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7.9 INCIDENTAL CHANGES The Contractor may direct the Subcontractor to perform incidental changes in the Subcontract Work which do not involve adjustments in the Subcontract Amount or Subcontract Time. Incidental changes shall be consistent with the scope and intent of the Subcontract Documents. The Contractor shall initiate an incidental change in the Subcontract Work by issuing a written order to the Subcontractor. Such written notice shall be carried out promptly and are binding on the parties.

ARTICLE 8 PAYMENT

8.1 SCHEDULE OF VALUES As a condition to payment, the Subcontractor shall provide a schedule of values satisfactory to the Contractor not more than fifteen (15) days from the date of execution of this Agreement.

8.2 PROGRESS PAYMENTS

8.2.1 APPLICATIONS The Subcontractor's applications for payment shall be itemized and supported by substantiating data as required by the Subcontract Documents. If the Subcontractor is obligated to provide design services pursuant to Paragraph 3.8, Subcontractor's applications for payment shall show the Designer's fee and expenses as a separate cost item. The Subcontractor's application shall be notarized if required and if allowed under the Subcontract Documents may include properly authorized Subcontract Construction Change Directives. The Subcontractor's progress payment application for the Subcontract Work performed in the preceding payment period shall be submitted for approval of the Contractor in accordance with the Schedule of values if required and Subparagraphs 8.2.2, 8.2.3, and 8.2.4. The Contractor shall incorporate the approved amount of the Subcontractor's progress payment application into the Contractor's payment application to the Owner for the same period and submit it to the Owner in a timely fashion. The Contractor shall immediately notify the Subcontractor of any changes in the amount requested on behalf of the Subcontractor.

8.2.2 RETAINAGE The rate of retainage shall be _____ percent (____%) which is equal to the percentage retained from the Contractor's payment by the Owner for the Subcontract Work. If the Subcontract Work is satisfactory and the Subcontract Documents provide for reduction of retainage at a specified percentage of completion, the Subcontractor's retainage shall also be reduced when the Subcontract Work has attained the same percentage of completion and the Contractor's retainage for the Subcontract Work has been so reduced by the Owner.

8.2.3 TIME OF APPLICATION The Subcontractor shall submit progress payment applications to the Contractor no

later than the _____ day of each payment period for the Subcontract Work performed up to and including the _____ day of the payment period indicating work completed and, to the extent allowed under Subparagraph 8.2.4, materials suitably stored during the preceding payment period.

8.2.4 STORED MATERIALS Unless otherwise provided in the Subcontract Documents, and if approved in advance by the Owner, applications for payment may include materials and equipment not incorporated in the Subcontract Work but delivered to and suitably stored at the site or at some other location agreed upon in writing. Approval of payment applications for such stored items on or off the site shall be conditioned upon submission by the Subcontractor of bills of sale and applicable insurance or such other procedures satisfactory to the Owner and Contractor to establish the Owner's title to such materials and equipment, or otherwise to protect the Owner's and Contractor's interest including transportation to the site.

8.2.5 TIME OF PAYMENT Progress payments to the Subcontractor for satisfactory performance of the Subcontract Work shall be made no later than seven (7) days after receipt by the Contractor of payment from the Owner for the Subcontract Work. If payment from the Owner for such Subcontract Work is not received by the Contractor, through no fault of the Subcontractor, the Contractor will make payment to the Subcontractor within a reasonable time for the Subcontract Work satisfactorily performed.

8.2.6 PAYMENT DELAY If the Contractor has received payment from the Owner and if for any reason not the fault of the Subcontractor, the Subcontractor does not receive a progress payment from the Contractor within seven (7) days after the date such payment is due, as defined in Subparagraph 8.2.5, or, if the Contractor has failed to pay the Subcontractor within a reasonable time for the Subcontract Work satisfactorily performed, the Subcontractor, upon giving seven (7) days' written notice to the Contractor, and without prejudice to and in addition to any other legal remedies, may stop work until payment of the full amount owing to the Subcontractor has been received. The Subcontract Amount and Time shall be adjusted by the amount of the Subcontractor's reasonable and verified cost of shutdown, delay, and startup, which shall be effected by an appropriate Subcontractor Change Order.

8.2.7 PAYMENTS WITHHELD The Contractor may reject a Subcontractor payment application or nullify a previously approved Subcontractor payment application, in whole or in part, as may reasonably be necessary to protect the Contractor from loss or damage based upon:

- .1 the Subcontractor's repeated failure to perform the Subcontract Work as required by this Agreement;

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.2 loss or damage arising out of or relating to this Agreement and caused by the Subcontractor to the Owner, Contractor or others to whom the Contractor may be liable;

.3 the Subcontractor's failure to properly pay for labor, materials, equipment or supplies furnished in connection with the Subcontract Work;

.4 rejected, nonconforming or defective Subcontract Work which has not been corrected in a timely fashion;

.5 reasonable evidence of delay in performance of the Subcontract Work such that the Work will not be completed within the Subcontract Time, and that the unpaid balance of the Subcontract Amount is not sufficient to offset the liquidated damages or actual damages that may be sustained by the Contractor as a result of the anticipated delay caused by the Subcontractor.

.6 reasonable evidence demonstrating that the unpaid balance of the Subcontract Amount is insufficient to cover the cost to complete the Subcontract Work;

.7 third party claims involving the Subcontractor or reasonable evidence demonstrating that third party claims are likely to be filed unless and until the Subcontractor furnishes the Contractor with adequate security in the form of a surety bond, letter of credit or other collateral or commitment which are sufficient to discharge such claims if established.

The Contractor shall give written notice to the Subcontractor at the time of disapproving or nullifying an application for payment stating its specific reasons for such disapproval or nullification. When the above reasons for disapproving or nullifying an application for payment are removed, payment will be made for amounts previously withheld.

.3 FINAL PAYMENT

.3.1 APPLICATION Upon acceptance of the Subcontract Work by the Owner and the Contractor and receipt from the Subcontractor of evidence of fulfillment of the Subcontractor's obligations in accordance with the Subcontract Documents and Subparagraph 8.3.2, the Contractor shall incorporate the Subcontractor's application for final payment into the Contractor's next application for payment to the Owner without delay, or notify the Subcontractor if there is a delay and the reasons therefor.

.3.2 REQUIREMENTS Before the Contractor shall be required to incorporate the Subcontractor's application for

final payment into the Contractor's next application for payment, the Subcontractor shall submit to the Contractor:

.1 an affidavit that all payrolls, bills for materials and equipment, and other indebtedness connected with the Subcontract Work for which the Owner or its property or the Contractor or the Contractor's surety might in any way be liable, have been paid or otherwise satisfied;

.2 consent of surety to final payment, if required;

.3 satisfaction of required closeout procedures;

.4 certification that insurance required by the Subcontract Documents to remain in effect beyond final payment pursuant to Clauses 9.2.3.1 and 9.2.6 is in effect and will not be cancelled or allowed to expire without at least thirty (30) days' written notice to the Contractor unless a longer period is stipulated in this Agreement;

.5 other data, if required by the Contractor or Owner, such as receipts, releases, and waivers of liens to the extent and in such form as may be designated by the Contractor or Owner;

.6 written warranties, equipment manuals, startup and testing required in Paragraph 3.28; and

.7 as-built drawings if required by the Subcontract Documents.

8.3.3 TIME OF PAYMENT Final payment of the balance due of the Subcontract Amount shall be made to the Subcontractor within seven (7) days after receipt by the Contractor of final payment from the Owner for such Subcontract Work.

8.3.4 FINAL PAYMENT DELAY If the Owner or its designated agent does not issue a certificate for final payment or the Contractor does not receive such payment for any cause which is not the fault of the Subcontractor, the Contractor shall promptly inform the Subcontractor in writing. The Contractor shall also diligently pursue, with the assistance of the Subcontractor, the prompt release by the Owner of the final payment due for the Subcontract Work. At the Subcontractor's request and expense, to the extent agreed upon in writing, the Contractor shall institute reasonable legal remedies to mitigate the damages and pursue payment of the Subcontractor's final payment including interest. If final payment from the Owner for such Subcontract Work is not received by the Contractor, through no fault of the Subcontractor, the Contractor will make payment to the Subcontractor within a reasonable time.

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8.3.5 WAIVER OF CLAIMS Final payment shall constitute a waiver of all claims by the Subcontractor relating to the Subcontract Work, but shall in no way relieve the Subcontractor of liability for the obligations assumed under Paragraphs 3.21 and 3.22, or for faulty or defective work or services discovered after final payment.

8.4 LATE PAYMENT INTEREST Progress payments or final payment due and unpaid under this Agreement, as defined in Subparagraphs 8.2.5, 8.3.3 and 8.3.4, shall bear interest from the date payment is due at the prime rate prevailing at the place of the Project. However, if the Owner fails to timely pay the Contractor as required under the Owner-Contractor agreement through no fault or neglect of the Contractor, and the Contractor fails to timely pay the Subcontractor as a result of such nonpayment, the Contractor's obligation to pay the Subcontractor interest on corresponding payments due and unpaid under this Agreement shall be extinguished by the Contractor promptly paying to the Subcontractor the Subcontractor's proportionate share of the interest, if any, received by the Contractor from the Owner on such late payments.

8.5 CONTINUING OBLIGATIONS Provided the Contractor is making payments on or has made payments to the Subcontractor in accordance with the terms of this Agreement, the Subcontractor shall reimburse the Contractor for any costs and expenses for any claim, obligation or lien asserted before or after final payment is made that arises from the performance of the Subcontract Work. The Subcontractor shall reimburse the Contractor for costs and expenses including attorneys' fees and costs and expenses incurred by the Contractor in satisfying, discharging or defending against any such claims, obligation or lien including any action brought or judgment recovered. In the event that any applicable law, statute, regulation or bond requires the Subcontractor to take any action prior to the expiration of the reasonable time for payment referred in Subparagraph 8.2.5 in order to preserve or protect the Subcontractor's rights, if any, with respect to mechanic's lien or bond claims, then the Subcontractor may take that action prior to the expiration of the reasonable time for payment and such action will not create the reimbursement obligation recited above nor be in violation of this Agreement or considered premature for purposes of preserving and protecting the Subcontractor's rights.

8.6 PAYMENT USE RESTRICTION Payments received by the Subcontractor shall be used to satisfy the indebtedness owed by the Subcontractor to any person furnishing labor or materials, or both, for use in performing the Subcontract Work through the most current period applicable to progress payments received from the Contractor before it is used for any other purpose. In the same manner, payments received by the Contractor from the Owner for the Subcontract Work shall be dedicated to payment to the Subcontractor. This provision shall bear on this Agreement only,

and is not for the benefit of third parties. Moreover, it shall not be construed by the parties to this Agreement or third parties to require that dedicated sums of money or payments be deposited in separate accounts, or that there be other restrictions on commingling of funds. Neither shall these mutual covenants be construed to create any fiduciary duty on the Subcontractor or Contractor, nor create any tort cause of action or liability for breach of trust, punitive damages, or other equitable remedy or liability for alleged breach.

8.7 PAYMENT USE VERIFICATION If the Contractor has reason to believe that the Subcontractor is not complying with the payment terms of this Agreement, the Contractor shall have the right to contact the Subcontractor's subcontractors and suppliers to ascertain whether they are being paid by the Subcontractor in accordance with this Agreement.

8.8 PARTIAL LIEN WAIVERS AND AFFIDAVITS As a prerequisite for payments, the Subcontractor shall provide, in a form satisfactory to the Owner and Contractor, partial lien or claim waivers in the amount of the application for payment and affidavits covering its subcontractors and suppliers for completed Subcontract Work. Such waivers may be conditional upon payment. In no event shall Contractor require the Subcontractor to provide an unconditional waiver of lien or claim, either partial or final, prior to receiving payment or in an amount in excess of what it has been paid.

8.9 SUBCONTRACTOR PAYMENT FAILURE Upon payment by the Contractor, the Subcontractor shall promptly pay its subcontractors and suppliers the amounts to which they are entitled. In the event the Contractor has reason to believe that labor, material or other obligations incurred in the performance of the Subcontract Work are not being paid, the Contractor may give written notice of a potential claim or lien to the Subcontractor and may take any steps deemed necessary to assure that progress payments are utilized to pay such obligations, including but not limited to the issuance of joint checks. If upon receipt of notice, the Subcontractor does not (a) supply evidence to the satisfaction of the Contractor that the moneys owing have been paid; or (b) post a bond indemnifying the Owner, the Contractor, the Contractor's surety, if any, and the premises from a claim or lien, the Contractor shall have the right to withhold from any payments due or to become due to the Subcontractor a reasonable amount to protect the Contractor from any and all loss, damage or expense including attorneys' fees that may arise out of or relate to any such claim or lien.

