SETTLEMENT AGREEMENT

The Great Lakes Water Authority ("GLWA"), and Colasanti Construction Services, Inc. ("Colasanti"), J.F. Cavanaugh Company ("Cavanaugh") and Evoqua Water Technologies LLC ("EWT") enter into the following agreement ("Agreement") as of _____, 2019. Colasanti, Cavanaugh, and EWT may be collectively referred to herein as "CCE," and the GLWA, Colasanti, Cavanaugh, and EWT may be individually referred to herein as a "Party" and collectively as the "Parties."

RECITALS

A. On or about April 12, 2010, Colasanti and the City of Detroit Water and Sewerage Department ("DWSD") entered into Contract SW-548 (the "Contract") for the construction of certain improvements at DWSD's Southwest Water Treatment Plant (the "Project").

B. The GLWA is the successor-in-interest to DWSD's rights and obligations under the Contract.

C. The Project improvements included supply and installation, in each of four sedimentation basins, of certain components ("Collector Components") for construction of chain and flight sludge collector mechanisms (the "Collector Mechanisms").

D. Colasanti contracted with Cavanaugh via purchase order and subcontract, respectively, for the supply and installation of the Collector Components.

E. Cavanaugh contracted with Siemens Water Technologies Corp. n/k/a EWT via purchase order for the supply of the Collector Components.

F. On April 6, 2013, DWSD issued its Certificate of Substantial Completion for the Project.

G. Both prior to and after the Substantial Completion Certificate was issued, DWSD/GLWA reported inoperability of certain Collector Mechanisms and damage to certain Collector Components.

H. Disputes and differences arose among the Parties relating to the Project including, but not limited to, the cause(s) of and responsibility for inoperability of certain Collector Mechanisms and/or damage to certain Collector Components, and payments due under the Contract.

I. The GLWA default terminated the Contract and made a claim against the Performance Bond issued by Liberty Mutual Insurance Company ("Liberty") with respect to the Contract. Colasanti contested the default termination as wrongful and requested that the GLWA withdraw the default termination.

J. After negotiation and facilitation, the Parties desire to resolve, contingently, their disputes and differences on the terms stated in this Agreement.

PROMISES AND AGREEMENTS

1. Upgraded Basins.

a. CCE will perform the Work described in Section 1. c. (the "Work") to:

i. upgrade one basin of GLWA's selection (the "First Upgraded Basin"), in exchange for GLWA's payment to CCE of $100,000;

ii. upgrade an additional basin of GLWA's selection (the "Second Upgraded Basin") in exchange for GLWA's payment of each of CCE's actual cost, computed in accordance with Contract General Conditions Section 12.3.6, provided that CCE's subcontractors may charge overhead and profit at the percentages allowed under General Conditions Section 12.3.3 and CCE's material suppliers may charge commercially-reasonable overhead and profit. EWT shall provide a schedule listing the Collector Components it will supply for the Work and stating its aggregate actual cost;

iii. upgrade an additional basin of GLWA's selection (the "Third Upgraded Basin") in exchange for GLWA's payment of "Market Price," as defined in Section 1. i.; and

iv. subject to Section 1. b. iv., upgrade the final basin (the "Fourth Upgraded Basin") in exchange for GLWA's payment of "Market Price" less a $100,000 credit.

GLWA acknowledges receipt from CCE of CCE's good faith estimates of CCE's actual cost to complete the Second Upgraded Basin, and of CCE's Market Price. GLWA shall treat this information as confidential, subject to the requirements of Michigan's Freedom of Information Act.

GLWA has selected Basin 2B for the First Upgraded Basin and Basin 1B for the Second Upgraded Basin. GLWA shall give Notice (pursuant to Section 8) to CCE of its selection for the Third Upgraded Basin within 10 calendar days after the First Upgraded Basin has been "commissioned and accepted" as described in Section 1. h. ii.

b. Work on the Upgraded Basins shall proceed as follows:

i. Material procurement preceding the Work on the First Upgraded Basin shall commence within 10 calendar days after receipt of the fully executed Agreement and is expected to take approximately 18 weeks. CCE shall provide GLWA at least 21 calendar days' notice before commencement of the Work in each Upgraded Basin and, subject to GLWA's approval, shall be permitted to commence demolition activities associated with the Work prior to material delivery. Subject to unanticipated delays, disruptions, or interferences, CCE expects that material installation associated with the Work in each Upgraded Basin will be substantially complete within 12 weeks after material delivery and CCE shall work in good faith to complete the Work on each Upgraded Basin within 12 weeks after material delivery.

ii. Upon commissioning and acceptance of the First Upgraded Basin in accordance with this Agreement, CCE will commence the Work, pursuant to a

schedule agreed-upon by the Parties, on the Second Upgraded Basin. The Work on the Second Upgraded Basin shall commence as soon as reasonably practicable after the commissioning and acceptance of the First Upgraded Basin and CCE shall work in good faith to complete the Work on the Second Upgraded Basin within 12 weeks after material delivery, subject to unanticipated delays, disruptions, or interferences.

iii. Upon the completion of the Work on the Second Upgraded Basin, CCE will commence the Work, pursuant to a schedule agreed-upon by the Parties, on the Third Upgraded Basin. The Work on the Third Upgraded Basin shall commence as soon as reasonably practicable after completion of the Second Upgraded Basin and CCE shall work in good faith to complete the Work on the Third Upgraded Basin within 12 weeks after material delivery, subject to unanticipated delays, disruptions, or interferences.

iv. Within 30 calendar days after the completion of the Work on the Third Upgraded Basin, the GLWA shall advise CCE by written Notice whether it wants to upgrade the fourth basin. If the GLWA fails to give timely written Notice of its election to upgrade the fourth basin, the GLWA shall waive the $100,000 credit and CCE shall have no obligation to perform any Work on the fourth basin.

When the Work is completed in any basin, such basin will be referred to herein as an "Upgraded Basin" (with more than one Upgraded Basin being collectively referred to as the "Upgraded Basins").

c. The Work shall consist of the following in each basin:

i. Reduce collector speed from 2 fpm to 1 fpm

ii. Disable collector drive reversing function. (Upon Notice from GLWA during the 12-Month Operation Test for the First Upgraded Basin, CCE shall promptly provide necessary labor to replace broken shear pins).

iii. Replace flights, brackets, and rails.

iv. Replace all collector chain sprockets, wear shoes and shear pin hubs with the following upgraded materials:

1. SS Sprockets
2. PU Wear Shoes
3. SS Shear Pin Hub

v. Shorten longitudinal collector length by 100 feet. With respect to the First Upgraded Basin only, CCE shall be responsible for all costs associated with shortening the chains to lengths that function with the Upgraded Basins. With respect to the Second Basin this work will be performed at CCE's actual cost, computed in accordance with Contract General Conditions Section 12.3.6, provided that CCE's subcontractors may charge overhead and profit at the percentages allowed under General Conditions Section 12.3.3 and CCE's material suppliers may charge commercially-reasonable overhead and profit.

With respect to any subsequent basin, the work will be performed at "Market Price."

d. EWT has provided, and GLWA has approved, operation and maintenance guidelines for the Upgraded Basins, attached as Exhibit 5 (the "O&M Guidelines"). Prior to the start of the 12-Month Operation Test for the First Upgraded Basin, EWT shall conduct an onsite operation and maintenance training refresher for GLWA staff without cost to the GLWA. GLWA is responsible for the attendance of its staff at the training refresher.

e. GLWA is responsible for, and shall bear all costs relating to: (i) dewatering and removing all sludge in all basins to allow for CCE's undisrupted performance of the Work under this Agreement, and (ii) operating and maintaining in good working order all other processes, systems, equipment, and component parts at the Southwest Water Treatment Plant that could impact the Work and/or the 12-Month Operation Test.

f. GLWA shall receive, unload, handle, and store all new material deliveries. CCE will inventory and inspect the delivered materials.

g. The Parties assume that the drives, drive shafts, and chains are in workable condition. If not, GLWA shall replace them at GLWA's cost.

h. Inspection, 12-Month Operation Test, and Commissioning and Acceptance of the First Upgraded Basin:

   i. Upon completion of the Work at the First Upgraded Basin, GLWA shall operate the First Upgraded Basin for a six month period, after which the First Upgraded Basin shall be dewatered and inspected (the "Six-Month Inspection"). During the Six-Month Inspection, CCE shall not flip or replace any wear shoes except only to replace wear shoes to the extent required to fulfill CCE's obligations under the Warranties in Exhibits 3 and/or 4. Promptly after the Six-Month Inspection and determination that the First Upgraded Basin remains operational, GLWA shall operate the First Upgraded Basin for an additional six months (total of 12 months of operation), after which the First Upgraded Basin shall again be dewatered and inspected (the "12-Month Operation Test"). The GLWA is not required to flip or replace any wear shoes during the period of the 12-Month Operation Test despite any provisions in the O&M Guidelines to the contrary. In computing the 12 months of operation, the following shall be excluded:

      (1) the period (not to exceed three calendar days) commencing with GLWA's Notice to CCE that GLWA has discontinued operation of the First Upgraded Basin to allow for the Six-Month Inspection, and ending when GLWA has given access to CCE to perform the Six-Month Inspection;

      (2) the period commencing with CCE's access to perform the Six-Month Inspection and ending two calendar days after CCE's Notice to GLWA that the Six-Month Inspection is complete and the First Upgraded Basin is ready to be put back into service; and

(3) the period in excess of seven calendar days required by CCE to fulfill obligations under the Warranties in Exhibits 3 and/or 4. For the purposes of this calculation, the period begins when the First Upgraded Basin is drained and made available to CCE for Warranty repairs, and concludes when CCE provides Notice that it has completed its Warranty work and the First Upgraded Basin is ready to be put back into service.

ii. Upon completion of the 12-Month Operation Test without a "Failure" (defined below), the First Upgraded Basin shall be considered commissioned and accepted.

iii. Following completion of the Work at each Upgraded Basin, CCE shall provide the GLWA with as-built drawings.

i. "Market Price" means CCE's actual costs, computed in accordance with Contract General Conditions Section 12.3.6 and including materials supplied by EWT at its then-existing retail price, plus overhead and profit at the percentages allowed under Contract General Conditions Section 12.3.3.

j. The Parties expressly acknowledge and agree that the Work as outlined and performed under this Agreement shall not be deemed a design or redesign by CCE, and that, except as expressly set forth in this Agreement, CCE shall have no obligation or liability with respect to the Work. By way of further clarification, and not limitation, the Parties expressly acknowledge and agree that: (i) the Work is not subject to any of the provisions in Subsection 4.3.4.2 (including its subparts) of the Contract General Conditions; (ii) except as provided in this Agreement, in the event the First Upgraded Basin fails to pass its 12-Month Operation Test, the GLWA is not waiving or otherwise compromising its claims against Colasanti under the Contract and Liberty under the Performance Bond with respect to the performance of any Collector Mechanisms, and that CCE and Liberty are not waiving or compromising any of their claims against the GLWA and/or defenses to the GLWA's claims; and (iii) this Agreement shall not be admissible as evidence of CCE's and/or Liberty's responsibilities under the Contract, the Performance Bond, or for the Project.

k. At no additional cost to the GLWA, EWT shall supply the spare parts listed on Exhibit 1 from a combination of existing inventory (to the extent applicable and available) and additional spare parts, and Cavanaugh shall supply additional wear shoes listed on Exhibit 2. The GLWA may purchase additional spare parts at retail prices existing at the time of purchase.

2. Operation of the Upgraded Basins and Process in the Event of Failure at the First Upgraded Basin.

a. At all times, the GLWA shall follow the O&M Guidelines, including the "troubleshooting" provisions of the O&M Guidelines. Notwithstanding the foregoing: (a) prior to commissioning and acceptance of the First Upgraded Basin, the GLWA shall be required to follow the "troubleshooting" provisions only to the extent such provisions pertain to any Collector Components not comprising the Work; and (b) the "troubleshooting" provisions of the O&M Guidelines are

independent of, and do not supersede, whether a “Failure” has occurred within the meaning of Section 2. e., the cause of a “Failure,” and any warranty obligations.

b. The GLWA shall grant CCE unlimited access with reasonable advance notification (by attempted personal contact via telephone and via email) to Ian Thompson (or his successor identified in a Notice to CCE) to observe operation and/or maintenance of each Upgraded Basin prior to commissioning and acceptance of the First Upgraded Basin and during the Warranty Period for subsequently Upgraded Basins. In connection with such access, CCE personnel shall comply with GLWA safety requirements. The GLWA shall promptly (and in no case more than 24 hours) give prompt notification (by attempted personal contact via telephone and via email) to CCE of any problem operating an Upgraded Basin. To facilitate communication, the GLWA shall appoint and make available Ian Thompson (or his successor identified in a Notice to CCE) and CCE shall appoint and make available Scott Meredith and Jerry Schmitt (or their successor(s) identified in a Notice to the GLWA) to communicate and respond to any issues with any Upgraded Basin and/or questions or concerns raised by any Party.

c. During the first 12 months of operation of each Upgraded Basin, the GLWA shall keep a written record of daily operation, noting normal operation, any operational issues including shear pin failure and/or equipment downtime, any equipment or component repair or replacement, and any instances of taking the Upgraded Basin offline and operating it manually. During the 12-Month Operation Test for the First Upgraded Basin, on a weekly basis, the GLWA shall provide such daily operation reports to CCE.

d. If the First Upgraded Basin experiences a Failure (as defined in Section 2. e.) during the 12-Month Operation Test, then, without modifying GLWA’s 24-hour notice obligations under Section 2. b., within 14 calendar days of the event deemed to constitute a Failure, GLWA shall give Notice to CCE that a Failure has occurred. Within 14 calendar days of GLWA’s Notice of the Failure, CCE shall give Notice to GLWA either disputing or confirming the Failure. Unless the Parties agree otherwise the Parties shall then proceed as follows:

   i. If the Parties dispute whether the First Upgraded Basin has experienced a Failure during the 12-Month Operation Test, the dispute shall be resolved in accordance with Section 2. f.

   ii. If CCE confirms that the First Upgraded Basin has experienced a Failure during the 12-Month Operation Test, or if a Failure is confirmed by an arbitrator in accordance with Section 2. f., then:

      (1) CCE may, in its sole discretion exercised by Notice within 21 calendar days after confirmation of the Failure, elect to make adjustments to the Work in order to remediate the Failure. If CCE so elects, CCE shall diligently make the adjustments and a new 12-Month Operation Test shall begin on the date the First Upgraded Basin recommences operation. CCE may make this election up to two times.

(2) If CCE does not elect to make adjustments to the Work in order to remediate the Failure, then all remaining respective obligations of the Parties under this Agreement shall terminate, and except as provided in Section 2. h. of this Agreement, the Parties may pursue any and all claims available to them under the law, including pursuing any and all claims they had prior to entering into this Agreement. Any and all such claims shall be pursued in a legal action commenced by any Party within ninety (90) calendar days after confirmation of the Failure. Failure by any Party to institute a legal action within the 90-day period shall constitute a full waiver and release by all Parties of any and all claims, demands, damages, causes of action, and obligations whatsoever, known or unknown, now existing or hereafter arising, whether at law or in equity, relating to or arising in any way from the Contract, the Project, and/or the Work.

e. "Failure" means the malfunction of a Collector Mechanism which (a) occurs during operation of the First Upgraded Basin in accordance with Section 2. a. and under design flows and up to the solids loading conditions prescribed in the May 2008 "Basis of Design" for the Project, (b) prevents the function of the First Upgraded Basin, and (c) requires dewatering of the First Upgraded Basin to repair the malfunctioned Collector Mechanism. "Failure" does not include (v) wear rate of any Collector Components (unless the wearing of the Collector Components causes a "Failure" as described in subparts (a), (b) and (c) in this Failure definition section), (w) shear pin failure, (x) any malfunction that is attributable to an installation error that is promptly remediated under warranty, (y) any malfunction that is attributable to a manufacturing defect in a Collector Component that is promptly remediated under warranty, and/or (z) any malfunction caused by any systems, parts, equipment, or Collector Components not expressly comprising the parts replaced under Sections 1. c. iii. and iv. with respect to the Work.

f. Any dispute regarding whether the First Upgraded Basin has experienced a Failure during the 12-Month Operation Test shall be determined by final and binding arbitration within 60 calendar days after the Parties select an arbitrator. The demand for arbitration shall be made as soon as practicable, but in no event later than seven (7) calendar days after CCE gives Notice that it disputes the alleged Failure. After any Party gives Notice of a demand for arbitration, the Parties shall in good faith attempt to select an arbitrator agreeable to all Parties. However, if the Parties are unable to unanimously agree on an arbitrator within fourteen (14) calendar days after a Party gives notice of a demand for arbitration, the Parties shall use the American Arbitration Association's ("AAA's") "List and Appointment" service to select the arbitrator from a list of ten (10) potential arbitrators provided by the AAA. The cost for the AAA's "List and Appointment" service shall be divided equally among the Parties. The Parties shall advise the AAA that the preferred credentials for potential arbitrators include education, training, or experience in: (a) water treatment facilities construction or management, (b) law, and (c) civil and/or mechanical engineering. The selected arbitrator shall determine the arbitration protocol and render a standard award within five (5) business days of the hearing, with the goal of fair and expeditious

resolution of whether the alleged failure constitutes a Failure within the meaning of this Agreement. For good cause shown, the arbitrator may allow limited discovery. The arbitrator's award shall require the non-prevailing party to pay the entirety of the arbitrator's compensation.

g. The Parties agree to extend all existing tolling agreements from the date of this Agreement until (a) 90 calendar days after the confirmation of a Failure at the First Upgraded Basin that CCE elects not to remediate under Section 2. d. ii. (1); or (b) the commissioning and acceptance of the First Upgraded Basin. Liberty's agreement to the terms of this extended tolling provision is attached hereto as Exhibit 6.

h. Notwithstanding any other provision in this Agreement to the contrary, as further consideration for the promises in this Agreement, in connection with any claims made pursuant to Section 2. d. ii. (2):

   i. CCE waives any and all damages relating to costs and/or expenses incurred to perform the Work on the First Upgraded Basin; and

   ii. To the full extent of CCE's costs and/or expenses incurred to perform the Work on the First Upgraded Basin, GLWA waives any and all damages relating to costs and/or expenses incurred during or based on the time period between the date of Substantial Completion and the filing and service of the legal action, including, by way of example and not limitation, all claims for liquidated damages and/or sludge-removal costs. Nothing in this paragraph shall be deemed an admission by CCE of the legal validity of any GLWA claims or entitlement to liquidated damages and/or sludge-removal costs.

i. Upon commissioning and acceptance of the First Upgraded Basin, GLWA shall issue a final closeout change order adjusting the final contract price and final contract completion date, and the Contract shall be closed out. Work in subsequent Upgraded Basins shall be subject to the terms of this Agreement only, and shall not extend the Contract closeout.

