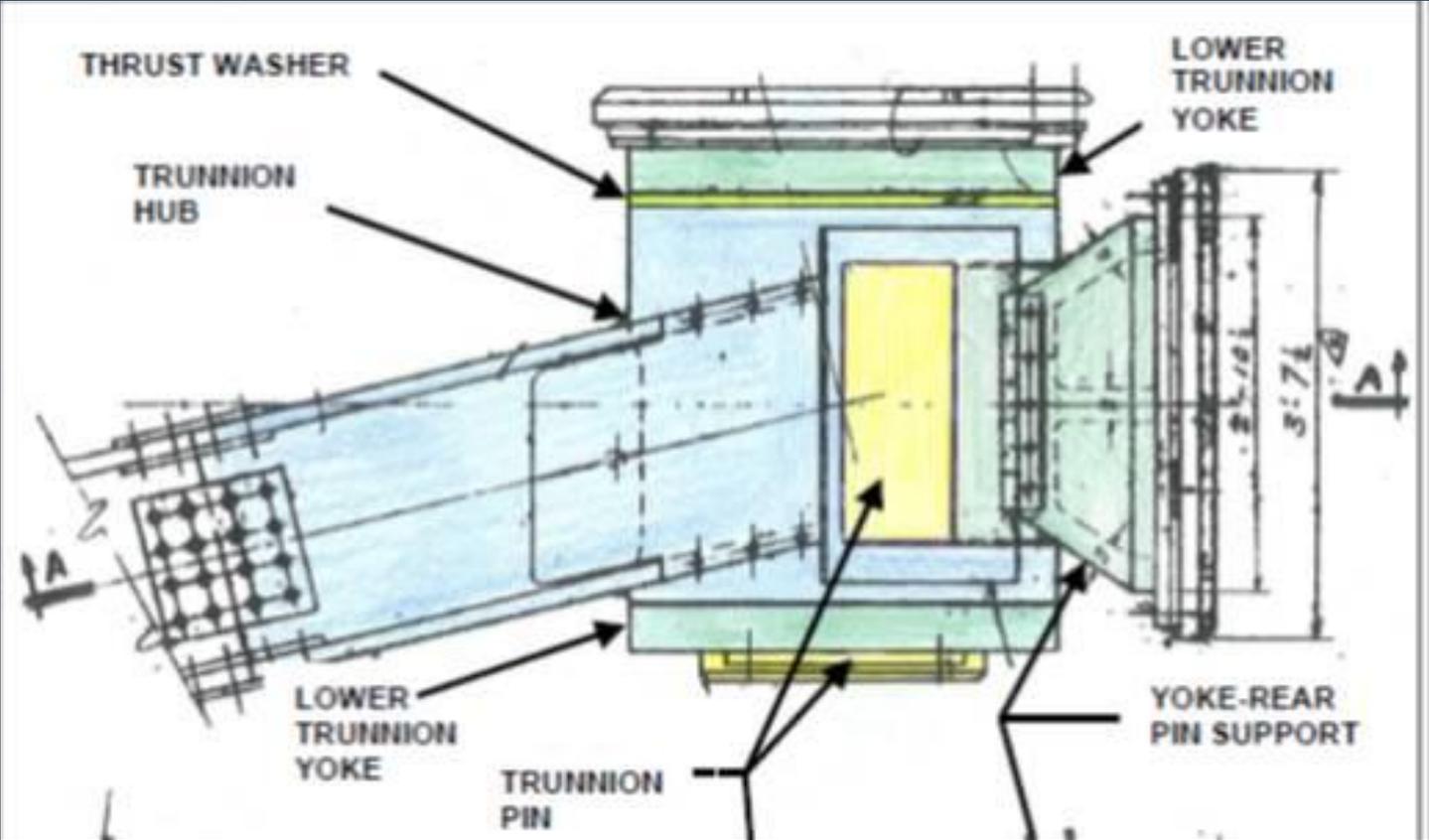


Wanapum Dam Spillway Gate Trunnion Bearings

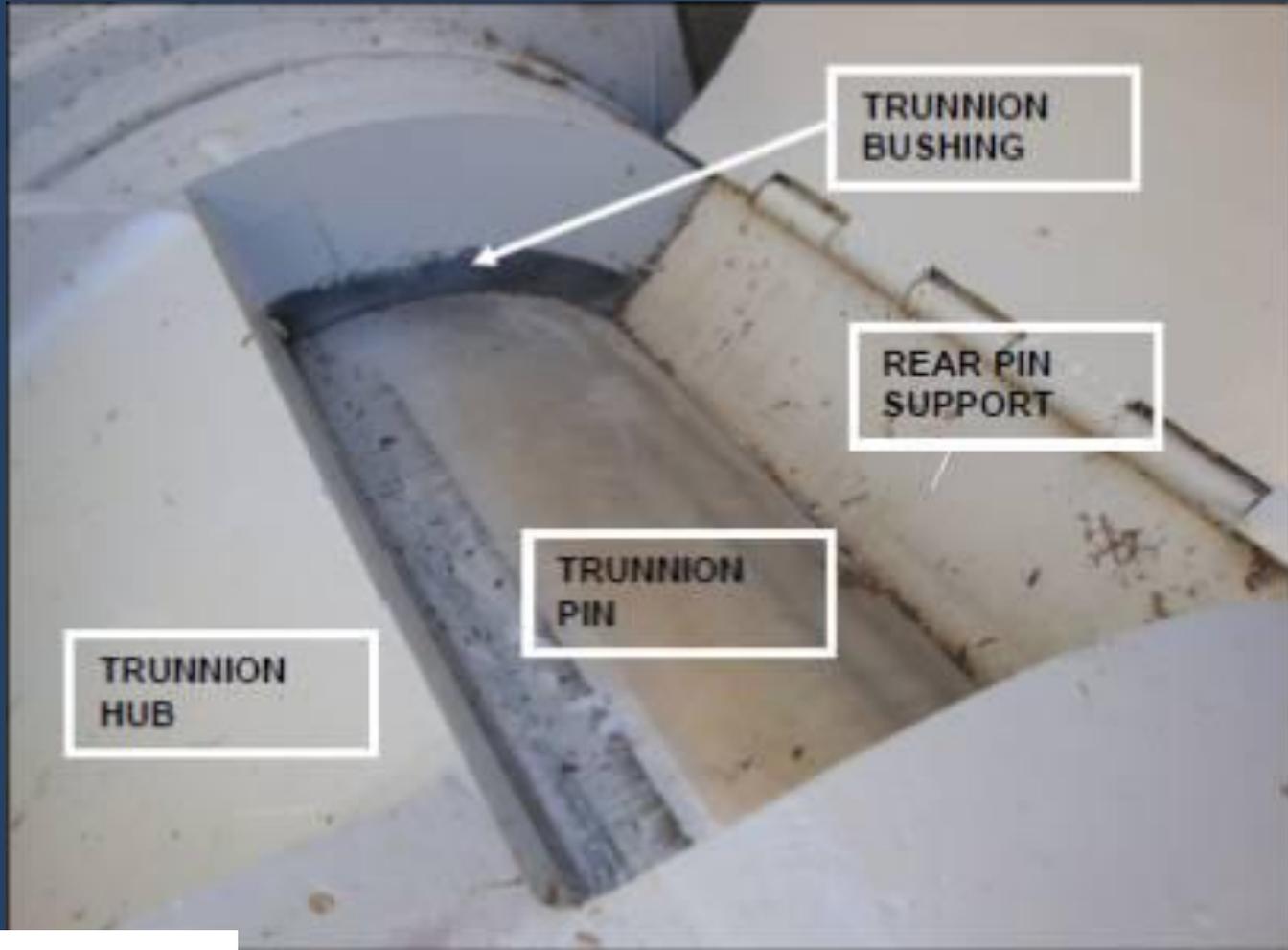


Nathan Manning
Grant County PUD

Plan View of Wanapum Trunnion



Wanapum Trunnion Details



Motivation Behind Original Trunnion Bearing Replacement Program

- 1999 FERC Part 12 Inspection
- Cracked / Crumbling Thrust Washers Observed at Priest Rapids
- Cracked Thrust Washer Observed at Wanapum
- Lab Analysis Determined Type C86100 Manganese Bronze
- Ammonia Induced Stress Corrosion Cracking



Priest Rapids Thrust Washer



Wanapum Thrust Washer Crack



Wanapum Bushing Crack



Wanapum Thrust Washer Crack



Replacement Bearing Selection – Choosing Orkot

- 1998 USACE / Powertech Labs Greaseless Bushings Report
- Favorable Friction Coefficient
- Ease of Installation
- Quick Turn Around Time for Final Machining
- Significant Cost Savings
- Good Test Results at Priest Rapids Installations
- Priest Rapids Bearing Replacement from 2000 – 2001
- Wanapum Bearing Replacement from 2002 – 2011



Issues Attributed to Orkot Trunnion Bearings

- Rotated Pins at Priest Rapids – Remedied with Stronger Keeper Plate Bolts
- Rotated Pins at Wanapum (11 of 24) – Doweled Pin to Prevent Future Rotation
- One Bearing Rotated Inside Housing
- Loose Tubular Support Bolts Possibly Due to Stretch
- Burn Type Wear Marks Observed on Some Pins