8.10 SUBCONTRACTOR ASSIGNMENT OF PAYMENTS The Subcontractor shall not assign any moneys due or to become due under this Agreement, without the written consent of the Contractor, unless the assignment is intended to create a new security interest within the scope of Article 9 of the Uniform Commercial Code. Should the Subcontractor assign all or any part of any moneys due or to

become due under this Agreement to create a new security interest or for any other purpose, the instrument of assignment shall contain a clause to the effect that the assignee's right in and to any money due or to become due to the Subcontractor shall be subject to the claims of all persons, firms and corporations for services rendered or materials supplied for the performance of the Subcontract Work.

8.11 PAYMENT NOT ACCEPTANCE Payment to the Subcontractor does not constitute or imply acceptance of any portion of the Subcontract Work.

ARTICLE 9

INDEMNITY, INSURANCE AND WAIVER OF SUBROGATION

9.1 INDEMNITY

9.1.1 INDEMNITY To the fullest extent permitted by law, the Subcontractor shall defend, indemnify and hold harmless the Contractor, the Contractor's other subcontractors, the Architect/Engineer, the Owner and their agents, consultants and employees (the Indemnitees) from all claims for bodily injury and property damage that may arise from the performance of the Subcontract Work to the extent of the negligence attributed to such acts or omissions by the Subcontractor, the Subcontractor's subcontractors or anyone employed directly or indirectly by any of them or by anyone or whose acts any of them may be liable.

9.1.2 NO LIMITATION ON LIABILITY In any and all claims against the Indemnitees by any employee of the Subcontractor, anyone directly or indirectly employed by the Subcontractor or anyone for whose acts the Subcontractor may be liable, the indemnification obligation shall not be limited in any way by any limitation on the amount or type of damages, compensation or benefits payable by or to the Subcontractor under workers' compensation acts, disability benefit acts or other employee benefit acts.

9.2 INSURANCE

9.2.1 SUBCONTRACTOR'S INSURANCE Before commencing the Subcontract Work, and as a condition of payment, the Subcontractor shall purchase and maintain insurance that will protect it from the claims arising out of its operations under this Agreement, whether the operations are by the Subcontractor, or any of its consultants or subcontractors or anyone directly or indirectly employed by any of them, or by anyone for whose acts any of them may be liable.

9.2.2 MINIMUM LIMITS OF LIABILITY The Subcontractor shall maintain at least the limits of liability in a company satisfactory to the Contractor as set forth in Exhibit _____.

9.2.3 PROFESSIONAL LIABILITY INSURANCE

9.2.3.1 PROFESSIONAL LIABILITY INSURANCE The Subcontractor shall require the Designer(s) to maintain Project Specific Professional Liability Insurance with a company satisfactory to the Contractor, including contractual liability insurance against the liability assumed in Paragraph 3.8, and including coverage for any professional liability caused by any of the Designer(s)' consultants. Said insurance shall have specific minimum limits as set forth below:

Limit of \$ _____ per claim.♦
General Aggregate of \$ _____ for the subcontract services rendered.♦

The Professional Liability Insurance shall contain prior acts coverage sufficient to cover all subcontract services rendered by the Designer. Said insurance shall be continued in effect with an extended period of _____ years following final payment to the Designer.♦

Such insurance shall have a maximum deductible amount of \$ _____ per occurrence. The deductible shall be paid by the Subcontractor or Designer.♦

9.2.3.2 The Subcontractor shall require the Designer to furnish to the Subcontractor and Contractor, before the Designer commences its services, a copy of its professional liability policy evidencing the coverages required in this Paragraph. No policy shall be cancelled or modified without thirty (30) days' prior written notice to the Subcontractor and Contractor.

9.2.4 NUMBER OF POLICIES Commercial General Liability Insurance and other liability insurance may be arranged under a single policy for the full limits required or by a combination of underlying policies with the balance provided by an Excess or Umbrella Liability Policy.

9.2.5 CANCELLATION, RENEWAL AND MODIFICATION The Subcontractor shall maintain in effect all insurance coverages required under this Agreement at the Subcontractor's sole expense and with insurance companies acceptable to the Contractor. The policies shall contain a provision that coverage will not be cancelled or not renewed until at least thirty (30) days' prior written notice has been given to the Contractor. Certificates of insurance showing required coverage to be in force pursuant to Subparagraph 9.2.2 shall be filed with the Contractor prior to commencement of the Subcontract Work. In the event the Subcontractor fails to obtain or maintain any insurance coverage required under this Agreement, the Contractor may purchase such coverage as desired for the Contractor's benefit and charge the expense to the Subcontractor, or terminate this Agreement.♦

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9.2.6 CONTINUATION OF COVERAGE The Subcontractor shall continue to carry Completed Operations Liability Insurance for at least _____ years after either ninety (90) days following Substantial Completion of the Work or final payment to the Contractor, whichever is earlier. The Subcontractor shall furnish the Contractor evidence of such insurance at final payment and one year from final payment.

9.2.7 BUILDER'S RISK INSURANCE

9.2.7.1 Upon written request of the Subcontractor, the Contractor shall provide the Subcontractor with a copy of the Builder's Risk policy of insurance or any other property or equipment insurance in force for the Project and procured by the Owner or Contractor. The Contractor will advise the Subcontractor if a Builder's Risk policy of insurance is not in force.

9.2.7.2 If the Owner or Contractor has not purchased Builder's Risk insurance satisfactory to the Subcontractor, the Subcontractor may procure such insurance as will protect the interests of the Subcontractor, its subcontractors and their subcontractors in the Subcontract Work.

9.2.7.3 If not covered under the Builder's Risk policy of insurance or any other property or equipment insurance required by the Subcontract Documents, the Subcontractor shall procure and maintain at the Subcontractor's own expense property and equipment insurance for the Subcontract Work including portions of the Subcontract Work stored off the site or in transit, when such portions of the Subcontract Work are to be included in an application for payment under Article 8.

9.2.8 WAIVER OF SUBROGATION

9.2.8.1 The Contractor and Subcontractor waive all rights against each other, the Owner and the Architect/Engineer, and any of their respective consultants, subcontractors, and sub-subcontractors, agents and employees, for damages caused by perils to the extent covered by the proceeds of the insurance provided in Clause 9.2.7., except such rights as they may have to the insurance proceeds. The Subcontractor shall require similar waivers from its subcontractors.

9.2.9 ENDORSEMENT If the policies of insurance referred to in this Article require an endorsement to provide for continued coverage where there is a waiver of subrogation, the owners of such policies will cause them to be so endorsed.

ARTICLE 10

CONTRACTOR'S RIGHT TO PERFORM SUBCONTRACTOR'S RESPONSIBILITIES AND TERMINATION OF AGREEMENT

10.1 FAILURE OF PERFORMANCE

10.1.1 NOTICE TO CURE If the Subcontractor refuses or fails to supply enough properly skilled workers, proper materials, or maintain the Progress Schedule, or fails to make prompt payment to its workers, subcontractors or suppliers, or disregards laws, ordinances, rules, regulations or orders of any public authority having jurisdiction, or otherwise is guilty of a material breach of a provision of this Agreement, the Subcontractor shall be deemed in default of this Agreement. If the Subcontractor fails within three (3) days after written notification to commence and continue satisfactory correction of the default with diligence and promptness, then the Contractor without prejudice to any other rights or remedies, shall have the right to any or all of the following remedies:

.1 supply workers, materials, equipment and facilities as the Contractor deems necessary for the completion of the Subcontract Work or any part which the Subcontractor has failed to complete or perform after written notification, and charge the cost, including reasonable overhead, profit, attorneys' fees, costs and expenses to the Subcontractor;

.2 contract with one or more additional contractors to perform such part of the Subcontract Work as the Contractor determines will provide the most expeditious completion of the Work, and charge the cost to the Subcontractor as provided under Clause 10.1.1.1; and/or

.3 withhold any payments due or to become due the Subcontractor pending corrective action in amounts sufficient to cover losses and compel performance to the extent required by and to the satisfaction of the Contractor.

In the event of an emergency affecting the safety of persons or property, the Contractor may proceed as above without notice, but the Contractor shall give the Subcontractor notice promptly after the fact as a precondition of cost recovery.

10.1.2 TERMINATION BY CONTRACTOR If the Subcontractor fails to commence and satisfactorily continue correction of a default within three (3) days after written notification issued under Subparagraph 10.1.1, then the Contractor may, in lieu of or in addition to Subparagraph

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10.1.1, issue a second written notification, to the Subcontractor and its surety, if any. Such notice shall state that if the Subcontractor fails to commence and continue correction of a default within seven (7) days of the written notification, the Agreement will be deemed terminated. A written notice of termination shall be issued by the Contractor to the Subcontractor at the time the Subcontractor is terminated. The Contractor may furnish those materials, equipment and/or employ such workers or subcontractors as the Contractor deems necessary to maintain the orderly progress of the Work. All costs incurred by the Contractor in performing the Subcontract Work, including reasonable overhead, profit and attorneys' fees, costs and expenses, shall be deducted from any moneys due or to become due the Subcontractor. The Subcontractor shall be liable for the payment of any amount by which such expense may exceed the unpaid balance of the Subcontract Amount. At the Subcontractor's request, the Contractor shall provide a detailed accounting of the costs to finish the Subcontract Work.

10.1.3 USE OF SUBCONTRACTOR'S EQUIPMENT If the Contractor performs work under this Article, either directly or through other subcontractors, the Contractor or other subcontractors shall have the right to take and use any materials, implements, equipment, appliances or tools furnished by, or belonging to the Subcontractor and located at the Project site for the purpose of completing any remaining Subcontract Work. Immediately upon completion of the Subcontract Work, any remaining materials, implements, equipment, appliances or tools not consumed or incorporated in performance of the Subcontract Work, and furnished by, belonging to, or delivered to the Project by or on behalf of the Subcontractor, shall be returned to the Subcontractor in substantially the same condition as when they were taken, normal wear and tear excepted.

10.2. BANKRUPTCY

10.2.1 TERMINATION ABSENT CURE If the Subcontractor files a petition under the Bankruptcy Code, this Agreement shall terminate if the Subcontractor or the Subcontractor's trustee rejects the Agreement or, if there has been a default, the Subcontractor is unable to give adequate assurance that the Subcontractor will perform as required by this Agreement or otherwise is unable to comply with the requirements for assuming this Agreement under the applicable provisions of the Bankruptcy Code.

10.2.2 INTERIM REMEDIES If the Subcontractor is not performing in accordance with the Progress Schedule at the time a petition in bankruptcy is filed, or at any subsequent time, the Contractor, while awaiting the decision of the Subcontractor or its trustee to reject or to assume this Agreement and provide adequate assurance of its ability to perform, may avail itself of such remedies under this Article as are reasonably necessary to maintain the Progress

Schedule. The Contractor may offset against any sums due or to become due the Subcontractor all costs incurred in pursuing any of the remedies provided including, but not limited to, reasonable overhead, profit and attorneys' fees. The Subcontractor shall be liable for the payment of any amount by which costs incurred may exceed the unpaid balance of the Subcontract Price.

10.3 SUSPENSION BY OWNER Should the Owner suspend the Work or any part which includes the Subcontract Work and such suspension is not due to any act or omission of the Contractor, or any other person or entity for whose acts or omissions the Contractor may be liable, the Contractor shall notify the Subcontractor in writing and upon receiving notification the Subcontractor shall immediately suspend the Subcontract Work. In the event of Owner suspension, the Contractor's liability to the Subcontractor shall be limited to the extent of the Contractor's recovery on the Subcontractor's behalf under the Subcontract Documents. The Contractor agrees to cooperate with the Subcontractor, at the Subcontractor's expense, in the prosecution of any Subcontractor claim arising out of an Owner suspension and to permit the Subcontractor to prosecute the claim, in the name of the Contractor, for the use and benefit of the Subcontractor.

10.4 TERMINATION BY OWNER Should the Owner terminate its contract with the Contractor or any part which includes the Subcontract Work, the Contractor shall notify the Subcontractor in writing within three (3) days of the termination and upon written notification, this Agreement shall be terminated and the Subcontractor shall immediately stop the Subcontract Work, follow all of Contractor's instructions, and mitigate all costs. In the event of Owner termination, the Contractor's liability to the Subcontractor shall be limited to the extent of the Contractor's recovery on the Subcontractor's behalf under the Subcontract Documents. The Contractor agrees to cooperate with the Subcontractor, at the Subcontractor's expense, in the prosecution of any Subcontractor claim arising out of the Owner termination and to permit the Subcontractor to prosecute the claim, in the name of the Contractor, for the use and benefit of the Subcontractor, or assign the claim to the Subcontractor.

10.5 CONTINGENT ASSIGNMENT OF THIS AGREEMENT The Contractor's contingent assignment of this Agreement to the Owner, as provided in the Owner-Contractor agreement, is effective when the Owner has terminated the Owner-Contractor agreement for cause and has accepted the assignment by notifying the Subcontractor in writing. This contingent assignment is subject to the prior rights of a surety that may be obligated under the Contractor's bond, if any. Subcontractor consents to such assignment and agrees to be bound to the assignee by the terms of this Agreement, provided that the assignee fulfills the obligations of the Contractor.