3. Payments to CCE.

a. GLWA shall pay CCE $100,000 upon CCE's commencement of the Work on the First Upgraded Basin. GLWA shall pay CCE progress payments for the Work on the Second Upgraded Basin, the Third Upgraded Basin and, if elected by GLWA, the Fourth Upgraded Basin, in accordance with monthly payment applications submitted by CCE. Progress payments shall be made within 45 calendar days after submission of each payment application. There shall be no retention withheld from such progress payments.

b. In addition to the payments in Section 3. a., GLWA shall pay CCE the unpaid Contract balance, unpaid Contract retention, and accrued interest on the unpaid Contract retention as follows:

   i. $150,000 upon commencement of the Work on the First Upgraded Basin;

   ii. $326,173.07 upon completion of the Work on the First Upgraded Basin; and

iii. $326,173.07, plus all accrued interest on the retention account, upon commissioning and acceptance of the First Upgraded Basin.

4. GLWA Default. If the GLWA fails to (a) make any payment required under this Agreement, or (b) fulfill its obligations under Sections 1. e., 2. a., b., or c., after being provided Notice and ten (10) business days to cure, then CCE's obligations under this Agreement will terminate and the GLWA shall pay CCE all remaining amounts under Section 3.

5. Warranties. For the Upgraded Basins, EWT provides its standard equipment warranty (Exhibit 3). Colasanti/Cavanaugh provides a one year supply and installation warranty for the Upgraded Basins (Exhibit 4). All warranties begin when each Upgraded Basin is placed into operation. THERE ARE NO OTHER WARRANTIES, EXPRESS OR IMPLIED, ARISING FROM THE EQUIPMENT, MATERIALS, LABOR AND/OR OTHER WORK TO BE SUPPLIED OR PERFORMED HEREUNDER FOR THE UPGRADED BASINS. ALL OTHER WARRANTIES AND OBLIGATIONS RELATING TO THE WORK ARE EXPRESSLY DISCLAIMED, INCLUDING, BUT NOT LIMITED TO, ANY AND ALL IMPLIED WARRANTIES OF SUITABILITY, MERCHANTABILITY AND/OR FITNESS FOR A PARTICULAR PURPOSE. Subject to Section 2. d. ii (2), GLWA's sole rights and CCE's sole liability with respect to the Work, or any portion thereof, prescribed by this Agreement are expressly limited to the express Warranties described above.

6. Default and Bond Claim. The GLWA shall immediately, and in writing, withdraw its notice of default and termination of the Contract and withdraw its claim against the Performance Bond, both without prejudice. This paragraph is without prejudice to any of the GLWA's rights and remedies provided in this Agreement and the Parties agree that if CCE fails to comply with the terms of this Agreement or the First Upgraded Basin experiences a Failure that is not remediated, the GLWA has the right to reinstate the default and claim against Liberty and pursue its claims against CCE and Liberty pursuant to Section 2. d. ii. (2) of this Agreement. Liberty's written agreement to this provision is attached hereto as Exhibit 6.

7. Releases. Upon commissioning and acceptance of the First Upgraded Basin, other than the duties, rights, and obligations contained in this Agreement, each of CCE releases and covenants not to sue GLWA, and GLWA releases and covenants not to sue each of CCE (and each of their respective sureties, subcontractors, suppliers and affiliated entities), from any and all claims, demands, damages, causes of action, and obligations whatsoever, known or unknown, now existing or hereafter arising, whether at law or in equity, relating to or arising in any way from the Contract, the Project, and/or the Work.

8. Notice. Notice to the Parties shall be sent by both email and by overnight courier on the same date as follows:

a. To the GLWA:

Mr. Randal M. Brown
General Counsel
Great Lakes Water Authority

735 Randolph St Ste 1900
Detroit, MI 48226-2830
Email: randal.brown@glwater.org

With a copy to:

Mr. Matthew G. McNaughton
Zausmer, PC
32255 Northwestern Hwy Ste 225
Farmington Hills, MI 48334-1574
Email: mmcnaughton@zausmer.com

b. To Colasanti:

Mr. John T. Clappison
General Counsel
Colasanti Construction Services, Inc.
24500 Wood Ct.
Macomb MI 48042
Email: jclappison@colasantigroup.com

With a copy to:

Mr. Edward J. Hood
Clark Hill PLC
500 Woodward Avenue, Suite 3500
Detroit, MI 48226
Email: ehood@clarkhill.com

c. To Cavanaugh:

Mr. Jerry Schmitt
J.F. Cavanaugh Company
20750 Sunnydale
Farmington Hills, MI 48336
Email: jerry@jfcav.com

With a copy to:

Mr. Jeffrey G. Heuer
Jaffe Raitt Heuer & Weiss, P.C.
27777 Franklin Rd Ste 2500
Southfield, MI 48034-8222
Email: jheuer@jaffelaw.com

d. To EWT:

Mr. Marc Roehl/Mr. Allen Lepak
Evoqua Water Technologies
N19W23993 Ridgeview Pkwy, Suite 200
Waukesha, WI 53188
Email: marc.roehl@evoqua.com / allen.lepak@evoqua.com

With a copy to:

Mr. Ralph Finizio
Pepper Hamilton LLP
Suite 300 | 501 Grant Street
Pittsburgh, Pennsylvania 15219-4429
Email: finizior@pepperlaw.com

Notice shall be deemed given on the date sent.

9. Integration. This Agreement is intended by the Parties as a final expression of their agreement regarding the contingent resolution of their disputes and differences regarding the subject matter hereof, and is intended to be a complete, final and exclusive statement of the agreement and understanding of the Parties with respect thereto. Except under the circumstances where Section 2. d. ii. (2) applies, this Agreement supersedes any and all prior promises, representations, warranties, agreements, understandings and undertakings between or among the Parties with respect thereto, and there are no other or further promises, representations, warranties, agreements, understandings or undertakings with respect thereto**.**

10. Modification. Neither this Agreement nor any term set forth herein may be modified, waived, discharged or terminated, orally or in writing, except by a writing signed by the Parties, and the observance of any such term may be waived (either generally or in a particular instance either retroactively or prospectively) only by a writing signed by the Party or Parties against whom such waiver is to be asserted.

11. Electronic Signatures and Counterparts. This Agreement will be signed by the Parties. Counterparts of the signature pages may be combined to create a document binding on all of the Parties, and together shall constitute one and the same instrument. An electronic reproduction of an original executed copy of the Agreement shall be of the same binding effect as the original.

12. No Admission. By entering into this Agreement, no Party is making any admission, express or implied, that it or any of its respective successors in interest or affiliates is liable to any other Party for any matter, cause, or thing whatsoever. Specifically, this Agreement, and each Party's performance of the obligations hereunder, are without prejudice to any Party's legal position regarding whether the Contract imposed on CCE any performance requirements and/or whether CCE satisfied any such requirements.

13. Interpretation. This Agreement has been negotiated at arm's length and between and among sophisticated and knowledgeable Parties in the matters dealt with in this Agreement. In addition, this Agreement was drafted jointly by experienced and

knowledgeable legal counsel for the Parties. Accordingly, no Party shall be presumptively entitled to have any provisions of the Agreement construed in accordance with any rule of law, legal decision or doctrine, such as the doctrine of *contra proferentem* that would require interpretation of any ambiguities in this Agreement against the party that has drafted it. This Agreement and its terms shall be interpreted in a reasonable manner to effectuate the purposes of the Parties and this Agreement.

14. Successors and Assigns. The Parties understand and agree that the agreements, undertakings, acts and other things done or to be done by them in this Agreement shall run to and be binding upon each of their successors and assigns.

15. Severability. If any provision of this Agreement, or the application thereof, shall for any reason or to any extent be construed by a court of competent jurisdiction to be invalid or unenforceable, the remainder of this Agreement, and application of such provisions to other circumstances, shall remain in effect and be interpreted so as to reasonably effect the intent of the Parties.

16. Governing Law. This Agreement is entered into and shall be governed, construed and interpreted in accordance with the substantive laws of the State of Michigan, regardless of conflict of laws principles.

17. Further Assurances. The Parties agree to collaborate on and provide any documents that may reasonably be required to effectuate the intent of this Agreement.

18. Time is of the Essence. Time is of the essence of this Agreement.

19. Warranty of Signature. Each person executing this Agreement on behalf of a Party represents and warrants that s/he is authorized to execute this Agreement on that Party's behalf, and that all organizational formalities requisite to such authority have been accomplished and/or satisfied.

MUTUAL ASSENT

_____
Great Lakes Water Authority

_____
Colasanti Construction Services, Inc.

_____
J.F. Cavanaugh Company

_____
Evoqua Water Technologies LLC

EXHIBIT 1

EXHIBIT 1 – LIST OF SPARE PARTS FOR ALL BASINS

QTY	PART NUMBER	DESCRIPTION
100	43891-111	Flight – Sigma Plus, 3 x 8 x 200”, blank
3312	303-70493-1	Wear Shoe, Carry – Polyurethane w/PTFE
3312	303-70493-2	Wear Shoe, Return – Polyurethane w/PTFE
62	W2T120041	Wear Strips – Return Track
68	W2T120041	Wear Strips – Floor
4	TBD	Driver Sprocket teeth, 11 tooth segment kits, 15-5PH stainless steel
2	TBD	Driven Sprocket, 40 tooth complete ductile iron sprocket
12	TBD	Collector Sprocket teeth, 23 tooth segment kits, 15-5PH stainless steel
6	W2t490948	Wall Bearing replacement inserts, 4.44” bore
6	W2T500794	Wall Bearing replacement inserts, 4.00” bore
6	43891-115-3.50	Wall Bearing replacement inserts, 3.50” bore
6	W2T500793	Wall Bearing replacement inserts, 2.50” bore
1	W3T138674	Drive Mechanism – R67R37 – Cross Collector
1	W3T138672	Drive Mechanism – R87R57 – Long Collector

* Spare parts will be provided after commissioning and acceptance of the First Upgraded Basin.

* These quantities reflect the total number of spare parts to be in GLWA’s inventory, including existing inventory.

EXHIBIT 2

EXHIBIT 2 – LIST OF REPLACEMENT SHOES FOR ALL BASINS

By J.F. Cavanaugh:

QTY	PART NUMBER	DESCRIPTION
9,936	303-70493-1	Wear Shoe, Carry – Polyurethane w/PTFE
9,936	303-70493-2	Wear Shoe, Return – Polyurethane w/PTFE

2484 of each kind of wear shoe will be provided only upon commissioning and acceptance of each Upgraded Basin.

EXHIBIT 3

SETTLEMENT AGREEMENT EXHIBIT 3 – STANDARD EQUIPMENT WARRANTY OF EWT

A. Warranty. EWT warrants to GLWA that the equipment to be supplied by EWT under the Settlement Agreement (the "Equipment") shall materially conform to the description in the Settlement Agreement and shall be free from defects in material and workmanship. EWT warrants the Equipment, or any components thereof, through the earlier of (i) eighteen (18) months from delivery of the Equipment or (ii) twelve (12) months from initial operation of the Equipment (the "Warranty Period"). If GLWA gives EWT prompt written notice of breach of this warranty within the Warranty Period, EWT shall, at its sole option and as GLWA's sole and exclusive remedy, repair or replace the subject parts or refund the purchase price. EWT's warranty is conditioned on GLWA's (a) operating and maintaining the Equipment in accordance with EWT's instructions, (b) not making any unauthorized repairs or alterations, and (c) not being in default of any payment obligation to EWT. EWT's warranty does not cover damage caused by chemical action or abrasive material, misuse or improper operation or installation.

B. DISCLAIMER. THE WARRANTIES SET FORTH IN SECTION A ARE EWT'S SOLE AND EXCLUSIVE WARRANTIES AND ARE SUBJECT TO THE LIMITATION OF LIABILITY PROVISION BELOW. EWT MAKES NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF SUITABILITY, MERCHANTABILITY OR FITNESS FOR PURPOSE.

C. LIMITATION OF LIABILITY. EWT SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES, INCLUDING, BUT NOT LIMITED TO, LOSS OF PROFITS OR LOSS OF USE, AND EWT'S TOTAL LIABILITY ARISING AT ANY TIME FROM THE SUPPLY, SALE

OR USE OF THE EQUIPMENT, OR IN ANY WAY RELATED TO THIS STANDARD EQUIPMENT WARRANTY, SHALL NOT EXCEED THE VALUE OF THE EQUIPMENT. THESE LIMITATIONS APPLY WHETHER THE LIABILITY IS BASED ON CONTRACT, WARRANTY, TORT, STRICT LIABILITY OR ANY OTHER THEORY.

D. This Standard Equipment Warranty cannot be amended, altered or modified in any way except in writing signed by an authorized representative of EWT.

E. This Warranty does not supersede any provision in the Settlement Agreement, including the provisions included therein to address an event of "Failure," and to the extent this Warranty conflicts with the Settlement Agreement, the Settlement Agreement prevails.

EXHIBIT 4

SETTLEMENT AGREEMENT EXHIBIT 4 – SUPPLY AND INSTALLATION WARRANTY OF COLASANTI AND CAVANAUGH

A. Supply Warranty: Cavanaugh expressly warrants the replacement wear shoes to be supplied by Cavanaugh under the Settlement Agreement to the same extent, on the same terms, as the express warranty provided by EWT in Settlement Agreement Exhibit 3.

B. Installation Warranty: Colasanti and Cavanaugh expressly warrant that, for a period of one (1) year after commencing operation of an Upgraded Basin (the "Installation Warranty Period"), the installation portion of the Work in such Upgraded Basin shall be free from defects that impair the functionality of one or more Collector Mechanisms ("Installation Warranty Coverage"). If any of the Work is defective within the Installation Warranty Coverage and the GLWA gives written notice of such defect(s) during the Installation Warranty Period, then Colasanti and Cavanaugh shall make any and all repairs necessary to cure such defects, and repair any damage caused by such defective installation. GLWA shall give Colasanti and Cavanaugh prompt written notice of any defect within the Installation Warranty Coverage and, within seven (7) days of such written notice, Colasanti and Cavanaugh shall commence repairs and faithfully and diligently prosecute the same to conclusion, without cost to GLWA, such repair constituting GLWA's sole and exclusive remedy under this Warranty. This Installation Warranty excludes damage or defect caused by abuse, alterations to the Work not executed by Colasanti or Cavanaugh, improper or insufficient maintenance, improper operation, and/or operational wear and tear.

COLASANTI AND CAVANAUGH EXPRESSLY DISCLAIM ANY AND ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO

ALL WARRANTIES OF SUITABILITY, MERCHANTABILITY, AND/OR FITNESS FOR A PARTICULAR PURPOSE.

In no event shall Colasanti and/or Cavanaugh be liable for any indirect, special, incidental, consequential, punitive, or liquidated damages or other damages of any kind with respect to the Work, or in any way related to this Supply and Installation Warranty, regardless of the form of action (be it for breach of contract, warranty, negligence, strict liability, tort, or otherwise), including, but not limited to, loss of profits or loss of use.

Capitalized Terms not defined in this Supply and Installation Warranty shall have the meaning stated in the Settlement Agreement.

This Supply and Installation Warranty cannot be amended, altered or modified in any way except in writing signed by authorized representatives of Colasanti and Cavanaugh.

This Supply and Installation Warranty does not supersede any provision in the Settlement Agreement, including the provisions included therein in to address an event of "Failure," and to the extent this Warranty conflicts with the Settlement Agreement, the Settlement Agreement prevails.

EXHIBIT 5

CHAIN AND SCRAPER SLUDGE COLLECTORS

INSTALLATION
OPERATING AND MAINTENANCE
MANUAL

DETROIT DWSD SW Drinking Water Treatment Plant

46349 Preliminary Document
(24 Long Collectors & 8 Cross Collectors)

July 11, 2019

TABLE OF CONTENTS

INSTALLATION 3

1.1 CHAIN AND SCRAPER SLUDGE COLLECTOR 3
1.2 SAFETY PRECAUTIONS 3
1.3 INSTALLATION SEQUENCE 6
1.4 LOCATING SHAFTS 6
1.5 ANCHOR BOLTS 7
1.6 BEARING, SHAFT AND SPROCKET ASSEMBLY 7
1.6.1 SHAFT CLEANING (IF NECESSARY) 7
1.6.2 BEARING PRE-LUBRICATION 8
1.6.3 SHAFT AND SPROCKET PRE-ASSEMBLY (WHEN NECESSARY) 8
1.7 BEARING AND SHAFT ASSEMBLY 8
1.8 LIVE CORNER SHAFTS (FULL TANK WIDTH) 11
1.9 SPROCKET TO SHAFT ASSEMBLY 11
1.9.1 COLLECTOR SPROCKETS-TO-HEAD SHAFT AND LIVE CORNER SHAFT INSTALLATION 12
1.9.2 DRIVEN SPROCKET (Cast Ductile Iron Body with 40Tooth Segment Kit) TO-HEAD SHAFT INSTALLATION 13
1.9.3 SHAFT AND SPROCKET OVERALL ALIGNMENT 14
1.10 RETURN TRACKS 16
1.10.1 INSTALLATION 16
1.10.2 RETURN TRACKS AND MATING UHMW-PE WEAR STRIPS 17
1.10.3 FLOOR WEAR BARS FOR ANCHOR MOUNTED DESIGN 18
1.11 CHAIN AND FLIGHT ASSEMBLY 20
1.11.1 ASSEMBLING 715SS METAL COLLECTOR CHAIN 20
1.11.2 INSTALLING COLLECTOR CHAIN 21
1.11.3 INSTALLING WEAR SHOES AND FLIGHTS 22
1.11.4 COLLECTOR CHAIN TENSION 23
1.11 NA 24
1.12 DRIVES AND DRIVE CHAINS 24
1.12.1 DRIVE ASSEMBLY / INSTALLATION 24
1.12.2 TORQUE LIMITER PROTECTION 25
1.13 SHEAR PIN ALARM TRIP LEVER – EXISTING CAST IRON SPROCKET DESIGN 27
1.14 SHEAR PIN ALARM SWITCH 29
1.15 DRIVE CHAIN INSTALLATION 29
1.16 DRIVE CHAIN SLACK 30
1.17 DRIVE CHAIN TIGHTENERS 31
1.18 DRIVE ROTATION CHECK 31
1.19 CHAIN GUARDS 32

OPERATION 34

2.1 SAFETY PRECAUTIONS 34
2.2 PRE-START-UP (DRY TANK) 34
2.3 FIELD SERVICE TECHNICIAN SUPERVISED CHECKOUT 35
2.4 COLLECTOR CHAIN SLACK - (THREE SHAFT CROSS COLLECTORS) 35
2.5 CROSS-COLLECTOR CHAIN SLACK - (3-SHAFT CROSS COLLECTORS) 36
2.6 SPROCKETS 36
2.7 WEIRS 36
2.8 FILLING THE TANK 36
2.9 INITIAL OPERATION 36
2.10 SHUT-DOWN PROCEDURES 37
2.11 EMERGENCY OPERATING SHUT-DOWN PROCEDURES 37
2.12 PROCEDURE FOR SHUT DOWN LONGER THAN 3 WEEKS 38

MAINTENANCE / TROUBLESHOOTING 39

3.1 SAFETY PRECAUTIONS 39
3.2 PERSONNEL PROCEDURES 39
3.3 PREVENTIVE MAINTENANCE 42
3.4 RECOMMENDED LUBRICANTS 42
3.5 MAINTENANCE SCHEDULE 43

3.6 TROUBLESHOOTING 46
3.6.1 EXCESSIVE TORQUE LIMITER DEVICE ACTIVATION 46
3.6.2 FLIGHTS MOVING IN A STOP-START FASHION 46
3.6.3 CHAIN JUMPING A TOOTH ON ONE COLLECTOR CHAIN SPROCKET, FLIGHTS SKEWED 47
3.6.4 COLLECTOR CHAIN BREAKS 48
3.6.5 FLIGHTS NOT SUBMERGED EVENLY 49
3.6.6 FLIGHT ENDS DAMAGED 49
3.6.7 COLLECTOR OR DRIVE CHAIN BREAKS, BUT TORQUE LIMITER DEVICE DOES NOT ACTIVATE 50
3.6.8 TORQUE LIMITER DEVICE ACTIVATES TO SHUT DOWN COLLECTOR, BUT MOTOR CONTINUES TO RUN (if limit switch is furnished) 51
3.6.9 FLIGHT CARRYING CHAIN WEARING ON INNER SURFACE OF SIDE BAR 51
3.6.10 FLIGHTS WEARING ON BOTTOM EDGE 52
3.6.11 NOISY OR VIBRATING DRIVE ASSEMBLY 52
3.6.12 GEAR REDUCER LEAKING OIL THROUGH SEALS 53
3.6.13 GEAR REDUCER WILL NOT ACCEPT USUAL AMOUNT OF OIL IN GEAR CASE 53
3.6.14 GEAR LUBRICANT IS MILKY OR LUMPY 53
3.6.15 WEAR ON DRIVE CHAIN SIDE BARS AND SIDE OF SPROCKET TEETH 53
3.6.16 DRIVE CHAIN: BROKEN PINS, BUSHINGS OR ROLLERS (as applicable) 54
3.6.17 COTTER PINS COME OUT (where applicable) 54
3.6.18 EXCESSIVE NOISE IN DRIVE CHAIN 54
3.6.19 DRIVE CHAIN CLIMBS SPROCKETS 55
3.6.20 BROKEN SPROCKET TEETH 55

SPARE PARTS ..... **ERROR! BOOKMARK NOT DEFINED.**

4.1 RECOMMENDED SPARE PARTS* ..... **ERROR! BOOKMARK NOT DEFINED.**

VENDOR INFORMATION 56

5.1 REDUCERS – EXISTING SEW EURODRIVE R87R57AM143 OR REPLACEMENT NORD SK63/23 56
5.2 MOTORS – EXISTING BALDOR / RELIANCE OR REPLACEMENT NORD 71L/4-56C CUS 56
5.3 LIMIT SWITCH – HONEYWELL 11CX12 56
5.4 ADHESIVE ANCHORS – HILTI HIT HY200A 56
5.5 SNAP IDLE CHAIN TENSIONERS 56

INSTALLATION

1.1 CHAIN AND SCRAPER SLUDGE COLLECTOR

The instructions and recommendations in this manual are intended to assist the Erecting Contractor, the Plant Operator and Maintenance Personnel.

