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DNV·GL

Water System Model Construction Project

Prepared for:
The City of Duluth, MN

August 07, 2015
PSP1533

SAFER, SMARTER, GREENER

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1 UNDERSTANDING AND RELATIONSHIP

The City of Duluth is an existing user of DNV GL's Synergi Gas Modeling software. DNV GL and the City worked together to implement Synergi Gas models of the distribution network recently. The City is now planning to use Synergi Water to model the distribution system.

This proposal is in response to the City's request of June 2015 for a proposal for building an all-mains model of the water distribution network.

1.1 DNV GL Overview

DNV GL is a world-class technical assurance and consulting company that provides technical engineering services to the industrial (oil and gas, water, and renewables) and maritime (ship classification society) business sectors.

Both business fields follow the same approach of technical competence, uncompromising quality and first-class services around the world. DNV GL employs more than 16,000 engineers, surveyors, experts and support staff in 100 countries. The global network consists of more than 300 offices worldwide, with its head office in Oslo, Norway.

DNV GL understands the challenges faced to ensure compliance, manage safety and reduce costs, while at the same time achieve operational excellence and optimize assets performance. These challenges can all seem complex and daunting when viewed in isolation. Our highly skilled, experienced and dynamic personnel take a holistic approach to deliver safe, smart, sustainable and innovative solutions to complex problems. As a truly independent advisor we understand when designs are optimal, when installations fit for purpose and how to maximize operational efficiency. We generate genuine added value to you, as a client.

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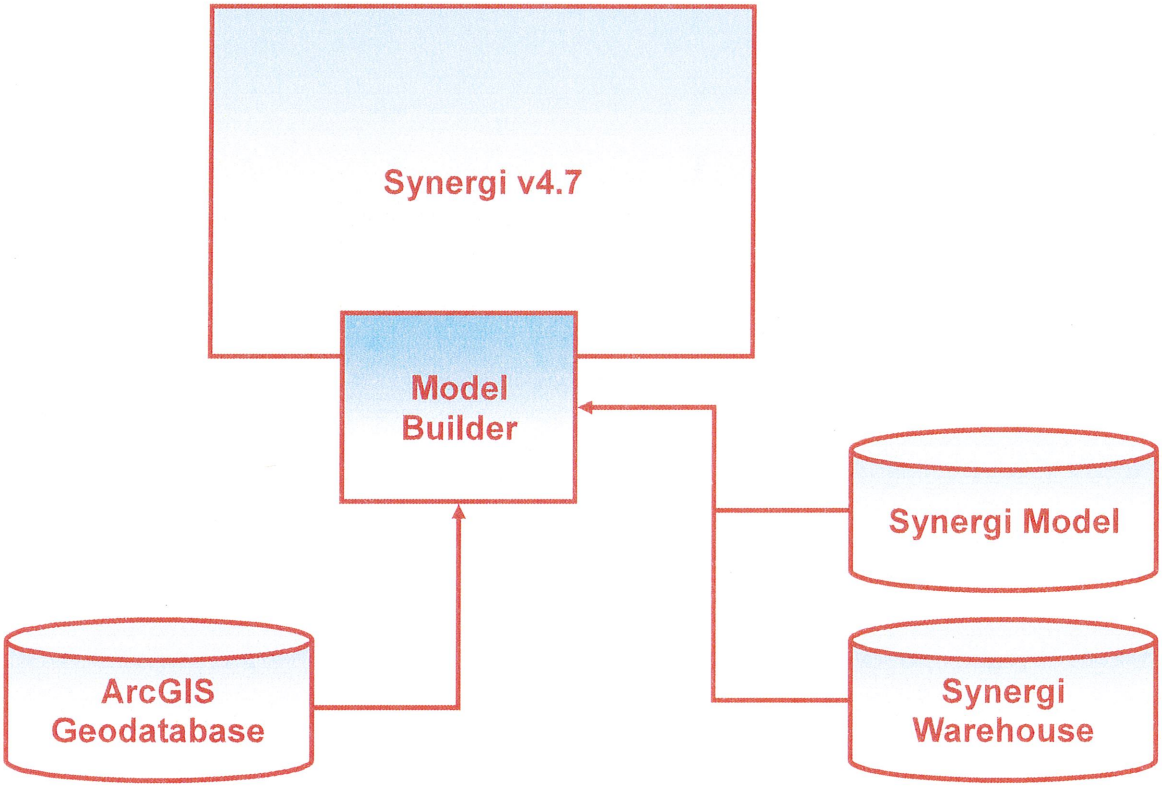
2 MODEL BUILDER OVERVIEW

