneous supporting loads.

With the estimated peak operating demand in mind, a 600 V, 3-phase, 3,000 Amp service will be required from BC Hydro to power the DBPS. At this size, it is very likely that a new primary metered service with a 3 MVA unit substation, like what currently exists on site, will be required. This will increase total capital costs (installation and engineering) for the project as more engineering and coordination are required with BC Hydro. From a maintenance perspective, the RDN will also need to take on the responsibility for maintaining the unit substation.

During the Phase 2 build out, the site will see a peak power increase of approximately 266% from the existing facility, it is likely that the power utility "backbone" / transmission line to the facility will need to be upgraded with this increased demand. BC Hydro will typically pass a portion of these costs along to their consumer. It is recommended that BC Hydro is engaged at the earliest possible stage to ensure this item is coordinated and these costs are provided.

The selected pumps are also available at a voltage rating of 4,160 V with the implications of selecting a medium voltage system to be addressed during later design stages.

4.5 Other Electrical Impacts

The following electrical equipment and systems will also be impacted by the increase in pump size (based on the 2021 Concept Design):

Equipment	Impact(s) to design	Impact(s) to RDN & Facility
Standby generator(s)	Switching motors could result in significant disruptions to both the motor itself and any nearby connected load, due to their size. Additional review of motor starting is recommended.	• Increased capital costs.
Standby generator(s)	Feasibility of using existing generator for Phase 1 installation needs to be reviewed. Likely unable to run 2 large pumps off it.	• Increased capital costs.
Standby generator(s)	Increase size to meet new load requirements. Will need 3 – 1,250 kW, in parallel.	• Increased capital costs. • Increased maintenance costs. • More physical space required. • Access constraints. • Added complexity to generator control. • Fuel considerations, should look at consolidating to a single tank that could be fueled in a more accessible way.

Equipment	Impact(s) to design	Impact(s) to RDN & Facility
Main distribution equipment	Size of bus is outside of typical construction for an MCC. Solution will need to be an LV Metal Clad Switchgear.	• Increased capital costs. • More physical space required. • Access constraints.
Variable frequency drives	Increase size to meet new load requirements.	• Increased capital costs. • More physical space required. • Access constraints. • Increased bldg. heat loads.
Harmonic filters	Increase size to meet new load requirements.	• Increased capital costs.
Site grounding	Increased site grounding requirements due to unit sub-station.	• Increased capital costs. • More physical space required. A larger grid is typically required to reduce step and touch hazard.

5 CONCLUSIONS

It was concluded that a new 1050 mm HDPE force main has the capacity to carry the design flow rate of 2,460 L/s, with three pumps operating. Three Xylem Flygt shrouded impeller CT 3351/965 pumps operating at 820 L/s at 72 m head have been selected for this purpose. The hydraulic profiles presented demonstrate that the pump hydraulics can overcome the high points in each of the 900 mm and 1050 mm force mains operating individually, or with both force mains operating together.

The power requirements for the new pump selection have increased. It is anticipated that the site will have a peak operating demand of approximately 2,600 kW. At this size, a primary metered service is common. This will require the design and purchase of a unit substation that typically involves close coordination with BC Hydro. It is also likely that the RDN will see additional power utility costs from BC Hydro, as the transmission lines (utility “backbone”) will need to be upgraded to accommodate the site’s demand. It is recommended that the RDN engage BC Hydro on the matter as soon as possible to determine what the associated costs could potentially be.

Prepared by:

Shane Duggan
Mechanical Designer

Reviewed by:

Alexander Jancker, M.Sc., CEM, P.Eng.
Mechanical / Environmental Engineer

SD/AJ

Attachment:

- Appendix A – Pump Data Sheet

APPENDIX A - PUMP DATA SHEET

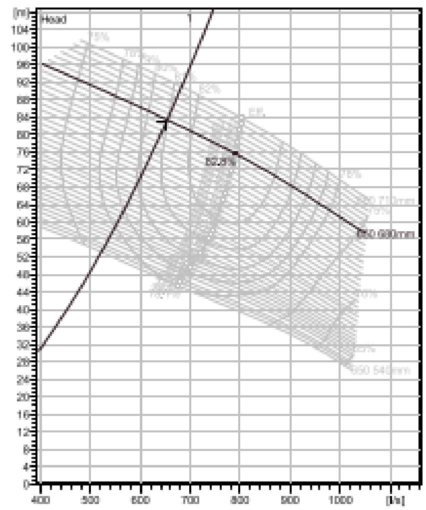
CT 3351/965 3~ 650

Shrouded single or multi-channel impeller pumps with large throughlets and single volute pump casing for liquids containing solids and fibres. Cast iron design with double sealing technology. Some models available as stainless steel versions.

FLYGT
a xylem brand

Technical specification

Curves according to: Water, pure Water, pure [100%],4 °C,999.9 kg/m³,1.5702 mm²/s



Curve: ISO 9906

Configuration

Motor number C0965.000 66-92-6AA-D IE3 1040hp	**Installation type** T - Vertical Permanent, Dry
Impeller diameter 680 mm	**Discharge diameter** 350 mm

Pump information

Impeller diameter
680 mm

Discharge diameter
350 mm

Inlet diameter
450 mm

Maximum operating speed
1195 rpm

Number of blades
3

Throughlet diameter
110 mm

Max. fluid temperature
40 °C

Materials

Impeller
Grey cast iron

Project		**Created by**	Marius Bocu		
Block		**Created on**	7/8/2022	**Last update**	7/8/2022

CT 3351/965 3~ 650

Technical specification

FLYGT a xylem brand

Motor - General

Motor number	Phases	Rated speed	Rated power
C0965.000 66-92-6AA-D IE3 1040hp	3~	1195 rpm	1040 hp
ATEX approved	**Number of poles**	**Rated current**	**Stator variant**
No	6	915 A	2
Frequency	**Rated voltage**	**Insulation class**	**Type of Duty**
60 Hz	600 V	H	
Version code			
000			

Motor - Technical

Power factor - 1/1 Load	Motor efficiency - 1/1 Load	Total moment of inertia	Starts per hour max.
0.84	96.0 %	40 kg m²	0
Power factor - 3/4 Load	**Motor efficiency - 3/4 Load**	**Starting current, direct starting**	
0.81	96.0 %	6250 A	
Power factor - 1/2 Load	**Motor efficiency - 1/2 Load**	**Starting current, star-delta**	
0.72	95.5 %	2080 A	

Project		Created by	Marius Bocu		
Block		Created on	7/8/2022	Last update	7/8/2022

CT 3351/965 3~ 650

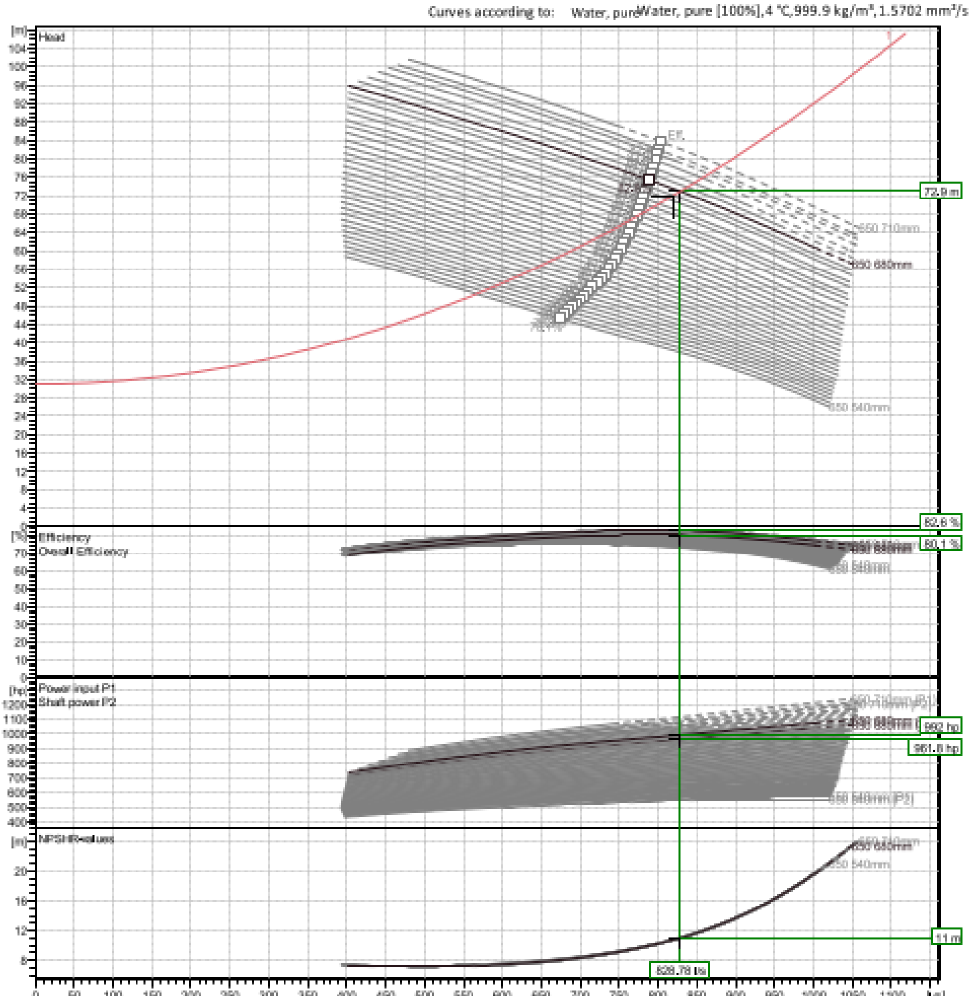
Performance curve

FLYGT
a xylem brand

Duty point

Flow	Head
829 l/s	72.9 m

Curves according to: Water, pure Water, pure [100%],4 °C,999.9 kg/m³,1.5702 mm²/s



Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances.
Please consult your local Flygt representative for performance guarantees.