Because plant design varies according to Engineer's specifications, State and Local codes and Insurance and Underwriters' requirements, the instructions are necessarily general in nature. If more specific information is required or if questions of a technical nature arise, please contact your local **Evoqua** representative or customer service. (See GENERAL INFORMATION section)

Recommendations on the storage of this equipment are included in the GENERAL INFORMATION section of this manual.

All drawings submitted are found in the manual Drawings Section. These include General Arrangement Drawings specifically for installation.

1.2 SAFETY PRECAUTIONS

General Safety Precautions to be used in erecting, operating and maintaining this equipment are included in the GENERAL INFORMATION section of this manual. Precautions that are specific to Sludge Collectors are included within the text of this manual. A caption of CAUTION, WARNING or DANGER indicates the severity of the hazard and a graphic symbol indicates the nature of the hazard. Recommended precautions are included in the text, adjacent to the symbol.

The primary hazards associated with installing Sludge Collectors are identified below.

HANDLING HEAVY EQUIPMENT

Sludge Collectors have large and heavy parts, which must be lifted and located during assembly.

Cranes, hoists and lifting gear must have a load capacity greater than the loads to be lifted. Lifting points should be selected with care and lifting harness should be stabilized. **Avoid hand lifting of heavy parts.**

PERSONNEL PROCEDURES

Installation procedures will require working in elevated positions where there is a potential for falling. Personal injury may result. Safety harness should be worn when there is danger of falling.

Use care in handling drive chain guards, return tracks, flights and other parts that are fabricated of Fiberglass Reinforced Plastic (FRP), particularly at edges and cut areas. Glass fibers are a skin irritant. Cut edges can cause slivers and abrasions. Use gloves when handling FRP material.

FIRE HAZARDS

The use of welding equipment and cutting torches may be required in the erection of Sludge Collectors. Some components may be made from polymeric materials. These materials are combustible and some may burn with a non-visible flame. Foam or other means of suffocation may be required to extinguish burning plastics. Metal equipment is frequently coated with combustible substances. A fire can grow quickly, sometimes emitting toxic gases. Move combustible materials away from an area in which welding or cutting is being done. **Keep combustible materials away from heat and open flame. If a fire occurs, do not breathe fumes.**

Fire extinguishers and plant water must be available in the area. Workers must be able to leave the tank quickly.

WELDING HEALTH HAZARDS

Since **Evoqua** does not know what welding processes and filler materials will be used for field welding, the following general welding health hazard data should be conveyed to welding personnel.

Arc rays can injure eyes and burn skin. **Heat rays** (infrared radiation from flame or hot metal) can injure eyes.

Overexposure to electric arc welding or oxy-fuel gas processes may create one or more of the following hazards. **Carbon Steels** - Excessive inhalation of metal fumes and dusts may result in irritation of eyes, nose and throat. **Stainless Steels -** Cancer hazard (contains chromium and nickel); Excessive inhalation of metal fumes and dusts may cause sensitization, dermatitis, inflammation and/or ulceration of the upper respiratory tract and possible cancer of nasal passages and lungs.

Electric shock can cause injury or death.

Noise can damage hearing.

Read and understand the welding materials manufacturer's instructions and precautionary label on the product being used. For further health hazard details, consult the welding materials manufacturer's Material Safety Data Sheets.

OPERATING ENVIRONMENT

Sludge Collectors are usually exposed to the elements. Access points may become slippery when wet or icy. The potential for falling is present. Personal injury may result. Handrails and other safeguards must be in place when operating the equipment. Use care when access is necessary**.**

If this equipment is being used in conjunction with a biological treatment system, care should be taken to avoid direct contact with the water and sludges. Appropriate personal protective equipment and good hygiene practices should be used to prevent viral and bacterial infections.

Hands should be washed frequently and cuts and scrapes should be kept clean and covered when working around the equipment. Gauze-type respirators should be used where aerosols or mists are present.

Personnel should be aware of and observe all local safety codes and OSHA regulations. The safety precautions recommended in this manual do not replace these codes and regulations.

Guards cover several points on Sludge Collectors to prevent personal injury from moving parts. If guards are not in place during installation procedures, use caution when operating equipment and put guards in place when these procedures are complete.

1.3 INSTALLATION SEQUENCE

Evoqua recommends that where possible the equipment should be installed in the following sequence:

1. Shafts/Bearings
2. Collector Sprockets
3. Return Tracks Angles
4. Floor Wear Strips
5. Collector Chains with flights and flight attachments
6. Drives and Drive Chains

NOTE: Throughout the installation, the tank centerline should be used as a reference point unless otherwise stated. One method of establishing the tank centerline is suggested below.

To establish a centerline for a tank, place two work points at floor level, one at the lower effluent idler shaft location and the other at the lower influent idler shaft location. The distance between the concrete walls (curbs) at floor level at those two locations should be divided in half and each work point established. A chalk line stretched between those two points will be the true centerline for that particular tank. **All equipment positioned in that tank must be positioned off this centerline, not the concrete wall.**

Note that it is not essential that adjacent tank centerlines be parallel to each other even though, by design, they should be. It is more important that the centerline conforms to the inevitable irregularities that concrete walls have for the individual tank in which the centerline is located.

1.4 LOCATING SHAFTS

Head shaft – First locate the head shaft vertical and horizontal centerlines based on the General Arrangement drawings. The head shaft is to be perpendicular to the centerline of the tank.

Lower Influent Idler shaft (Long Collector) – The shaft below the head shaft, is located by measuring off of the centerline of the head shaft for the horizontal distance shown on the General Arrangement drawings. The elevation of the shaft is measured from the finished floor surface on one side of the channel. At the opposite side of the channel the shaft elevation is determined by establishing a point level with the previously established point. All shafts must be parallel to the head shaft and level within the tolerances shown in *Figure 6*.

Upper Effluent Idler shaft – Is located by measuring off of the centerline of the head shaft for the horizontal distance shown on the General Arrangement drawings. The elevation of the shaft is measured from the water surface elevation shown on the General Arrangement drawings. Mark a point on the wall. At the opposite side of the channel, the shaft elevation is determined by establishing a point level to the previously established point. All shafts must be parallel to the head shaft and level within the tolerances described in the Shaft and Sprocket Overall Alignment Section of this manual.

Effluent Idler shaft (Long Collector) – If there is a vertical wall at the end of the tank, the effluent idler shaft or its supports are to be located from that wall's surface per the dimension shown on the General Arrangement drawings. The distance at the end of the shaft should not be less than the dimension shown on the General Arrangement drawings and the shaft centerline must be perpendicular to the centerline of the tank. The elevation of the shaft is measured from the finished floor surface on one side of the channel. At the opposite side of the channel the shaft elevation is determined by establishing a point level with the previously established point. All shafts must be parallel to the head shaft and level within the tolerances shown in *Figure 6*.

NOTE: The distance between lower influent and effluent idler shaft shown on the General Arrangement drawing is for reference only, it is not essential that the actual distance equal the drawing dimension as long as the shafts are located as previously described. If there is no vertical wall at the effluent end of the tank then the distance between the lower influent and effluent idler shafts is to be maintained per the General Arrangement drawing dimension.

All shaft center lines should now be properly located.

1.5 ANCHOR BOLTS

All wedge style or adhesive type anchors should be installed per the manufacturer's instructions prior to assembly of equipment to the anchors. For adhesive anchors it is extremely important to follow manufacturer's instructions for the drilled hole diameter size, hole cleaning and proper cure time. Locate shaft support or bearing anchors with respect to the shaft centers previously marked on the tank walls.

1.6 BEARING, SHAFT AND SPROCKET ASSEMBLY

1.6.1 SHAFT CLEANING (IF NECESSARY)

When using chemical solvents, observe the solvent manufacturer's and OSHA safety recommendations at all times

As received in the field, most shafting is protected with a coating (**Evoqua** standard shop preservative) that extends to the set collars or bearings at the shaft ends. In order to move the collars and/or bearings along the shaft (so that the bearings can be placed over anchor bolts projecting from the tank walls), it will be necessary to remove a small portion of the coating on the shaft. Use fuel oil or kerosene if the coating is still soft, Toluene if the coating has "set". Do not remove coating from static shafts (shafts that do not rotate during operation).

1.6.2 BEARING PRE-LUBRICATION

If self-aligning (SA) wall bearings have been provided, we recommend that a light coat of grease be applied to the wall bearing bores. If your order specified grease lubricated wall bearings, use the lube fittings. Otherwise, smear the bearing bores and the shaft ends before installing the bearings on the shaft ends. **DO NOT** grease set collar area of shafts. **Since this is for a drinking water application, apply only an ANSI/NSF 61 approved grease.**

1.6.3 SHAFT AND SPROCKET PRE-ASSEMBLY (WHEN NECESSARY)

All bearings and sprockets are shipped loose. The shafting, bearings or support brackets and collector sprockets may be pre-assembled outside the tank and installed as an assembly.

CAUTION: Do not use sprockets to support the shaft assembly; place supports under the shaft to keep sprockets off the ground. Sprocket teeth may be damaged if sprockets are used to support the shafts. Wall bearings must be secured (tie-wired) to the sprockets to prevent bearings from slipping off the shaft.

1.7 BEARING AND SHAFT ASSEMBLY

NOTE: The instructions shown below are typical for split or solid Self-Aligning (SA) wall bearings. Wall bearings are used for head shafts and some live corner (or idle) shafts.

1. Self-aligning (SA) wall bearings (see *Figure 1*) will not require shimming or grouting if the distance between walls, as dimensioned on the General Arrangement Drawing(s), is maintained within +/- 1/2 inch (13 mm). The SA ball and socket wall bearing is designed to allow reasonable misalignment.

   If the distance between the tank walls exceeds the ½ inch tolerance (to the plus side), **Evoqua** recommends the use of a grout shield (not furnished by **Evoqua**) to be placed immediately behind the bearing. A grout shield can easily be made from #14 gauge (steel or stainless steel) using the wall bearing as a template. Bearings must be shimmed and grouted in place, when this condition occurs.

   If the distance between the tank walls is less than the ½ inch tolerance (to the minus side), contact **Evoqua** for evaluation and recommendation.

CAUTION

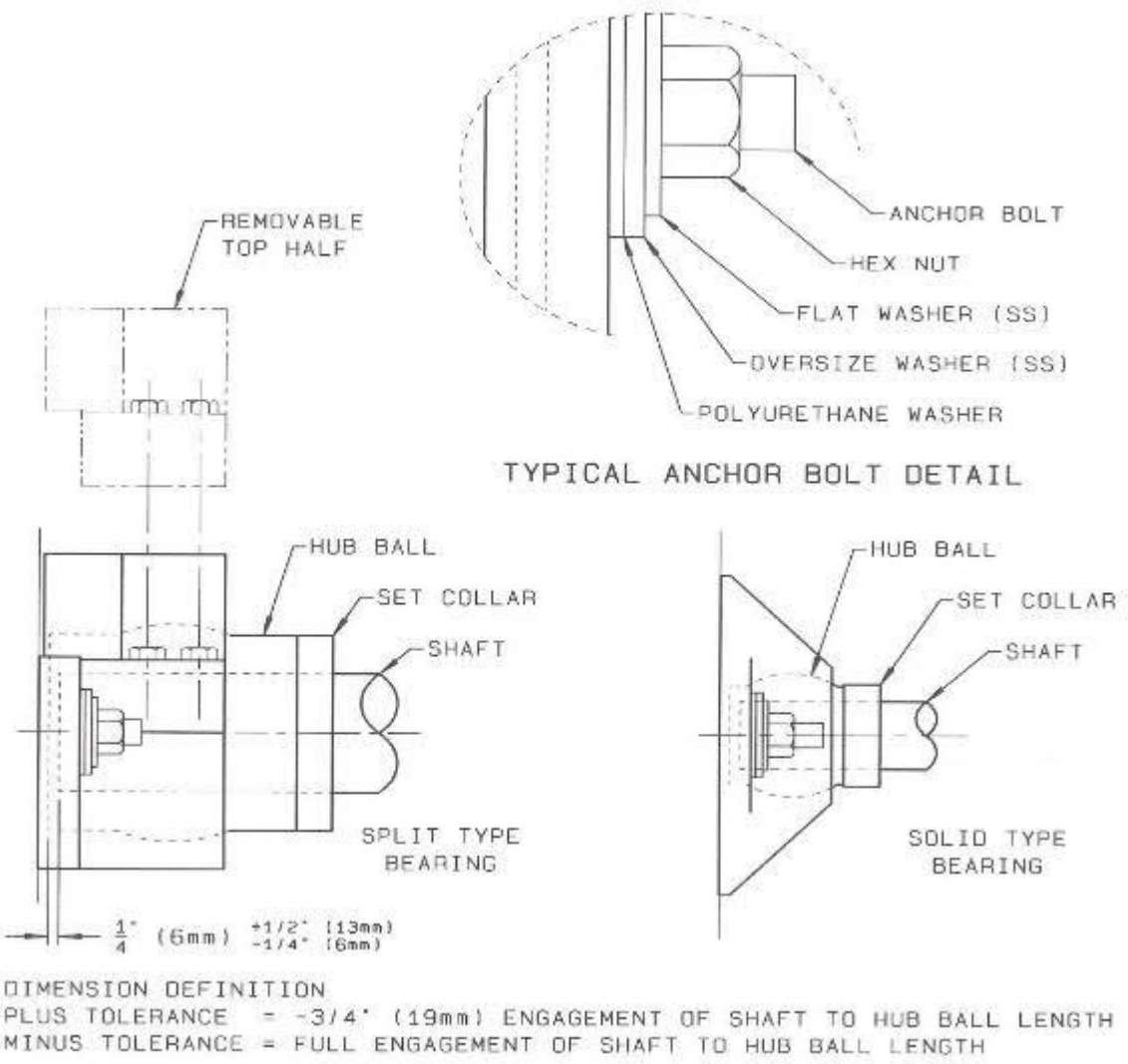
316SS Bolted Set Collar Assembly Note:

When assembling the set collars to the shafts, care must be used to avoid over- tightening the hardware. It is only necessary to mate these parts firmly. Torque the stainless steel set collar nuts to 372 lb-in. (42 Nm) using a hand operated torque wrench only.

If the fasteners are over-tightened, stresses generated in the parts may cause cracking and eventual part failure. **DO NOT USE AN IMPACT OR ELECTRO-MECHANICAL WRENCH.**

2. Coat shaft end only with NSF 61 approved grease before insertion into wall bearing.

3. Wall mounted bearings should have the shaft inserted the full length of bearing bore to within a tolerance of full length minus ¾ inch (19 mm) engagement with the shaft. (See *Figure 1*) If necessary shim and grout behind bearing housing so that the shaft is engaged within this tolerance.



ASSEMBLY OF SELF-ALIGNING WALL BEARING
Figure 1

PEAK CAP SPLIT HOUSING WITH SELF-ALIGNING POLYURETHANE BEARING
Figure 2
(LONGITUDINAL and Cross COLLECTORS)

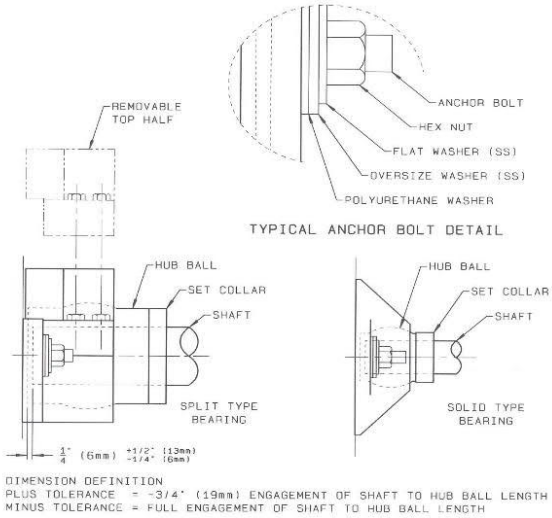
4. With wall bearings installed on the shaft, place the head shaft assembly at the location of the wall anchors and slide the wall bearings toward the wall and over the anchors taking care not to damage the anchor threads.
5. Since no take-up shafts assemblies (cross collector) are present, skip this step.
6. With the shaft assemblies ready to be secured to the walls, apply an anti-seizing compound to the stainless-steel anchor bolt threads. Slip a polyurethane washer over each wall bearing anchor bolt. Place an oversized stainless-steel washer followed by an oversized flat washer, followed by a standard sized stainless-steel washer, followed by a full hex nut (See *Figure 1*).

   Check the shaft for level (+/- 1/8 inch (3 mm) over the entire length) and tighten each hex nut until the polyurethane washer is forced into the serrations on the surface of the bearing face.