Synergi Water's "Model Builder" module allows the software to link to an ArcGIS database for the purpose of creating models for hydraulic simulation. Model Builder includes a number of features that helps it perform the model construction process. After the initial model construction, Synergi contains complementary features for checking the results of the model construction process – such as "spatial tools" that can locate pipes that appear to be connected visually but are actually not logically connected after the model construction process. The following diagram shows how the GIS feeds into Model Builder. Model Builder then uses the Synergi Model Database and Warehouse of pipe definitions along with the GIS data to create the initial model network.



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3 CMM PRODUCT OVERVIEW

CMM provides a link between Synergi and the City of Duluth's CIS (Customer Information System). Using information from the CIS database, CMM establishes a relationship among user-supplied average metered demand and customer location. Specifically, CMM provides the capability to:

- Assign each customer's demand to the closest appropriate pipe or node based upon provided x,y coordinates
- Apply the demand to the Synergi Model
- Display customer information within the Synergi network analysis environment to enhance modeling effectiveness and system knowledge

CMM has the capability to assign customers to the network using customer geographic coordinate information. Alternately, if logical links exist between the customer data in the CIS and the pipe or node identifier in the network model, the data can be imported into CMM.

4 SCOPE OF WORK

The proposed Scope of Work involves working with the City to construct an all-mains detailed model of the Duluth Distribution System.

Detailed hydraulic modeling can be approached in a multi-stage manner. The following is a suggested set of steps:

1. (This Step): Construct an initial all-mains Steady State Peak Day Model. Verify the model in Steady State.
2. (Future Step): Augment the model to do Time Varying simulation and calibrate for a peak day.
3. (Future Step): Augment the model to perform detailed Water Quality Simulation. Detailed WQ simulation requires a calibrated time varying model.

The first step in the process provides a model of the system for peak hour considerations. With it the software can also estimate water quality parameters based upon the "steady state" assumption.

4.1 Build the All-Pipes Model

DNV GL will use the City of Duluth's GIS data to construct the all-pipes model of the system.

4.1.1 ArcGIS Data Extraction

Synergi's Model Builder application will be used to extract the data from the ArcGIS geodatabase. The City of Duluth will deliver an ESRI geodatabase that contains the data necessary for the facilities model. DNV GL will import the geodatabase data into Synergi using Model Builder. The raw model, built from the GIS, will be called the 'time zero' model. Any errors that exist in the GIS data will be built into the 'time zero' model. DNV GL will assess the data once the model is in Synergi. Any changes to the data that are necessary to build an analytical model will be made in Synergi and not in ESRI. DNV GL will provide the City of Duluth with a summary of those changes made in Synergi in order for the City of Duluth to update the ESRI production environment at a future date if they choose.

Model Construction Plan: At the start of the project, DNV GL will work with the City of Duluth to create a formal Model Construction Plan. DNV GL has reviewed the City's data and has the following notes that will help to develop the Model Construction Plan.

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MAINS: The wGravityMain is the layer with the water distribution piping. This layer includes a status called "LifecycleStatus" and Active pipes would be used to build the model from this status. Material, Install Date, and NominalDiameter data would be brought over as well as "Shape_Length" (to be confirmed with the City). The combination of Material, Install Date, and Diameter would be used to generate C Factors for the mains. OperationalArea may be used to confirm the zone assignment.

VALVES: The w_SystemValve layer contains valves for the system. At the start of the project, the team will decide whether or not all of the valves should be modeled or just the closed zone (Operational Area) valves. Valves include Diameter and OperationalArea as well as Comments. They also include Use_ and other fields that may or may not indicate status/use (open/closed). DNV GL's review of the wSystemValve data implies that "Comments" are used to flag valves that have special purposes like "SYSTEM SEPARATION VALVE" for valves at borders which would be needed to separate pipes in different zones. And a few valves are listed as "CROSS OVER VALVE". The "comments" for valves also include some "NORMALLY CLOSED" notes that need to be tracked.