Curve: ISO 9906

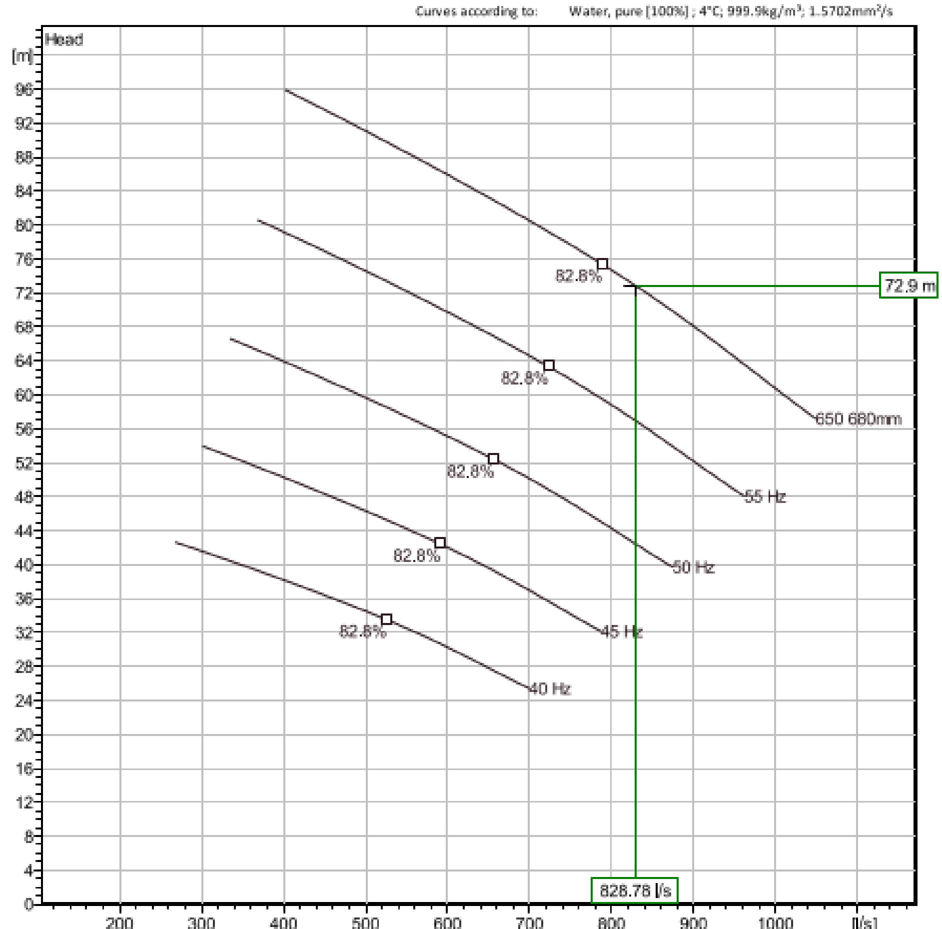
		Marius Bocu		
0	Created on	7/20/2023	Last update	7/20/2023

CT 3351/965 3~ 650

Duty Analysis

FLYGT a xylem brand

Curves according to: Water, pure [100%] ; 4°C; 999.9kg/m³; 1.5702mm²/s



Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances.
Please consult your local Flygt representative for performance guarantees.

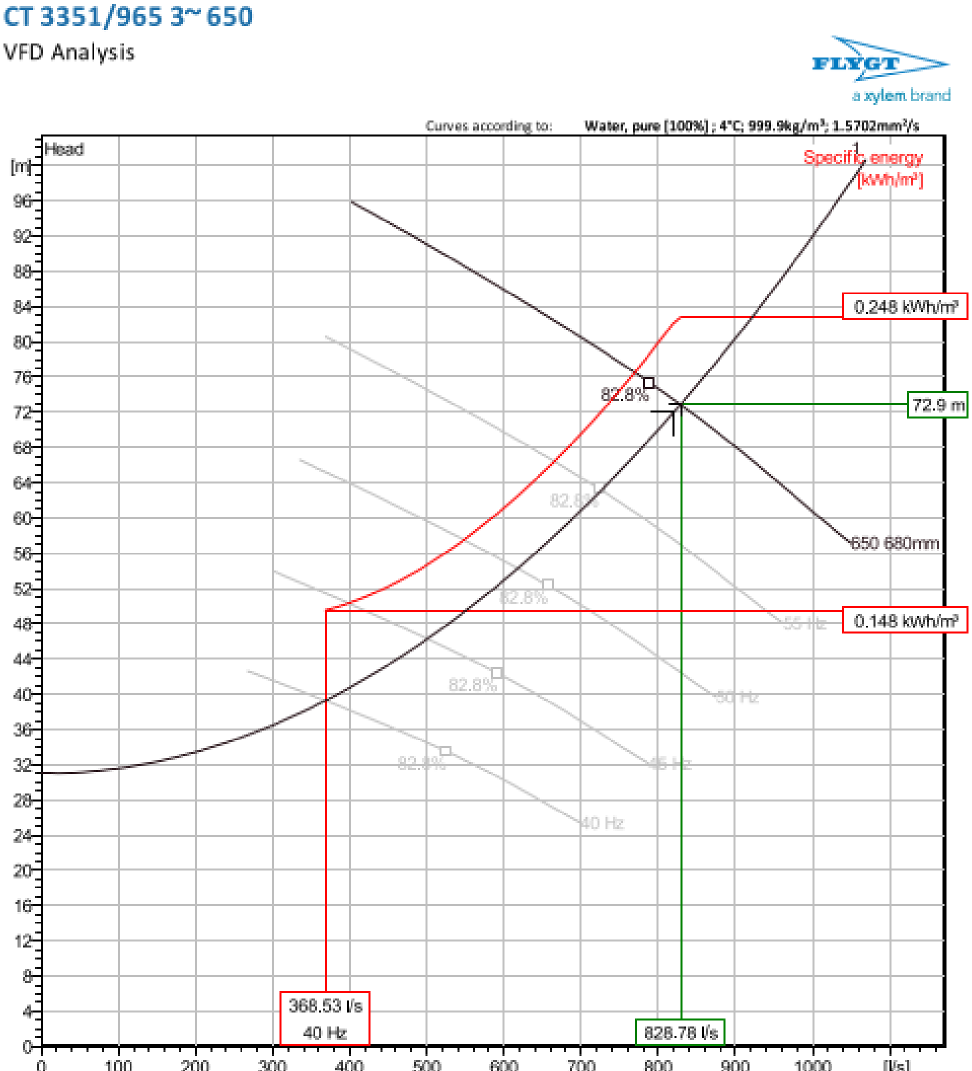
Operating characteristics

Pumps / Systems	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Spec. Energy	NPSHre
	l/s	m	hp	l/s	m	hp		kWh/m³	m
1	829	72.9	962	829	72.9	962	82.6 %	0.248	11

Project		Created by	Marius Bocu		
Block		Created on	7/20/2023	Last update	7/20/2023

CT 3351/965 3~ 650

VFD Analysis

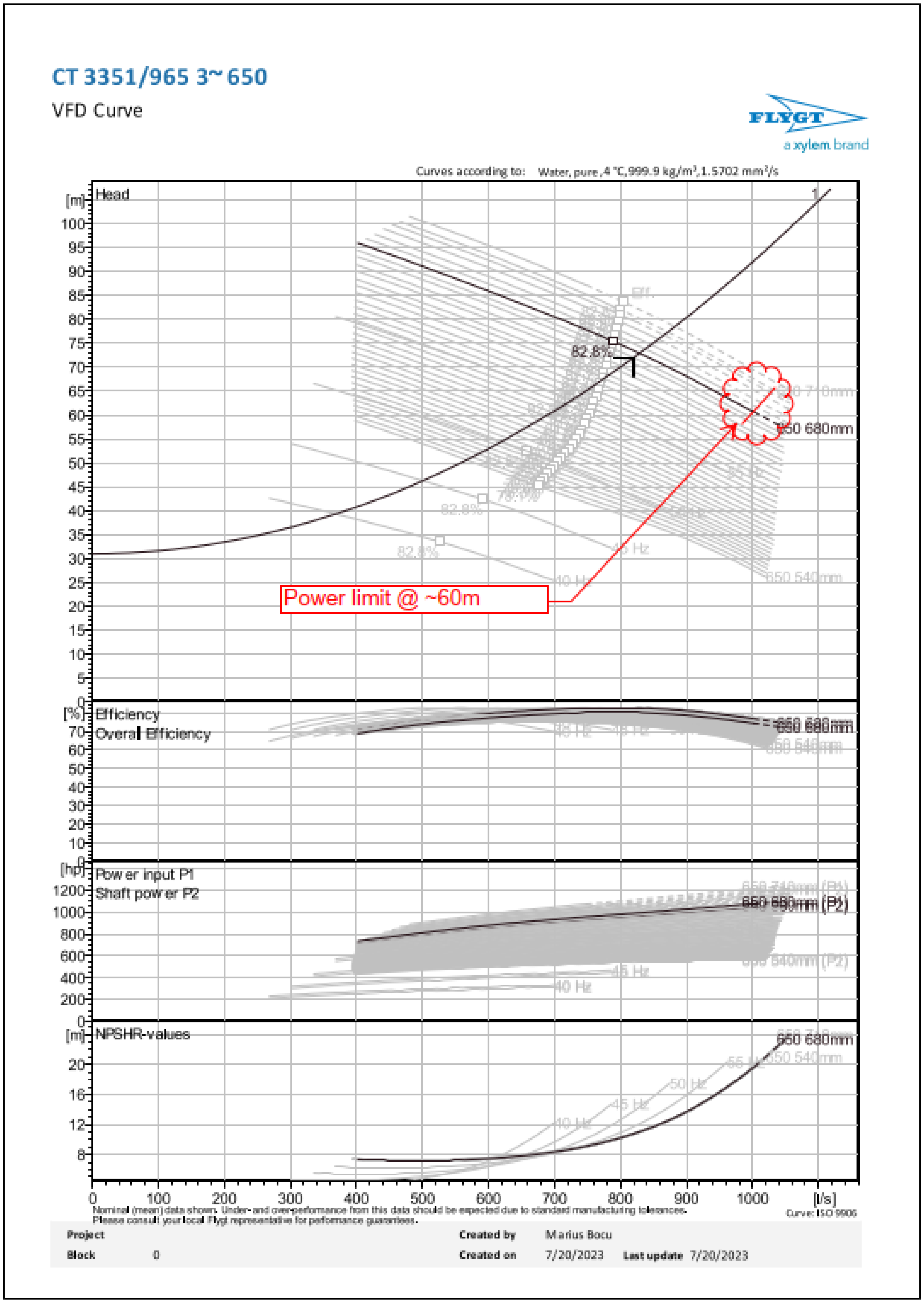


Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances.
Please consult your local Flygt representative for performance guarantees.