   Check the shaft for level again after securing. Reposition the set collars as needed and secure. All shafts are to be level, parallel to each other and free to turn by hand force on a sprocket.
7. Install grease line from operating floor level nearest the drive unit to the head shaft wall bearing before installing the driven sprocket. If the driven sprocket is already installed, it may be necessary to slide the driven sprocket away from the wall to install the grease line.

1.8 LIVE CORNER SHAFTS (FULL TANK WIDTH)

8. Locate the shaft support anchors with respect to the shaft center points previously marked on the tank walls. Install the self-aligning wall bearings per the General Arrangement drawing. Bearings must be installed as shown on the General Arrangement drawings and in alignment with each other to allow the shaft to be installed square and parallel to the other shafting. Wall mounted bearings should have the shaft inserted the full length of bearing bore to within a tolerance of full length minus ¾ inch (19 mm) engagement with the shaft. (See *Figure 2*) If necessary shim and grout behind bearing housing so that the shaft is engaged within this tolerance.



ASSEMBLY OF SELF-ALIGNING WALL BEARING
Figure 2

1.9 SPROCKET TO SHAFT ASSEMBLY

NOTE: **Evoqua** sprockets are available in various materials. Stainless steel 715-23T sprockets will be provided for every position in the tanks, Refer to the General Arrangement drawings for location.

Stainless Steel sprockets are provided for both types of shafts:

LIVE HEAD SHAFT SPROCKETS: Sprockets are bolted (with keys) to a rotating shaft.

LIVE CORENERSHAFT SPROCKETS: Sprockets are mounted on a live shaft without key to assure the sprockets are allowed to maintain timing using the keyed Headshaft sprockets.

Be sure the shafts are clean. If the shafts have been painted or coated with rust inhibitor, it is necessary to remove this only in the area where the sprockets are located to assure appropriate contact of shaft to sprocket bore.

1.9.1 COLLECTOR SPROCKETS-TO-HEAD SHAFT AND LIVE CORNER SHAFT INSTALLATION

Note: Head shaft sprockets are always keyed and live corner shafts may or may not be keyed.

1 Remove the sprocket bolts by loosening the hex nuts. Note that the nuts will need to be totally disassembled to fasten the sprocket around the shaft. Loosen or remove the segmental rim hardware on the sprocket split-line.

2 Rotate the head shaft so the keyseat (w/key) is facing up if required. Remove any tape that may be holding the key in place.

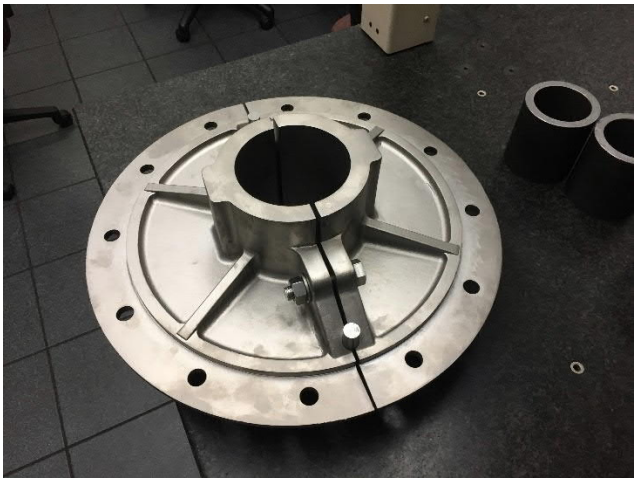
3 Place the sprocket half with the keyway over the key on the shaft and bring up the other sprocket half. If necessary, gently tap the sprocket hub with a rubber mallet so that the I.D. of the sprocket is in full contact with the shaft. Carefully tighten the sprocket mounting bolts (hand tight only) with the proper sized six-point deep socket. Hand tightening the hex nuts will allow for adjustment of the sprocket. **The hex nuts should not be fully torqued to the design values until <u>all the sprockets and shafts are aligned</u> as described in this section.**

NOTE: Failure to install the keys provided by **Evoqua** will result in voiding the sprocket warranty.

DO NOT USE HANDLE, EXTENSION, ETC., WITH SOCKET TO AVOID OVER-TORQUING. AT TIME OF FINAL TIGHTENING, USE A PROPERLY CALIBRATED TORQUE WRENCH WITH SOCKET. If the fasteners are over-tightened, stresses generated may exceed the proof load of the bolts cause bolt cracking and eventual part failure. **DO NOT USE AN IMPACT OR ELECTRO-MECHANICAL WRENCH.**

Tighten or re-assemble all the sprocket split-line hardware. The sprocket halves must bear tightly against the shaft with equal gap on both sides at assembly to assure segments bolt up.

4 Position the sprockets accurately on the shaft. Refer to the General Arrangement Drawings for the proper position/dimension. After the sprockets are positioned, tighten the M16 bolts to 133 lb.-ft (180 Nm). (*See Figure 5*)



TORQUE WRENCH REQURIED FOR ALL HARDWARE INSTALLATION
Figure 5

1.9.2 DRIVEN SPROCKET (Cast Ductile Iron Body with 40Tooth Segment Kit) TO-HEAD SHAFT INSTALLATION

1. Disassemble the sprocket by removing the hex nuts and washers from one side of the hub and web studs (through the hub and at the web split line), then separate the two sprocket halves. (The sprocket tooth segments and attachment hardware are boxed separate from the sprocket body).
2. Rotate the head shaft so the key seat (w/key) is facing up. Remove any tape that may be holding the key in place.
3. With the hub of the sprocket towards the tank centerline, place the sprocket half with the keyway over the key on the shaft and bring up the other sprocket half. Leave a space from the tank wall to the sprocket face to allow for tool clearance. If necessary, gently tap the sprocket hub with a rubber mallet so that the I.D. of the sprocket is in full contact with the shaft.
4. Assemble the hex nuts and washers on the hub and web bolts, starting with the four (4) main hub bolts and follow with the web split bolts. Carefully tighten the hex nuts to hold the sprocket firmly to the shaft yet leaving enough play to allow for adjustment of the sprocket. The sprocket halves must bear firmly against each other at assembly. **The main hub hex nuts should not be fully torqued to the design values until all the sprockets and shafts are aligned as described in this section.**
5. Place the tooth/rim segments on the hub, bolting loosely so the fit-up can be made more easily. **The hex nuts must be located nearest the wall**. The segments must be arranged so the hub split-line is bridged by the center of a tooth section. Once all the segments and hardware are assembled, use a short section of drive chain as a fixture to align all the tooth pitches. Wrap the chain around the sprockets and adjust the segments until all the chain barrels rest near the bottom of the tooth pockets. This step ensures that all the tooth segments are properly seated and the drive chain will properly engage the sprocket teeth. **TIGHTEN THE METALLIC TOOTH/RIM SEGMENT m16 HEX NUTS TO 133 lb-ft. (180 Nm).**
6. Position the sprocket accurately on the shaft in relation to centerline of the drive chain opening above. Refer to the General Arrangement Drawings for the proper position / dimension. After the sprocket is positioned, ensure the key is fully engaged with the sprocket hub. Tighten all the M16 hub bolts to 133 lb-ft (180 Nm). (SEE FIGURE 6).

   NOTE: Failure to install the keys provided by **Evoqua** will result in voiding the sprocket warranty.

DO NOT USE HANDLE, EXTENSION, ETC., WITH SOCKET TO AVOID OVER-TORQUING. AT TIME OF FINAL TIGHTENING, USE A PROPERLY CALIBRATED TORQUE WRENCH WITH SOCKET. If the fasteners are over-tightened, stresses generated in the parts may cause stress cracking and eventual bolt failure. **DO NOT USE AN IMPACT OR ELECTRO-MECHANICAL WRENCH.**

DRIVEN SPROCKET N78-40T DUCTILE IRON ASSEMBLY
Figure 6

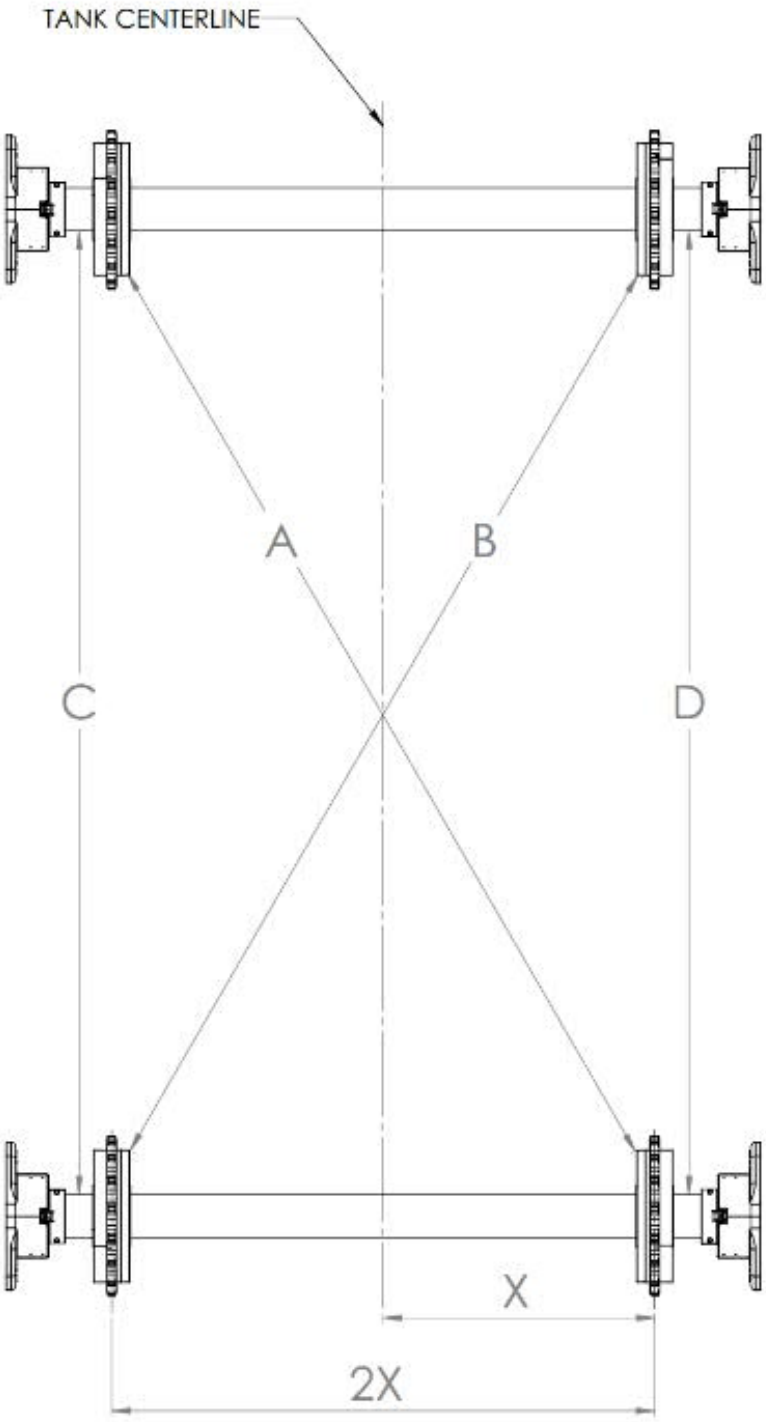
1.9.3 SHAFT AND SPROCKET OVERALL ALIGNMENT

To ensure correct alignment:

1. Align the head shaft so it is perpendicular to the tank centerline.
2. Carefully level all shafts. Use a transit to level the shaft to +/- 1/8 inch (3 mm) end to end.
3. Align all the idler shafts to be parallel to the head shaft to +/- 1/8 inch (3 mm) end-to-end by measuring between the shafts as illustrated (see *Figure 7*). Recheck the shafts for level.

Square the shafting by measuring diagonally from properly located sprocket hubs (See *Figure 7*). Do not use wall mounted bearings for diagonal reference. Tighten all securing bolts and nuts on the bearings to assure shaft alignment.

Proper alignment of sprockets and shafts is essential for maximum wear life. Rapid wear will result from misalignment due to rubbing of chain parts against sides of sprocket teeth and excessive friction wear in the chain joints caused by twist



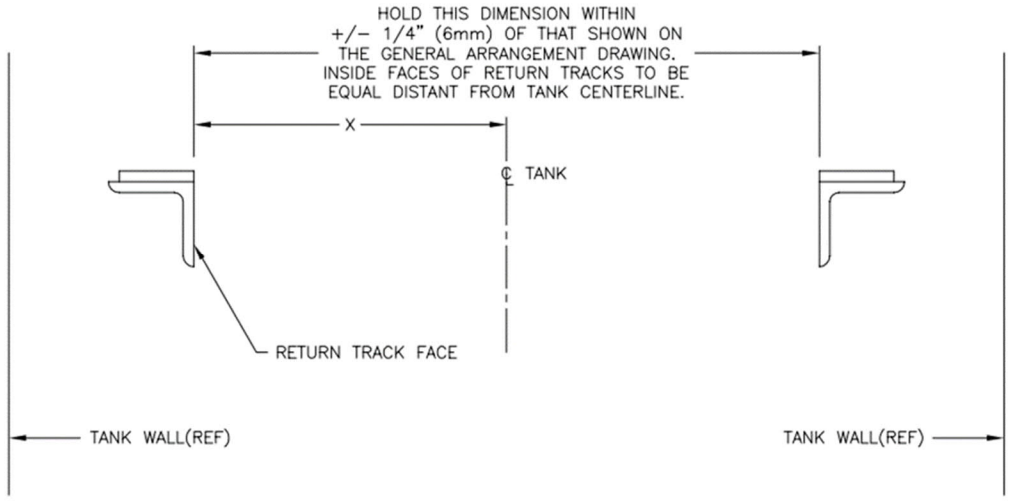
SHAFT AND SPROCKET ALIGNMENT
THIS ILLUSTRATION IS APPLICABLE TO PLAN
AND ELEVATION VIEWS
Figure 7

1.10 RETURN TRACKS

1.10.1 INSTALLATION

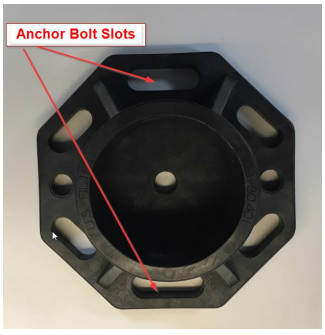
Refer to the General Arrangement drawings for return track bracket assembly and splicing instructions. Return tracks must be accurately located, both in elevation and distance, from the centerline of the tank if the flights are to function properly and not hang up on the tank walls.

Refer to the General Arrangement Drawings and note the "face to face of return track" dimension. Work off the centerline of the tank when locating the track brackets. If necessary for steel support brackets, shim the brackets out from the wall to attain the "face to face of return track" dimension. The distances from the centerline of the tank to the face of the opposite return track must be held within +/- 1/4 inch (6 mm). See *Figure 8*. Set all tracks in this manner. Be sure the tops of the tracks are in line at the designed elevation. Level them throughout their entire length within 1/4 inch (6 mm) (+/-1/8 inch [3 mm]).



RETURN TRACK ALIGNMENT
Figure 8

In a three-shaft tank, the chain is supported at the low point of its catenary by return tracks. Refer to the General Arrangement drawings furnished with this manual for shaft and return track locations. Return tracks are typically attached to the Universal Wall Bracket as shown in the following photo. The Universal Wall Bracket must be installed in a manner where the concrete wall anchors protrude through the wall bracket slotted hole, allowing for anchor bolt mis-alignment:



1.10.2 RETURN TRACKS AND MATING UHMW-PE WEAR STRIPS

Fiberglass return tracks are supplied in twenty-foot lengths. Joints in the return tracks must occur at support brackets. Return tracks will be cut to length to suit in the field. Holes for mounting the fiberglass return track to the support brackets must be drilled in the field. Refer to the General Arrangement drawings for the proper orientation of the return tracks and the cut lengths required.

Do not use fiberglass return tracks to walk on, to rest ladders on or to tie ladders off to. The support given by the FRP member will be springy and, in case of an impact load, the member could fail.

Use care in handling drive chain guards, flights and other parts that are fabricated of Fiberglass Reinforced Plastic, particularly at edges and cut areas. Glass fibers are a skin irritant. Cut edges can cause slivers and abrasions. Use gloves when handling FRP material.

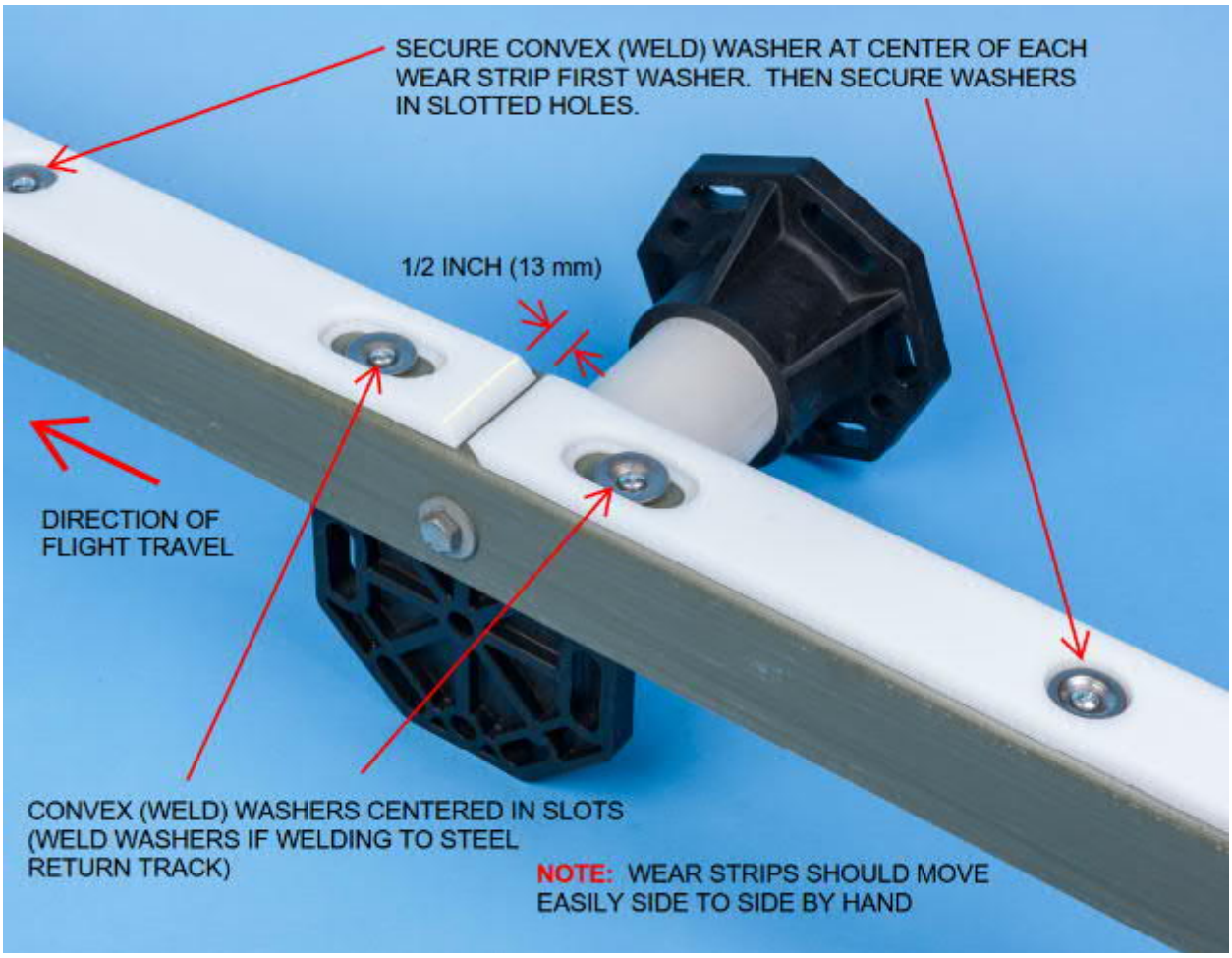
Note: existing wall anchor bolts can be re-used so long as they have not been damaged. Slowly remove the stainless-steel nut so as to not cross-thread the stainless-steel anchors.