LATERALS/FIRE SYSTEMS: The GIS includes information that seems to be for hydrant laterals and fire systems on the wLateralLine layer. This layer includes Subtype "HydrantLaterals". It includes Installdate, Material, and Diameter information as well as a "LifecycleStatus" field [Assume using "Active"]. The project team may want to include all "HydrantLateral" pipes so that the wHydrant layer can be included and linked to the hydrant laterals – providing a location for hydrants in the model. The wLateralLine layer includes other mains – including Subtype Irrigation and Subtype Fire. The team will need to decide if these additional pipes should be added to the model or if their demands should simply be modeled at their connection point to the system.

ZONES/OPERATIONAL AREAS: The w_OperationalAreas layer contains polygons that display pressure zone borders and this information will be extracted. Operational Area information is also contained on several devices on other layers to aid in identification of Zones.

HYDRANTS: The wHydrant layer contains hydrants with a UDI's like H13035 . This hydrant ID is assumed to be a unique hydrant number. Hydrants appear to also include their OperationalArea and Elevation. This information about the hydrant can be brought over as node information in the model if the Hydrant Laterals are included in the model. The project team will reconfirm how hydrants are to be modeled and the confidence of their elevations.

CUSTOMERS: The GIS data does not appear to include specific Customer Meter locations, however, it does include wServiceValves which also include address information. This data will not be converted by Model Builder but may be of use in checking/confirming customer assignment. The wMeter field in the GIS appears to exist for just a small set of large customers. This data will be used to help confirm large customer assignments.

REGULATORS/PRV's: The wRegulatorStation layer will be used to flag the location of PRV's. Data on this layer includes P_In and P_Out and Diameter and SystemSupply. There are 10 objects in the wRegulatorStation layer.

PUMPS: The wPump layer will not be directly converted because pump stations will be built as a separate task. There are 31 objects on the wPump layer. The wWaterStructure layer can coordinate with the wPump layer in indicating pump station locations. The wPump layer contains limited information about the pump – which will be used as a reference. The locations of wPumps will be noted during the "time0" model construction process. Pumps will be added in more detail at a later step in the project.

RESERVOIRS: The wWaterStructure layer also includes Subtype Reservoir which indicates the location of system storage. Reservoirs include an "Elevation" field. Reservoir locations will be noted from the GIS but probably manually added after the initial model extraction as discussed later in this document.

4.1.2 Data Connectivity Review

DNV GL acknowledges that some connectivity issues might not be detected during the initial review. If DNV GL is able to create the facility model based on the data provided by the City of Duluth, and connectivity issues surface during model balance or model verification by DNV GL, these types of connectivity issues will be corrected in the Synergi model by DNV GL, and reported to the City of Duluth. DNV GL assumes that not more than 16 hours will need to be spent cleaning up connectivity or poor quality data issues that would result in a hydraulically inaccurate model. If the data is not clean, DNV GL may request a scope change to re-import the data after the City of Duluth has performed additional GIS data cleanup.

4.1.3 Elevation Assignment (Bulk)

DNV GL will work with the City of Duluth to assign elevations to the nodes of the model. To support this analysis the City will provide an appropriate data set that can be used to create contour data and then overlaid onto the "time0" model to give elevations to every node. Hydrant Nodes will be excluded from the process and their GIS elevations will be retained. Other "control" locations for elevation will also be updated/modified throughout the project such as elevations at pressure gauges, pumps, reservoirs, and pressure regulating valves.

4.1.4 Operational Area (Zone) Setup

DNV GL will use the wSystemValve "Comments" and the wOperationalArea boundaries to insert closed valves at zone borders. wRegulators will also be set up at borders. The City of Duluth will provide additional information about wRegulator Stations such as elevation, set points/function, and size. Function can include PRV only or PRV with a "sustain" feature on the upstream side. DNV GL will work with the City around facility sites (pump and reservoir locations) to confirm zone configurations.

4.2 Model Pumps and Reservoirs

The City of Duluth will provide additional information about pump and tank sites to support modeling of these locations. Reservoir information should include data that allows a volume profile of the reservoir to be constructed (diameter and height to overflow). Reservoir bottom and overflow information will be needed as well as operating controls on pumps that work off of reservoir levels. Reservoir fill line details will be needed along with the size of fill/altitude valves. City staff will need to be available to explain how the sites are set up and operated. DNV GL may combine some reservoirs into an equivalent reservoir at some locations for model stability.