Operating Characteristics

Pumps / Systems	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific energy	NPSHre
		l/s	m	hp	l/s	m	hp		kWh/m³	m
1	60 Hz	829	72.9	962	829	72.9	962	82.6 %	0.248	11
1	55 Hz	726	63.2	728	726	63.2	728	82.8 %	0.216	8.73
1	50 Hz	618	54.3	534	618	54.3	534	82.6 %	0.187	6.72
1	45 Hz	501	46.3	375	501	46.3	375	81.3 %	0.164	5.04

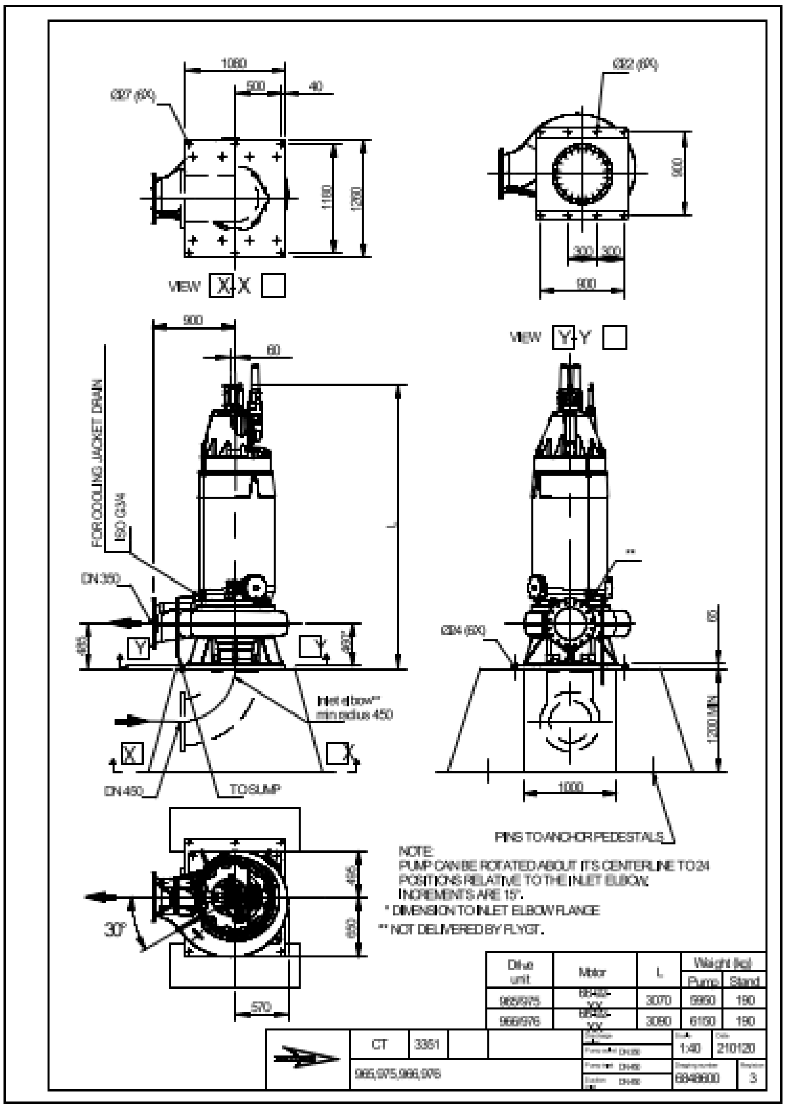
Project		Created by	Marius Bocu		
Block	0	Created on	7/20/2023	Last update	7/20/2023


CT 3351/965 3~ 650
VFD Curve
FLYGT
a xylem brand
Curves according to: Water, pure,4 °C,999.9 kg/m³,1.5702 mm²/s
Head
[m]
82.8%
650 680mm
Power limit @ ~60m
45 Hz
40 Hz
650 540mm
Efficiency
Overall Efficiency
[%]
Power input P1
Shaft power P2
[hp]
650 680mm (P2)
NPSHR-values
[m]
650 680mm
[l/s]
Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances.
Please consult your local Flygt representative for performance guarantees.
Curve: ISO 9906
Project
Block 0
Created by Marius Bocu
Created on 7/20/2023
Last update 7/20/2023

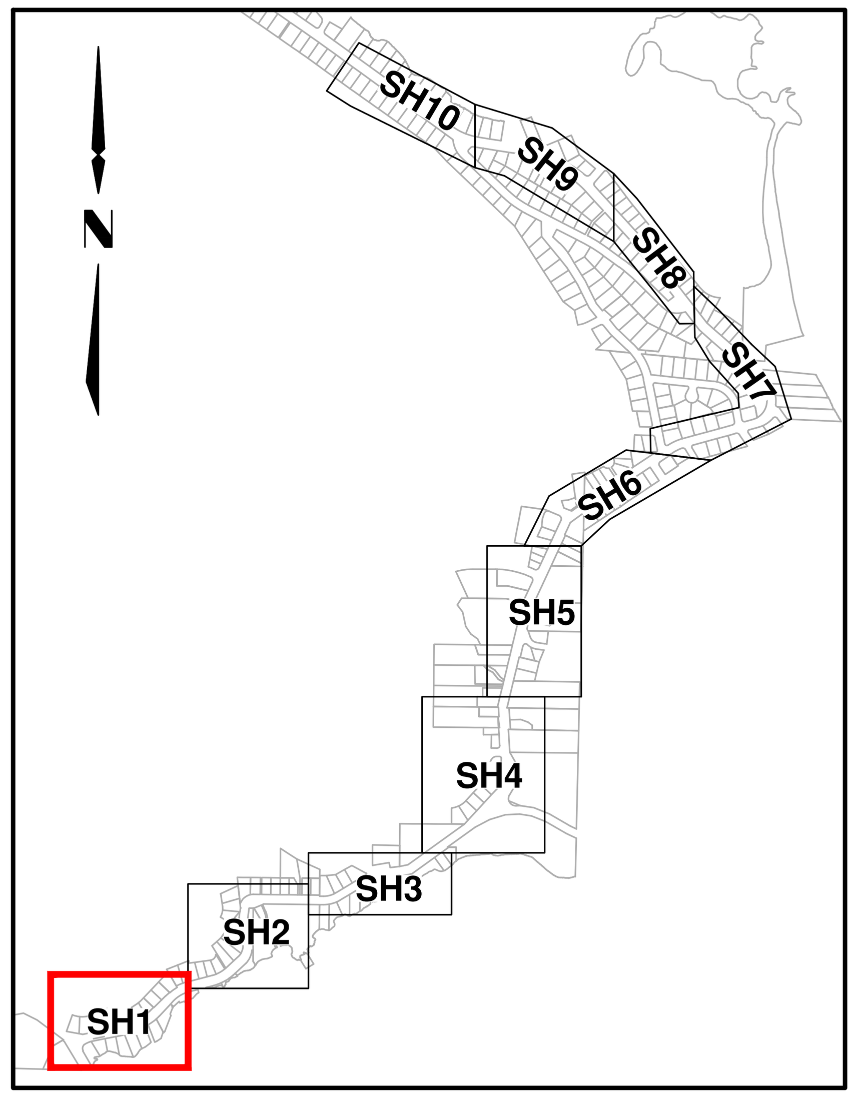
CT 3351/965 3~ 650

Dimensional drawing

FLYGT
a xylem brand

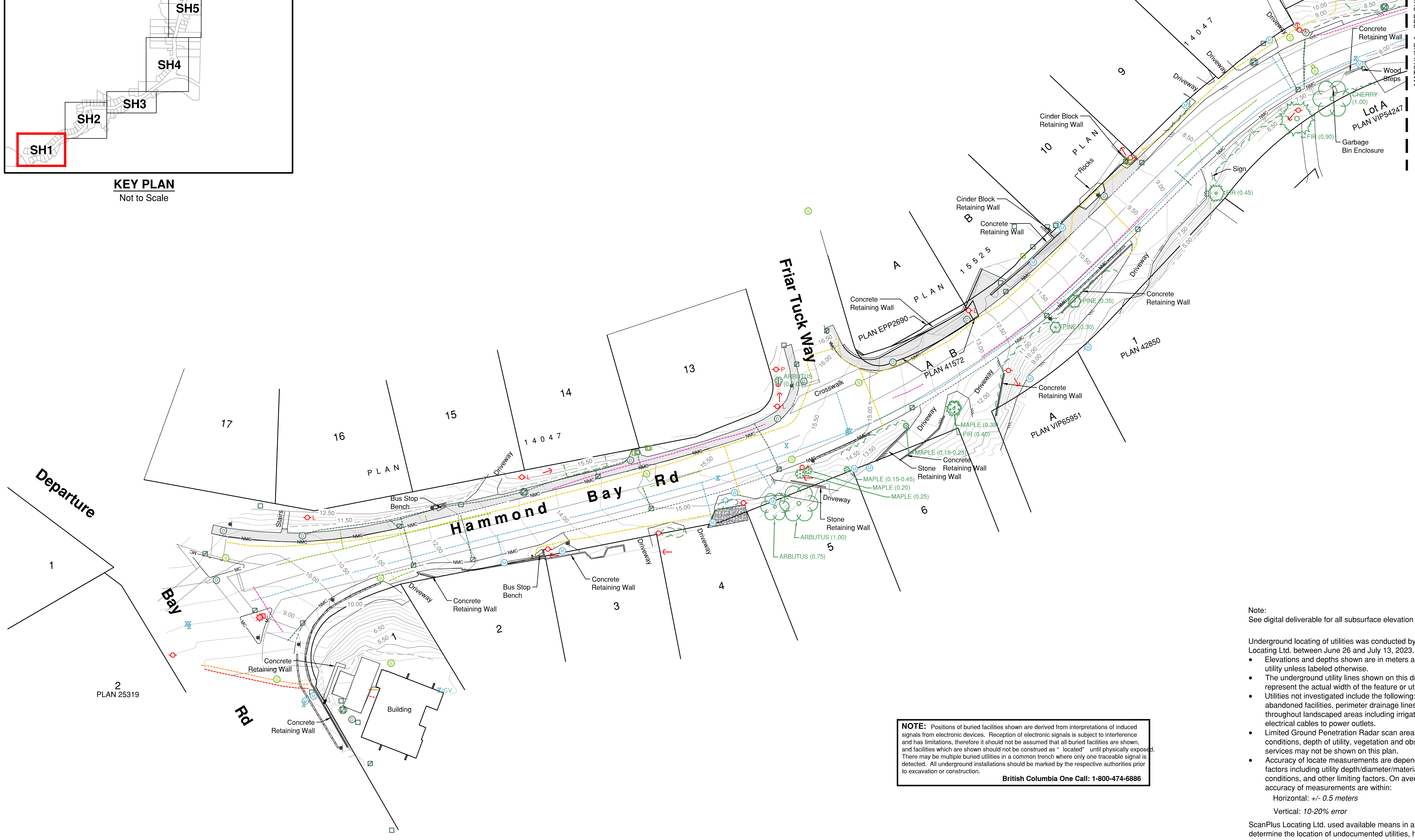


Project		Created by	Marius Bocu		
Block		Created on	7/8/2022	Last update	7/8/2022



KEY PLAN

Not to Scale



NOTE: Positions of buried facilities shown are derived from interpretations of induced signals from electronic devices. Reception of electronic signals is subject to interference and has limitations, therefore it should not be assumed that all buried facilities are shown, and facilities which are shown should not be construed as " located" until physically exposed. There may be multiple buried utilities in a common trench where only one traceable signal is detected. All underground installations should be marked by the respective authorities prior to excavation or construction.