Wear Strip to Fiberglass Return Track

When installing polymeric wear strips, all wear strips should be positioned and spaced per the drawings before attempting to assemble the convex washers. (See *Figure 9*). Place wear strip on top of return track and flush to the inside edge of the return track.

Place the convex washer in the center of each countersunk hole or slot in the wear strip. Attach the convex washers with self-drilling screws as shown on the Wear Strip Installation Drawing.

CAUTION:
Do not overtighten self-drilling screws. Overtightening may cause the screws to strip. The wear strips should easily move side to side with slight hand pressure. **DO NOT** install wear strips if the ambient temperature is less than 32° F (0° C) or greater than 80° F (25°C).



WEAR STRIP TO TRACK ASSEMBLY
Figure 9

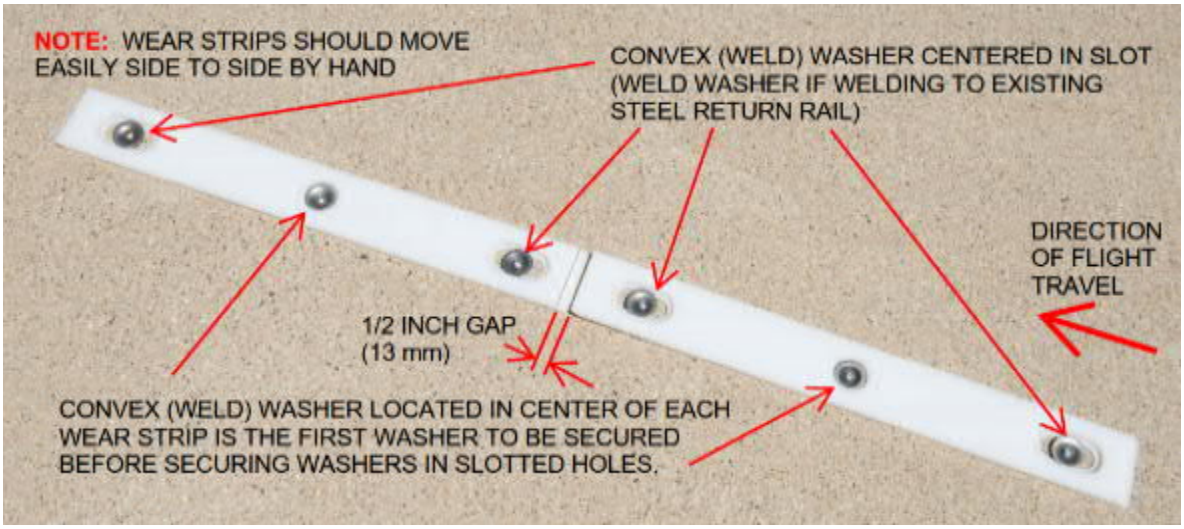
1.10.3 FLOOR WEAR BARS FOR ANCHOR MOUNTED DESIGN

When installing polymeric wear strips, all wear strips should be positioned and spaced per the drawings before attempting to field drill and install anchors.

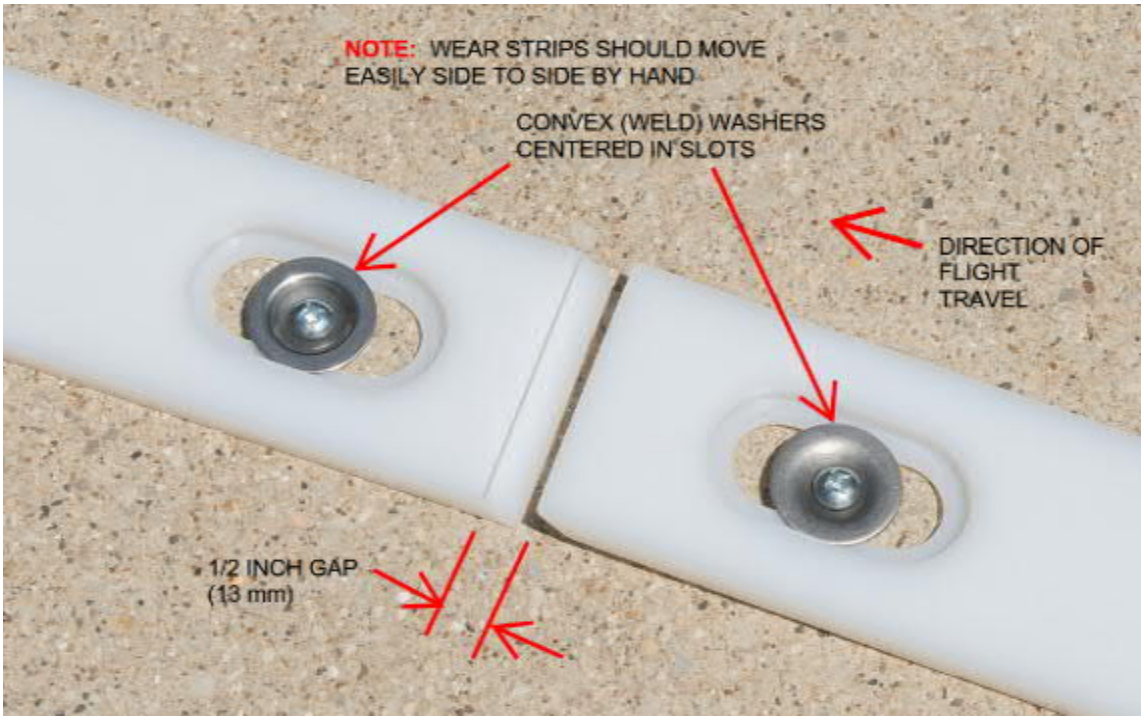
Locate and drill the holes for the anchors in the center of the countersunk hole or slot in the wear strip. (See *Figure 12a and 12b*). This will allow maximum expansion of wear strips. Install convex washers and anchors as shown on the Wear Strip Installation Drawing. **The floor wear strips must move easily after securing to the floor; if they cannot easily be shifted, loosen the screws.**

When attaching the wear strip to a steel rail, place the convex washer in the center of each countersunk hole or slot in the wear strip. Plug weld convex washers as shown on the Wear Strip Installation Drawing.

DO NOT install wear strips if the ambient temperature is less than 32° F (0° C) or greater than 80° F (25°C).



INSTALLING WEAR STRIP TO FLOOR
Figure 10a



WEAR STRIP GAP SETTING
Figure 10b

1.11 CHAIN AND FLIGHT ASSEMBLY

Do not install chain and flights if the ambient temperature is below 0º F (-18º C). Do not perform any chain tensioning when ambient temperature is below 32º F (0º C).

While assembling the chain, move the system manually. Use of the drive may cause damage to chain, flights or drive units.

Molded non-metal chain (NCS720S) is typically shipped in 9'-6" (2895 mm) long coils of plain chain with one flight attachment link for a total of 10 ft (3048 mm). The chain strands are easily assembled using the chain assembly tool provided. The use of this tool is described below.

When laying out the chain strands, confirm the flight attachment links are oriented so as to push the flight in the proper direction of travel.

Each strand should be laid out into a right hand length and a left hand length as viewed from the end of the tank. Follow with another pair of strands. **Be sure that the chain/flight attachments of the right and left hand strands are matched to one another.**

NOTE: The right hand / left hand designation refers only to how the chain is laid out, as viewed from the center of the tank during installation. Molded non-metal chain (NCS720S) is not manufactured or shipped as “RIGHT” or “LEFT” hand sections.

Collectors are always furnished with excess chain links to ensure against shortage due to catenary requirements. Approximate total length of a chain circuit for one side of the tank is indicated on the General Arrangement Drawing.

NOTE: Each chain circuit must always be the same length.

1.11.1 ASSEMBLING 715SS METAL COLLECTOR CHAIN

Do not install chain and flights if the ambient temperature is below 0º F (-18º C). Do not perform any chain tensioning when ambient temperature is below 32º F (0º C).

While assembling the chain, move the system manually. Use of the drive may cause damage to chain, flights or drive units.

Metal collector chain is supplied in bundles consisting of one Right Hand and one Left Hand length, approximately 10 feet long each, carefully matched and tagged. Each bundle should be laid out into a right-hand length and a left hand length. Follow with another bundle so separated. **Be sure that the chain/flight attachments of the right- and left-hand strands are opposite one another. Evoqua** collectors are always furnished with excess chain links to ensure against shortage due to catenary requirements. Total length of chain furnished is indicated on the General Arrangement Drawing.

NOTE: Strands must always be the same length.

It should be noted that the chain pins are press fit and will require great force to install. The use of a 20 lb. sledge hammer and a 1-inch diameter pipe cut to fit in the space between the chain and the wall will be required to drive the pins in place. Another alternative is to fabricate a fixture to hold a hydraulic jack or "porta power" to press the pins into place.

After assembling both strands of chain, check to be sure each chain has the same number of links and that the flight attachments are opposite each other. Normally, attachments are spaced 10 feet (3 m) apart in longitudinal collectors and 5 feet (1524 mm) apart in cross collectors. Check for proper flight spacing on the General Arrangement Drawing.

Note: When laying out the chain strands, confirm the flight attachment links are oriented so as to push the flight in the proper direction of travel:

ASSEMBLY OF 715SS CHAIN WITH FLIGHT ATTACHMENT
Figure 11

1.11.2 INSTALLING COLLECTOR CHAIN

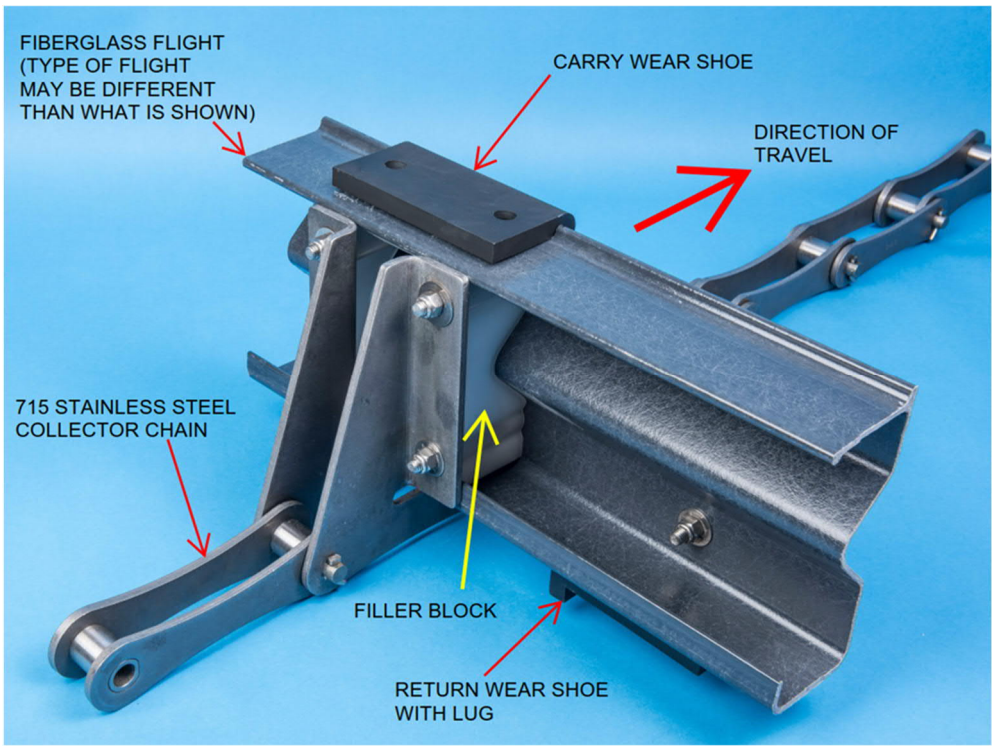
It is easier and safer to put chain coils with flights and attachments together into strands by working on the tank floor, pulling the chain around the lower idler shaft sprockets, up to and over the head shaft sprockets. Assemble chain so the open end is pulled in the direction of chain travel. (See the General Arrangement Drawings for a typical view of the collector chain.) The flight attachment link should be oriented so that the flight attachment pushes the flight in the direction of chain travel. Be sure to arrange the two chain strands so that flight attachments are directly opposite one another as they come over the head shaft.

In assembling the chain over the sprockets, be sure to tie off the chain so it cannot "run". If allowed to run, falling chain can cause personal injury.

1.11.3 INSTALLING WEAR SHOES AND FLIGHTS

NOTE: Illustrations shown below are for 715SS collector chain.

Evoqua recommends attaching the wear shoes to the flights prior to attaching flights to the chain. (See *Figures 12*).



BACK VIEW REX NCS720S CHAIN AND FLIGHT ASSEMBLY
Figure 12

After assembling both strands of chain, check to be sure each chain has the same number of links and that the flight attachments are opposite each other. Normally, attachments are spaced 10 feet (3 m) apart in longitudinal collectors and 5 feet (1524 mm) apart in cross collectors. Check for proper flight spacing on the General Arrangement Drawing.

When properly assembled, the flight attachments push the flights along the scraping run at the tank floor and the chain is above the flights. The vertical legs of the wear shoes precede the flight down the tank floor.

When assembling the wear shoes to the flights and the flights to the chain attachments, care must be used to avoid over-tightening the hardware. It is only necessary to mate these parts firmly. The locknuts will prevent the parts from loosening. After the nuts are run down to the washers, final tightening torque should be 36 to 60 lbf-in (4 Nm to 7 Nm).

If the fasteners are over-tightened, stresses generated in the parts may cause cracking and eventual part failure. **Evoqua** recommends slow speed and caution when using power tools to assemble stainless steel fasteners.

Assemble the return run wearing shoes to the flights before attaching the flights to the chain. These shoes are located nearest the flight ends. The chain attachment filler block needs to be inserted into the end of the flight (and located in position) before assembling the return run wearing shoe. The return run wearing shoes include a guide lug to ensure that the flights track properly on the return tracks. See the General Arrangement Drawings for the correct orientation of the return run wearing shoe guide lugs.

Attach the flights and the carry run wear shoes to the chain attachments. Refer to the installation details sheet of the General Arrangement Drawings for the attachment hardware sizes and locations on each flight. Note that all the attachment hardware bolt heads should be facing the direction of flight travel.

Keep feeding chain and adding flights until the chain strand ends approach each other on the tank floor and all the flights are installed. Connect the chain ends.

NOTE: While feeding the chain and adding flights, inspect the flight clearance against the wall to ensure they do not bind. Trimming of flights may be necessary if binding occurs. Contact **Evoqua** for instructions before trimming.

Wear appropriate personal protective equipment, including face mask, eye protections and leather gloves when cutting or grinding fiberglass flights.

1.11.4 COLLECTOR CHAIN TENSION

Initial Adjustment

Chain tension must be adjusted before dry tank check-out. The instructions for setting chain tension are general. The actual chain tension is effected by tank length. Contact the **Evoqua** Service Department if there is a question. The bottom strands of chain should be taught throughout the length of the tank.

Determining Proper Adjustment

Determine proper chain tension by stepping on the chain using your own weight and one foot midway between the third and fourth flight back from the head shaft. The pressure should be approximately 140 to 160 lb. The chain should clear the wear strip about 1 or 2 inches. This check should be made prior to running the collector. After adjusting, the mechanism should be run dry at least once around the tank and the tension rechecked in the same manner prior to putting the tank in service.

Three-Shaft Collectors – When properly adjusted, a small amount of slack (chain catenary) will accumulate immediately after the head shaft on the upper run during operation. In addition to maintaining the bottom strands of chain taut, the catenary should span approximately one-third the tank length before a flight touches the return tracks.

Method of Adjustment

To adjust tension use a chain fall or "come-along" of 2000 lbf (908 kg) **maximum capacity.** Connect the come-along to the chain with heavy-duty fabric straps looped around the chain barrels. **Do not use metal chain or cable** to avoid damage to the chain.

Make all adjustments at the tank's floor level and approximately midway between the effluent and influent ends of the tank (head shaft and idler shaft for cross collectors). Remove all visible slack from all sections of the chain, **excluding** the catenary. **Remember to remove the same number of links from each strand and that flight attachments must remain opposite one another to assure proper flight timing over the sprocket teeth!!**

For final collector chain adjustment, with all flights installed, start the collector for a dry run. Operate the unit for one half of a full tank revolution. If more slack develops remove an equal number of links from each strand.

Frequency of Adjustments

Since collector chain tension cannot be observed in these tanks, the tanks will require draining 3 to 4 weeks after initial operation to check and adjust chain tension. Future chain tension checks are required on a **one (1) time semi-annual basis and annually thereafter**.

When disassembling and reassembling the chain, be sure to snub the chain so it cannot "run". If allowed to "run", falling chain can cause personal injury.

1.12 DRIVES AND DRIVE CHAINS

1.12.1 DRIVE ASSEMBLY / INSTALLATION

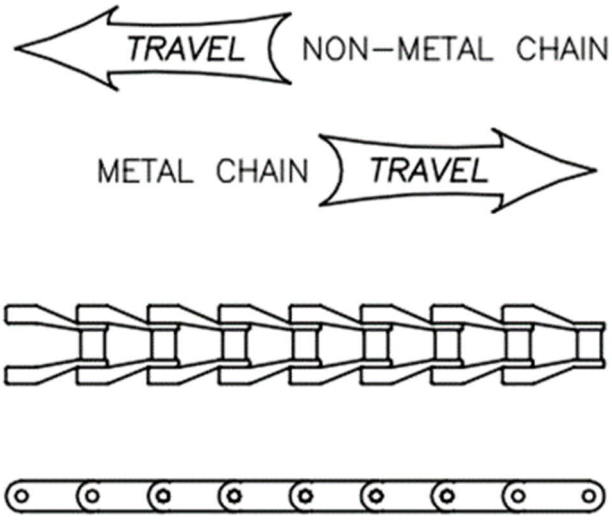
Refer to the General Arrangement Drawings. These drawings show, dimensionally, the relationship of the drive and driven sprockets and reducer.

Assemble the drive unit to the drive base and assemble the drive sprocket to the gear reducer output shaft as shown on the Drive Arrangement General Arrangement Drawing. Clean the gear reducer output and lubricate shaft with grease compatible with plant conditions before assembling drive sprocket.