The City of Duluth will provide additional information about pumps. Information about the station, the suction elevation and discharge elevation of the pump, the inlet and outlet size of the pump (if available), NPSHR, Pump Curve (incl Eff, NPSHR), Type (Fixed or VFD), and Rating (GPM and Head) will be needed. Pressure gauge locations and elevations at pump stations will also be needed. It is assumed that gauges are calibrated and accurate to within 2 psig.

Additional data may be requested to support Pump and Reservoir Modeling.

4.3 Model Customer Demand

The City of Duluth will provide an extraction of its Customer Information System (CIS) in the input format provided by DNV GL. DNV GL will use the Customer Management Module (CMM) of Synergi to

load this data. DNV GL assumes that, for each customer, this data will include an appropriate average consumption in gpm. DNV GL assumes that the City's data will include x,y coordinates for each customer and/or another means of linking the customer to a location in the model. The work of assigning customers to their locations in the model can be labor intensive. This proposal assumes that this work will be minimal by assuming that the City has provided the information needed to perform automated customer assignment. Assignments will be made to pipes in the model and demands will ultimately be migrated to the nodes on the pipes of the model. Customer demand will be assigned to an appropriate category based upon the CIS – like "Residential", "Commercial", "Irrigation", etc. DNV GL has built in 16 hours of effort for manual customer assignment activities related to the average customers of the system.

The GIS includes a wMeter layer that has 8 objects. It appears that this layer flags "large customers" of the system. DNV GL will work with the City to manually place up to 20 of the system's largest users. The City will provide information about these large users to support assignment. If information is known about the usage patterns of these accounts then that information will also be included. It is assumed that these large customers will have accounts in the CIS. They will be flagged as large customers in the CMM data.

NOTE ABOUT DIURNAL PATTERNS: Because the initial model for the City of Duluth is a Steady State Model, no work is planned with regards to creating demand profiles for the customers of the system. In the future, when the system is moved to Time Varying Mode, demand profiles would be needed.

4.4 Steady State Verification

The City of Duluth will provide information that DNV GL can use to perform Steady State Verification of the model.

4.4.1 System Verification

A high-sendout day is typically used for verification. For this Steady State Verification, DNV GL will compare the model at a specific peak hour (like 7 AM) to see if model pressures and flows align with system pressures and flows.

To support verification, the City will need to capture as much operational information about the system as possible for the target verification day. DNV GL will verify the model to the extent possible given the data provided by the City. Typically, system pressures are within 7% for pressures above 15-20 psig with the % error being greater at locations where pressures are low. At flow locations a typical target is 15% for flows above a lower threshold (i.e. low flows can have higher % differences). Experience has shown that system verification effort can vary depending upon many factors. DNV GL has allocated 24 hours of additional investigation of verification findings to resolve situations where the % difference between the model and the field is higher than expected.

4.4.2 Extra Fire Flow Checks – (Not on the Verification Day)

The City of Duluth can also obtain fire flow tests during the high-flow period of the system. These tests should not be performed on the day of model verification. Rather, these tests should be performed a few days after the target verification day.

DNV GL will first verify the model using the selected verification day and then up to 12 fire flow tests will be run on the model as a second "check" of the model. DNV GL will devote up to 16 hours to investigate discrepancies between fire flow test data and model performance. Fire flow test results will be included in a separate section of the project report.

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4.5 Project Report

At the conclusion of the project, DNV GL will provide a project report of about 20 pages in length. The report will summarize the model construction process. It will provide the results of the verification and fire flow testing processes.

4.6 Training

This project does not include any project-specific training.

If the City would like additional training then this effort can be added to this project.

Please see www.DNVGL.com/software/training for our catalog of standard product training.