British Columbia One Call: 1-800-474-6886

10 5 0 10 20 30

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LEGEND

- denotes catchbasin
- denotes catchbasin/manhole
- denotes drain
- denotes drain manhole
- denotes drain cleanout
- denotes culvert invert
- denotes ditch/swale direction of flow
- denotes ditch/swale
- denotes sewer manhole
- denotes sewer cleanout
- denotes sewer inspection chamber
- denotes combination storm sewer manhole
- denotes water manhole
- denotes water meter
- denotes water valve
- denotes hydrant
- denotes water well
- denotes gas valve
- denotes gas meter
- denotes communications vault
- denotes communications kiosk
- denotes hydro pole
- denotes hydro pole with light
- denotes hydro pole with transformer
- denotes anchor pole
- denotes hydro pole with pilaster
- denotes pole anchor
- denotes traffic signal pole
- denotes junction box
- denotes hydro vault
- denotes streetlight davit
- denotes lamp pole
- denotes unknown utility manhole
- denotes bollard
- denotes sign
- denotes fence gate post
- denotes fence
- denotes barrier
- denotes top of bank
- denotes bottom of bank
- denotes building overhang
- denotes sidewalk
- denotes concrete
- denotes roadside concrete barrier
- NMC denotes non-mountable curb
- denotes curb letdown
- denotes edge of pavement
- denotes edge of gravel
- denotes center line of road
- denotes paint line
- denotes underground communications service
- denotes underground gas service
- denotes underground power service
- denotes underground sewer service
- denotes underground water service
- denotes unknown underground service
- denotes property line
- denotes interest line
- denotes tree line
- Maple (0.75) denotes deciduous tree, species and diameter
- Cedar (0.75) denotes coniferous tree, species and diameter

Note:
See digital deliverable for all subsurface elevation data.

Underground locating of utilities was conducted by ScanPlus Locating Ltd. between June 26 and July 13, 2023.

- Elevations and depths shown are in meters and are to top of utility unless labeled otherwise.
- The underground utility lines shown on this drawing do not represent the actual width of the feature or utility.
- Utilities not investigated include the following: empty or abandoned facilities, perimeter drainage lines, and services throughout landscaped areas including irrigation lines and electrical cables to power outlets.
- Limited Ground Penetration Radar scan areas due to ground conditions, depth of utility, vegetation and obstructions. Some services may not be shown on this plan.
- Accuracy of locate measurements are dependant on various factors including utility depth/diameter/material, soil conditions, and other limiting factors. On average, the accuracy of measurements are within:
  - Horizontal: *+/- 0.5 meters*
  - Vertical: *10-20% error*

ScanPlus Locating Ltd. used available means in an attempt to determine the location of undocumented utilities, however, cannot be responsible for finding all undocumented utilities. ScanPlus Locating Ltd. is not responsible for any loss or damage arising out of the use of, or reliance on, the subsurface data collected or the report presented.

Date of Field Survey: June 26, 2023 - July 20, 2023.

Contour interval = 0.5 m.

Vertical Datum CGVD28 (HTV2.0).

Tree diameters are taken at breast height. Tree symbols are diagrammatic only to show relative sizes.

Overhead lines are diagrammatic only and may not include all connections.

Lot boundaries shown hereon are derived from ties to existing survey evidence and Land Title Office records. Lot boundaries are subject to change upon legal survey.

This plan represents the best information available at the time of survey. GeoVerra Surveys (BC) Limited Partnership and its employees take no responsibility for the location of any underground conduits, pipes, or other facilities whether shown on or omitted from this plan. All underground installations should be located by the respective authorities prior to construction.

Plotted: 7/31/2023 3:08 PM User: Hugo.Chisholm

ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	RA/BKS	JP

CLIENT: REGIONAL DISTRICT OF NANAIMO

CLIENT REF. NO:

GeoVerra
795 Market Street
Victoria, BC • V8T 0B4
t: 250-342-9767 • www.geoverra.com

PROJECT: HAMMOND BAY ROAD (23-028)

PROJECT NO: 23-01892

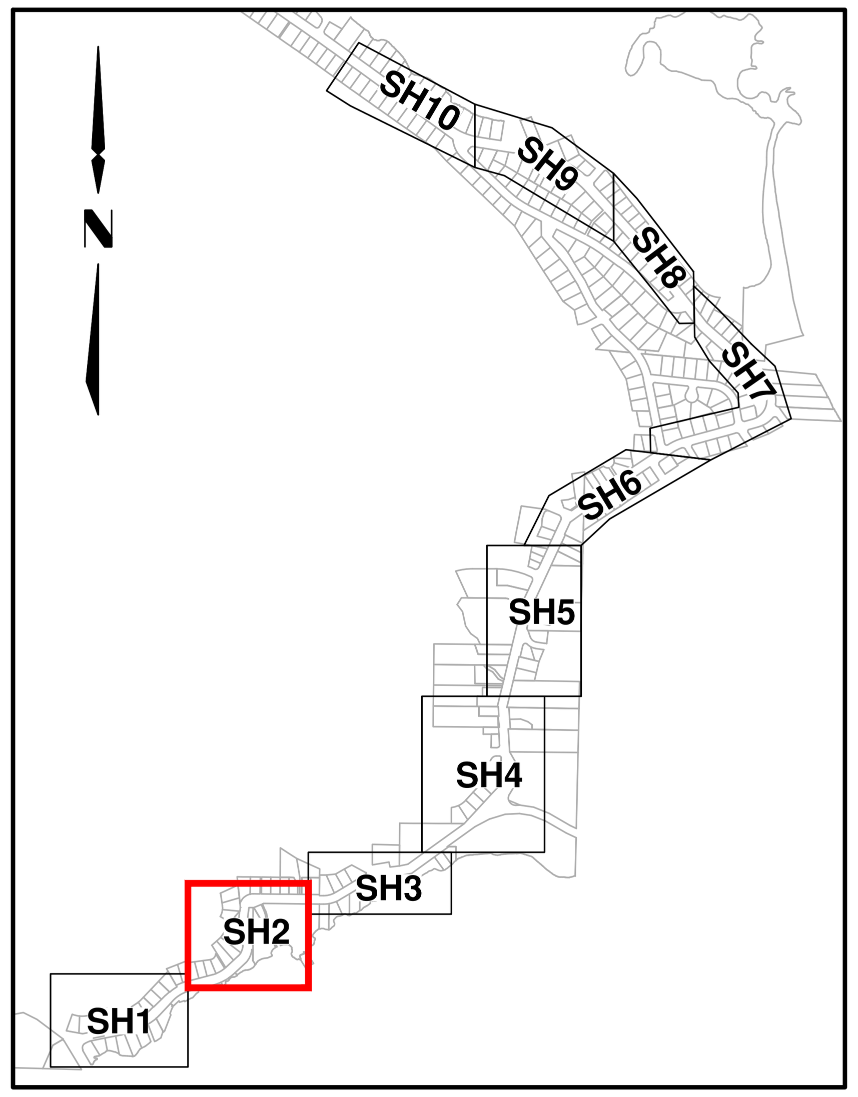
SCALE: As-Noted

DISCIPLINE: GEOMATICS

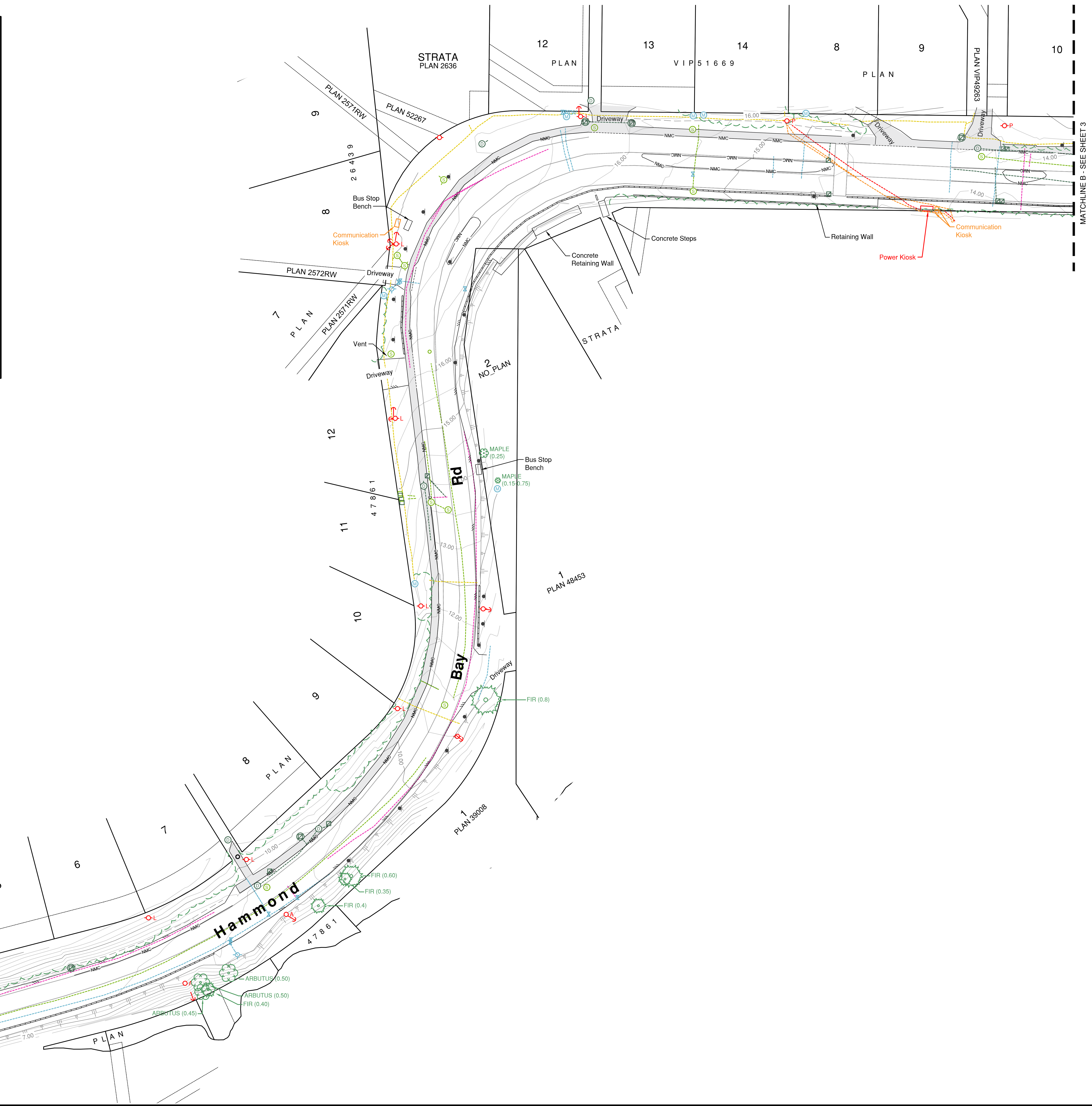
TITLE: CORRIDOR TOPOGRAPHIC SURVEY

DRAWING NO: 23-01892-001-TOPO01-R02

SHEET NO: 1 of 10



KEY PLAN
Not to Scale



10 5 0 10 20 30

The intended plot size of this plan is 841mm in width by 594mm in height (ISO A1 size) when plotted at a scale of 1:500

All distances are in metres and decimals thereof.