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10.6 SUSPENSION BY CONTRACTOR The Contractor may order the Subcontractor in writing to suspend all or any part of the Subcontract Work for such period of time as may be determined to be appropriate for the convenience of the Contractor. Phased Work or interruptions of the Subcontract Work for short periods of time shall not be considered a suspension. The Subcontractor, after receipt of the Contractor's order, shall notify the Contractor in writing in sufficient time to permit the Contractor to provide timely notice to the Owner in accordance with the Owner-Contractor agreement of the effect of such order upon the Subcontract Work. The Subcontract Amount or Progress Schedule shall be adjusted by Subcontract Change Order for any increase in the time or cost of performance of this Agreement caused by such suspension. No claim under this Paragraph shall be allowed for any costs incurred more than fourteen (14) days prior to the Subcontractor's notice to the Contractor. Neither the Subcontract Amount nor the Progress Schedule shall be adjusted for any suspension, to the extent that performance would have been suspended, due in whole or in part to the fault or negligence of the Subcontractor or by a cause for which Subcontractor would have been responsible. The Subcontract Amount shall not be adjusted for any suspension to the extent that performance would have been suspended by a cause for which the Subcontractor would have been entitled only to a time extension under this Agreement.

10.7 WRONGFUL EXERCISE If the Contractor wrongfully exercises any option under this Article, the Contractor shall be liable to the Subcontractor solely for the reasonable value of Subcontract Work performed by the Subcontractor prior to the Contractor's wrongful action, including reasonable overhead and profit on the Subcontract Work performed, less prior payments made, together with reasonable overhead and profit on the Subcontract Work not executed, and other costs incurred by reason of such action.

10.8 TERMINATION BY SUBCONTRACTOR If the Subcontract Work has been stopped for thirty (30) days because the Subcontractor has not received progress payments or has been abandoned or suspended for an unreasonable period of time not due to the fault or neglect of the Subcontractor, then the Subcontractor may terminate this Agreement upon giving the Contractor seven (7) days' written notice. Upon such termination, Subcontractor shall be entitled to recover from the Contractor payment for all Subcontract Work satisfactorily performed but not yet paid for, including reasonable overhead, profit and attorneys' fees, costs and expenses. However, if the Owner has not paid the Contractor for the satisfactory performance of the Subcontract Work through no fault or neglect of the Contractor, and the Subcontractor terminates this Agreement under this Article because it has not received corresponding progress payments, the Subcontractor shall be entitled to recover from the Contractor, within a reasonable period of time following termination, payment for all Subcontract Work satisfactorily

performed but not yet paid for, including reasonable overhead and profit. The Contractor's liability for any other damages claimed by the Subcontractor under such circumstances shall be extinguished by the Contractor pursuing said damages and claims against the Owner, on the Subcontractor's behalf, in the manner provided for in Subparagraphs 10.3 and 10.4 of this Agreement.

ARTICLE 11

DISPUTE RESOLUTION

11.1 INITIAL DISPUTE RESOLUTION If a dispute arises out of or relates to this Agreement or its breach, the parties shall endeavor to settle the dispute first through direct discussions. If the dispute cannot be resolved through direct discussions, the parties shall participate in mediation under the Construction Industry Mediation Rules of the American Arbitration Association before recourse to any other form of binding dispute resolution. The location of the mediation shall be the location of the Project. Once a party files a request for mediation with the other party and with the American Arbitration Association, the parties agree to commence such mediation within thirty (30) days of filing of the request. Either party may terminate the mediation at any time after the first session, but the decision to terminate must be delivered in person to the other party and the mediator. Engaging in mediation is a condition precedent to any other form of binding dispute resolution.

11.2 WORK CONTINUATION AND PAYMENT Unless otherwise agreed in writing, the Subcontractor shall continue the Subcontract Work and maintain the Progress Schedule during any dispute resolution proceedings. If the Subcontractor continues to perform, the Contractor shall continue to make payments in accordance with this Agreement.

11.3 NO LIMITATION OF RIGHTS OR REMEDIES Nothing in this Article shall limit any rights or remedies not expressly waived by the Subcontractor which the Subcontractor may have under lien laws or payment bonds.

11.4 MULTIPARTY PROCEEDING The parties agree that to the extent permitted by Subcontract Document all parties necessary to resolve a claim shall be parties to the same dispute resolution proceeding. To the extent disputes between the Contractor and Subcontractor involve in whole or in part disputes between the Contractor and the Owner, disputes between the Subcontractor and the Contractor shall be decided by the same tribunal and in the same forum as disputes between the Contractor and the Owner.

11.5 DISPUTES BETWEEN CONTRACTOR AND SUBCONTRACTOR In the event that the provisions for resolution of disputes between the Contractor and the Owner contained in the Subcontract Documents do not permit con-

solidation or joinder with disputes of third parties, such as the Subcontractor, resolution of disputes between the Subcontractor and the Contractor involving in whole or in part disputes between the Contractor and the Owner shall be stayed pending conclusion of any dispute resolution proceeding between the Contractor and the Owner. At the conclusion of those proceedings, disputes between the Subcontractor and the Contractor shall be submitted again to mediation pursuant to Paragraph 11.1. Any disputes not resolved by mediation shall be decided in the manner selected in the agreement between the Owner and the Contractor.

11.6 COST OF DISPUTE RESOLUTION The cost of any mediation proceeding shall be shared equally by the parties participating. The prevailing party in any dispute arising out of or relating to this Agreement or its breach that is resolved by a dispute resolution procedure designated in the Subcontract Documents shall be entitled to recover from the other party reasonable attorneys' fees, costs and expenses incurred by the prevailing party in connection with such dispute resolution process.

SAMPLE

ARTICLE 12

MISCELLANEOUS PROVISIONS

12.1 GOVERNING LAW This Agreement shall be governed by the law in effect at the location of the Project.

12.2 SEVERABILITY The partial or complete invalidity of any one or more provisions of this Agreement shall not affect the validity or continuing force and effect of any other provision.

12.3 NO WAIVER OF PERFORMANCE The failure of either party to insist, in any one or more instances, upon the performance of any of the terms, covenants or conditions of this Agreement, or to exercise any of its rights, shall not be construed as a waiver or relinquishment of term, covenant, condition or right with respect to further performance.

12.4 TITLES The titles given to the Articles of this Agreement are for ease of reference only and shall not be relied upon or cited for any other purpose.

12.5 OTHER PROVISIONS AND DOCUMENTS Other provisions and documents applicable to the Subcontract Work are set forth in Exhibit _____.

12.6 JOINT DRAFTING The parties expressly agree that this Agreement was jointly drafted, and that they both had opportunity to negotiate its terms and to obtain the assistance of counsel in reviewing its terms prior to execution. Therefore, this Agreement shall be construed neither against nor in favor of either party, but shall be construed in a neutral manner.

384 Appendix G**ARTICLE 13****EXISTING SUBCONTRACT DOCUMENT**

As defined in Paragraph 2.3, the following Exhibits are a part of this Agreement.

- EXHIBIT _____ ♦ The Subcontract Work, _____ pages. ♦
- EXHIBIT _____ ♦ The Drawings, Specifications, General and other conditions, addenda and other information.
(Attach a complete listing by title, date and number of pages.)
- EXHIBIT _____ ♦ Progress Schedule, _____ pages. ♦
- EXHIBIT _____ ♦ Alternates and Unit Prices, include dates when alternates and unit prices no longer apply,
_____ pages. ♦
- EXHIBIT _____ ♦ Temporary Services, stating specific responsibilities of the Subcontractor, _____ pages. ♦
- EXHIBIT _____ ♦ Insurance Provisions, _____ pages. ♦
- EXHIBIT _____ ♦ Other Provisions and Documents, _____ pages. ♦

SAMPLE

This Agreement is entered into as of the date entered in Article 1.

SIGNATURES

ATTEST: _____ ♦

CONTRACTOR: _____ ♦

BY: _____ ♦

PRINT NAME: _____ ♦

PRINT TITLE: _____ ♦

ATTEST: _____ ♦

SUBCONTRACTOR: _____ ♦

BY: _____ ♦

PRINT NAME: _____ ♦

PRINT TITLE: _____ ♦

11/01

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Appendix H

Interest Tables

386 Appendix H**5% FACTORS INTEREST**

Single Payment			Uniform Series			<i>n</i>
Compound Amount	Present Worth	Compound Amount	Sinking Fund	Present Worth	Capital Recovery	
Factor CAF	Factor PWSP	USCA	Factor SFF	Factor PWUS	Factor CRF	
<i>n</i>	Given <i>P</i> to Find <i>F</i>	Given <i>F</i> to Find <i>P</i>	Given <i>A</i> to Find <i>F</i>	Given <i>F</i> to Find <i>A</i>	Given <i>A</i> to Find <i>P</i>	Given <i>P</i> to Find <i>A</i>
	(1 + <i>i</i>) ^{<i>n</i>}	$\frac{1}{(1 + i)^n}$	$\frac{(1 + i)^n - 1}{i}$	$\frac{i}{(1 + i)^n - 1}$	$\frac{(1 + i)^n - 1}{i(1 + i)^n}$	$\frac{i(1 + i)^n}{(1 + i) - 1}$
1	1.050	0.9524	1.000	1.00001	0.952	1.05001
2	1.102	0.9070	2.050	0.48781	1.859	0.53781
3	1.158	0.8638	3.152	0.31722	2.723	0.36722
4	1.216	0.8227	4.310	0.23202	3.546	0.28202
5	1.276	0.7835	5.526	0.18098	4.329	0.23098
6	1.340	0.7462	6.802	0.14702	5.076	0.19702
7	1.407	0.7107	8.142	0.12282	5.786	0.17282
8	1.477	0.6768	9.549	0.10472	6.463	0.15472
9	1.551	0.6446	11.026	0.09069	7.108	0.14069
10	1.629	0.6139	12.578	0.07951	7.722	0.12951
11	1.710	0.5847	14.206	0.07039	8.306	0.12039
12	1.796	0.5568	15.917	0.06283	8.863	0.11283
13	1.886	0.5303	17.712	0.05646	9.393	0.10646
14	1.980	0.5051	19.598	0.05103	9.899	0.10103
15	2.079	0.4810	21.578	0.04634	10.380	0.09634
16	2.183	0.4581	23.657	0.04227	10.838	0.09227
17	2.292	0.4363	25.840	0.03870	11.274	0.08870
18	2.407	0.4155	28.132	0.03555	11.689	0.08555
19	2.527	0.3957	30.538	0.03275	12.085	0.08275
20	2.653	0.3769	33.065	0.03024	12.462	0.08024
21	2.786	0.3589	35.718	0.02800	12.821	0.07800
22	2.925	0.3419	38.504	0.02597	13.163	0.07597
23	3.071	0.3256	41.429	0.02414	13.488	0.07414
24	3.225	0.3101	44.500	0.02247	13.798	0.07247
25	3.386	0.2953	47.725	0.02095	14.094	0.07095
26	3.556	0.2812	51.112	0.01957	14.375	0.06956
27	3.733	0.2679	54.667	0.01829	14.643	0.06829
28	3.920	0.2551	58.400	0.01712	14.898	0.06712
29	4.116	0.2430	62.320	0.01605	15.141	0.06605
30	4.322	0.2314	66.436	0.01505	15.372	0.06505
35	5.516	0.1813	90.316	0.01107	16.374	0.06107
40	7.040	0.1421	120.794	0.00828	17.159	0.05828
50	11.467	0.0872	209.336	0.00478	18.256	0.05478
75	38.830	0.0258	756.594	0.00132	19.485	0.05132
100	131.488	0.0076	2609.761	0.00038	19.848	0.05038