4.7 The City of Duluth Responsibilities

Involvement of the City of Duluth staff throughout the project is essential to ensure that the City of Duluth receives maximum benefit from the project. While it is not possible to foresee or delineate in advance all the specific contributions that will be required, the following is offered to provide an indication of the scope of the anticipated contributions:

4.7.1 Personnel Requirements

- Appoint a designated single representative, a project manager, who will have the authority to transmit instructions, receive information, and enunciate the City of Duluth's policies and decisions.
- Assistance and cooperation in completing the work in a timely and effective manner. A schedule will be provided at the start of the project. DNV GL will work with the City of Duluth to meet an agreed set of delivery dates
- Information about the City of Duluth's specific requirements with regard to Model Builder, CMM and Synergi Modeling
- All data identified as required in this proposal and any additional data not specifically called out in the proposal that is necessary to complete the implementation of Model Builder and CMM

4.7.2 Data Requirements – Model Builder

- A complete GIS data set (ESRI geodatabase)
- Confirmation of Model Construction Details as discussed earlier in this Scope of Work

4.7.3 Data Requirements – CMM

- Generate and deliver a set of CIS extraction files in CMM format
- Definitions for all rate, status, and usage read codes and any additional codes as required
- Provide XY coordinates for all customers in the CIS extraction files

4.7.4 Data Requirements – Verification

- Verification data as described in the Model Verification section of this proposal

4.8 Project Deliverables

4.8.1 Deliverables

As a result of completing the project, DNV GL will provide the City of Duluth with the following project deliverables:

- Verified Synergi Water model (.mdb) – (Synergi Water Release Version to be Determined at Project Start)
- Final report detailing the facilities model development, demand model development, and model verification processes.

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5 PROJECT FEES

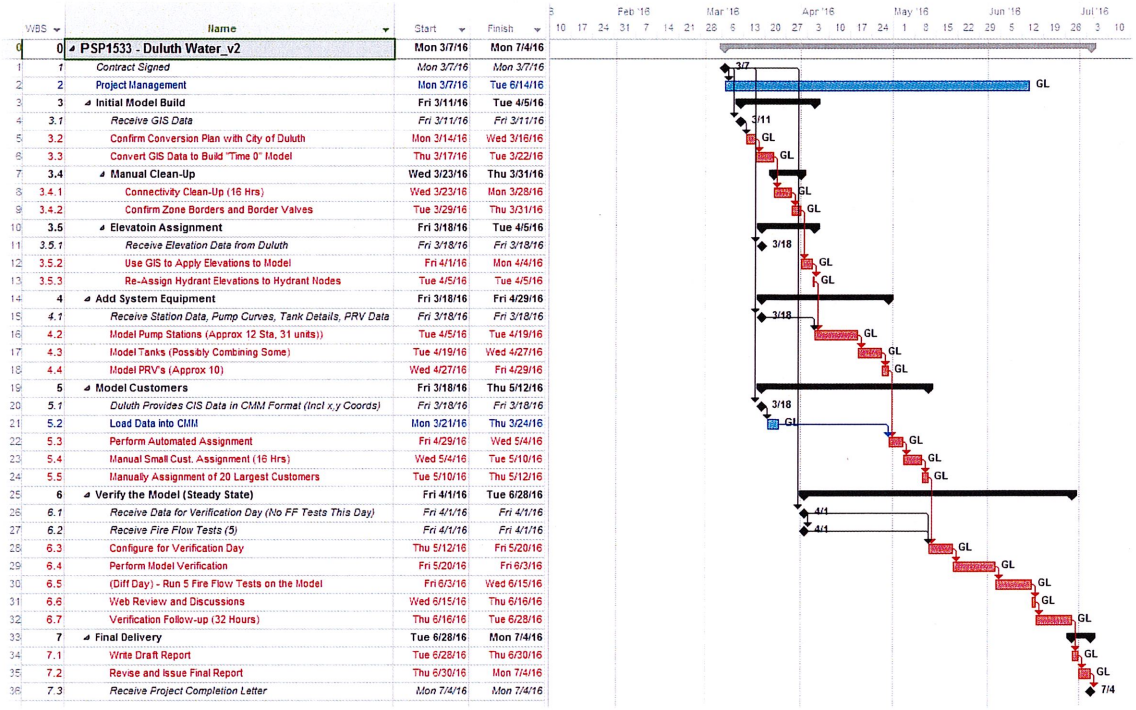
Services	Fee
Water Model Development & Model Verification	$78,000

In addition, travel related expenses are billed at cost plus 10% for any on-site workshops, training, or assistance. There are not any trips scheduled with this project.