See sheet 1 for legend.

Note:
See digital deliverable for all subsurface elevation data.

ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	RA/BKS	JP

CLIENT: REGIONAL DISTRICT OF NANAIMO

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t: 250-342-9767 • www.geoverra.com

PROJECT: HAMMOND BAY ROAD (23-028)

PROJECT NO: 23-01892

SCALE: As-Noted

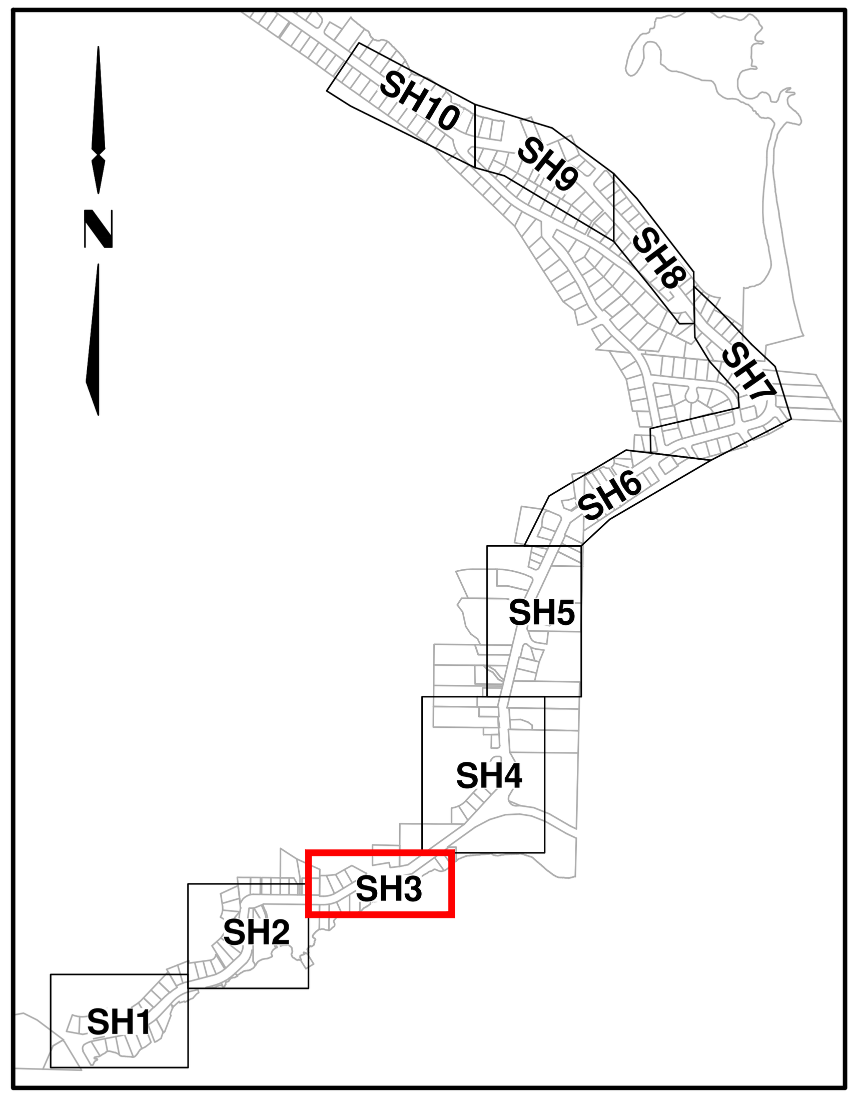
DISCIPLINE: GEOMATICS

TITLE: CORRIDOR TOPOGRAPHIC SURVEY

DRAWING NO: 23-01892-001-TOPO01-R02

SHEET NO: 2 of 10

Plotted: 7/31/2023 3:09 PM User: Hugo Chisholm



KEY PLAN

Not to Scale

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All distances are in metres and decimals thereof.

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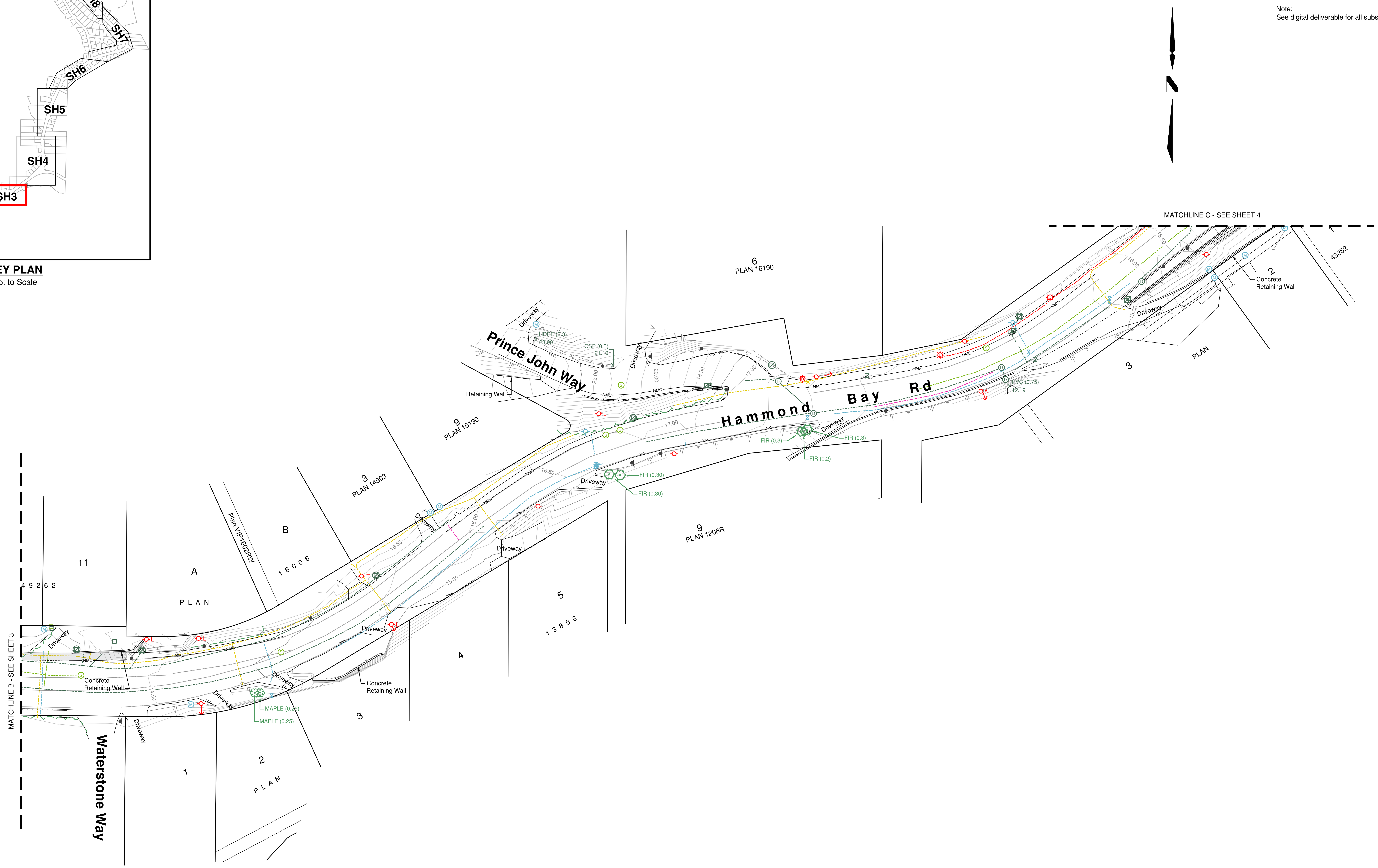

0	2023-07-28	ORIGINAL PLAN PREPARED	RA/BKS	JP
ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK

Plotted: 7/31/2023 3:09 PM User: Hugo Chisholm

CLIENT: REGIONAL DISTRICT OF NANAIMO

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PROJECT: HAMMOND BAY ROAD (23-028)