6% FACTORS INTEREST

<i>n</i>	Single Payment			Uniform Series			<i>n</i>
	Compound Amount	Present Worth	Compound Factor	Sinking Fund	Present Worth	Capital Recovery	
	CAF	PWSP	USCA	SFF	Factor	Factor	
1	Given <i>P</i> to Find <i>F</i> $(1+i)^n$	Given <i>F</i> to Find <i>P</i> $\frac{1}{(1+i)^n}$	Given <i>A</i> to Find <i>F</i> $\frac{(1+i)^n - 1}{i}$	Given <i>F</i> to Find <i>A</i> $i - 1$	Given <i>A</i> to Find <i>P</i> $\frac{(1+i)^n - 1}{i(1+i)^n}$	Given <i>P</i> to Find <i>A</i> $i(1+i)^n$	Given <i>P</i> to Find <i>F</i> $(1+i)^n - 1$
2	1.060	0.9434	1.000	1.00001	0.943	1.06001	1
3	1.124	0.8900	2.060	0.48544	1.833	0.54544	2
4	1.191	0.8396	3.184	0.31411	2.673	0.37411	3
5	1.262	0.7921	4.375	0.22860	3.465	0.28860	4
6	1.338	0.7473	5.637	0.17740	4.212	0.23740	5
7	1.419	0.7050	6.975	0.14337	4.917	0.20337	6
8	1.504	0.6651	8.394	0.11914	5.582	0.17914	7
9	1.594	0.6274	9.897	0.10104	6.210	0.16104	8
10	1.689	0.5919	11.491	0.08702	6.802	0.14702	9
11	1.791	0.5584	13.181	0.07587	7.360	0.13587	10
12	1.898	0.5268	14.971	0.06679	7.887	0.12679	11
13	2.012	0.4970	16.870	0.05928	8.384	0.11928	12
14	2.133	0.4688	18.882	0.05296	8.853	0.11296	13
15	2.261	0.4423	21.015	0.04759	9.295	0.10759	14
16	2.397	0.4173	23.275	0.04296	9.712	0.10296	15
17	2.540	0.3937	25.672	0.03895	10.106	0.09895	16
18	2.693	0.3714	28.212	0.03545	10.477	0.09545	17
19	2.854	0.3503	30.905	0.03236	10.828	0.09236	18
20	3.026	0.3305	33.759	0.02962	11.158	0.08962	19
21	3.207	0.3118	36.785	0.02719	11.470	0.08719	20
22	3.399	0.2942	39.992	0.02501	11.764	0.08501	21
23	3.603	0.2775	43.391	0.02305	12.041	0.08305	22
24	3.820	0.2618	46.994	0.02128	12.303	0.08128	23
25	4.049	0.2470	50.814	0.01968	12.550	0.07968	24
26	4.292	0.2330	54.863	0.01823	12.783	0.07823	25
27	4.549	0.2198	59.154	0.01690	13.003	0.07690	26
28	4.822	0.2074	63.704	0.01570	13.210	0.07570	27
29	5.112	0.1956	68.526	0.01459	13.406	0.07459	28
30	5.418	0.1846	73.637	0.01358	13.591	0.07358	29
35	7.686	0.1301	111.430	0.00897	14.498	0.06897	35
40	10.285	0.0972	154.755	0.00646	15.046	0.06646	40
50	18.419	0.0543	290.321	0.00344	15.762	0.06344	50
75	79.051	0.0127	1300.852	0.00077	16.456	0.06077	75
100	339.269	0.0029	5637.809	0.00018	16.618	0.06018	100

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7% FACTORS INTEREST

	Single Payment			Uniform Series			
	Compound Amount Factor CAF	Present Worth Factor PWSP	Compound Amount Factor USCA	Sinking Fund Factor SFF	Present Worth Factor PWUS	Capital Recovery Factor CRF	
<i>n</i>	Given <i>P</i> to Find <i>F</i>	Given <i>F</i> to Find <i>P</i>	Given <i>A</i> to Find <i>F</i> $(1+i)^n - 1$	Given <i>F</i> to Find <i>A</i> i	Given <i>A</i> to Find <i>P</i> $(1+i)^n - 1$	Given <i>P</i> to Find <i>A</i> $i(1+i)^n$	<i>n</i>
		$\frac{1}{(1+i)^n}$	i	$\frac{1}{(1+i)^n - 1}$	$i(1+i)^n$	$\frac{i}{(1+i)^n - 1}$	
1	1.070	0.9346	1.000	1.00000	0.935	1.07000	1
2	1.145	0.8734	2.070	0.48310	1.808	0.55310	2
3	1.225	0.8163	3.215	0.31106	2.624	0.38105	3
4	1.311	0.7629	4.440	0.22523	3.387	0.29523	4
5	1.403	0.7130	5.751	0.17389	4.100	0.24389	5
6	1.501	0.6663	7.153	0.13980	4.766	0.20980	6
7	1.606	0.6228	8.654	0.11555	5.389	0.18555	7
8	1.718	0.5820	10.260	0.09747	5.971	0.16747	8
9	1.838	0.5439	11.978	0.08349	6.515	0.15349	9
10	1.967	0.5084	13.816	0.07238	7.024	0.14238	10
11	2.105	0.4751	15.783	0.06336	7.499	0.13336	11
12	2.252	0.4440	17.888	0.05590	7.943	0.12590	12
13	2.410	0.4150	20.140	0.04965	8.358	0.11965	13
14	2.579	0.3878	22.550	0.04435	8.745	0.11435	14
15	2.759	0.3625	25.129	0.03980	9.108	0.10980	15
16	2.952	0.3387	27.887	0.03586	9.447	0.10586	16
17	3.159	0.3166	30.840	0.03243	9.763	0.10243	17
18	3.380	0.2959	33.998	0.02941	10.059	0.09941	18
19	3.616	0.2765	37.378	0.02675	10.336	0.09675	19
20	3.870	0.2584	40.995	0.02439	10.594	0.09439	20
21	4.140	0.2415	44.864	0.02229	10.835	0.09229	21
22	4.430	0.2257	49.005	0.02041	11.061	0.09041	22
23	4.740	0.2110	53.435	0.01871	11.272	0.08871	23
24	5.072	0.1972	58.175	0.01719	11.469	0.08719	24
25	5.427	0.1843	63.247	0.01581	11.654	0.08581	25
26	5.807	0.1722	68.675	0.01456	11.826	0.08456	26
27	6.214	0.1609	74.482	0.01343	11.987	0.08343	27
28	6.649	0.1504	80.695	0.01239	12.137	0.08239	28
29	7.114	0.1406	87.344	0.01145	12.278	0.08145	29
30	7.612	0.1314	94.458	0.01059	12.409	0.08059	30
35	10.676	0.0937	138.233	0.00723	12.948	0.07723	35
40	14.974	0.0668	199.628	0.00501	13.332	0.07501	40
50	29.456	0.0339	406.511	0.00246	13.801	0.07246	50
75	159.866	0.0063	2269.516	0.00044	14.196	0.07044	75
100	867.644	0.0012	12380.633	0.00008	14.269	0.07008	100

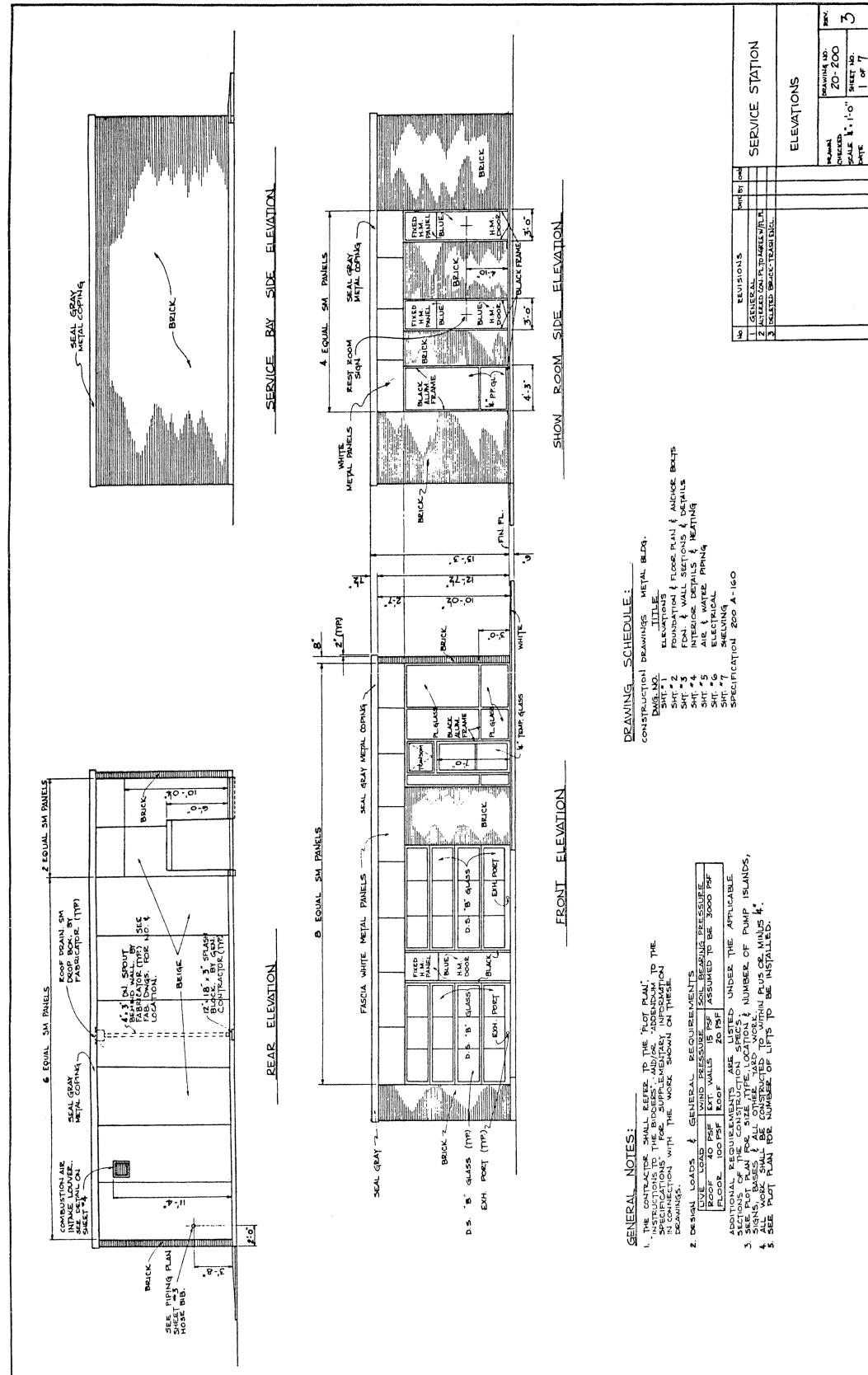
8% FACTORS INTEREST

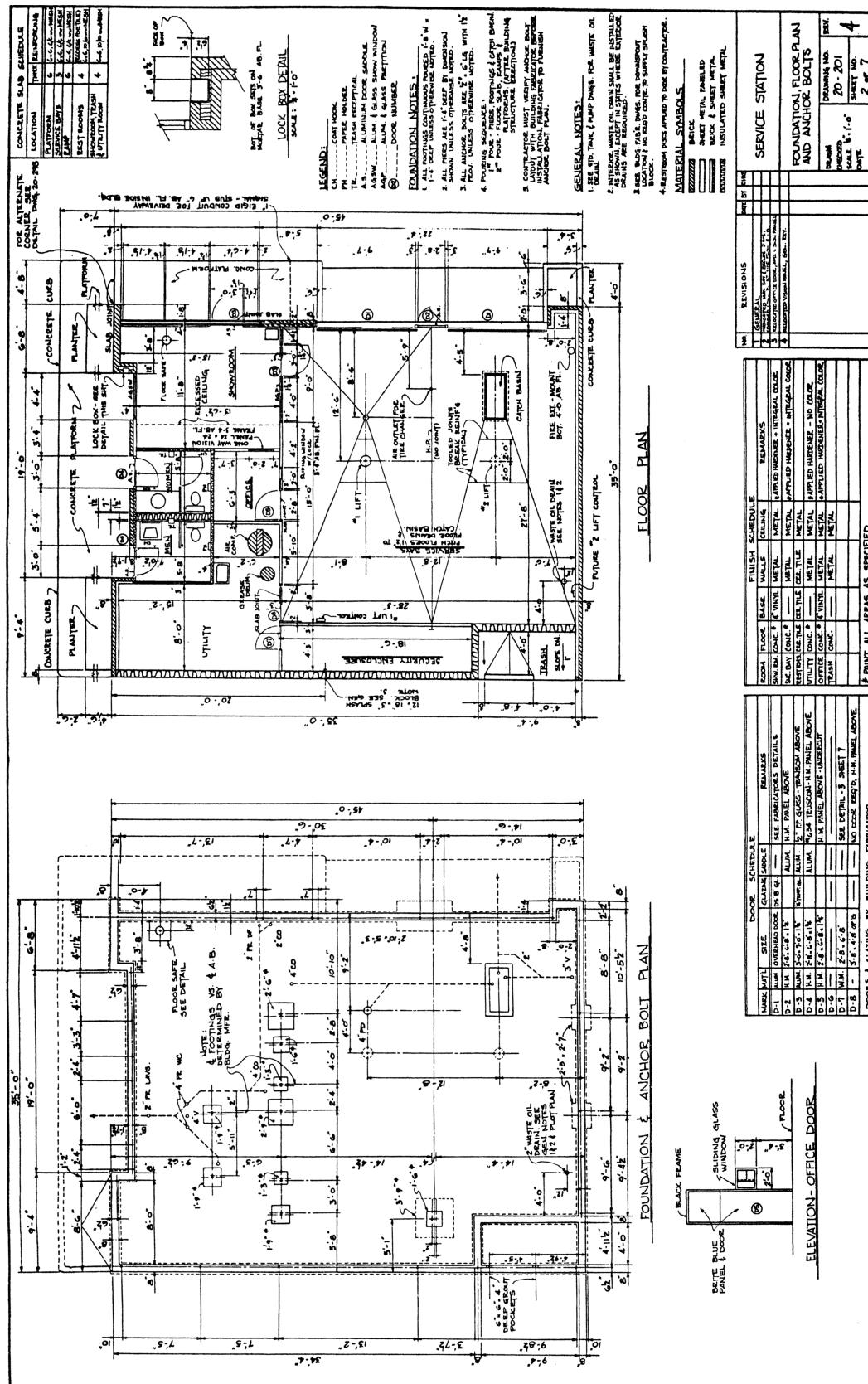
<i>n</i>	Single Payment			Uniform Series			<i>n</i>
	Compound Amount	Present Worth	Compound Factor	Sinking Fund	Present Worth	Capital Recovery	
	CAF	PWSP	USCA	SFF	Factor	Factor	
Given <i>P</i> to Find <i>F</i>	Given <i>F</i> to Find <i>P</i>	Given <i>A</i> to Find <i>F</i>	Given <i>F</i> $(1+i)^n - 1$	Given <i>F</i> to Find <i>A</i>	Given <i>A</i> $(1+i)^n - 1$	Given <i>P</i> to Find <i>A</i>	
$(1+i)^n$	$\frac{1}{(1+i)^n}$	i	$(1+i)^n - 1$	$(1+i)^n - 1$	$i(1+i)^n$	$i(1+i)^n - 1$	
1	1.080	0.9259	1.000	1.00000	0.926	1.08000	1
2	1.166	0.8573	2.080	0.48077	1.783	0.56077	2
3	1.260	0.7938	3.246	0.30804	2.577	0.38804	3
4	1.360	0.7350	4.506	0.22192	3.312	0.30192	4
5	1.469	0.6806	5.867	0.17046	3.993	0.25046	5
6	1.587	0.6302	7.336	0.13632	4.623	0.21632	6
7	1.714	0.5835	8.923	0.11207	5.206	0.19207	7
8	1.851	0.5403	10.637	0.09402	5.747	0.17402	8
9	1.999	0.5003	12.487	0.08008	6.247	0.16008	9
10	2.159	0.4632	14.486	0.06903	6.710	0.14903	10
11	2.332	0.4289	16.645	0.06008	7.139	0.14008	11
12	2.518	0.3971	18.977	0.05270	7.536	0.13270	12
13	2.720	0.3677	21.495	0.04652	7.904	0.12652	13
14	2.937	0.3405	24.215	0.04130	8.244	0.12130	14
15	3.172	0.3152	27.152	0.03683	8.559	0.11683	15
16	3.426	0.2919	30.324	0.03298	8.851	0.11298	16
17	3.700	0.2703	33.750	0.02963	9.122	0.10963	17
18	3.996	0.2503	37.450	0.02670	9.372	0.10670	18
19	4.316	0.2317	41.446	0.02413	9.604	0.10413	19
20	4.661	0.2146	45.761	0.02185	9.818	0.10185	20
21	5.034	0.1987	50.422	0.01983	10.017	0.09983	21
22	5.436	0.1839	55.456	0.01803	10.201	0.09803	22
23	5.871	0.1703	60.892	0.01642	10.371	0.09642	23
24	6.341	0.1577	66.764	0.01498	10.529	0.09498	24
25	6.848	0.1460	73.105	0.01368	10.675	0.09368	25
26	7.396	0.1352	79.953	0.01251	10.810	0.09251	26
27	7.988	0.1252	87.349	0.01145	10.935	0.09145	27
28	8.627	0.1159	95.337	0.01049	11.051	0.09049	28
29	9.317	0.1073	103.964	0.00962	11.158	0.08962	29
30	10.062	0.0994	113.281	0.00883	11.258	0.08883	30
35	14.785	0.0676	172.313	0.00580	11.655	0.08580	35
40	21.724	0.0460	259.050	0.00386	11.925	0.08386	40
50	46.900	0.0213	573.753	0.00174	11.233	0.08174	50
75	321.190	0.0031	4002.378	0.00025	11.461	0.08025	75
100	2199.630	0.0005	27482.879	0.00004	11.494	0.08004	100