Services are invoiced monthly based on percent of work completed in that month.
All charges will be invoiced to the client at the end of the month in which the work is performed.
Invoices are due thirty (30) days from the date of invoice. A 1-1/2 percent per month late charge will be applied for all outstanding invoices not paid within (30) days

6 SCHEDULE

The following schedule is tentative. It will be discussed and adjusted as needed at the start of the project.



WBS	Name	Start	Finish
0	PSP1533 - Duluth Water_v2	Mon 3/7/16	Mon 7/4/16
1	Contract Signed	Mon 3/7/16	Mon 3/7/16
2	Project Management	Mon 3/7/16	Tue 6/14/16
3	Initial Model Build	Fri 3/11/16	Tue 4/5/16
3.1	Receive GIS Data	Fri 3/11/16	Fri 3/11/16
3.2	Confirm Conversion Plan with City of Duluth	Mon 3/14/16	Wed 3/16/16
3.3	Convert GIS Data to Build "Time 0" Model	Thu 3/17/16	Tue 3/22/16
3.4	Manual Clean-Up	Wed 3/23/16	Thu 3/31/16
3.4.1	Connectivity Clean-Up (16 Hrs)	Wed 3/23/16	Mon 3/28/16
3.4.2	Confirm Zone Borders and Border Valves	Tue 3/29/16	Thu 3/31/16
3.5	Elevatoin Assignment	Fri 3/18/16	Tue 4/5/16
3.5.1	Receive Elevation Data from Duluth	Fri 3/18/16	Fri 3/18/16
3.5.2	Use GIS to Apply Elevations to Model	Fri 4/1/16	Mon 4/4/16
3.5.3	Re-Assign Hydrant Elevations to Hydrant Nodes	Tue 4/5/16	Tue 4/5/16
4	Add System Equipment	Fri 3/18/16	Fri 4/29/16
4.1	Receive Station Data, Pump Curves, Tank Details, PRV Data	Fri 3/18/16	Fri 3/18/16
4.2	Model Pump Stations (Approx 12 Sta, 31 units))	Tue 4/5/16	Tue 4/19/16
4.3	Model Tanks (Possibly Combining Some)	Tue 4/19/16	Wed 4/27/16
4.4	Model PRV's (Approx 10)	Wed 4/27/16	Fri 4/29/16
5	Model Customers	Fri 3/18/16	Thu 5/12/16
5.1	Duluth Provides CIS Data in CMM Format (Incl x,y Coords)	Fri 3/18/16	Fri 3/18/16
5.2	Load Data into CMM	Mon 3/21/16	Thu 3/24/16
5.3	Perform Automated Assignment	Fri 4/29/16	Wed 5/4/16
5.4	Manual Small Cust. Assignment (16 Hrs)	Wed 5/4/16	Tue 5/10/16
5.5	Manually Assignment of 20 Largest Customers	Tue 5/10/16	Thu 5/12/16
6	Verify the Model (Steady State)	Fri 4/1/16	Tue 6/28/16
6.1	Receive Data for Verification Day (No FF Tests This Day)	Fri 4/1/16	Fri 4/1/16
6.2	Receive Fire Flow Tests (5)	Fri 4/1/16	Fri 4/1/16
6.3	Configure for Verification Day	Thu 5/12/16	Fri 5/20/16
6.4	Perform Model Verification	Fri 5/20/16	Fri 6/3/16
6.5	(Diff Day) - Run 5 Fire Flow Tests on the Model	Fri 6/3/16	Wed 6/15/16
6.6	Web Review and Discussions	Wed 6/15/16	Thu 6/16/16
6.7	Verification Follow-up (32 Hours)	Thu 6/16/16	Tue 6/28/16
7	Final Delivery	Tue 6/28/16	Mon 7/4/16
7.1	Write Draft Report	Tue 6/28/16	Thu 6/30/16
7.2	Revise and Issue Final Report	Thu 6/30/16	Mon 7/4/16
7.3	Receive Project Completion Letter	Mon 7/4/16	Mon 7/4/16

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7 SERVICES AGREEMENT

This Scope of Services assumes that this work will be performed under an amendment to the existing Master Services Agreement between the City of Duluth and DNV GL from 2014. DNV GL reserves the right to modify this proposal if different terms will be applied.

This proposal is valid through December 31, 2015.