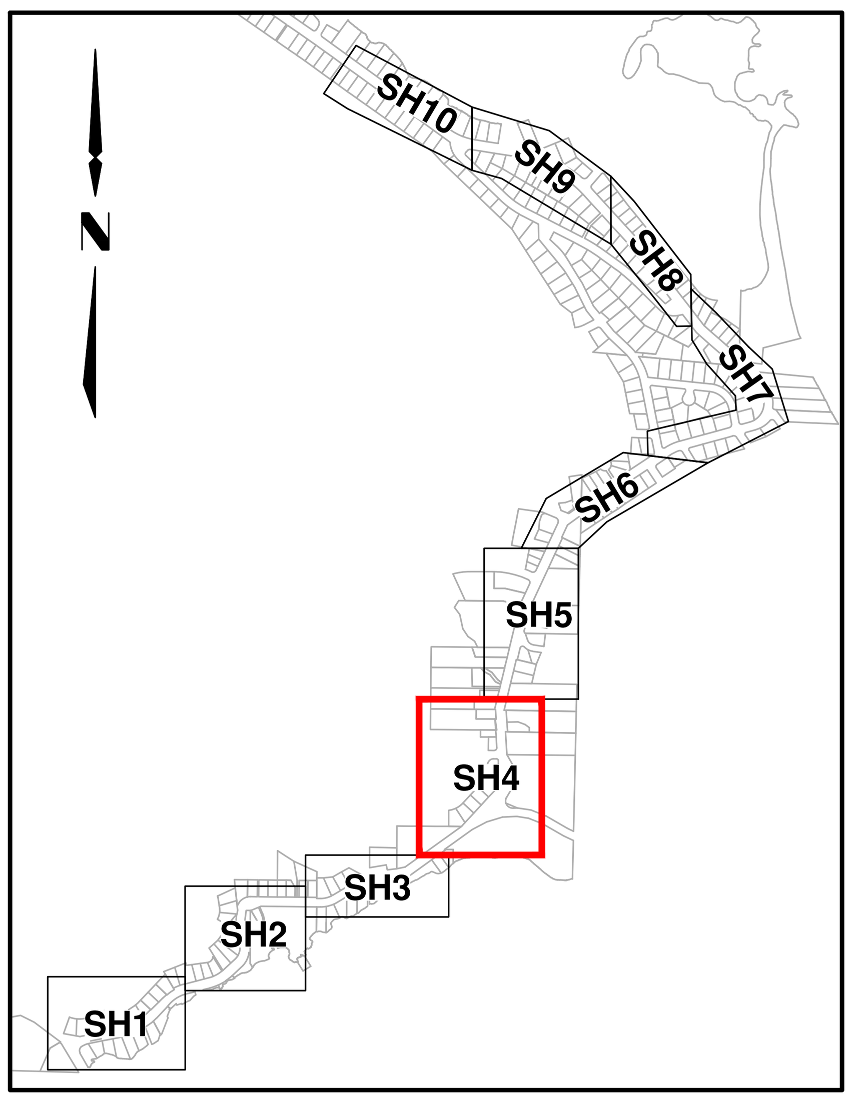
PROJECT NO: 23-01892

SCALE: As-Noted

DISCIPLINE: GEOMATICS

TITLE: CORRIDOR TOPOGRAPHIC SURVEY

DRAWING NO: 23-01892-001-TOPO01-R02



KEY PLAN
Not to Scale

10 5 0 10 20 30

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All distances are in metres and decimals thereof.

See sheet 1 for legend.

Note:
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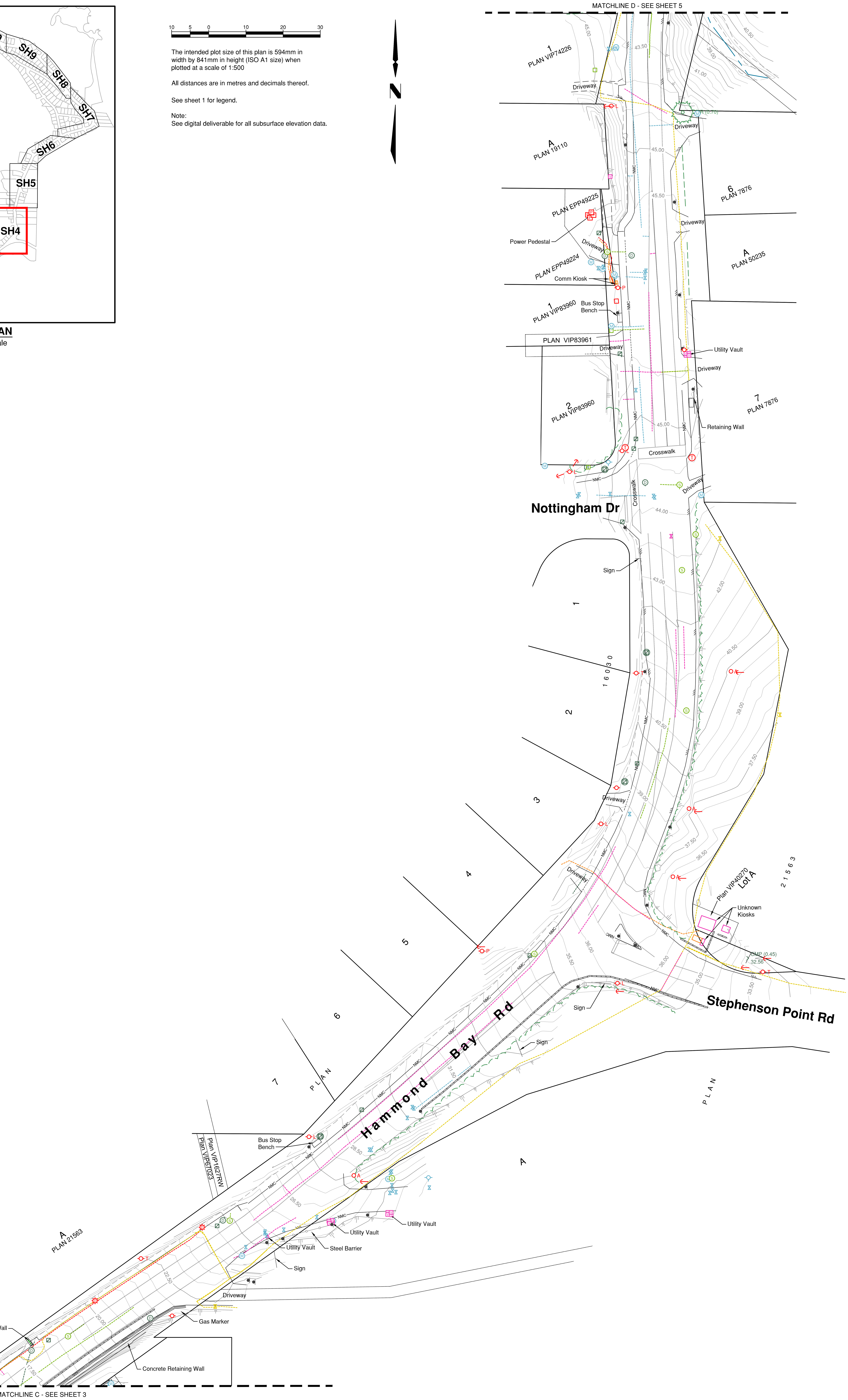

ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	JA/BKS	JP

CLIENT: REGIONAL DISTRICT OF NANAIMO
CLIENT REF. NO:

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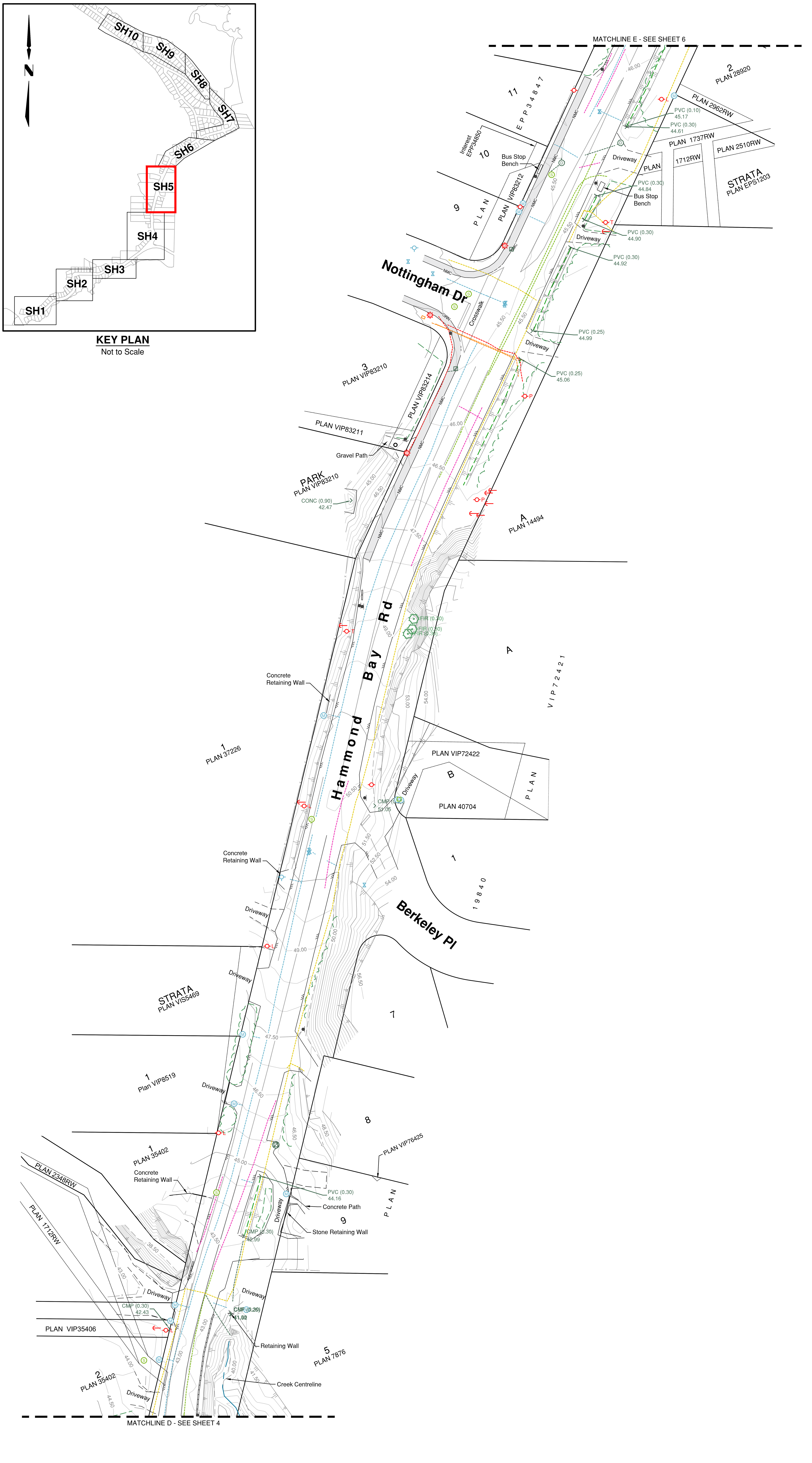
PROJECT: HAMMOND BAY ROAD (23-028)
PROJECT NO: 23-01892
SCALE: As-Noted
DISCIPLINE: GEOMATICS

TITLE: CORRIDOR TOPOGRAPHIC SURVEY
DRAWING NO: 23-01892-001-TOPO01-R02
SHEET NO: 4 of 10



10 5 0 10 20 30

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All distances are in metres and decimals thereof.

See sheet 1 for legend.