Appendix I

Plans for Small Gas Station

Appendix I 391





Appendix J

Site Reconnaissance Checklist

GENERAL CONSIDERATIONS

- A. What features are native to topography and climate?
 - B. What is required for construction method selected?
 - C. What features are needed to support construction force?
 - D. What features might encroach on local society or environment?
- A. Features native to topography and climate
 - 1. Actual topography (excessive grades, etc.)
 - 2. Elevation
 - 3. Geology (soil characteristics, rock, etc.)
 - 4. Ground cover
 - 5. Excessive seasonal effects
 - 6. Wind direction
 - 7. Natural defenses
 - 8. Drainage
 - 9. Subsurface water conditions
 - 10. Seismic zones
- B. Features required that contribute to construction method
 - 1. Accessibility to site (rail, road, water)
 - 2. Labor availability (skill, cost, attitude)
 - 3. Material availability (salvage, cost, attitude)
 - 4. Locate borrow pits (gravel, sand, base, fill)
 - 5. Locate storage areas, plant sites
 - 6. Alternate building, campsites
 - 7. General working room about site
 - 8. Location of existing structures and utilities
 - 9. Conflicts with existing structures and utilities
 - 10. Overhead
 - 11. Disposal areas
 - 12. Land usage
 - 13. Local building practices
- C. Features to support construction force
 - 1. Billeting/shelter
 - 2. Food (also on-job meals)
 - 3. Special equipment

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- 4.** Clothing
 - 5.** Communications
 - 6.** Local hazards
 - 7.** Fire/security protection available
 - 8.** Local customs/culture
 - 9.** Potable H₂O
 - 10.** Sanitary facilities (also for job)
 - 11.** Entertainment
 - 12.** Small stores
 - 13.** Medical
 - 14.** Banking, currency
 - 15.** Transportation
 - 16.** Local maintenance available
- D.** Features that might encroach on local society or environment
- 1.** Noise
 - 2.** Dust
 - 3.** Blasting
 - 4.** Hauling over roads
 - 5.** Use of water
 - 6.** Burning (smoke)
 - 7.** Drainage (create problems)
 - 8.** Flight operations
 - 9.** Disposal areas
 - 10.** Utility disruption
 - 11.** Relocation problems
 - 12.** Work hours
 - 13.** Economy impact
 - 14.** Community attitude
 - 15.** Security
 - 16.** Political

Appendix K(1)

The Cumulative Normal Distribution Function[†]

$$\Phi(z) = \int_{-\infty}^z \phi(t) dt$$

for $(-\infty < z \leq 0)$

<i>z</i>	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
- .0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641
- .1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
- .2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
- .3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
- .4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
- .5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
- .6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
- .7	.2420	.2389	.2358	.2327	.2297	.2266	.2236	.2206	.2177	.2148
- .8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
- .9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
-1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
-1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
-1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0983
-1.3	.09680	.09510	.09342	.09176	.09012	.08851	.08691	.08534	.08379	.08226
-1.4	.08076	.07927	.07780	.07636	.07493	.07353	.07215	.07078	.06944	.06811
-1.5	.06681	.06552	.06426	.06301	.06178	.06057	.05938	.05821	.05705	.05592
-1.6	.05480	.05370	.05262	.05155	.05050	.04947	.04846	.04746	.04648	.04551
-1.7	.04457	.04363	.04272	.04182	.04093	.04006	.03920	.03836	.03754	.03673
-1.8	.03593	.03515	.03438	.03362	.03288	.03216	.03144	.03074	.03005	.02938
-1.9	.02872	.02807	.02743	.02680	.02619	.02559	.02500	.02442	.02385	.02330
-2.0	.02275	.02222	.02169	.02118	.02068	.02018	.01970	.01923	.01876	.01831
-2.1	.01786	.01743	.01700	.01659	.01618	.01578	.01539	.01500	.01463	.01426
-2.2	.01390	.01355	.01321	.01287	.01255	.01222	.01191	.01160	.01130	.01101
-2.3	.01072	.01044	.01017	.00993	.009642	.009387	.009137	.008894	.008656	.008424
-2.4	.008198	.007976	.007760	.007549	.007344	.007143	.006947	.006756	.006569	.006387
-2.5	.006210	.006037	.005868	.005703	.005543	.005386	.005234	.005085	.004940	.004799
-2.6	.004661	.004527	.004396	.004269	.004145	.004025	.003907	.003793	.003681	.003573
-2.7	.003467	.003364	.003264	.003167	.003072	.002980	.002890	.002803	.002718	.002635
-2.8	.002555	.002477	.002401	.002327	.002256	.002186	.002118	.002052	.001988	.001926
-2.9	.001866	.001807	.001750	.001695	.001641	.001589	.001538	.001489	.001441	.001395
-3.0	.001350	.001306	.001264	.001223	.001183	.001144	.001107	.001070	.001035	.001001
-3.1	.009676	.009354	.009043	.008740	.008447	.008164	.007888	.007622	.007304	.007114
-3.2	.006871	.006637	.006410	.006190	.005976	.005770	.005571	.005377	.005190	.005009
-3.3	.004834	.004665	.004501	.004342	.004189	.004041	.003897	.003758	.003624	.003495
-3.4	.003369	.003248	.003131	.003018	.002909	.002803	.002701	.002602	.002507	.002415
-3.5	.002326	.002241	.002158	.002078	.002001	.001926	.001854	.001785	.001718	.001653
-3.6	.001591	.001531	.001473	.001417	.001363	.001311	.001261	.001213	.001166	.001121
-3.7	.001078	.001036	.001000	.0009574	.0009201	.0008842	.0008496	.0008162	.0007841	.0007532
-3.8	.007235	.006948	.006673	.006407	.006152	.005906	.005669	.005442	.005223	.005012
-3.9	.004810	.004615	.004427	.004247	.004074	.003908	.003747	.003594	.003446	.003304
-4.0	.0043167	.0043036	.0042910	.0042789	.0042673	.0042561	.0042454	.0042351	.0042252	.0042157
-4.1	.0042066	.0041978	.0041894	.0041814	.0041737	.0041662	.0041591	.0041523	.0041458	.0041395
-4.2	.0041335	.0041277	.0041222	.0041168	.0041118	.0041069	.0041022	.0040974	.00409345	.00408934
-4.3	.0058540	.0058163	.0057801	.0057455	.0057124	.0056807	.0056503	.0056212	.0055934	.0055668
-4.4	.0055413	.0055169	.0054935	.0054712	.0054498	.0054294	.0054098	.0053911	.0053732	.0053561
-4.5	.0053398	.0053241	.0053092	.0052949	.0052813	.0052682	.0052558	.0052439	.0052325	.0052216
-4.6	.0052112	.0052013	.0051919	.0051828	.0051742	.0051660	.0051581	.0051506	.0051434	.0051366
-4.7	.0051301	.0051239	.0051179	.0051123	.0051069	.0051017	.0051060	.0051021	.00508765	.00508339
-4.8	.0067933	.0067547	.0067178	.0066827	.0066492	.0066173	.0065869	.0065580	.0065304	.0065042
-4.9	.0064792	.0064554	.0064327	.0064111	.0063906	.0063711	.0063525	.0063348	.0063179	.0063019

Example: $\Phi(-3.57) = .001785 = 0.0001785$.

[†] By permission from A. Hald, *Statistical Tables, and Formulas*, John Wiley & Sons, Inc., New York, 1952.

Appendix K(2)

The Cumulative Normal Distribution Function[†]

$$\Phi(z) = \int_{-\infty}^z \phi(t) dt$$

for $0 \leq z < \infty$

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7703	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.990097	.990358	.990613	.990863	.991106	.991344	.991576
2.4	.992182	.992240	.992451	.992656	.992857	.993053	.993244	.993431	.993613	
2.5	.9923790	.9923963	.9924132	.9924297	.9924457	.9924614	.9924766	.9924915	.9925060	.9925201
2.6	.9925339	.9925473	.9925604	.9925731	.9925855	.9925975	.9926093	.9926207	.9926319	.9926427
2.7	.9926533	.9926636	.9926736	.9926833	.9926928	.9927020	.9927110	.9927197	.9927282	.9927365
2.8	.9927445	.9927523	.9927599	.9927673	.9927744	.9927814	.9927882	.9927948	.9928012	.9928074
2.9	.9928134	.9928193	.9928250	.9928305	.9928359	.9928411	.9928462	.9928511	.9928559	.9928605
3.0	.9928650	.9928694	.9928736	.9928777	.9928817	.9928856	.9928893	.9928930	.9928965	.9928999
3.1	.9930324	.9930646	.9930957	.9931260	.9931553	.9931836	.9932112	.9932378	.9932636	.9932886
3.2	.9933129	.9933363	.9933590	.9933810	.9934024	.9934230	.9934429	.9934623	.9934810	.9934991
3.3	.9935166	.9935335	.9935499	.9935658	.9935811	.9935959	.9936103	.9936242	.9936376	.9936505
3.4	.9936631	.9936752	.9936869	.9936982	.9937091	.9937197	.9937299	.9937398	.9937493	.9937585
3.5	.9937674	.9937759	.9937842	.9937922	.9937999	.9938074	.9938146	.9938215	.9938282	.9938347
3.6	.9938409	.9938469	.9938527	.9938583	.9938637	.9938689	.9938739	.9938787	.9938834	.9938879
3.7	.9938922	.9938964	.9939039	.99390426	.99390799	.9939158	.99391504	.99391838	.99392159	.99392468
3.8	.99392765	.99393052	.99393327	.99393593	.99393848	.99394094	.99394331	.99394558	.99394777	.99394988
3.9	.99395190	.99395385	.99395573	.99395753	.99395926	.99396092	.99396253	.99396406	.99396554	.99396696
4.0	.9946833	.9946964	.9947090	.9947211	.9947327	.9947439	.9947546	.9947649	.9947748	.9947843
4.1	.9947934	.9948022	.9948106	.9948186	.9948263	.9948338	.9948409	.9948477	.9948542	.9948605
4.2	.9948665	.9948723	.9948778	.9948832	.9948882	.9948931	.9948978	.9949026	.9949055	.99491066
4.3	.9951460	.9951837	.9952199	.9952545	.9952876	.9953193	.9953497	.9953788	.9954066	.9954332
4.4	.9954587	.9954831	.9955065	.9955288	.9955502	.9955706	.9955902	.9956089	.9956268	.9956439
4.5	.9956602	.9956759	.9956908	.9957051	.9957187	.9957318	.9957442	.9957561	.9957675	.9957784
4.6	.9957888	.9957987	.9958083	.9958172	.9958258	.9958340	.9958419	.9958494	.9958566	.9958634
4.7	.9958699	.9958761	.9958821	.9958877	.9958931	.9958983	.99590320	.99590789	.99591235	.99591661
4.8	.9959267	.99592453	.99592822	.99593173	.99593508	.99593827	.99594131	.99594420	.99594666	.99594958
4.9	.99595208	.9959446	.99595673	.99595889	.99596094	.99596289	.99596475	.99596652	.99596821	.99596981

Example: $\Phi(3.57) = .998215 = 0.9998215.$

[†] By permission from A. Hald, *Statistical Tables, and Formulas*, John Wiley & Sons, Inc., New York, 1952.