Locate the drive base anchors, and limit switch anchors as shown on the General Arrangement Drawings. **Install chain guard anchors after all drive unit components are installed.** Install the anchors according to the anchor manufacturer's instructions. Place the drive base over the properly installed and cured anchor bolts. Level the drive base by shimming as required. After installing the drive, install the drive sprocket, shear pin, shear pin alarm trip lever, shear pin

alarm switch, drive chain, “Snap Idle chain tightener” and guards as described in the following paragraphs.

NOTE: To assure proper operation, and minimize chain and sprocket wear, align the drive and driven sprockets to within +/- 1/16 inch (2 mm) using a plumb bob.

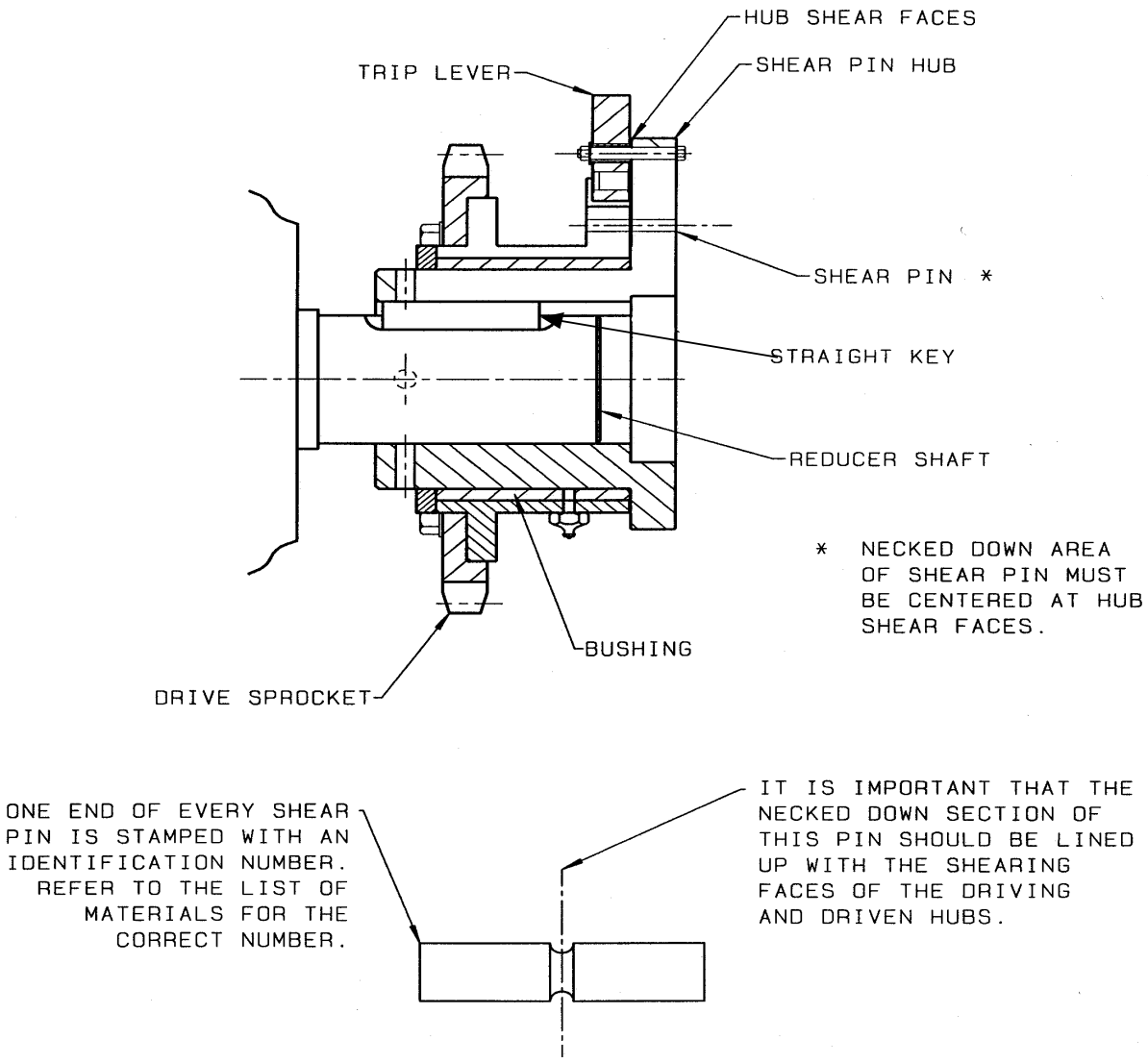


DRIVE CHAIN TRAVEL
Figure 13

1.12.2 TORQUE LIMITER PROTECTION

The drive sprockets used with the sludge collector drives are equipped with a shear pin device as protection against torque overload. (See *Figure 14*) The shear pin strength for any particular drive unit has been carefully chosen to protect the drive unit. **Substitutes must not be used at any time. Use of any pin with a shear value higher than that specified will void the warranty.** Each shear pin has a number stamped on its end. When ordering additional pins, refer to this number. The List of Materials will list the complete part number of the shear pin used on your drive. Do not use a bolt or the stub of a broken shear pin as a substitute. Considerable damage can result should an overload occur.

WARNING: When a shear pin breaks, determine and remedy the cause of failure before inserting a new pin and starting the drive.



SHEAR PIN SPROCKET HUB ASSEMBLY

Figure 14

In operating conditions where corrosion is likely, a coating of grease can be applied to the ends of the shear pin after assembly to help seal the pin from the elements. Insert the shear pin so that the shear pin number stamped on the end of the shear pin faces outward for easy verification of shear pin size. **Evoqua** recommends shear pins be replaced every 6-months with a new correctly sized pin. **Use of an incorrectly sized shear pin will void the warranty.**

On the following pages are instructions for setting up shear pin alarm limit switches for the drive sprockets. Refer to the General Arrangement Drawings which show the type of arrangement found on the particular drive for your order.

1.13 SHEAR PIN ALARM TRIP LEVER – EXISTING CAST IRON SPROCKET DESIGN

The shearing surfaces, shear pin, and the bore of the non-keyed hub must be lubricated before initial operation and at 6-month intervals with any major brand of NSF61 approved grease. Remove the shear pin, rotate the hub and swab the surfaces. Pump grease into the grease fitting on the hub and rotate several times while applying grease to distribute evenly through entire bore and shaft surface.

Before the shear pin has been installed, the shear pin alarm trip lever can be attached to the drive sprocket. The trip lever is included in a kit that is attached to the drive sprocket. (See *Figures 15, 16 and 17*).

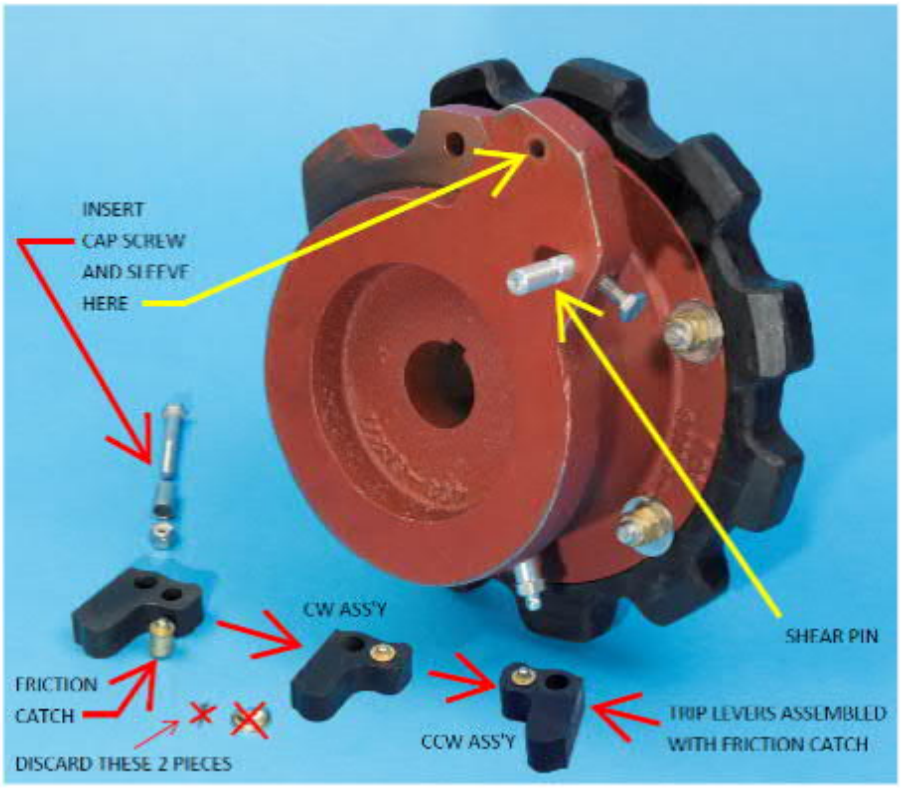
This kit also includes a friction catch, spacer, hex head cap screw, locknut and typical installation drawings. The trip lever should be attached per these installation drawings keeping the direction of the rotation of the drive reducer output shaft in mind.

NOTE: Check clearances on the trip lever. The trip lever must be able to pivot to a position 90° from its original position when the shear pin breaks.

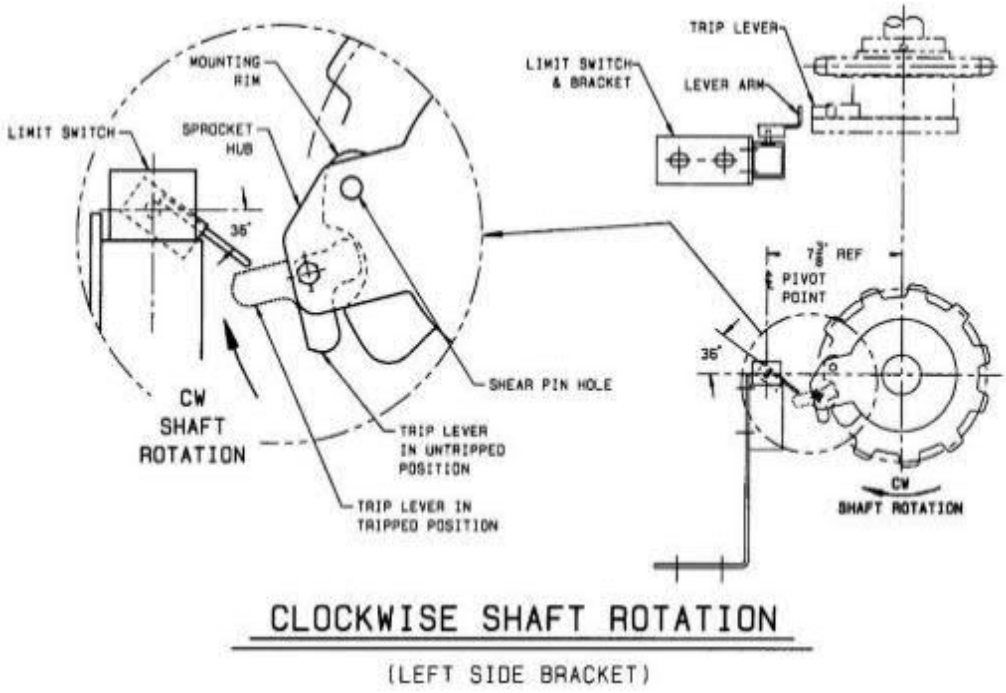
CAUTION: When installing the shear pin alarm trip lever:

1. Make sure the trip lever is positioned so the long, rounded projection swings out in the direction of shaft rotation. (See *Figures 16 and 17*).
2. Make sure the trip lever moves freely after tightening the cap screw.
3. Operate the drive unit before installing the shear pin and verify the trip lever functions properly and actuates the shear pin limit switch.
4. **NEVER** operate the drive in reverse. The trip lever and collector components will be damaged.

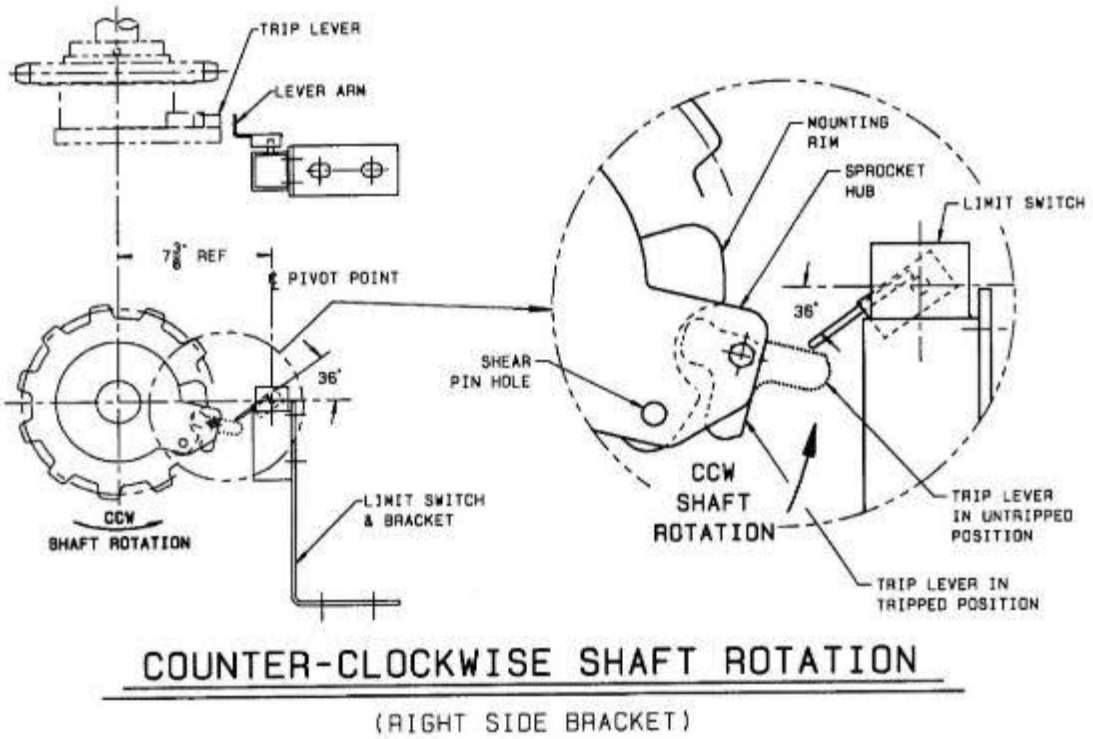
CAUTION: When reinserting shear pins, be sure trip lever does not interfere with the cams on the mating drive hub. Be sure trip lever is repositioned in its normal running orientation.



CAST IRON SHEAR PIN ASSEMBLY
Figure 15



CAST IRON SHEAR PIN ASSEMBLY
Figure 16



CAST IRON SHEAR PIN ASSEMBLY
Figure 17

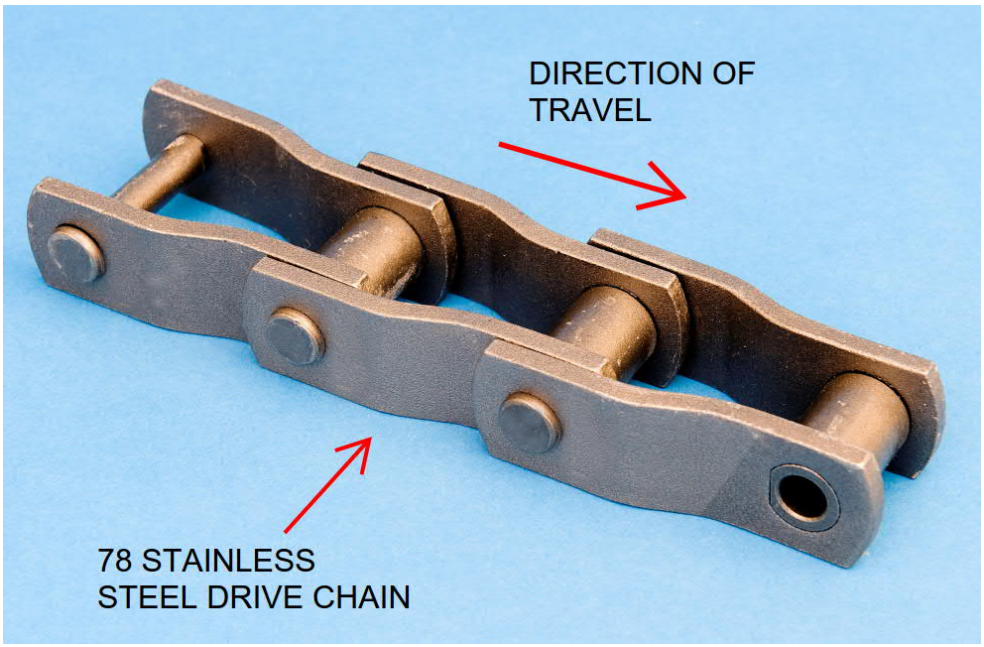
1.14 SHEAR PIN ALARM SWITCH

To be effective, the shear pin alarm switch must be correctly located. **The limit switch and support bracket should be positioned as shown on the Limit Switch Kit and Installation Drawing**. After locating the alarm switch, remove the shear pin, turn on the power and rotate the sprocket (with trip lever) to the approximate position of the alarm switch. This will determine if the correct contact will be made between the trip lever and the switch arm. Upon contact, an alarm will sound and/or the unit will shut down.

If the lever arm of the switch pivots in the wrong direction, check the vendor literature provided for method of adjustment. The arm should be checked to see that it does not come to the end of its travel when the trip lever hits it. The arm mounts on a splined shaft and can be adjusted. If the switch trip arm reaches the end of its travel while still in contact with the trip lever it could break the trip lever.

1.15 DRIVE CHAIN INSTALLATION

NOTE: Metal drive chain is to travel with the narrow end of the link in the direction of the chain travel. (See *Figure 18)*



DRIVE CHAIN TRAVEL
Figure 18

1.16 DRIVE CHAIN SLACK

The correct amount of slack is essential to the proper operation of chain. Unlike belts, chain requires no initial tension and should not be tight around the sprockets. Properly adjusted drive chain should permit slight flexure by hand in the slack side of the strand. (See *Figure 19*).

NOTE: Verify the drive chain is completely engaged in the tooth pockets at the bottom of the driven sprocket. This can only be properly observed from inside the tank.

DRIVE CHAIN SLACK with “SNAP IDLE TESNIONER”
Figure 19

Chain Tightener should be inspected yearly to maintain proper chain slack. Remove chain link(s) when slack cannot be properly maintained through chain tightener adjustment.

Check the collector drive motor unit for proper rotation. Check the sprocket location against the Drive Assembly Drawing. If the drive lubricant has not been checked for condensation or operating level, do both checks now. Most drives are shipped filled to capacity. Refer to the specific manufacturer's bulletin in the VENDOR INFORMATION section for type, quantity and viscosity of lubricant to be used.

Be sure vent plug is in place in the gear case.

1.17 DRIVE CHAIN TIGHTENERS

Locate the “Snap Idler Chain Tensioner” assembly as shown on the General Arrangement Drawings with the adjustment plate set to provide maximum future chain take-up. The chain tightener idler sprocket must be in line with the drive and driven sprocket. The mounting bracket must be installed plumb and square to the drive reducer and the head shaft. The adjustment plate must have sufficient clearance from any concrete surfaces to allow for future adjustment. If any one of these requirements cannot be met contact **Evoqua**.