Note:
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ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	JA/BKS	JP

CLIENT: REGIONAL DISTRICT OF NANAIMO

CLIENT REF. NO:

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PROJECT: HAMMOND BAY ROAD (23-028)

PROJECT NO: 23-01892

SCALE: As-Noted

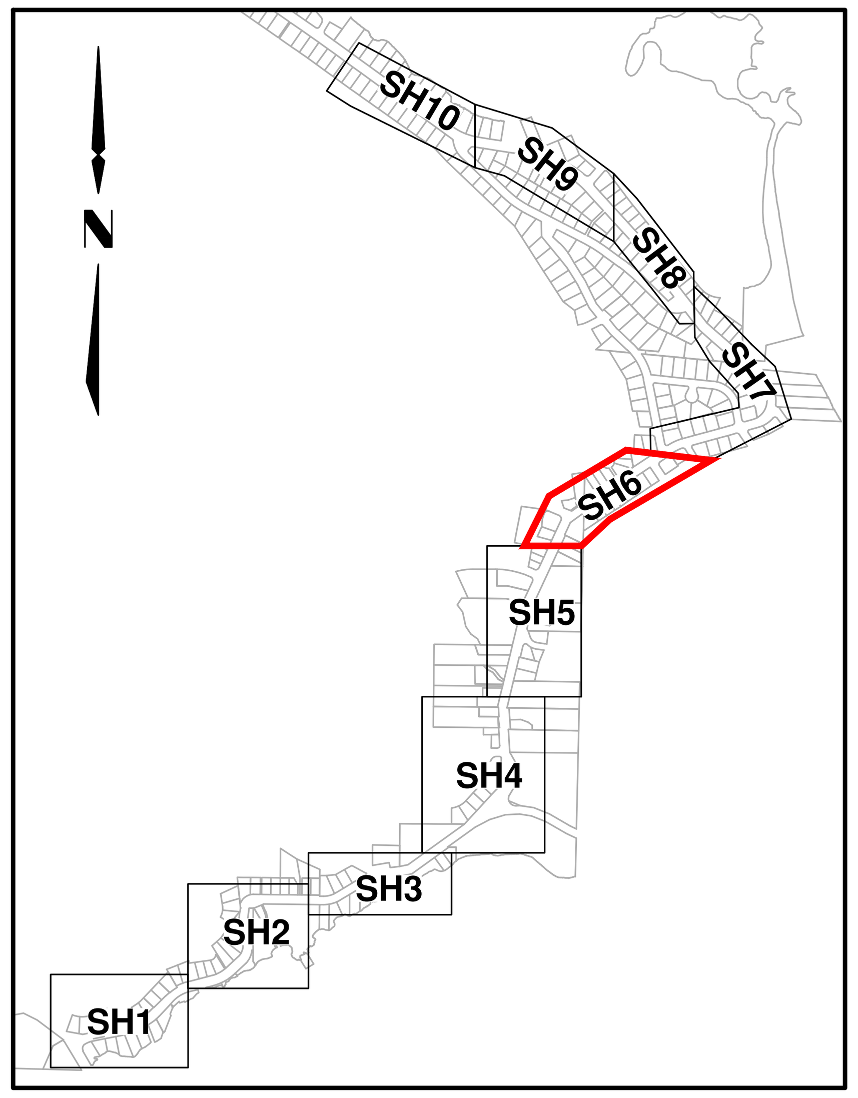
DISCIPLINE: GEOMATICS

TITLE: CORRIDOR TOPOGRAPHIC SURVEY

DRAWING NO: 23-01892-001-TOPO01-R02

SHEET NO: 5 of 10

Plotted: 7/31/2023 3:09 PM User: Hugo.Chisholm



KEY PLAN
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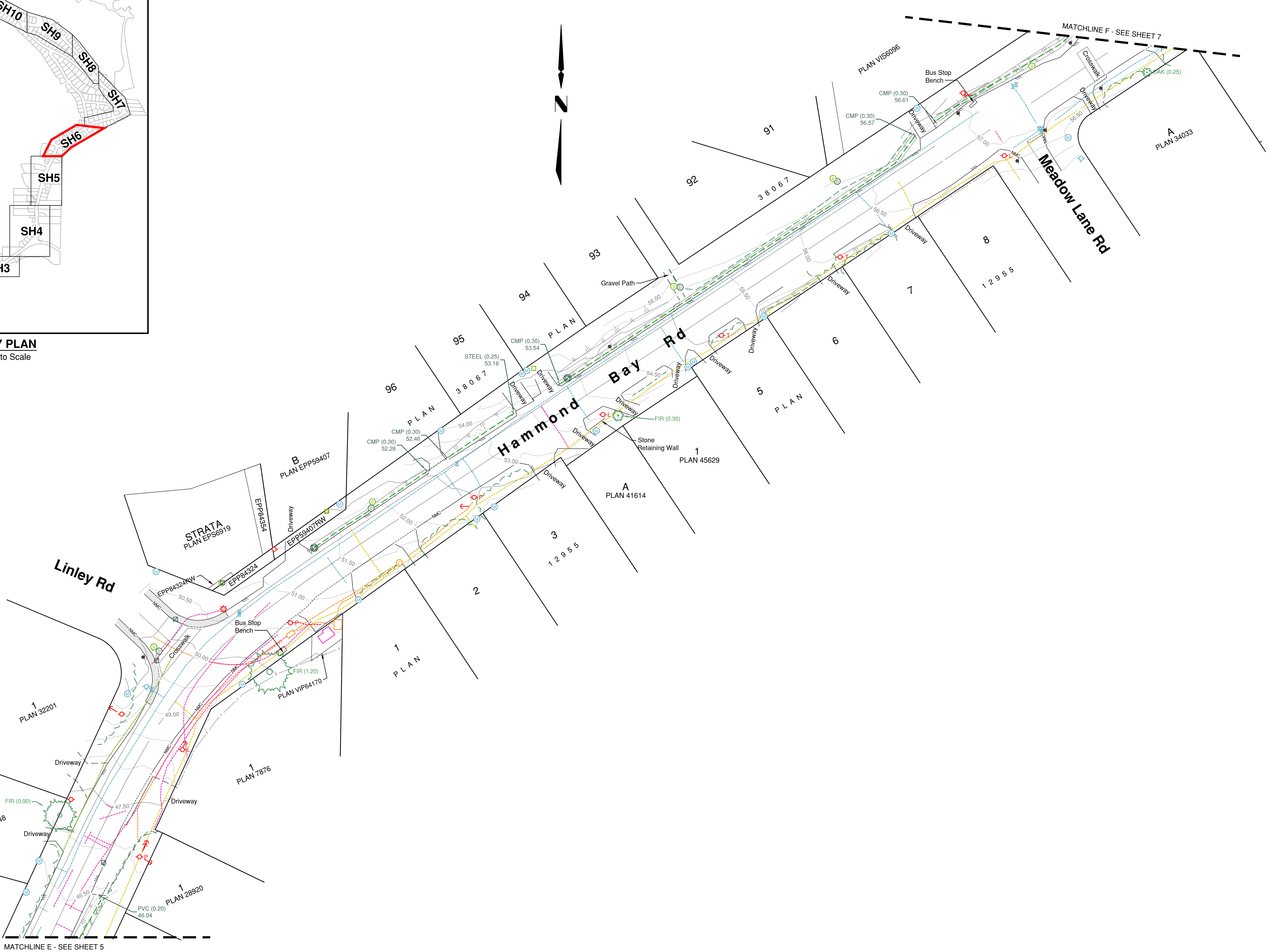

N

10 5 0 10 20 30

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All distances are in metres and decimals thereof.

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Note:
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ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	RA/BKS	JP

Plotted: 7/31/2023 3:09 PM User: Hugo Chisholm

CLIENT: REGIONAL DISTRICT OF NANAIMO

CLIENT REF. NO:

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PROJECT: HAMMOND BAY ROAD (23-028)

PROJECT NO: 23-01892

SCALE: As-Noted

DISCIPLINE: GEOMATICS

TITLE: CORRIDOR TOPOGRAPHIC SURVEY

DRAWING NO: 23-01892-001-TOPO01-R02

SHEET NO: 6 of 10

10 5 0 10 20 30

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See sheet 1 for legend.

Note:
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ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	RA/BKS	JP

Plotted: 7/31/2023 3:09 PM User: Hugo.Chisholm

CLIENT:
REGIONAL DISTRICT OF NANAIMO

CLIENT REF. NO:

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PROJECT:
HAMMOND BAY ROAD (23-028)