Appendix L

WebCYCLONE Users Manual

INTRODUCTION

This is a tutorial for WebCYCLONE, a web-based construction simulation program based on MicroCYCLONE developed by Dr. Daniel W. Halpin. The basic logic of the program as well as most of the input data has not been changed from the original CYCLONE.

WebCYCLONE is composed of a series of independent modules, each of which is in control of a particular segment of the overall system. There are four different modules:

1. Data input module
2. Simulation module
3. Report generation module
4. Sensitivity analysis module

The first part of this tutorial will offer introduction to CYCLONE network and syntaxes; the practical use of WebCYCLONE will be demonstrated by using an example with step-by-step screenshots.

1. Data Input

A WebCYCLONE input file is the means by which the user translates a CYCLONE graphical model into a Problem-Oriented Language (POL) input that can be understood by the WebCYCLONE program. A typical WebCYCLONE input file has five required sections:

1. General information
2. Network input
3. Duration input
4. Resource input
5. Enddata

The user can create and edit WebCYCLONE input files in two ways.

1. Use word-processing software: The user can use readily available word-processing software such as Word, Notepad, and WordPerfect to create and edit the input files. Since WebCYCLONE only recognizes text file, the user must save the file in text format (e.g., .txt in MS Windows). Otherwise, WebCYCLONE will NOT accept the file.
2. Use WebCYCLONE input panel. The user can directly key in the CYCLONE program on the WebCYCLONE input panel (Figure L-1). However, it is strongly recommended that the user save the file before executing the program. Although sometimes the user can use the “BACK” function of the browser to go back to the input page, it is possible the program is not cached in the memory and cannot be recovered. In

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Welcome to Purdue CEM Web-Cyclone Simulation Lab:

You can use the default CYCLONE model here

```
NAME EARTHMoving PROCESS LENGTH 1000 CYCLES 30
NETWORK INPUT
1 QUE 'LOADER WT'
2 QUE 'TRUCK WT'
3 COM 'LOAD TRUCK' SET 3 PRE 1 2 FOL 1 4
4 NOR 'TRL' SET 4 FOL 5
5 QUE 'WAIT SPOTTER'
6 QUE 'SPOTTER STATION'
7 COM 'SPOT & DUMP' SET 7 PRE 5 6 FOL 6 8
8 FUN COU FOL 2 QUA 1
DURATION INPUT
SET 3 TRI 1 1.5 2
SET 4 TRI 5 6 7
SET 7 DET 1.5
RESOURCE INPUT
2 'LOADER' AT 1 FIX 60
10 'TRUCKS' AT 2 FIX 25
1 'SPOTTER' AT 6 FIX 30
```

[Compile](#)[Trace Run](#)[Run w/Prod. Info](#)[Run](#)

Upload your model file:

[Browse...](#)[Upload](#)[Back to top](#)

Figure L.1 WebCYCLONE input panel.

the Windows environment, the user can use “copy-and-paste” functions to copy the program to any word-processing software and save into text format.

1.1 General System Information

General system information is the first section of a WebCYCLONE input file. It is the first line of information concerning the network, and it must always contain the standard header for general system information, which is defined as follows:

```
NAME (name of process) LENGTH (length of run) CYCLES (# of cycles)
```

NAME	User-defined keyword assigned to this network.
LENGTH	The length of time for the simulation running of the process.
CYCLES	Maximum number of cycles that will be processed during simulation. This will be determined by the number of times the COUNTER function is passed in the process model.
Example:	NAME TUNNEL LENGTH 100 CYCLES 10

1.2 Network Input

This section of input is used to enter the elements of the actual process network. Each statement of this section specifies one network element, its attributes, and its logical relationship to other elements in the network. The header for this section is

NETWORK INPUT

The header should be typed in LINE #2. Four types of elements are used in WebCYCLONE network.

1. COMBI
2. NORMAL
3. QUEUE
4. FUNCTION

Each individual element should be entered in a separate line. If the element will not fit on one line of the screen, the user can keep typing on to succeeding lines. The program will automatically enter this as a single line or record.

COMBI Work Tasks

The following attributes are used to define the COMBI:

- Numerical label
- Element type
- Work task description (optional)
- Duration set number
- Preceding QUEUE nodes
- Following nodes

The general form of the input statement for a COMBI element is

```
(Label.C) COMBI ‘descr.’ SET (set) PREC (Labels.P) FOLL (Labels.F)
```

where

1. All underlined letters are keywords and should appear in the line as shown.

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2. All words enclosed in parentheses () would not be entered as typed above; their corresponding entries are described below.
3. (Label.C): is the numeric label (i.e., integer) of the COMBI being specified.
4. ‘descr.’: is a description of the COMBI specified.
5. (Set): is the number (i.e., integer label) of the set where the duration parameters of this COMBI are specified.
6. (Labels.P) are the labels of the preceding nodes of this COMBI.
7. (Labels.F) are labels of the following nodes of this COMBI.

EXAMPLE

17 COMBI ‘LOAD TRK’ SET 6 PRECEDERS 2 5 FOLLOWERS 9 11 15

This specifies a COMBI with the numerical label 17 and the description is ‘load trk’. Its corresponding time parameters would be defined in SET 6. It is preceded by the nodes 2 and 5 and succeeded by the nodes 9, 11, and 15.

Note that we could have used the first three letters of any of the keywords like FOL for FOLLOWERS.

NORMAL Work Tasks

Specification of the NORMAL work task is similar to the COMBI except that the preceding operations need not to be specified. The attributes required for a NORMAL element are:

- Numerical label
- Element type
- Work task description (optional)
- Duration set number
- Following nodes

The general form of input for a NORMAL is

(Label) NORMAL ‘descr.’ SET (set) FOLLOWERS (label of fol.)

EXAMPLE

23 NORMAL ‘Trk Return’ SET 4 FOLLOWERS 27 30

QUEUE Nodes

The following attributes are required to define a QUEUE node or a QUEUE node acting as a GENERATE function:

- Numerical label
- Element type
- QUEUE node title (optional)
- GENERATE function and number (when required)

The general format for a GENERATE function is

(Label) QUEUE ‘description’ GENERATE (number to be generated)

EXAMPLE

5 QUEUE ‘Loader Idle’

9 QUEUE ‘Truck Queue’ GENERATE 5

Function Nodes

Two separate function nodes are used in WebCYCLONE: COUNTER and CONSOLIDATE. The general format for the accumulator (counter) function node is
 (Label.C) FUNCTION COUNTER FOLL (Label.F) QUANTITY (Quant.)
 where

1. All underlined letters are keywords and should be entered as shown.
 2. Words enclosed in parentheses () correspond to the following:
 - a. (Label.C) is the numeric label of the function being specified.
 - b. (Label.F) are the numeric labels of the following nodes of this function COUNTER.
 - c. (Quant.) is the quantity multiplier (the number of productive units produced by the system at the end of each cycle).
-

EXAMPLE

9 FUNCTION COUNTER FOLLOWERS 11 7 QUANTITY 1
 (Label.C) FUNCTION CONSOL (No. to Con.) FOLL (Label.F)
 where

3. All underlined letters are keywords and should be entered as shown.
 4. Words enclosed in parentheses () correspond to the following:
 - a. (Label.C) is the numeric label of the function being specified.
 - b. (No. to Con.) is the number to be consolidated before the entity exists this node.
 - c. (Label.F) is the numeric labels of the following nodes of this function consolidate.
-

EXAMPLE

3 FUNCTION CONSOLIDATE 5 FOLLOWERS 12

Probability Arcs

COMBIs and NORMALs can be followed by a probabilistic exit of two or more ARCs.

EXAMPLE

(Figure 2)

The sum of the probabilities must add up to 1.0.

3 NORMAL FOLLOWER 4 5 PROBABILITY .2 .8

This specifies that the entity flowing through element 3 (which is a normal) is to go to element 4 for 20% of the time and to element 5 for 80% of the time. Each time such a probabilistic branching is specified the program generates a uniformly distributed random number in the range (0, 1). If the generated number is <0.2, the unit will branch to 4, otherwise it will branch to 5.

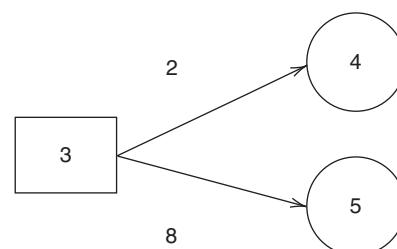


Figure L.2 Probabilistic branching.

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1.3 Duration Input

Each task element should be accompanied with a duration set number that defines the duration type of the task and the parameters of the distribution from which the duration of the task will be sampled. There are two categories of tasks based on duration–stationary tasks and nonstationary tasks. Currently WebCYCLONE only recognizes stationary tasks.

A stationary task requires no modification of the associated duration parameters as the associated task is repeated. Unlike stationary tasks, nonstationary tasks require modification of the duration parameters that define distribution from which duration will be sampled.

The statistical distributions recognized by the input module of the program are deterministic, uniform, triangular, beta, normal, and exponential. When using any of these distributions, the user is required to include the first three characters of the selected distributions and then the parameters that define the statistical distribution. The following are examples of how each distribution should be defined.

<u>Constant</u>	C:	<u>DETERMINISTIC C</u>
		The constant duration
<u>Uniform</u>	A:	<u>UNIFORM A B</u>
	B:	The low value of the duration
		The high value of the duration
<u>Triangular</u>	A:	<u>TRIANGULAR A M B</u>
	M:	The low value of the duration
	B:	The mode value of the duration
		The high value of the duration
<u>Beta</u>	A:	<u>BETA A B α β</u>
	B:	The lowest value of the duration
	α:	The highest value of the duration
	β:	The first shape parameter of the beta distribution
		The second shape parameter of the beta distribution
<u>Normal</u>	μ :	<u>NORMAL μ σ²</u>
	σ^2 :	The mean of the duration
		The variance of the duration
<u>Exponential</u>	μ :	<u>EXPONENTIAL μ</u>
		The mean of the duration

The following is the general format for defining a stationary duration:

SET (set number) (distribution) SEED (seed number)

Where set number is a constant number that should be associated with a defined task, distribution should be one of the distributions given above, and seed number is a constant value that should not less than 1 or larger than 999999999.

The user may default on the value of the seed number, whereby the computer will randomly assign an initial seed number associated with the task. It should be noted that no seed number is required to be assigned when a deterministic duration is selected. The following are examples of how a distribution could be defined:

```
Deterministic: SET 2 DET 12
Beta:      SET 2 BET 10 15 12 .5 SEED 4561111
or:       SET 2 BET 10 15 12 .5
```

1.4 Resource Input

In this section, the number of units of each resource type to be used in the network process is initialized. The types of resources include equipment (crane, trucks), labor (concrete placing

crew), or materials (a pallet of bricks). To initialize a resource, two items of information are required: (1) number of units in the network and (2) the QUEUE node that will be the starting point for these units in the network. The header for this section is RESOURCE INPUT, which must be typed on the first line of the section.

The general format for the input lines is

(# of units) ‘description’ AT (label.N.) VAR (VC) FIX (FC)

where

1. All underlined letters are keywords and should be entered as shown.
2. All words enclosed in parentheses () correspond to the following:
 - a. (No. units,) is the number of units to be initialized at this node.
 - b. (Label.N.) is the numeric label of the QUEUE node where the units are to be initialized.
 - c. (VC) is the variable cost associated with this unit.
 - d. (FC) is the fixed cost associated with this unit.