Cross collector drive chain tightening is done by removing links in the chain. After adjusting tension verify the drive base plate is level in both directions. It is important not to overtighten the drive chain since damage to the sprockets or the head shaft can occur. The additional Snap-Idler chain tightener, for the 3-shaft cross collector, will provide the final proper chain tension. Refer to Manufacturer’s instructions on proper installation, operation and maintenance of the Snap-Idler chain tensioner.

1.18 DRIVE ROTATION CHECK

As chain guards have not yet been installed, use caution when working around energized and rotating equipment. Several pinch points exist between chain and sprockets, keep hands and clothing clear.

Follow POWER SOURCE LOCKOUT procedures prior to any electrical changes.

Once all drive components are installed, check drive motor for proper rotation with the shear pin removed. If the drive rotation is incorrect, reverse the motor power leads to correct the rotation.

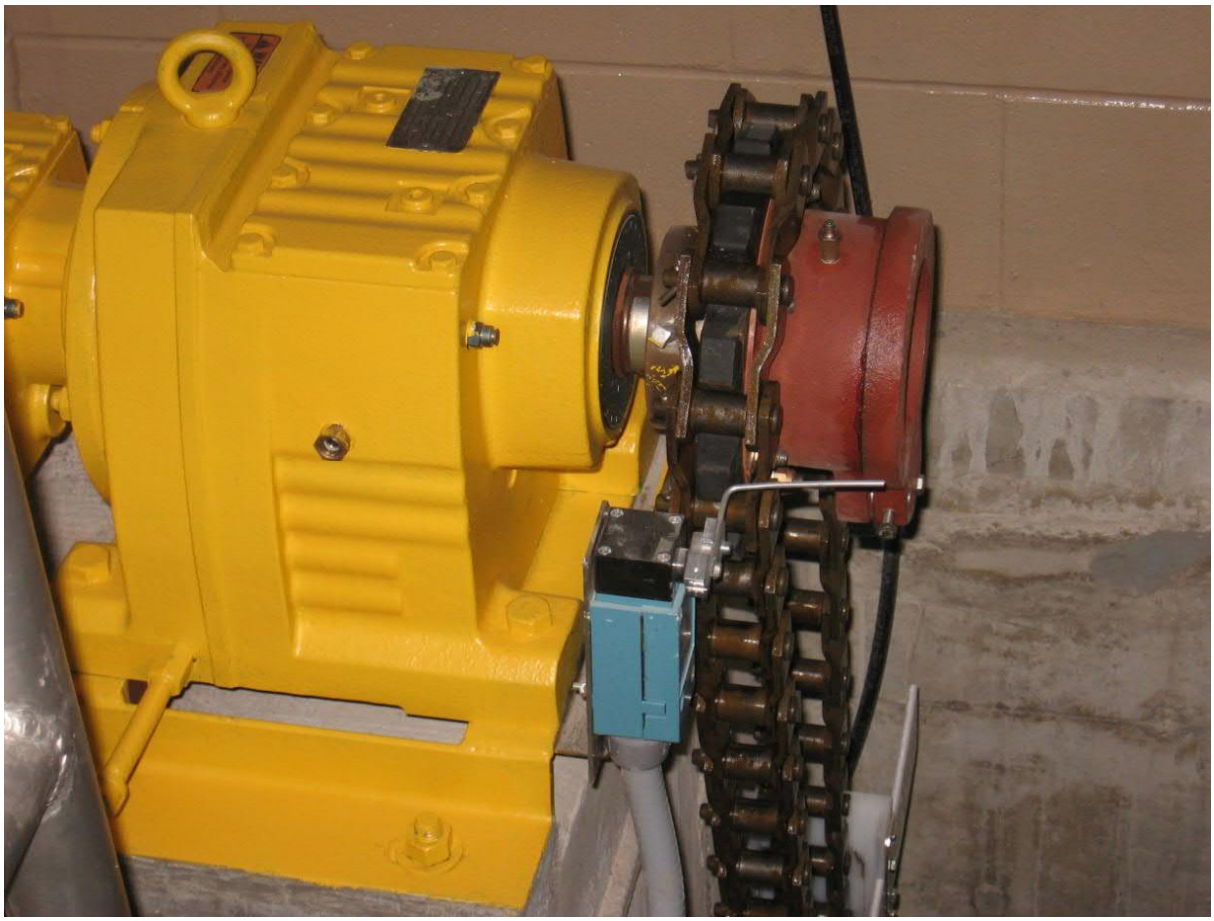
Reinsert the shear pin and start the drive. Allow the chain and flight system to move at least 10 feet (3 m). While the system is moving, carefully observe the chain and flight operation, looking for any interference or binding. This precaution may pinpoint interferences which need to be corrected before the **Evoqua** Service Technician check out.

1.19 CHAIN GUARDS

After installing the drive assembly, drive chain and the other drive assembly components, the chain guard should be installed. Locate the chain guard as shown on the General Arrangement Drawings; making sure that it covers all the moving parts in the drive area. The chain guard may be removed during dry tank check-out but must be in place during normal operation.

Proper operation and maintenance may require removal of the guard depending on the type of guard ordered. To determine the exact type of drive arrangements furnished on your order refer to the separate views on the General Arrangement Drawings and the drive prints, which are included with the supplier's maintenance bulletin.

Before removing any chain guard or other guard from around drive machinery turn off power and lock out the drive. Replace all guards before returning machinery to operation. See the MAINTENANCE section of this manual for additional information.



Typical SEW Drive unit located at Detroit Drinking Water w/o Guard

POWER SOURCE LOCK-OUT

Failure to lock out all sources of power during maintenance procedures may result in serious personal injury. Following are the steps of a typical lock-out procedure that can be used by maintenance and repair crews:

1. Alert the operator and supervisor.
2. Identify all sources of residual energy.
3. Before starting work, place padlocks on the switch, lever or valve, locking it in the "off" position, installing tags at such locations to indicate maintenance in progress.
4. Ensure that all power sources are off and "bleed off" hydraulic or pneumatic pressure or "bleed off" any electrical current (capacitance), as required, so machine components will not accidentally move.
5. Test operator controls.
6. After maintenance is completed, all machine safeguards that were removed should be replaced, secured and checked to be sure that they are functioning properly.
7. Only after ascertaining that the machine is ready to perform safely should padlocks be removed and the machine cleared for operation.

(From Concepts and Techniques of Machine Safeguarding, 1980; U.S. Dept. of Labor OSHA)

OPERATION

2.1 SAFETY PRECAUTIONS

The primary hazards associated with operating Sludge Collectors are unsafe procedures by personnel.

OPERATING ENVIRONMENT

Sludge Collectors are usually exposed to the elements. Access points may become slippery when wet or icy. The danger of falling is present. Handrails and other safeguards must be in place when operating the equipment. Use care when access is necessary.

GUARDS

Guards cover several points on the collector to prevent personal injury from moving parts. **Chain guards must be in place when operating Sludge Collectors.**

2.2 PRE-START-UP (DRY TANK)

If **Evoqua** field start-up services were purchased, arrange for a field service technician a minimum of six weeks prior to equipment check out. See GENERAL INFORMATION SECTION.

Complete the requirements in this section prior to field service technician arrival.

Apply field finish paint to all prime painted components and allow to dry prior to start up.

Check reducers for proper oil level and vents. See the manufacturer's maintenance bulletin in the vendor section of the manual. Check to be sure the vent covers are removed and vents are not clogged with paint or other materials.

Grease all wall bearings with NSF61 approved grease (see Section 3 -MAINTENANCE).

Lubricate sprocket/sleeve bearings with silicon based lubricating spray or with silicon based grease. **Lubricants containing phosphate ester additives will attack polymeric material and must not be used**.

Check the alignment of the shafts on all machinery connected through flexible couplings, if provided. Shipping movements or rough handling can cause misalignment in excess of that for which the coupling was designed. The alignment was checked and all fastenings secured at the

factory, but to assure uninterrupted operation, it must be rechecked at the site just before operation. If these items are out of alignment, realign shafts according to coupling manufacturer's installation instructions.

When the drive components are properly aligned and checked, begin dry tank check-out of the unit. Double check to see that all debris has been removed from the tank. Wear strips and return tracks must be clean and smooth. Wear strips **DO NOT** require lubrication prior to operation unless the torque limiter device disengages. If this happens lubricate wear strips with vegetable oil to reduce friction. Vegetable oil does not require removal once the tank is placed into service.

Drives are protected with limiter devices. Remove the shear pin from the sprocket and hub or disengage the ball detent torque limiter and make sure the sprocket and hub faces move freely past each other. If not, remove any rust or paint that may be prohibiting free movement. Re-lubricate the sprocket and hub faces. Verify the trip lever or actuating pin properly actuates the limit switch lever or proximity switch. Confirm the switch is sending a signal to the control box when actuated.

2.3 FIELD SERVICE TECHNICIAN SUPERVISED CHECKOUT

NOTE: All activities are to be performed by the installing contractor.

Mark one flight with caution tape (for visibility) and operate the mechanism through one complete circuit of collector chain. Note whether the wear shoes have proper contact with the floor wear strips and return tracks. The return track lugged wear shoes should not bind at any point between the return tracks along the entire tank length. If binding occurs, correct the spacing between the return tracks.

Check flight clearance as they travel around the idler shaft. Check the clearance between the flight ends and the walls. Note whether the flight ends rub anywhere. Watch the flights as they pass over the wear strips on the floor and return track for smooth transition over joints. Smooth these transitions if necessary. Eliminate any projections on the tank walls or floor that interfere with the flights.

Ideally, the tank walls should be plumb where the flights should not contact them at all; however, realistically there may be some gentle bumping and brushing of flight ends with the walls. Although the flights may have been trimmed earlier (see chain installation sections), the walls will require grinding at the interfering high spots. **Flight trimming is discouraged so as not to affect future flight replacement**.

2.4 COLLECTOR CHAIN SLACK - (THREE SHAFT CROSS COLLECTORS)

The bottom strands of chain should be taught. When operating, the chain may sag slightly between the first few flights just after the head shaft on the skimming run.

Run the collector for a minimum of five cycles and observe the collector chain tension just after the head shaft sprockets. Inspect the chain for excessive slack at this location and remove links from both chain circuits as needed. For more detailed information about chain adjustment and tensioning, refer to COLLECTOR CHAIN TENSION in the INSTALLATION section of this manual.

2.5 CROSS-COLLECTOR CHAIN SLACK - (3-SHAFT CROSS COLLECTORS)

Both upper and lower strands of chain should be taught. For more detailed information about chain adjustment and tensioning, refer to COLLECTOR CHAIN TENSION in the INSTALLATION section of this manual.

2.6 SPROCKETS

Check all hardware to the values listed in the INSTALLATION section in this manual.

2.7 WEIRS

It is essential that effluent weirs be installed level and properly sealed. If the weirs are level, uniform withdrawal of effluent over the entire weir length can be assured. If they are not level, or not properly sealed, the flow will short-circuit. This short-circuiting causes poor tank hydraulics and inefficient use of the settling tank volume available.

2.8 FILLING THE TANK

CAUTION: When filling a tank at any time, introduce water slowly until the chain and flights are covered by 1 to 2 feet (0.3 to 0.6 m) of water. Introduction of flow at a high rate to an empty tank can cause a force that will break flights. As an option for initial operation, clean effluent water can be used to fill the tank to allow better observation of collector operation.

After performing the pre-start-up check-outs, the tank may be filled. It is important to operate the equipment while filling. Solids will be introduced and should be removed. If the collector mechanism is not operated, solids may build up to an excessive level. The high solids level could cause shear pins to break and prevent the mechanism from starting. Until the tank is full the flights can be expected to move in a jerking fashion.

2.9 INITIAL OPERATION

After the first 6 to 8 weeks of operation, drain the tank and observe collector chain tension. Refer to the INSTALLATION section of this manual for proper chain adjustment and tensioning and when this is to be done.

While the tank is drawn down, check for condition of the flights, sprockets, sprocket sleeve bearings, chains, wear strips and wear shoes. There should be little noticeable wear on any of these components.

When disassembling and reassembling the chain, be sure to tie off the chain so it cannot "run". If allowed to "run", falling chain can cause personal injury.

DRIVE CHAIN

During the first 30 days' operation, it may be necessary to re-tension the drive chain. As it wears in slack can accumulate here also. Adjust the chain tightener and/or remove links (if necessary) to obtain correct chain tightness.

NORMAL OPERATION

Proper sludge removal procedures are necessary to ensure good collector performance. Good performance is seldom obtained from a tank where the sludge is not removed regularly. In addition to having good sludge removal procedures, it is necessary to remove the sludge while it is still fresh and to do so as often as necessary to prevent “SLUDGE CAKING”.

Evoqua recommends continuous operation of all Chain and Scraper mechanisms, and sludge withdrawal, on a continuous or regular basis, to maintain a 1 foot sludge blanket. If the owner elects to operate equipment intermittently or withdraw sludge infrequently, they assume responsibility for damage due to overloading of the mechanism.

Mechanism operation and sludge withdrawal is to continue after flow to the tank is stopped to remove any settled material. If material is not removed prior to shut down **Evoqua** recommends that it be manually removed prior to start-up to prevent damage on start-up. Most primary tank sludge conveyors operate at two feet (610 mm) per minute, and on this basis, it is a simple matter to determine the number of minutes required for a complete turnover or sweep of the bottom of any one tank.

In addition to the time required for operation of the sludge removal mechanism and the time required for sludge pump operation attention should also be directed to the pumping rate. Most sludge pumps can be adjusted to provide at least three different pumping capacities. It is very desirable to pump at the low rate even though the pump must then be run for a longer period of time. A high pumping rate will produce sludge less concentrated than a low rate and is very apt to cause the formation of channels or cones in the sludge blanket, allowing the clarifier liquid to be withdrawn from the tank before all the sludge is removed.

2.10 SHUT-DOWN PROCEDURES

1. With the equipment running, start to drain the tank.

2. Keep the equipment running until the tank is lowered to about 1 ft (0.3 m) liquid level. It is important to keep the settled solids moving as the tank drains. Continue to remove solids as the tank drains.

3. Grease all wall bearings and rotate equipment to distribute grease.

4. Turn off and lock out the drive.

NOTE: When refilling the tank, see “Filling the Tank” section above.

2.11 EMERGENCY OPERATING SHUT-DOWN PROCEDURES

If the equipment malfunctions, it should be shut down. Follow the sequence of operation of the controls for the equipment and turn off and lock out the drive(s). Follow the Lock-Out procedures shown under the Safety Precautions in the MAINTENANCE section of this manual.

Determine the reason for the malfunction and take corrective action. If a shut-down period is required to repair the situation, follow the plant procedures for taking the equipment off line.

CAUTION: **DO NOT OPERATE MECHANISM IN REVERSE. DOING SO WILL CAUSE SEVERE DAMAGE.**

2.12 PROCEDURE FOR SHUT DOWN LONGER THAN 3 WEEKS

DO NOT operate the mechanism if the water surface has turned to ice. **DO NOT** change the water level if the water surface is frozen. Surface ice can form at the top of the tank and fall onto the components below, causing damage or injury.

MAINTENANCE / TROUBLESHOOTING

3.1 SAFETY PRECAUTIONS

The primary hazards associated with maintaining Sludge Collectors are identified below.

POWER SOURCE LOCK-OUT

Failure to lock out all sources of power during maintenance procedures may result in serious personal injury. Following are the steps of a typical lock-out procedure that can be used by maintenance and repair crews:

1. Alert the operator and supervisor.
2. Identify all sources of residual energy.
3. Before starting work, place padlocks on the switch, lever or valve, locking it in the "off" position, installing tags at such locations to indicate maintenance in progress.
4. Ensure that all power sources are off and "bleed off" hydraulic or pneumatic pressure or "bleed off" any electrical current (capacitance), as required, so machine components will not accidentally move.
5. Test operator controls.
6. After maintenance is completed, all machine safeguards that were removed should be replaced, secured and checked to be sure that they are functioning properly.
7. Only after ascertaining that the machine is ready to perform safely should padlocks be removed and the machine cleared for operation.

(From Concepts and Techniques of Machine Safeguarding, U.S. Dept. of Labor OSHA)

3.2 PERSONNEL PROCEDURES

Maintenance procedures may require personnel to work in an elevated position. The potential for falling is present. A safety platform is recommended. If ladders are used they should be secured but not to fiberglass return rails. Use particular care when surfaces are wet. Wipe up grease and oil spills.

When installing chain on the collector, be sure the chain is snubbed securely. A runaway chain can cause serious personal injury and can damage equipment.

Use care in handling drive chain guards, return tracks, flights and other parts that are fabricated of Fiberglass Reinforced Plastic (FRP), particularly at edges and cut areas. Glass fibers are a skin irritant. Cut edges can cause slivers and abrasions. Use gloves when handling FRP material.

CHAIN GUARDS

Guards cover several points on Sludge Collectors to prevent personal injury from moving parts. If guards must be removed during maintenance procedures, use caution when operating equipment and replace guards when maintenance has been completed.

OPERATING ENVIRONMENT

Sludge Collectors are usually exposed to the elements. Access points may become slippery when wet or icy. Handrails and other safeguards must be in place when working on the equipment. Use care when access is necessary.

VENTILATION

Noxious and possibly combustible fumes can be generated by decaying organic matter. Provide forced ventilation and exhaust facilities when workmen are in a drained tank. Use the confined space entry procedures defined by the treatment plant.

FIRE

Torch cutting, welding and the use of solvents present fire hazards. Non-metal equipment components are usually combustible and some may burn with a non-visible flame. Foam or other means of suffocation may be required to extinguish burning plastics. Water alone may not extinguish a plastics fire. Follow all local permit regulations. Keep combustible materials away from heat and open flame. Appropriate fire control equipment should always be provided in the working area.

WELDING HEALTH HAZARDS

Since **Evoqua** does not know what welding processes and filler materials will be used for field welding, the following general welding health hazard data should be conveyed to welding personnel.

Arc rays can injure eyes and burn skin. **Heat rays** (infrared radiation from flame or hot metal) can injure eyes.

Overexposure to electric arc, welding or oxy-fuel gas processes may create one or more of the following hazards. **Carbon Steels** - Excessive inhalation of metal fumes and dusts may result in irritation of eyes, nose and throat. **Stainless Steels -** Cancer hazard (contains chromium and nickel). Excessive inhalation of metal fumes and dusts may cause sensitization, dermatitis, inflammation and/or ulceration of the upper respiratory tract and possible cancer of nasal passages and lungs.

Electric shock can cause injury or death.

Noise can damage hearing.

Read and understand the welding materials manufacturer's instructions and precautionary label on the product being used. For further health hazard details, consult the welding materials manufacturer's Material Safety Data Sheets.

3.3 PREVENTIVE MAINTENANCE

Evoqua will not be responsible for any damage caused by operating the equipment without performing recommended maintenance.

To obtain maximum equipment life, it is necessary to perform the preventive maintenance services outlined in this section. Refer to the manufacturers' bulletins for equipment not manufactured by **Evoqua**. These instructions take precedence over those in this manual should any discrepancy be noted.

The maintenance instructions incorporated throughout this manual are meant to be used by capable service personnel **only.** Do not attempt to adjust or repair any components on this equipment without a thorough knowledge of this equipment. Read this manual completely. Practice preventive maintenance.