Wanapum Rotated Bearing

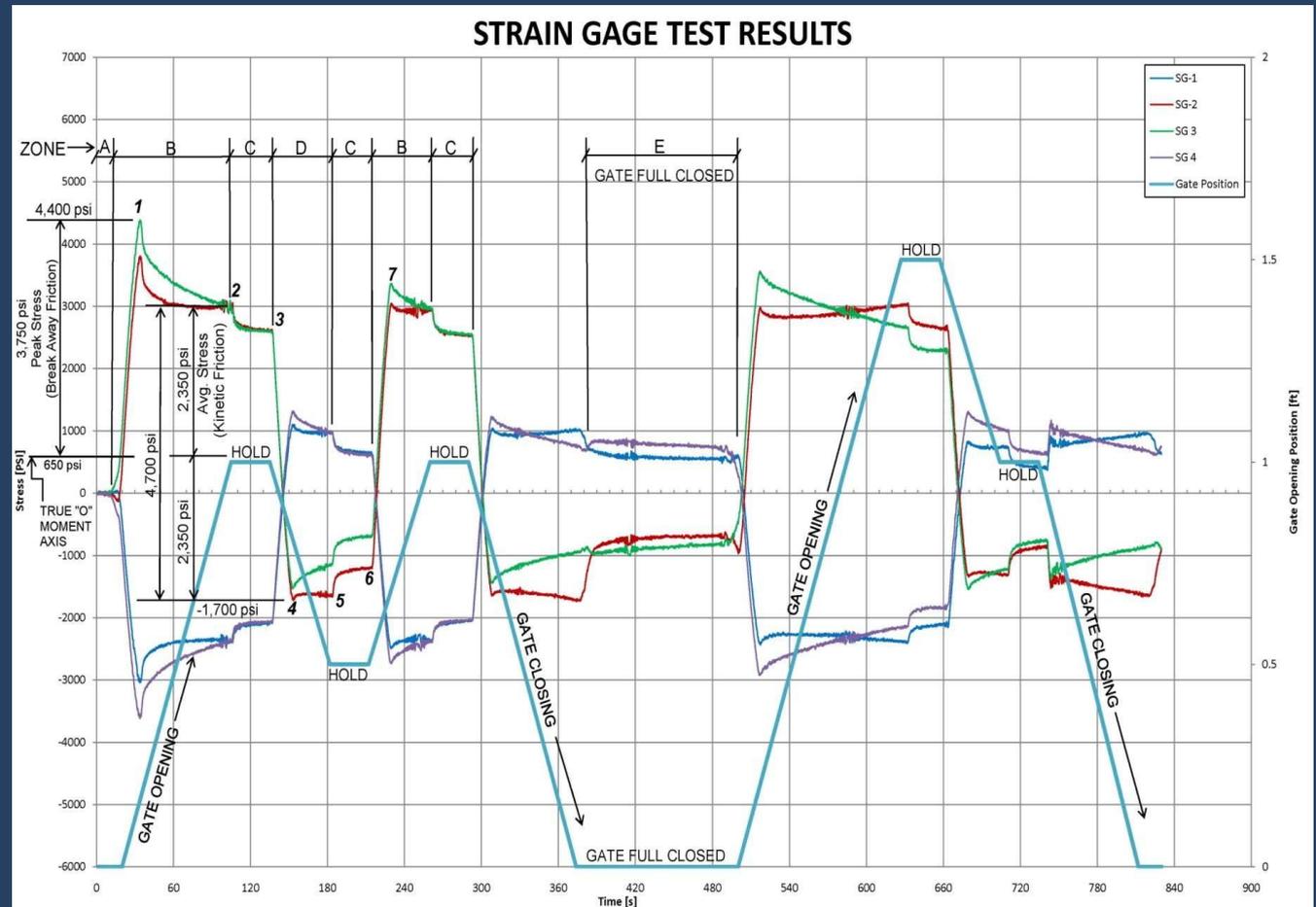


Wanapum Pin Wear Marks



Trunnion Bearing Friction Analysis

- TG-8 and TG-9, 2009 – 2011, Various Times of the Year, Various Trunnion Temperatures:
COF = 0.09 – 0.12
- TG-7, 2010 – 2012, First Set Installed, Chrome Plated Pin vs. Stainless Steel Sleeve: COF > 0.3
- TG-11, 2011 and 2012, Last Set Installed, Increased Clearance to Make up for Material Compression:
COF = 0.2



Possible Explanations of Orkot Poor Performance

- Creep
- Temperature Related Material Expansion
- Material Compression - Increased Bearing Contact Angle
- Lack of Lubricant Transfer – No “Break in Period”
- Bearing Shape – Lack of Full Circle Support
- Speed of Rotation – Near Static vs. Dynamic
- Possible Increased Sensitivity to Trunnion Alignment



Path Forward for Wanapum Trunnion Bearings

- Remove Orkot Bearings
- Install Graphite Plugged Bronze Bearings
- Insure Bronze is More Resistant to Ammonia Induce Corrosion Cracking than Original
- Evaluate Other Bearing Options Such as Spherical Types that Reduce Trunnion Alignment Criticality
- Monitor One Prototype Gate for a Full Season to Determine if Performance is Acceptable



Questions?