Note: VAR (VC) and FIX (FC) are optional.

EXAMPLE

4 ‘Trucks’ AT 8 VARIABLE 10.0 FIXED 25.5

The variable costs are hourly costs of the specified resource based on actual operation, (fuel, oil, labor, etc.). The fixed costs are the costs, converted to an hourly basis, that are incurred regardless of whether the item is in operation (depreciation, maintenance, etc.). Variable costs apply primarily to equipment operation. Listing of variable and fixed costs is not a requirement for the program to run. These are optional inputs.

1.5 ENDDATA

The procedural word ENDDATA (END) is used to signal the end of the WebCYCLONE input data. This will be the last line of data entered for the network.

STEP-BY-STEP EXAMPLE

2.1 Access WebCYCLONE

The WebCYCLONE is a web-based simulation program based on MicroCYCLONE. Unlike MicroCYCLONE which can only run on personal computers under Microsoft DOS or Windows operation systems, WebCYCLONE can be accessed and executed virtually anywhere as long as the user has web browser such as Microsoft Internet Explorer and Mozilla.

The user can access WebCYCLONE through the “Simulation in Construction” webpage (<http://bridge.ecn.purdue.edu/CEM/Sim/>). The website also includes examples of various construction operation simulations with WebCYCLONE input.

2.2 Data Input

As mentioned in Section 1 “Network Input,” the CYCLONE program can be submitted for processing in two ways (See Figure L-3). The default program can be deleted by highlighting then pressing “Delete” button. Then the user can begin to key in the CYCLONE program based on the procedure described in Section 1.1 through 1.5. If the CYCLONE program is available in text format, the user can import it into WebCYCLONE by following procedure.

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Welcome to Purdue CEM Web- Cyclone Simulation Lab:
You can use the default CYCLONE model here

```
NAME EARTHMoving PROCESS LENGTH 1000 CYCLES 30
NETWORK INPUT
1 QUE 'LOADER WT'
2 QUE 'TRUCK WT'
3 COM 'LOAD TRUCK' SET 3 PRE 1 2 FOL 1 4
4 NOR 'TRVL' SET 4 FOL 5
5 QUE 'WAIT SPOTTER'
6 QUE 'SPOTTER STATION'
7 COM 'SPOT & DUMP' SET 7 PRE 5 6 FOL 6 8
8 FUN COU FOL 2 QUA 1

DURATION INPUT
SET 3 TRI 1 1.5 2
SET 4 TRI 5 6 7
SET 7 DET 1.5

RESOURCE INPUT
2 'LOADER' AT 1 FIX 60
10 'TRUCKS' AT 2 FIX 25
1 'SPOTTER' AT 6 FIX 30
```

[Compile](#) [Trace Run](#) [Run w/Prod. Info](#) [Run](#)

Upload your model file: [Browse...](#) [Upload](#)

[Back to top](#)

Figure L.3 WebCYCLONE input panel.

1. Scroll down to the bottom of the page and select “Browse.”
2. A file upload dialogue will pop up. Designate the file location and then press “Open.” The path should appear in the box next to “Upload your model file.” (See Figure 4).
3. Press “Upload” and the default program will be replaced by the desired program.
4. The user can modify the input within the input panel. After necessary modification, press “Compile” to let WebCYCLONE check the logic of the program. If the WebCYCLONE does not find any logical error, it will show “Compile Successfully.” Otherwise, there will be warning in red telling the user where the possible errors are. The user has to go back to fix the errors and then compile the program until there is no error message.
5. Three options are available after the CYCLONE program is successfully compiled. “Run” option gives the most concise information on process productivity, active

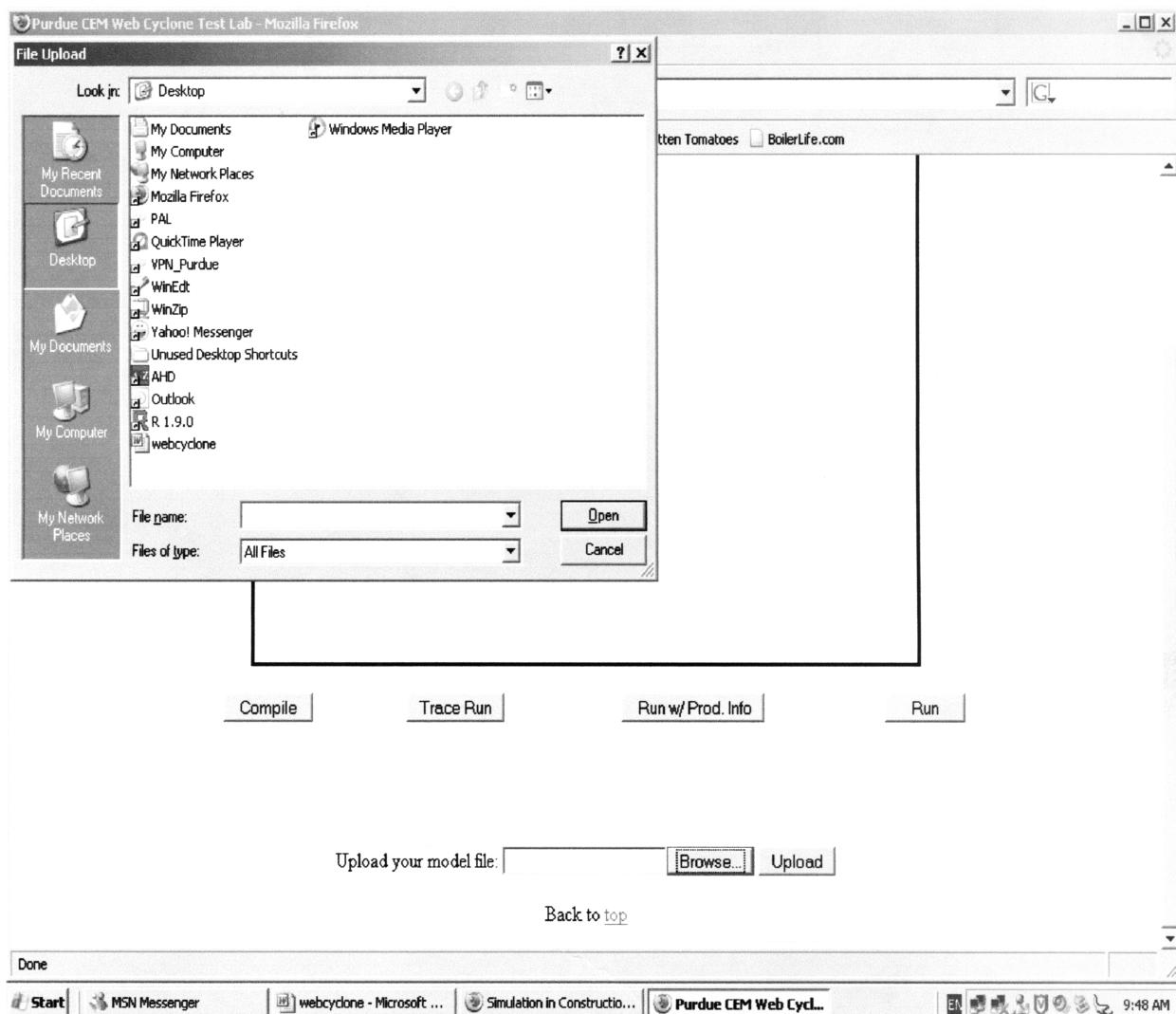


Figure L.4 Screen capture for file upload.

(NORMAL and COMBI) and passive (QUEUE and GEN) elements. “Run w/ Prod. Info” gives productivity of each cycle. It does not show the information of passive elements. “Trace Run” gives the most comprehensive information. Therefore, “Trace Run” option can be useful in “debugging” when unusual results occur. It has all the information, including the record of how each object flows through the process. The user can choose any of these three options based on his/her needs.

All three options generate the same set of charts—productivity and trace charts for all QUEUE nodes. The trace charts show the status of each QUEUE node and can be used to design “buffer.” If further analysis of any QUEUE node is of interest, the user can select “get excel output” to obtain the information of that specific QUEUE node in Microsoft Excel format.

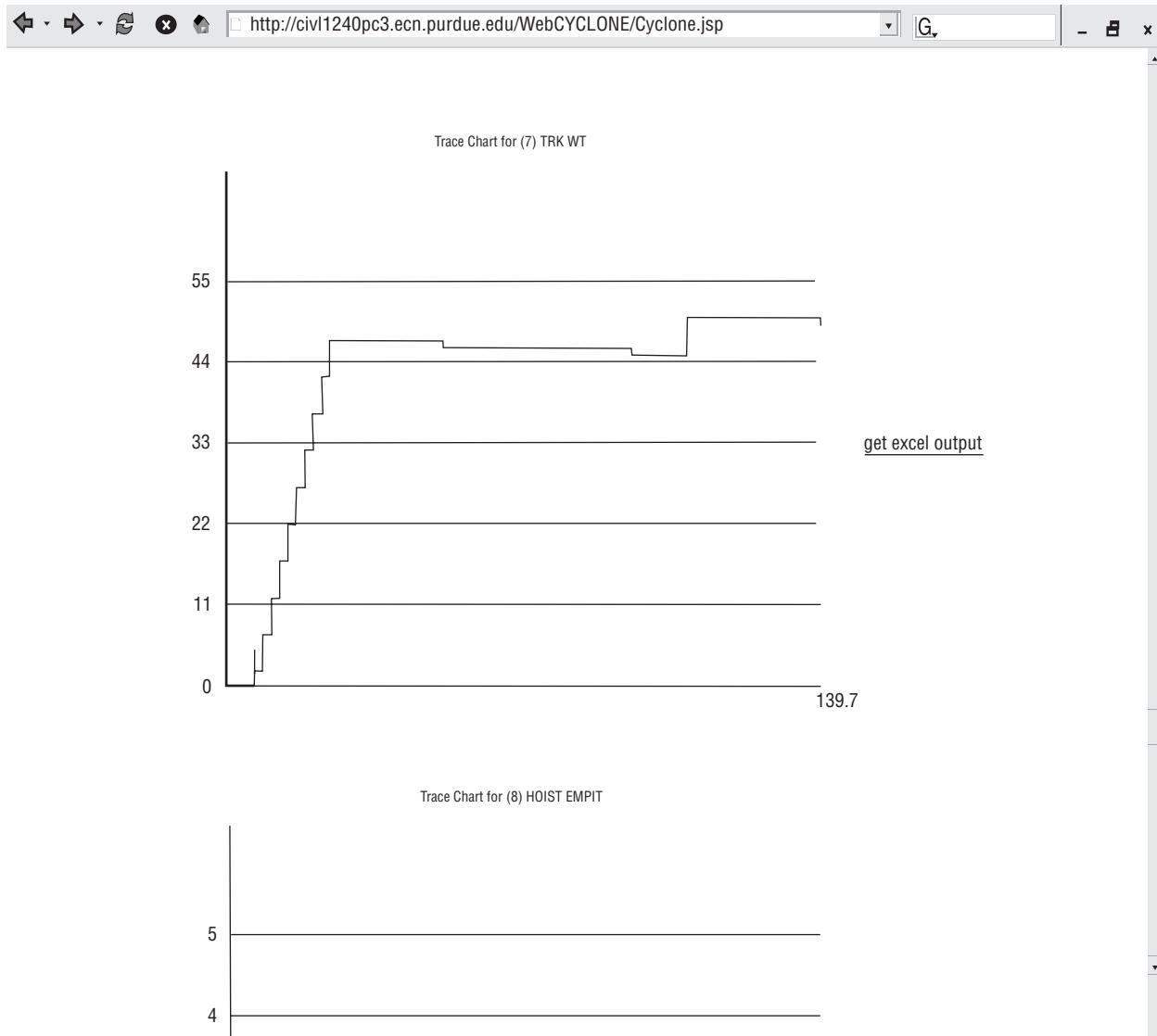
6. If the user would like to perform sensitivity analysis to investigate the impact of resource utilization on the overall productivity, scroll down to the end of the output and press “Yes” next to “Do you want to work the sensitivity analysis?”