DRAIN TANK FOR INSPECTION ONCE A YEAR. It is also recommended that a daily walk around the tank be made to check for debris that could cause damage or for other troubleshooting.

For additional details on any maintenance listed in the following schedule, see the main body of the manual.

3.4 RECOMMENDED LUBRICANTS

Any major brand of NSF61 approved grease or mineral oil is recommended unless other lubricants are defined for specific applications in the INSTALLATION or MAINTENANCE sections of this manual.

For vendor supplied components (i.e. reducer, motor, etc.), see VENDOR INFORMATION section of this manual for suggested lubricant type and frequency.

The following brands are acceptable:

- Mobil
- Exxon
- Pennzoil
- Shell
- Texaco
- Castrol
- Chevron

3.5 MAINTENANCE SCHEDULE

D-Daily W-Weekly M-Monthly Q-Quarterly S-Semi-Annually A-Annually

ITEM	DESCRIPTION	FREQUENCY
FLIGHTS / WEAR SHOES	During a weekly walk-by check for any visible damage, loose attaching bolts or missing wear shoes; replace immediately. If wear shoes are worn to a remaining thickness of 1/8 inch (3 mm), reverse to the unworn surface. For lug wear shoes, it will be necessary to switch wear shoes to the opposite ends of the flight.	W
	When the tank has been drained, examine the track angle and/or the wear strips and floor for bumps or loose joints.	A
COLLECTOR CHAIN	When the tank has been drained, hose down all submerged equipment and check chain for wear and tightness. See the INSTALLATION section of this manual for adjustment.	A
DRIVE CHAIN AND TIGHTENERS	Check for excessive slack. Remove slack by adjusting the chain tightener.	M

DRIVE CHAIN	Check chain side bars and barrels for wear. The chain may be reversed to provide extended life.	S
	After tank drain down, check chain wrap and engagement with driven sprocket teeth. If the gap between the chain barrel and tooth bottom diameter exceeds 1/4 inch (6 mm), adjust the chain tightener and evaluate tooth pocket wear. This should prevent potential chain-sprocket tooth jumping.	A
MOTOR, REDUCER, COUPLINGS	Refer to the manufacturer's bulletin in the VENDOR INFORMATION* section.	*
REDUCER	Check for loose fasteners, anchors and deteriorating grout.	S
	Check lubricant level and quality. Refer to the manufacturer's bulletin in the VENDOR INFORMATION* section.	*
	Change oil. Refer to the manufacturer's bulletin in the VENDOR INFORMATION* section.	*
	Check alignment - check all couplings when provided. Refer to the manufacturer's bulletin in the VENDOR INFORMATION* section.	*
DRIVE SHEAR PIN SPROCKET (STAINLESS HUB)	Remove shear pin, rotate shear pin hubs. Check teeth for wear. Replace as necessary. Grease the shear pin and re-install. In locations that have a possibility of corroding, a coating of grease should be applied to the ends of the shear pin after assembly to help seal the pin from the elements.	S
SHEAR PIN LIMIT SWITCH	Remove shear pin. Start drive and check that the switch activates. Grease the shear pin and re-install. In locations that have a possibility of corroding, a coating of grease should be applied to the ends of the shear pin after assembly to help seal the pin from the elements.	Q

WALL BEARINGS	If bearings are served by a grease line, or are not normally submerged, purge with NSF61 approved grease.	M
	When tank is drained, check fasteners and anchors for proper torque of 35 ft-lbs. Check for deteriorating grout.	A
	Lubricate with grease. If tank is to be drained down at any time for more than 48 hours, lubricate as above.	A
DRIVEN SPROCKET	Check for loose bolts and setscrews. If necessary, re-torque all the hub bolts to 100 lb-ft (136 Nm) and all web bolts to 50 lb-ft (68 Nm). Check for tooth wear and proper alignment.	A
COLLECTOR SPROCKETS	When the tank has been drained, examine the sprockets for wear. Check the torques on **all** fasteners - see INSTALLATION section of this manual for torque values. Check spacing on shaft. Check timing for live shafts.	A
FLOOR WEAR BARS	When the tank has been drained down, examine wear bar for wear and condition of welds. Replace or re-weld if necessary.	A
OTHER	All other items or components not mentioned here - see VENDOR INFORMATION section of this manual.	AS NOTED

3.6 TROUBLESHOOTING

It is the operator's responsibility to detect any unusual sound, motion, odors or other signs of abnormal performance that could indicate trouble. By detecting any problems in their early stages, unnecessary downtime may be saved. For the remedies suggested below, refer to the INSTALLATION section of this manual.

Follow a logical troubleshooting procedure. If the following troubleshooting guide does not help resolve the problem, call the **Evoqua** Field Service Department. See the GENERAL INFORMATION section of this manual for the **Evoqua** contact list.

3.6.1 EXCESSIVE TORQUE LIMITER DEVICE ACTIVATION

POSSIBLE CAUSE	REMEDY
See TROUBLESHOOTING section for cause.	Correct as needed.
Under sized shear pins.	Check General arrangement Drawing for correct pin size – install correct pin. Contact **Evoqua** if correct pin still breaks frequently for no apparent cause. **NOTE:** Do not use anything other than Evoqua approved shear pins to maintain warranty.

3.6.2 FLIGHTS MOVING IN A STOP-START FASHION

Excessive slack in collector chain.	Re-tension chain per INSTALLATION section.
Flights hanging up on obstruction.	Check flight ends for unusual wall contact. Check the flight shoes for unusual wear. If shoes are missing, replace. Drain tank if necessary and hose down thoroughly to find obstruction. Check shafts for level and square. Check for uneven return tracks or uneven wear strip splices. Check expansion joints in tank for movement – correct wall or floor as required.

Wear strip loose or detached entirely.	Drain tank, hose down with high pressure water. Replace missing section or replace fastener.
Wear bars weld broken.	Re-weld as needed.
Foreign object in tank.	As the object is conveyed away, pulsating may stop. If not, drain tank and remove object.
Return tracks and shafts at incorrect elevation relative to each other.	Reset to correct elevation per General Arrangement Drawings.
Collector chain sprockets tooth wear.	Inspect sprocket tooth for excessive wear (hooking). Reverse or replace sprocket segment teeth depending on condition of teeth.

3.6.3 CHAIN JUMPING A TOOTH ON ONE COLLECTOR CHAIN SPROCKET, FLIGHTS SKEWED

This causes flights to run at an angle other than a 90° angle to the wall. This condition must be corrected immediately.

Sprocket teeth worn excessively.	Replace sprocket(s) segments.
Excessive slack in collector chain.	Re-tension chain per INSTALLATION section.
Debris on sprocket teeth	Clean sprocket.
Missing sprocket teeth.	Replace sprocket segments.
Sprocket loose on shaft.	Re-torque sprocket hardware.
Shafts not parallel or level.	Realign shafts. Re-torque all hardware.
Chain too tight.	Check effluent idler shaft for excessive bow. Relieve chain tension – add links to both strands if necessary.
Bent steel shaft.	Replace shaft.

3.6.4 COLLECTOR CHAIN BREAKS

Chain too tight.	Add the same number of links to both sides.
Chain too loose.	Remove the same number of links from both sides.
HS730 Loop chain side bars not parallel, chain bushings not properly installed, missing or improperly bent cotter pins.	Reassemble chain correctly. See INSTALLATION section.
Shaft seized in wall bearing.	Free up shaft and grease wall bearing. Replace wall bearing self-aligning polyurethane hub ball. Repair or replace shaft if severely worn.
pH level below 4 or above 8.	Adjust pH level between 4 and 8. Examine process conditions. Examine chain for excessive deterioration. Replace all collector chain if necessary.
High hydrogen sulfide (H_2S) environment.	Eliminate source of H_2S. Contact **Evoqua** if this is not feasible.
Loose or damaged chain pin.	Loose or damaged pins often result from improper sprocket alignment. Replace and reseat new pins with new cotter pins.
Flight jammed from debris or obstruction in tank.	Remove debris or obstruction.
Misaligned flights from chain jumping sprocket.	See remedy for “CHAIN JUMPING A TOOTH ON ONE COLLECTOR CHAIN SPROCKET, FLIGHTS SKEWED”.
Chain worn out.	Replace chain.

3.6.5 FLIGHTS NOT SUBMERGED EVENLY

(One side deeper in water than the other side.)

Wear shoes missing.	Replace wear shoes.
Return tracks loose on wall or other support.	Drain tank to find loose connection. Re-level return track.
Missing or damaged wear bars.	Drain tank, hose down with high pressure water. Repair or replace wear bars as necessary.

3.6.6 FLIGHT ENDS DAMAGED

If lugged wear shoes supplied, lugs on wrong side of return track.	See the General Arrangement Drawings for the correct orientation of the wear shoes. **Lugs are to be positioned toward the center of tank.**
Sprocket(s) loose on shaft.	Realign sprockets. Re-torque sprocket hardware.
Wall bearing loose on anchor bolts.	Retighten or replace wall bearing anchor bolts. Inspect and repair grout if necessary.
Wall bearing liner material worn excessively.	Replace bearing and/or liner material.
Shaft set collars loose.	Realign shaft and sprockets. Tighten set collar hardware.
Return tracks and shafts at incorrect elevations relative to each other.	Reset to correct elevation per General Arrangement Drawings.
Flights too long or tank too narrow.	Check the width of the tank for the entire length of flight path. Check the length of the flights. Refer to the General Arrangement Drawings.
Return tracks not equidistant from centerline of tank.	Reposition return tracks per General Arrangement drawings.

3.6.7 COLLECTOR OR DRIVE CHAIN BREAKS, BUT TORQUE LIMITER DEVICE DOES NOT ACTIVATE

Shear pin sprocket cast iron hub shear faces seized together.	Drive out shear pin, rotate the sprocket to expose shear faces. Clean up faces and shear pin bores. Grease the shear faces and shear pin before reassembling. Repair any other damage. In locations that have a possibility of corroding, a coating of grease should be applied to the ends of the shear pin after assembly to help seal the pin from the elements. **NOTE: Do not damage parts when separating faces.**
Improper shear pin installed.	Replace with correctly sized pin as above.
Shear pin installed improperly.	Make sure necked-down area of pin is at hub shear faces.
Chain worn through.	Replace chain.
Shear pin limit switch not functioning.	See General Arrangement drawing for proper placement. See VENDOR INFORMATION.

3.6.8 TORQUE LIMITER DEVICE ACTIVATES TO SHUT DOWN COLLECTOR, BUT MOTOR CONTINUES TO RUN (if limit switch is furnished)

Faulty limit switch.	Replace switch.
Limit switch trip lever not hitting switch correctly.	Realign switch to contact trip lever properly (see VENDOR INFORMATION).
Limit switch lever bent or broken.	Replace the trip lever.

3.6.9 FLIGHT CARRYING CHAIN WEARING ON INNER SURFACE OF SIDE BAR

Shaft(s) not level.	Re-level shafts. Check wall bearings for heavy wear.
Shaft(s) not parallel	Set shafts parallel.
HS730 Loop chain side bars not parallel.	Reassemble chain correctly. See INSTALLATION section.
Sprockets not aligned with each other or out of position with respect to tank center.	Align all sprockets per INSTALLATION section of this manual.
Sprockets loose on shaft.	Re-align sprockets. Check location against drawings. Check set collars. Check all setscrews. Re-torque all hardware.
Shafts shifting laterally.	Reposition shaft. Secure set collars at bearings.
Chain too tight.	Check effluent idler shaft for excessive bow. Relieve chain tension - add links to both strands if needed.

3.6.10 FLIGHTS WEARING ON BOTTOM EDGE

Wear shoes worn out.	Replace or reverse shoes.
Wear strips worn.	Replace wear strips.
High spots on tank floor.	Level tank floor.

3.6.11 NOISY OR VIBRATING DRIVE ASSEMBLY

NOTE: Separate motor and reducer to determine if the motor is causing the undesirable noise or vibration.

Misalignment and/or insufficient lubrication of external coupling.	Inspect coupling for damage and replace damaged components. Realign coupling, tighten hub set screws and re-lubricate.
For C-face motors with vibration issue.	Reposition coupling hubs and properly tighten hub set screws. Replace elastomeric insert if worn.
Bearings corroded - condensation present.	Replace bearings, gears and seals. Flush and replace oil. Change oil more frequently.
Motor vibration due to fan or motor imbalance.	Mud dauber wasps or other debris in fan. Clean out carefully. Replace fan if damaged.
Loose mounting and/or assembly hardware.	Inspect for damaged or missing grout. Replace as needed. Realign all components and retighten all hardware.
Insufficient and/or improper lubricant in gear case.	Fill to proper level with recommended lubricant or flush and replace.

(Also see the VENDOR INFORMATION section for more information.)

3.6.12 GEAR REDUCER LEAKING OIL THROUGH SEALS

Too much oil in gear case.	Drain to proper level.
Water present in oil. (Result: foaming)	Drain, flush and refill. Drain more frequently to eliminate condensation build-up.
Air vent clogged.	Clean or replace if necessary.
Damaged seal.	Replace (see VENDOR INFORMATION).

3.6.13 GEAR REDUCER WILL NOT ACCEPT USUAL AMOUNT OF OIL IN GEAR CASE

Condensate and/or sludge build-up.	Drain, flush and refill with seasonal lubricant. Change lubricant more frequently.
Greasing of bearings (if applicable) has been too frequent or too much. Grease accumulates in housing.	Flush reducer, drain and refill to operating level with seasonally appropriate gear oil as recommended by the reducer manufacturer. (See VENDOR INFORMATION).

3.6.14 GEAR LUBRICANT IS MILKY OR LUMPY

Condensation or other water in oil.	Drain, flush and refill. Change oil more frequently.

3.6.15 WEAR ON DRIVE CHAIN SIDE BARS AND SIDE OF SPROCKET TEETH

Misalignment of sprockets.	Check alignment of drive and driven sprockets and correct.
Chain tightener not aligned.	Realign.
Chain too tight or too loose.	Adjust chain tightener or adjust chain length by adding or removing link(s).
Chain or sprocket worn out.	Replace chain and/or sprocket (some sprockets can be reversed, chain can be flipped over).
Reducer shaft not aligned to head shaft.	Realign the reducer shaft.

Material build-up in sprocket tooth pockets.	Remove material build-up - protect drive from contact with foreign material.

3.6.16 DRIVE CHAIN: BROKEN PINS, BUSHINGS OR ROLLERS (as applicable)

Material build-up in sprocket tooth pockets.	Remove material build-up.
Chain or sprocket excessive corrosion.	Replace.
Worn sprockets.	Check sprockets for wear and correct drive chain wrap.
Low pH (non-metal chain only).	Adjust pH level between 4 and 8. Examine process conditions. Examine chain for excessive deterioration. Replace all drive chain if necessary.
Improper shear pin.	Replace with properly sized shear pin. See drive assembly drawing.
Shear pin hub faces frozen together.	Free faces, clean and lubricate per Maintenance Section.

3.6.17 COTTER PINS COME OUT (where applicable)

Obstructions striking cotters.	Eliminate obstruction or bend cotter ends back until ends wrap around pin.
Cotters not installed properly.	Correct faulty installation. Bend cotter ends back until ends wrap around pin.

3.6.18 EXCESSIVE NOISE IN DRIVE CHAIN

Misalignment of sprockets.	Check alignment of drive, driven and chain tightener sprockets and correct.
Too little or too much slack.	Add or remove links or adjust chain tightener for proper slack
Chain or sprocket worn out.	Replace chain and/or sprocket (some sprockets can be reversed).

3.6.19 DRIVE CHAIN CLIMBS SPROCKETS

Chain or sprockets worn out	Replace chain and/or sprockets (some chain and sprockets can be flipped or reversed).
Excessive chain slack.	Remove links or adjust chain tightener for proper slack.
Material build-up in sprocket tooth pockets.	Remove material build-up, protect drive from contact with foreign material.

3.6.20 BROKEN SPROCKET TEETH

Improper shear pin used.	Replace with properly sized shear pin. See drive assembly drawing.
Obstructions or foreign material.	Check chain and sprocket clearances - remove foreign materials.
Excessive shock loads.	Drain, clean and inspect tank and equipment. Adjust process to avoid excessive sludge build up. Consider operating more frequently or continuously.
Chain climbing sprocket.	Replace chain and sprockets. Adjust centers, remove links or adjust chain tightener for proper slack. Remove material build-up.

VENDOR INFORMATION

1.1 REDUCERS – EXISTING SEW EURODRIVE R87R57AM143 OR REPLACEMENT NORD SK63/23

1.2 MOTORS – EXISTING BALDOR / RELIANCE OR REPLACEMENT NORD 71L/4-56C CUS

1.3 LIMIT SWITCH – HONEYWELL 11CX12

1.4 ADHESIVE ANCHORS – HILTI HIT HY200A

1.5 SNAP IDLE CHAIN TENSIONERS

EXHIBIT 6

EXHIBIT 6

Liberty Mutual Insurance Company ("Liberty"), in its capacity as performance bond surety for Colasanti Construction Services, Inc. ("Colasanti"), as principal, and the City of Detroit Water and Sewerage Department ("DWSD"), as obligee, with respect to Performance Bond No. 013022472 ("Performance Bond") issued in connection with Contract No. SW-548 (the "Contract") for construction of certain improvements at DWSD's Southwest Water Treatment Plant ("Project"), acknowledges and agrees as follows:

1. All capitalized terms and references used herein shall have the meaning as set forth in the Settlement Agreement ("Agreement") by and between the Great Lakes Water Authority ("GLWA"), as successor-in-interest to DWSD's rights and obligations under the Contract, Colasanti, J.F. Cavanaugh Company ("Cavanaugh"), and Evoqua Water Technologies LLC ("EWT").

2. Pursuant to Section 2. g. of the Agreement, the September 2017 Tolling Agreement between GLWA, Colasanti and Liberty, including Amendments 1 through 11, is extended from the date of the Agreement until: (a) the commissioning and acceptance of the First Upgraded Basin; or (b) 90 calendar days after the confirmation of a Failure at the First Upgraded Basin that CCE elects not to remediate under Section 2. d. ii. (1).

3. Pursuant to Section 6 of the Agreement, in exchange for GLWA's immediate written withdrawals of its notice of default and termination of the Contract and claim against the Performance Bond, both without prejudice to GLWA's rights and remedies provided in the Agreement, in the event that Colasanti fails to comply with the terms of the Agreement or the First Upgraded Basin experiences a Failure that is not remediated, GLWA has the right to reinstate the default and pursue its claims against the Performance Bond pursuant to Section 2. d. ii. (2) of the Agreement.

4. Any and all GLWA claims and rights whatsoever against Liberty or the Performance Bond shall be fully waived and released upon the first of the following events to occur: (a) the commissioning and acceptance of the First Upgraded Basin; or (b) 90 calendar days after the confirmation of a Failure at the First Upgraded Basin (i) that CCE elects not to remediate under Section 2. d. ii. (1) of the Agreement, and (ii) with respect to which no legal action is commenced by any Party during that 90-day time period.

5. This Exhibit 6 is subject to all of the terms and limitations of the Agreement and the September 2017 Tolling Agreement as amended.

LIBERTY MUTUAL INSURANCE COMPANY

_____ Dated: _____

By: Michele Killebrew

Its: Attorney in Fact