PROJECT NO:
23-01892

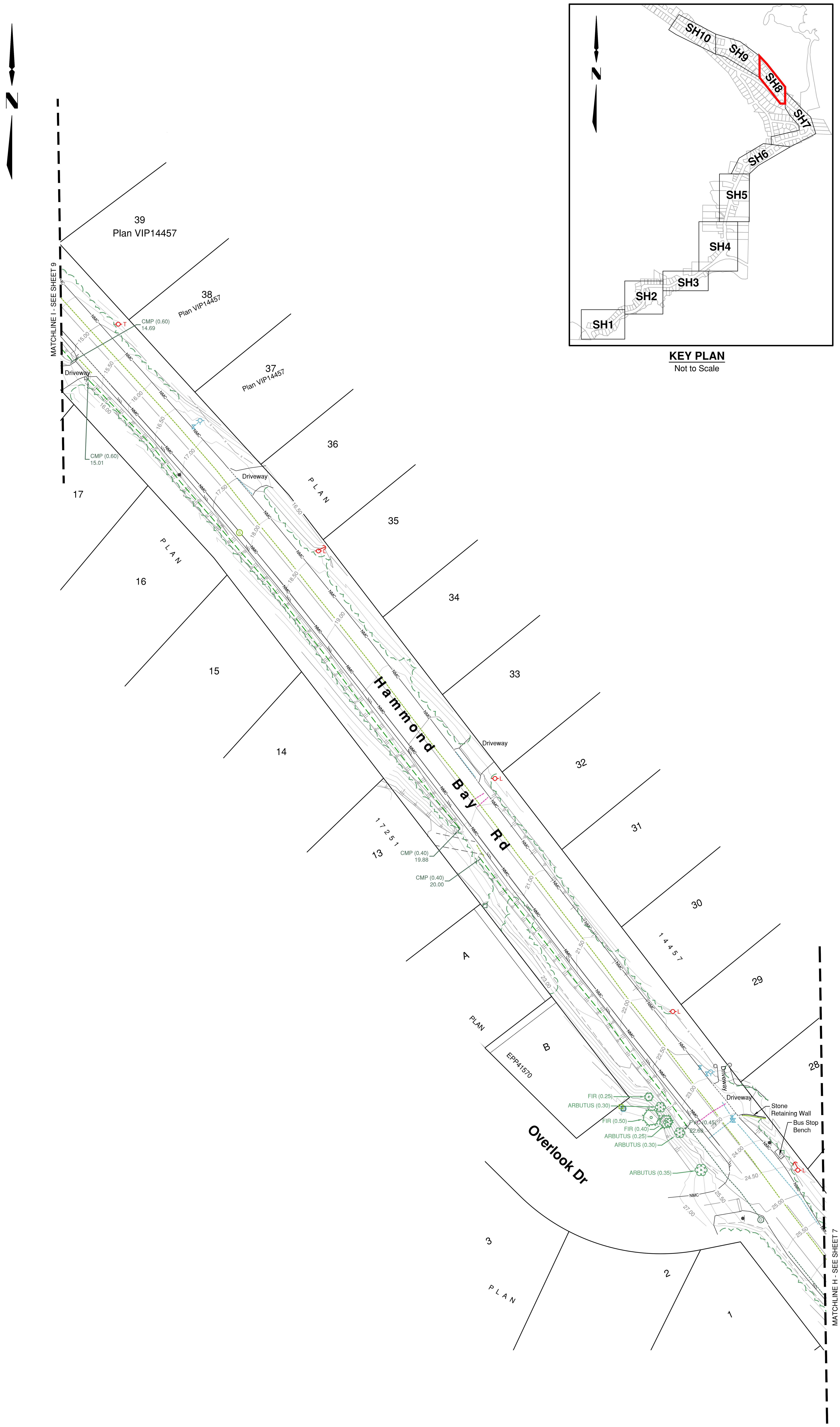
SCALE:
As-Noted

DISCIPLINE:
GEOMATICS

TITLE:
CORRIDOR
TOPOGRAPHIC SURVEY

DRAWING NO:
23-01892-001-TOPO01-R02

SHEET NO:
7 of 10



KEY PLAN
Not to Scale

10 5 0 10 20 30

The intended plot size of this plan is 594mm in width by 841mm in height (ISO A1 size) when plotted at a scale of 1:500

All distances are in metres and decimals thereof.

See sheet 1 for legend.

Note:
See digital deliverable for all subsurface elevation data.

ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	JA/BKS	JP

CLIENT:	REGIONAL DISTRCIT OF NANAIMO
CLIENT REF. NO:	
PROJECT:	HAMMOND BAY ROAD (23-028)
PROJECT NO:	23-01892
SCALE:	As-Noted
DISCIPLINE:	GEOMATICS
TITLE:	CORRIDOR TOPOGRAPHIC SURVEY
DRAWING NO:	23-01892-001-TOPO01-R02
SHEET NO:	8 of 10

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Plotted: 7/31/2023 3:09 PM User: Hugo.Chisholm

The intended plot size of this plan is 841mm in width by 594mm in height (ISO A1 size) when plotted at a scale of 1:500

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See sheet 1 for legend.

Note:
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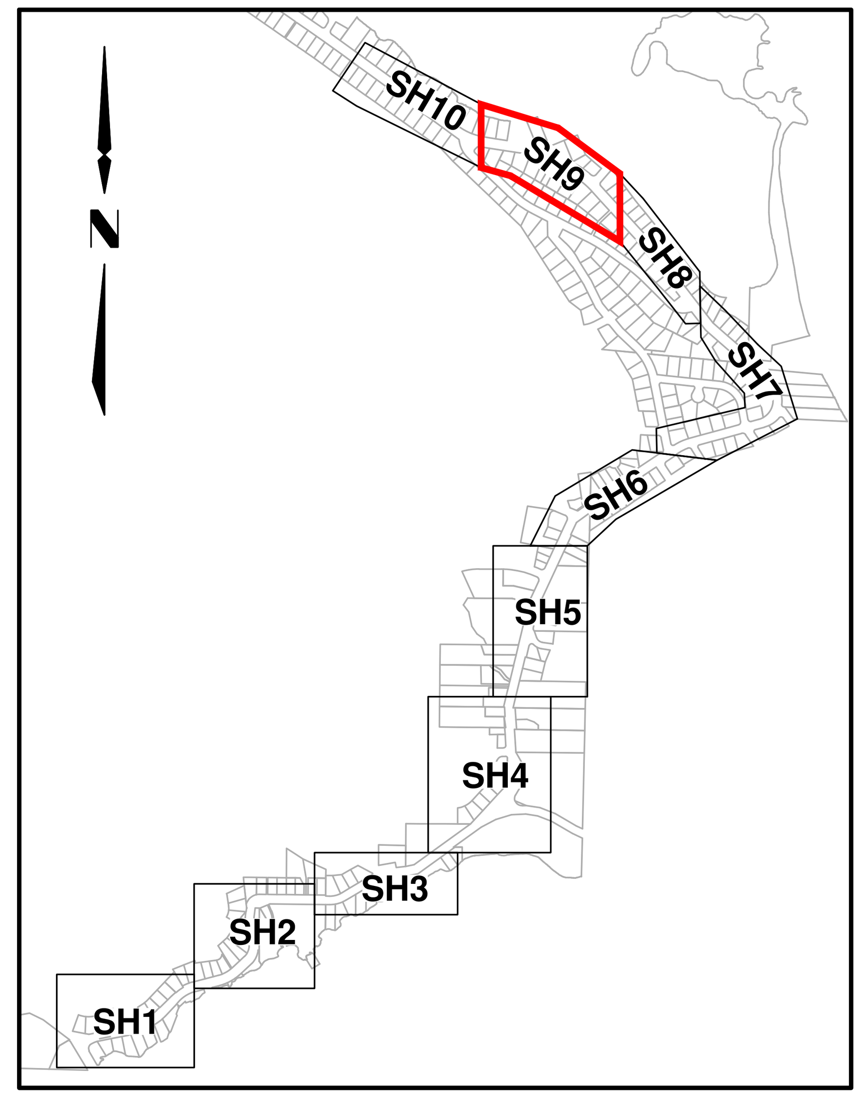

KEY PLAN
Not to Scale

ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	RA/BKS	JP

Plotted: 7/31/2023 3:19 PM User: Hugo Chisholm

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PROJECT: HAMMOND BAY ROAD (23-028)

PROJECT NO: 23-01892

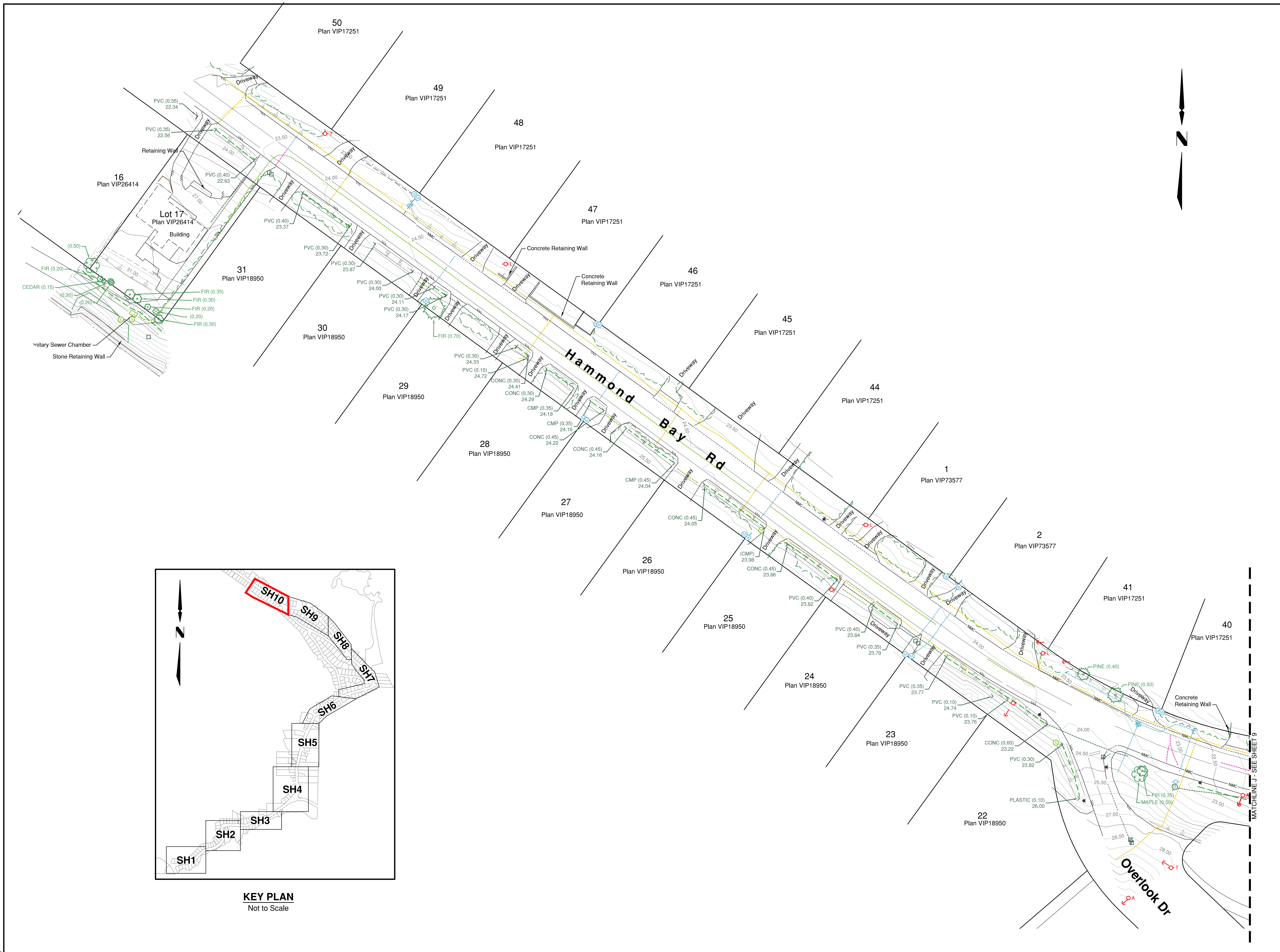
SCALE: As-Noted

DISCIPLINE: GEOMATICS

TITLE: CORRIDOR TOPOGRAPHIC SURVEY

DRAWING NO: 23-01892-001-TOPO01-R02

SHEET NO: 9 of 10



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All distances are in metres and decimals thereof.

See sheet 1 for legend.

Note:
See digital deliverable for all subsurface elevation data.

ISS/REV	YYYY-MM-DD	DESCRIPTION	DRN	CHK
0	2023-07-28	ORIGINAL PLAN PREPARED	RA/BKS	JP

Plotted: 7/31/2023 3:19 PM User: Hugo Chisholm

CLIENT: REGIONAL DISTRICT OF NANAIMO

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PROJECT: HAMMOND BAY ROAD (23-028)

PROJECT NO: 23-01892

SCALE: As-Noted

DISCIPLINE: GEOMATICS

TITLE: CORRIDOR TOPOGRAPHIC SURVEY

DRAWING NO: 23-01892-001-TOPO01-R02

SHEET NO: 10 of 10