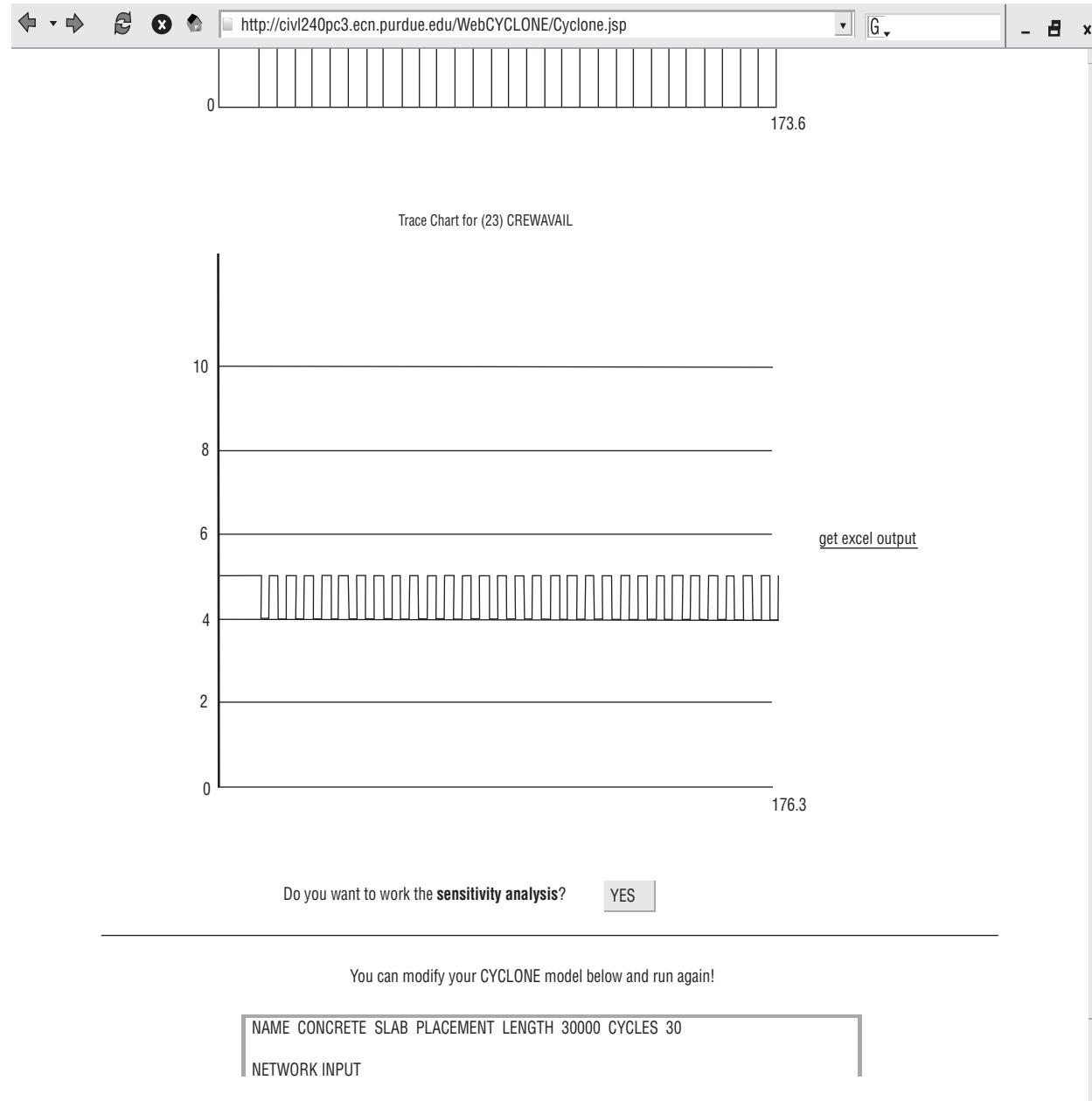
10 Appendix L

Results:

CONCRETE SLAB PLACEMENT			
TRACE INFORMATION			
SimTime	Activiy No.	Type	Name
2.0	4	COMBI	TRK LOAD
4.0	4	COMBI	TRK LOAD
6.0	5	NORMAL	TRK BACK
6.0	4	COMBI	TRK LOAD
8.0	5	NORMAL	TRK BACK
8.0	9	COMBI	FILL HOIST
8.0	9	COMBI	FILL HOIST
8.0	9	COMBI	FILL HOIST
8.0	4	COMBI	TRK LOAD
9.5	10	NORMAL	HOIST UP
9.5	10	NORMAL	HOIST UP
9.5	10	NORMAL	HOIST UP
10.0	5	NORMAL	TRK BACK
10.0	4	COMBI	TRK LOAD
10.5	17	COMBI	LOAD HOPPER
12.0	5	NORMAL	TRK BACK
12.0	4	COMBI	TRK LOAD
12.0	11	NORMAL	HOIST DOWN
12.0	18	COMBI	FILL BUGGY
12.7	24	NORMAL	BUGGY TRAVEL
14.0	5	NORMAL	TRK BACK
14.0	4	COMBI	TRK LOAD
15.4	21	COMBI	PLACE CONE
15.4	26	COUNTER	-

Figure L.5 Trace Information.

Appendix L **11****Figure L.6** Trace Charts.

12 Appendix L**Figure L.7** Key function of Sensitivity Analysis.

Appendix L 13

Line 91: 1 AT 15
Line 92:
Line 93: 1 AT 20
Line 94:
Line 95: 5 AT 23
Line 96:
Line 97: ENDDATA

Sensitivity Analysis Module				
Resource Name	Select (if unselected, use org. unit)	Orig. Res. Unit	Set Res. Range	
			From	To
default at BATCH PLANT AVAIL	<input type="checkbox"/>	1	<input type="text" value="0"/>	<input type="text" value="0"/>
default at TRK WT AT PLANT	<input type="checkbox"/>	10	<input type="text" value="0"/>	<input type="text" value="0"/>
default at HOIST EMPTY	<input checked="" type="checkbox"/>	3	<input type="text" value="1"/>	<input type="text" value="5"/>
default at HOIST IDLE	<input checked="" type="checkbox"/>	3	<input type="text" value="1"/>	<input type="text" value="6"/>
default at HOPPER IDLE	<input type="checkbox"/>	1	<input type="text" value="0"/>	<input type="text" value="0"/>
default at BUGGY WT	<input type="checkbox"/>	1	<input type="text" value="0"/>	<input type="text" value="0"/>
default at CREW AVAIL	<input type="checkbox"/>	5	<input type="text" value="0"/>	<input type="text" value="0"/>

[Back to Web- CYCLONE Home](#)

Figure L.8 Sensitivity Analysis Model.

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<<<Sensitivity Analysis Results:>>>

Resource Information		Productivity Information		
# of default at HOIST EMPTY	# of default at HOIST IDLE	Productivity Per Unit Time	Cost Per Unit Time	Cost Per Prod. Unit
1	1	0.1689	not available	not available
1	2	0.1689	not available	not available
1	3	0.1689	not available	not available
1	4	0.1689	not available	not available
1	5	0.1689	not available	not available
1	6	0.1689	not available	not available
2	1	0.1702	not available	not available
2	2	0.1702	not available	not available
2	3	0.1702	not available	not available
2	4	0.1702	not available	not available
2	5	0.1702	not available	not available
2	6	0.1702	not available	not available
3	1	0.1702	not available	not available
3	2	0.1702	not available	not available
3	3	0.1702	not available	not available
3	4	0.1702	not available	not available
3	5	0.1702	not available	not available
3	6	0.1702	not available	not available
4	1	0.1702	not available	not available
4	2	0.1702	not available	not available
4	3	0.1702	not available	not available
4	4	0.1702	not available	not available
4	5	0.1702	not available	not available
4	6	0.1702	not available	not available
-	-	--	-----

Figure L.9 Sensitivity Analysis Results.

7. In the sensitivity module, check all the resources of interest and enter the range associated with each resource. Press “Run Analysis.”
8. In the Sensitivity Analysis Results, the WebCYCLONE will show the productivity associated with every possible combination. If cost information is given in the CYCLONE program (i.e., VAR or FIX syntax is used), Cost Per Unit Time and Cost Per Prod. Unit will be also calculated.

IMPORTANT: It is strongly recommended that the user save the program on the local disk whenever there is any modification. The “BACK” button on the browser might NOT bring back the original program.

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CHAPTER 4

Four Types of Fee Structure

1. Cost + Percent of Cost
2. Cost + Fixed Fee
3. Cost + Fixed Fee + Profit Sharing
4. Cost + Sliding fee, Sliding Fee = $R(2T - A)$
where T = target price, R = base price value, A = actual cost of construction

CHAPTER 7**Forward Pass Equations**

$$EFT(I) = EST(I) + DUR(I)$$

$$EST(J) = \max_{I \in M} [EFT(I)]$$

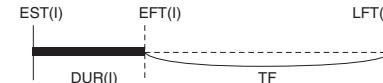
where I is a member of the set of M activities that precede activity J .**Backward Pass Equations**

$$LST(J) = LFT(J) - DUR(J)$$

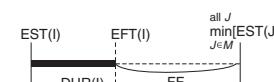
$$LFT(I) = \min_{J \in M} [LST(J)]$$

where J is a member of the set of M activities that follow activity I .**Four Types of Activity Float****Total Float**

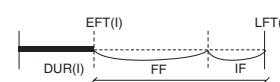
$$\begin{aligned} TF(I) &= LFT(I) - [EST(I) + DUR(I)] \\ &= LFT(I) - EFT(I) \end{aligned}$$

Where I is a member of the set of preceding activities.**Free Float**

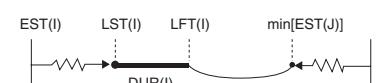
$$FF(I) = \min_{J \in M} [EST(J)] - EFT(I)$$

Where J is a member of the set of follower activities.**Interfering Float**

$$IF(I) = TF(I) - FF(I)$$

**Independent Float**

$$\text{Ind. F} = \min_{J \in M} [EST(J)] - LFT(I)$$



CHAPTER 8**PERT Equations**

$$\text{Expected duration } t_e = \frac{(t_a + 4t_m + t_b)}{6}$$

where t_a is the most optimistic duration estimate, t_m is the most likely duration estimate, and t_b is the most pessimistic duration estimate.

$$\text{Variance for each PERT activity } \sigma^2 = \left[\frac{(t_b - t_a)}{6} \right]^2$$

$$Z = \frac{\text{Mean} - x}{\sqrt{\text{Variance}}} \quad \text{or} \quad Z = \frac{(\bar{X} - x)}{\sigma}$$

where σ is the standard deviation of the cumulative normal distribution.

CHAPTER 9

$$\begin{aligned} \text{Pay} &= 1.25(\text{indirect expense} + \text{direct expense}) \\ &\quad - 0.10[1.25(\text{indirect expense} + \text{direct expense})] \end{aligned}$$

Rate of Return

$$\sum_{all I}^{all I} PW[REV(I)] - \sum_{all I}^{all I} PW[EXP(I)] = 0$$

where $REV(I)$ = revenue for period I

$EXP(I)$ = expenditure for period I

PW = present worth of these values

CHAPTER 11

$$\text{Depreciation Cost per Hour} = \frac{\text{Purchase Price} - \text{Tire Value}}{\text{Estimated Service Life in Hours}}$$

$$\text{Average Annual Value (AAV)} = \frac{C(n+1)}{2n},$$

where AAV is the average annual value, C is the initial new value of the asset, and n is the number of service life years.

$$\text{Average Annual Value (AAV), including the salvage value} = \frac{C(n+1) + S(n-1)}{2n}$$

The hourly charge for IIT is calculated as:

$$\text{IIT/hour} = \frac{\text{factor} \times \text{delivery price}}{1000}$$

CHAPTER 12

Power Required = RR ± GR

$$\text{Percent swell} = \left[\left(\frac{1}{\text{load factor}} \right) - 1 \right] \times 100$$

$$\text{where Load factor} = \frac{\text{pounds per cubic yard-loose}}{\text{pounds per cubic yard-bank}}$$

Grade Resistance (GR) = percent grade × 20 lb/ton/% grade × weight on wheels (tons)

$$\text{Equivalent percent grade} = \frac{\text{RR}}{20 \text{ lb/ton}/\% \text{ grade}}$$

Usable pounds pull = (coefficient of traction) × (weight on drivers)

CHAPTER 13

$$\frac{\text{Resource-hours per hour}}{\text{Units per hour}} = RH/\text{unit}, \text{ where } RH = \text{resource hour}$$

The basic equation for unit pricing:

$$\frac{\text{Resource cost per unit time}}{\text{Production rate}} = \frac{\$/\text{hr}}{\text{unit/hr}} = \$/\text{unit}$$

CHAPTER 15

The five parameters which form the foundation of the “earned” value concept are:

- Budgeted Cost of Work Schedule (BCWS) = Value of the baseline at a given time
- Actual Cost of Worked Performed (ACWP) – Measured in the field
- Budgeted Cost of Worked Performed (BCWP) = [% Complete] × BCAC
- Budgeted Cost At Completion (BCAC) = Estimated Total Cost for the work Package
- Actual Quantity of Worked Performed (AQWP) – Measured in the field

CV, Cost Variance = BCWP – ACWP

SV, Schedule Variance = BCWP – BCWS

CPI, Cost Performance Index = BCWP/ACWP

- CPI < 1.0 indicates cost overrun of budget
- CPI > 1.0 indicates actual cost less than budgeted cost

SPI, Schedule Performance Index = BCWP/BCWS

$$P_c = \frac{P_s}{(100 - P_s)}$$

where P_c = percentage applied to the project's total direct cost for the coming year

P_s = percentage of total volume in the reference year incurred as fixed or G&A expense